The propagation of a trade cost shock in the global production network

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Abstract
Given the fragmentation of global value chains, any major shock in one country could potentially create a transnational disruption. A recent body of the literature has devoted to exploring the propagation of shocks along the domestic input-output linkages. Our paper offers the first extensive study of a transnational propagation on a global scale. By leveraging the exogenous nature of the US import tariff reduction against Vietnamese products following the 2001 bilateral trade agreement and by taking guidance from a multi-country multi-sector model, we provide evidence that (i) the US producers substituted non-Vietnamese products with the lower-priced Vietnamese ones, (ii) Vietnamese producers diverted exports away from non-US markets, (iii) Vietnamese producers imported more foreign intermediate inputs to support a higher US demand, and (iv) the US producers gained market shares in foreign markets by using lower-priced Vietnamese inputs. These effects were concentrated in the trade links between Vietnam, the US and their largest trading partners. We find no evidence for a propagation further than the trade links directly connected to Vietnam and the US. One key feature of our paper is the ability to contrast cross-border and domestic transmission of shock, offering a unique perspective on the role of production networks in shock propagation.

Keywords: global production network, trade agreement, network effects, trade costs, shock propagation (JEL codes: F10, F14, F15, F42)

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1 Introduction

International trade of our generation has been defined by the increasing fragmentation of global value chains (GVCs). Far gone is the day when every stage of the production was confined within border of a country. With contributions from the continuous efforts to cut down international trade barriers\footnote{One driving force behind the fragmented GVCs is the emergence of multi-lateral trade agreements. Their impact on international trade flows and economic activities is a well-visited topic. On the theory front, models such as Alvarez and Lucas (2007), Caliendo and Parro (2015) and Eaton and Kortum (2002) provide standard frameworks to analyze the welfare impact of a trade agreement. On the empirical side, a large part of the literature builds upon the gravity model and assesses the impact of trade agreements on bilateral trade flows across the member countries. They typically look at preferential trade agreements in general (Anderson and Yotov, 2016; Baier and Bergstrand, 2007 and 2009; Freund, 2000; Magee, 2008), WTO accession (Amiti et al., 2017; Eicher and Henn, 2011; Feng, Li and Swenson, 2017; Ludema and Mayda, 2013), European Union membership (Bergin and Lin, 2012; Chen, 2004) or the NAFTA and CUSFTA (Romalis, 2007).} and from the progress of technologies that allow for better cross-national collaboration, we witness a reorganisation of the global production where countries become more specialised in certain stages of the value chains, with intermediate inputs flowing from and to different parts of the world. In fact, more than fifty percent of worldwide export values nowadays are of intermediate inputs and components. The increasing fragmentation of the global production network has inspired a large body of literature, both theoretically and empirically (Alfaro et al., forthcoming; Antras and Chor, 2013; Costinot, Vogel, and Wang, 2013; Hummels, Ishii, and Yi, 2001; Grossman and Rossi-Hansberg, 2008; Johnson and Noguera, 2012; Los et al., 2015; Timmer et al., 2014).

As a result of this intertwining in production processes, any major shock in one country could potentially create a transnational disruption in the value chains. A growing body of the literature has devoted to studying the propagation of shocks along the input-output linkages within an economy\footnote{Relatedly, a notable part of the literature study the role of networks in propagating and amplifying microeconomic shocks into aggregate fluctuations. See Acemoglu, Carvalho, Ozdaglar and Tabbaz-Salehi (2012), and Acemoglu, Ozdaglar and Tabbaz-Salehi (2016).}. Carvalho, Nirei, Saito and Tabbaz-Salehi (2016) exploit the exogenous nature of the Japanese earthquake in 2011 while Barrot and Sauvagnat (2016) leverage natural disasters and find evidence that suppliers and customers of disaster-stricken firms also suffered output losses. Acemoglu, Akcigit and Kerr (2015) find evidence for the propagation of supply and demand shocks at the industry level along the input-output linkages of the US economy. Outside the realm of domestic propagation, Boehm, Flaaen, and Pandalai-Nayar (2016) find that the US affiliates of the Japanese firms also suffered output losses in the months following the 2011 earthquake, documenting a very specific type of cross-border transmission. In this regard, we contribute to the literature by being the first to study extensively and provide credible evidence for the transnational propagation on a global scale, covering a large number of countries and sectors.

Our paper offers a comprehensive look at the propagation of a positive trade-cost shock in the global production network. We use the US-Vietnam bilateral trade agreement (BTA) in 2001 as the source of the trade shock. We look into the effects of the agreement on the trade flows between Vietnam and its non-US trade partners. In the same spirit, we also explore the effects on the trade flows between the US and non-Vietnamese partners. The disentanglement of these networks
effects is typically hindered by the two major difficulties. First, a bilateral trade agreement usually involves the two countries reducing trade barriers against each other. For instance, if there was a systematic correlation in sectoral tariff schemes between Vietnam and the US, a simultaneous reduction in trade barriers would obscure the propagation because it would be difficult to clearly determine which part of the effect came from the reduction in barriers imposed by Vietnam against the American products, and which part stemmed from the lower barriers imposed by the US against Vietnamese imports. Second, a trade agreement typically occurs between countries with good and growing economic relationships. As such, the possibility of endogeneity is prominent if we want to examine such a reduction in trade costs.

Nevertheless, the 2001 US-Vietnam trade agreement is a special case. Since the end of Vietnam War until 1994, the US imposed a complete embargo against trading with Vietnam. In 1995, the two countries normalized diplomatic relationship and, in the same year, started the process of reaching towards a trade agreement, which was signed in 2001. During 1995 and 2001, the US imposed the general non-preferential tariffs against Vietnamese products. Different from the lower tariffs granted with the most-favoured-nation (MFN) status, these general tariffs were dated back in the 1930s and typically charged against the communist economies following the outbreak of the Korean War. Before 2001 when the agreement was signed, Vietnam had already started to charge MFN tariffs on the American products. And thus, in 2001, the change in US tariffs against Vietnamese imports was essentially a one-sided reduction. The nature of this trade agreement helps to alleviate the two concerns stated above. First, the one-sided nature of the tariff adjustment allows for an examination of the network effects purely stemming from the drop in US tariffs against Vietnam. Second, the US general tariffs charged in 1995 and the MFN rates were not designed with Vietnam as the primary interest and thus independent of the economic situation of Vietnam at the time. Therefore, endogeneity becomes less of a concern.

Given such advantages, we explore four main network effects. We study the horizontal propagation with the substitution effect and the diversion effect, as shown in figure. We test if lower US import tariffs would allow Vietnamese products to gain shares in the US market at the expense of non-Vietnamese suppliers. Then, we test whether Vietnamese producers diverted products away from non-US export destinations in favour of exporting more to the US. These two effects can exist even when there is no fragmentation of the GVCs (i.e. all trade flows are of final products for consumption), and the exploration of this horizontal propagation is not unique to our paper.

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3 see Manyin (2001). By 2001, there were only six countries not granted the MFN status, namely Afghanistan, Cuba, Laos, North Korea, Vietnam and Yugoslavia.

4 Our use of the US-Vietnam bilateral trade agreement is inspired by the studies of McCaig (2011) and McCaig and Pavcnik (forthcoming), who, different from our paper, combine this tariff shock with data from the household surveys of Vietnam to analyse the impact of exporting on regional poverty levels and labour reallocation from household businesses into formal sectors. This exogenous shock allows us to improve upon the current empirical studies on trade agreements without the need of an instrumental variable.

5 Most of the empirical papers on trade agreements explore the impact on the intra-trade among member economies while there is a scarcity of studies on how these agreements have affected a third-party trade partner.

6 Related to the substitution effect, Romalis (2007) finds that NAFTA increased the competition in highly protected sectors and drove out imports from non-member economies. He also finds that the share of EU’s imports coming out of the NAFTA countries declined, which is similar to our trade-diversion effect.
What sets our paper apart is that we can offer a more comprehensive look that further includes the upstream and downstream propagation, whose existence is possible only when there is fragmentation of global value chains with intermediate inputs flowing across countries. That is, we study the vertical propagation with the upstream effect 3 and the downstream effect 4. More specifically, we test if the Vietnamese producers would import more intermediate inputs to meet the higher demand from the US, and whether the American producers would gain competitiveness (in terms of producer prices) by importing cheaper Vietnamese intermediate inputs. To see how far the shock could transmit in the networks, we also test if the propagation continued further upstream and downstream along the trade linkages connected to the suppliers and customers of Vietnam and the US (see figure 12 in section 6).

Methodology-wise, our approach is close to the studies of Romalis (2007), Acemoglu, Akcigit and Kerr (2015), and the natural disaster papers (Barrot and Sauvagnat, 2016; Carvalho et al., 2016; Boehm et al., 2016). Romalis (2007) takes advantage of the different tariffs imposed against different commodities to devise difference-in-difference specifications to test the trade creation and the trade diversion aspects of the NAFTA. Acemoglu, Akcigit and Kerr (2015) derive theory-based measures of upstream and downstream effects to explore the vertical propagation of demand shocks (Chinese import competition and federal spending) and supply shocks (TFP shocks and foreign patents) throughout the industries of the US economy. In our paper, by taking guidance from a multi-country multi-sector model, we derive exact measurements of exposure that show where and how we could see the manifestation of the network effects in the trade flows. And taking advantage of the fact that imports from different sectors of Vietnam were charged different levels of tariffs by the US, we devise difference-in-difference specifications to test the effects.

Note: RoW stands for "rest of the world", which represents the trade partners of either Vietnam or the US. The arrows indicate the directions of trade flows, and the sign "+" or "-" indicates the possibility of having a positive or a negative effect due to the US-Vietnam trade agreement.
Nevertheless, our study differs in three main ways. First, in the studies with natural disasters, the shock inflicted damage upon the firms, and the focus is on output fluctuation. In Acemoglu, Akcigit and Kerr (2015), the shocks occurred at the industry level, and they quantify the impact of these shocks on the gross value added, employment and labour productivity of the connected industries. An equivalence in our context would be to quantify how much the total output of a trade partner increased due to its position as a supplier to Vietnamese producers. However, in our case, the shock occurred along the trade links between Vietnam and the US. And given that we know the strength of all bilateral trade relationships, we estimate the average effects on the trade flows between Vietnam, the US and their partners. Furthermore, we can pin down exactly which trade partner would benefit the most.

Second, we use a positive shock, whose nature of propagating is different. With a disaster, damages to the supply chains are unavoidable. Output losses in the stricken firms are guaranteed, causing damages to also their suppliers and customers. In our case of a positive shock, Vietnamese and American producers had the option to not react. But they did, prompting the propagation that we can detect in the data. Third, given that we also know the domestic production linkages, we are able to contrast the differences between national and cross-border transmissions by comparing the upstream and downstream effects (in figure 1) to the propagation of the tariff shock within the Vietnamese and the American domestic input-output linkages.

Using data on trade flows from the OECD Inter-country Input-Output (ICIO) tables, 2016 edition, and import tariffs from the UNCTAD TRAINS database, we know exactly how much any sector of a particular country has traded with its foreign partners and the extent of import tariffs that this sector faces while trading. We find significant evidence for all four of the network effects. Not surprisingly, most affected suppliers and customers are those with tightest links to the production of Vietnam and the US. On average for the period 2000-2007, every 1 percentage point of decrease in US import tariff against any Vietnamese sector would cause (i) the market shares of a non-Vietnamese supplier in the US to decrease by 0.33% and (ii) the share of this Vietnamese sector in non-US markets to fall by 2.22%, but (iii) it induces an increase of 6000 US dollars in Vietnam’s demand for intermediate inputs from each foreign supplier. On the US side, a 1 percentage point of tariff cut against all Vietnamese sectors aggregately helps an average US producer to increase their foreign market shares by nearly 1.5%.

By computing the total changes in trade values because of the tariff cut, we see that non-Vietnamese producers of textiles lose the most from the competition with the Vietnamese. The diversion effect 2 is strongest with the Vietnamese producers of textiles, mining and computer input linkages, exemplified by Caliendo and Parro (2015). In any model with such input-output linkages, the network effects always exist. But direct empirical testing is still rare. Granted that given certain estimates of the elasticities of substitution between intermediate inputs in the production functions, we will be able to carry out an exercise to compute the economic impact of the tariff shock. Nevertheless, such an exercise relies heavily on a reasonable estimation of elasticities. For example, we would need precise elasticities of substitution between intermediate inputs in the production of Vietnam, the US and any other country in the sample, which probably require either more than just one trade cost shock or very specific identification assumptions. With our reduced-form diff-in-diff specifications, we provide evidence for the propagation and estimate the average effects of the tariff reduction without asking too much from the data.
equipments among others. On the positive side, the Japanese, Korean and Taiwanese suppliers of textile materials and inputs enjoy gains through their exports to Vietnam. And we see the US producers of textiles, petroleum products and vehicles gain market shares in the final consumption of major customers such as Canada, Mexico, Japan, Britain and Germany.

Given that the data include the input-output linkages of each country, we have the advantage to contrast the propagation of shock within the domestic networks of Vietnam and the US with the cross-border effects (in figure 1). We find strong evidence for a domestic propagation where the Vietnamese producers also demand more inputs from domestic suppliers (i.e. national upstream propagation) and the US producers gain market shares within the US economy (i.e. national downstream propagation). The demand for domestic inputs by the Vietnamese producers is much stronger than the demand for foreign inputs (in the upstream effect 3) while the gains in domestic sales by the US producers are on par with the increases in exports (due to the cross-border downstream effect 4). To see how far the shock can propagate in the global network, we test but find no evidence for a propagation further than the linkages directly connected to Vietnam and the US.

Our paper continues as follows. Section 2 explains the data source and provides information on the trade networks connected to Vietnam and the US by the time the agreement was signed. In section 3, we explain the theoretical framework before going into details on how we derive the diff-in-diff specifications. Section 4 provides the estimation results. We explore the domestic propagation of shock and its implications in section 5. In section 6, we continue to explore if the propagation continued further along the supply chains. And we conclude the paper in section 7.

2 Data and more details on the trade patterns

We use bilateral sectoral trade flows extracted from the OECD Inter-country Input-Output (ICIO) tables, 2016 edition. The data cover 63 countries, which account for at least about 90% of the bilateral trade flows that involved Vietnam and the US during 2000-2007. Besides, there is one entity that represents the rest of the world (‘RoW’). There are 34 sectors, which are grouped based on the sectoral classification of ISIC Revision 3 standard. The OECD ICIO tables contain data on bilateral trade flows of intermediate inputs across all sectors of all countries, as well as the total value added and total output of each sector. The tables also contain data on household consumption, government purchases, capital formation and changes in inventories. We combine all these non-

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intermediate-input trade values into one single entity "final demand". The 2016 edition includes data for each year from 1995 to 2011.

We obtain the data of import tariffs (together with the associated bilateral trade flows) from the UNCTAD TRAINS database. The \textit{ad valorem}-equivalent tariffs of nearly 5000 commodities at the 6-digit level of HS classification are obtained and then converted into ISIC Revision 3 classification based on the World Bank concordance table. We need to emphasize two main issues. First, the \textit{ad valorem} tariffs are only applicable to the primary (agricultural and mining) commodities and manufacturing products. It means that there will be no information on trade cost against the trading in services. As a result, we will only consider the non-service sectors of Vietnam throughout our paper.

Second, there are old commodities that stop being traded and also new traded commodities across different years. To have a consistent conversion from HS 6-digit to ISIC Revision 3 classification, we compute the changes in import tariffs $d\text{tariff}_{ij}$ imposed by a country $j$ against a sector $s$ of country $i$ between two any years as follows

$$d\text{tariff}_{ij}^s = \sum_{c \in C} \frac{x_{i,j}^c}{X_{i,j}^s} d\text{tariff}_{ij}^c$$

, where $C$ is the set of commodities that are exported by sector $s$ in both years, $d\text{tariff}_{ij}^c$ is the change of tariff against commodity $c$ between the two years, $x_{i,j}^c$ is how much of $c$ was exported by $i$ to $j$ in the initial year, and $X_{i,j}^s$ is the total exports of sector $s$ in $i$ to $j$ in the initial year. The sectoral tariff change is an average of commodity-level tariffs weighted by the trade values in the initial year. That is, we take into account only those commodities that are traded in both years in our computation at the sectoral level. One advantage of this commodity-matching approach is to avoid endogeneity due to the extensive margin that may be induced by the tariff change. For example, if Vietnamese producers dropped commodities or adopted the production of new products as a response to the higher demand from the US partners, not accounting for this margin would inevitably create correlation between our measure of tariff reduction and the changes in, say, technology \textsuperscript{10}. By using only the commodities that exist in both years, we avoid the complication from the product-level extensive margin.

Table I displays the 18 non-service sectors and the changes in US-Vietnam import tariffs between 2000 and 2007. In fact, the tariff adjustments look similar if we compute the changes between 2000 and any other year afterwards. For the service sectors, we do not have import tariffs. Furthermore, a special treatment is needed for three Vietnamese sectors, namely Mining, Petroleum and Other Transport. The reason is that there are no commodities that were traded both in 2000 and 2007 to derive a commodity-matching difference in tariffs based on the UNCTAD TRAINS dataset. For Mining, we use the weighted change in tariffs between 2000 and 2008 instead. In the case of Petroleum and Other Transport, we compute the simple average changes based on the official tariff

\textsuperscript{10}a notion that is central in the literature on the relationship between trade and product quality upgrading
schedules published by the United States International Trade Commission.\footnote{see https://www.usitc.gov/tariff_affairs/tariff_databases.htm}

In our analysis, we only have the data on import tariffs as the source of trade cost shock. Investigation on non-tariff barriers shows us that Vietnam and the US signed a separate agreement in 2003 to impose a quota on the imports of Vietnamese Textiles. In addition, there were anti-dumping duties against Vietnam’s frozen catfish and canned shrimps in 2003 and 2004 (Bown, 2016). Other than Textiles and these certain Food products, there was no other explicit measure against Vietnamese imports. The Textiles quota itself does not seem very strict, given that we do not see any major trend break after 2003 when we examine the growth trajectory of the Textiles exports to the US. In short, we have yet to find any evidence that should indicate a possibility of correlation between the US-Vietnam tariff reduction and non-tariff measures.\footnote{see key provisions of the BTA at http://www.usvtc.org/trade/bta/key_provisions.htm} Nevertheless, since we do not aim to estimate the effects of the tariff changes per se but to use the tariff cut as a proxy for the shock on the trade link between Vietnam and the US, the non-tariff barriers will only be a concern if they perfectly offset the effects of the tariff cut, which leads to no evidence for a propagation. In the case that there is a positive correlation between the changes in tariffs and non-tariffs barriers, our estimates will partly capture the non-tariff effects.

In our paper, choosing 2007 as the cut-off offers two main advantages. One, this is the year Vietnam joined WTO. Two, this was right before the Global Financial Crisis in late 2000s. Looking at the time period before 2007 saves us the complication of dealing with confounding effects due to these events. Even if there was a pre-WTO anticipation effect, it will be accounted for by our control variables. Another prominent event that happened during 2000-2007 was the accession of China into WTO in 2001, which coincided with the BTA and may raise some concern over the unbiasedness of our estimate. It is important to note that the US granted the most-favoured-nation status to China in the 1990s, which preceded our time period. China’s WTO accession simply made the MFN status permanent. Nevertheless, we should be concerned by a possibility of confounding effects due to the economic rise of China, which is documented to have profoundly impacted the US local market through import competition (notably in Autor, Dorn and Hanson, 2013). Our specifications explicitly control for this Chinese effect. Other than these, there was no other major event that should concern us, especially when any other change in trade costs will be included among the control variables and other developments of bilateral relationships are captured by our country-sector dummies.

Table\footnote{1} and figure\footnote{2} offer more insight into the exogenous and one-sided nature of the BTA. We see that the magnitude of the tariff cut granted by the US to Vietnam in 2001 is substantial and widely different across sectors, ranging from a low 0.5% in Agriculture up to a very high 40% in Manufacturing n.e.c. On the contrary, changes in the tariffs that Vietnam imposed against US imports were mostly negligible given that Vietnam had already granted the US most-favoured-nation status before 2001. Figure\footnote{2} compares the significance of the US as Vietnam’s major export destination and as one of Vietnam’s suppliers between 1995 and 2007. Before the BTA, Vietnam
sent around 5% of its total exports to the US. After 2001, this figure quickly rose to 20% and stayed around this level afterwards. The US has been Vietnam’s most important export market ever since. This sudden and tremendous change in Vietnam’s export trend shows how much of a shock the BTA was to the Vietnamese economy. On the other hand, the share of US products within Vietnam’s total imports has stayed around the same level since 1997 without any sudden adjustment after 2001, signifying that the tariff cut was truly one-sided from the US side.

Looking at the US side with figure 3, we contrast the growth trajectory of Vietnam’s share in the US’ total imports with the growth trends of import shares from some other suppliers, namely China, European Union, Canada, Mexico and India. We normalise the share of each country in 2001 to 1 to highlight the growth speed. The share of Vietnam in the US’ imports of goods increased six times within six years between 2001 and 2007. A part of this growth was probably contributed by the economic growth in Vietnam. Nevertheless, economic growth alone would not be able to account for an abrupt upward trend immediately after 2001. We see evidence of the trade creation aspect of the BTA. Despite the high growth rate, Vietnam remained a minor supplier of goods to the US by 2007, with the total market share of around 0.6% (increased from 0.1% in 2000)\(^\text{13}\). None of the other suppliers experienced such a growth rate in market shares. However, in terms of actual changes, China achieved a substantial market gain from around 10% in 2000 to 20% in 2007, which further convinces us to explicitly control for the Chinese effect in our specification.

At the sector-level, we see significant cross-sectoral variations. Related to figure 2, figure 4 plots the changes by sector in the fractions of Vietnamese goods exported to the US against the US import tariff cut between 2000 and 2007. And figure 5 plots the gains in the US market shares by Vietnamese sectors\(^\text{14}\). Overall, almost all sectors experienced substantial export growth to the US, but the growth rates were widely different. Sectors such as Motor & vehicles went from exporting only 113 thousand USD in 2000 to more than 178 million in 2007, while Textiles and Manufacturing n.e.c became the driving force in exporting to the US. In general, we see that a deeper tariff cut is correlated with a larger increase in goods exported to the US and a larger gain in market share.

Our empirical analysis relies not only on the variation of the US tariff cut against Vietnamese sectors but also the variation in the trade flows between Vietnam, the US and their trading partners before the shock occurred. In 2000, the fraction of Vietnamese exports being intermediate inputs ranged from around 30% (in Food, Textiles, N.e.c.) to more than 90% (in Mining, Minerals and Metals). These numbers are surprisingly similar when we look at the US sectors. On the importing side, about 10% (in Food and Wood) to 50% (in Textiles) of intermediate inputs used in the Vietnamese production were from abroad. The average across all sectors was 40%. This figure was smaller in the US, ranging from 8% in Pulp to nearly 30% in Petroleum with an average of 16%.

Overall, the main suppliers of Vietnam in 2000 were large East Asian economies, including Singapore, China, Japan, South Korea and Taiwan. Main customers were also large neighbouring

\(^{13}\)Our specifications look at the effect of tariff exposures on the growth rates of trade values and market shares. Thus, the small nominal gain is not a concern.

\(^{14}\)We do not show the trade flows out of Vietnamese services since there are no tariff data and these sectors are not included in the analysis.
economies together with European countries such as Germany, France and the UK. On the US side, most significant suppliers and customers were the neighbouring Canada, Mexico, together with Japan, major European economies and RoW. These patterns are reasonably consistent with a typical gravity model in which international trade is decaying with geographical distance and related to the sizes of the economies. At the sectoral level, we see differences in the extent to which each Vietnamese or American sector relied on these partners. They give us a general idea of who would benefit or suffer from the network effects.

This section so far also highlights three main advantages that will help us to implement the diff-in-diff specifications. They are (i) the variation in US tariffs against products from different Vietnamese sectors, (ii) the cross-sectoral heterogeneity in the export growth from Vietnam to the US between 2000 and 2007 and (iii) the fact that each sector in Vietnam and the US has distinctive network links to its suppliers and customers. These features constitute the backbone of our empirical analysis.

<table>
<thead>
<tr>
<th>Group ID</th>
<th>Sectors</th>
<th>Full names</th>
<th>US against VN</th>
<th>VN against US</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agriculture</td>
<td>Agriculture, hunting, forestry and fishing</td>
<td>-0.41</td>
<td>2.00</td>
</tr>
<tr>
<td>1</td>
<td>Mining</td>
<td>Mining and quarrying</td>
<td>-19.75</td>
<td>0.49</td>
</tr>
<tr>
<td>2</td>
<td>Food</td>
<td>Food products, beverages and tobacco</td>
<td>-2.27</td>
<td>0.15</td>
</tr>
<tr>
<td>2</td>
<td>Textiles</td>
<td>Textiles, textile products, leather and footwear</td>
<td>-29.73</td>
<td>3.22</td>
</tr>
<tr>
<td>2</td>
<td>Wood</td>
<td>Wood and products of wood and cork</td>
<td>-31.66</td>
<td>2.89</td>
</tr>
<tr>
<td>2</td>
<td>Pulp</td>
<td>Pulp, paper, paper products, printing and publishing</td>
<td>-11.06</td>
<td>-0.26</td>
</tr>
<tr>
<td>3</td>
<td>Petroleum</td>
<td>Coke, refined petroleum products and nuclear fuel</td>
<td>-6.71</td>
<td>n/a</td>
</tr>
<tr>
<td>3</td>
<td>Chemicals</td>
<td>Chemicals and chemical products</td>
<td>-12.66</td>
<td>-0.01</td>
</tr>
<tr>
<td>3</td>
<td>Rubber</td>
<td>Rubber and plastics products</td>
<td>-27.82</td>
<td>2.79</td>
</tr>
<tr>
<td>4</td>
<td>Minerals</td>
<td>Minerals, Other non-metallic mineral products</td>
<td>-37.46</td>
<td>6.82</td>
</tr>
<tr>
<td>4</td>
<td>Metals</td>
<td>Metals, Basic metals</td>
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</tr>
<tr>
<td>4</td>
<td>Fabricated metal</td>
<td>Fabricated metal products</td>
<td>-17.17</td>
<td>-0.73</td>
</tr>
<tr>
<td>4</td>
<td>Machinery</td>
<td>Machinery and equipment, nec</td>
<td>-25.16</td>
<td>-0.20</td>
</tr>
<tr>
<td>4</td>
<td>Computer</td>
<td>Computer, Electronic and optical equipment</td>
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<tr>
<td>4</td>
<td>Electrical</td>
<td>Electrical machinery and apparatus, nec</td>
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<td>0.25</td>
</tr>
<tr>
<td>6</td>
<td>Motor &amp; vehicles</td>
<td>Motor vehicles, trailers and semi-trailers</td>
<td>-18.98</td>
<td>-0.52</td>
</tr>
<tr>
<td>6</td>
<td>Other transport</td>
<td>Other transport equipment</td>
<td>-25.00</td>
<td>n/a</td>
</tr>
<tr>
<td>5</td>
<td>N.e.c</td>
<td>Manufacturing nec, recycling</td>
<td>-41.26</td>
<td>n/a</td>
</tr>
</tbody>
</table>

The US tariff reduction against a Vietnamese sector is computed as the weighted average of the tariff cut against the subset of commodities that are traded in both 2000 and 2007 (i.e. the intensive margin). The groups indicate the sets of sectors with probable similar characteristics in terms of skill/labour requirement and technology. There is no tariff against trading in services.
Figure 2: Trade with the US as % of total Vietnam’s exports and imports of goods, 1995-2007

Data sources: UN COMTRADE and United States Census Bureau

Figure 3: Trends in market shares of countries in the US’ total imports of goods, 1995-2007 (2001=1)

Data sources: UN COMTRADE and United States Census Bureau
Figure 4: Changes (by sector) in the fraction of Vietnamese goods exported to the US, 2000-2007

Figure 5: Changes (by sector) in the market shares of Vietnamese goods in the US, 2000-2007
3 The theoretical framework and baseline specifications

Our empirical specifications are guided by the following standard Ricardian-type trade model with (i) Cobb-Douglas production and utility functions (ii) one original input factor, (iii) perfect competition, (iv) market clearing in all markets, (v) inelastic labor supply, and (vi) a small shock to the levels of prices, expenditure shares and cost shares. Further assume that there are $N$ countries, with $S$ intermediate-goods sectors and one final consumption category $f$ in each country.

In particular, the Cobb-Douglas production function of sector $t \in S$ in country $j \in N$ is given by:

$$l_j^t \geq 0, \quad (q_{ij}^{st} \geq 0) \quad \text{such that:} \quad q_j^t = (l_j^t)^{\lambda_j^t} \prod_{s \in S} (q_{ij}^{st})^{\lambda_j^st}$$

with the composite good of sector $s \in S$, $q_j^{st}$, produced by sourcing sector-$s$ goods from all countries $i \in N$

$$q_j^{st} = \left[ \sum_{i \in N} (q_{ij}^{st})^{1 - \gamma_j^{st}} \right]^{-\frac{1}{1 - \gamma_j^{st}}}$$

and the Cobb-Douglas utility

$$u_j^f = \prod_{s \in S} (q_{j}^{sf})^{\lambda_j^f}$$

with $q_j^{sf}$ as defined in (2). Here, $l_j^t$ is the labour, $\lambda_j^t$ is the labour cost share and $\lambda_j^{st}$ is the expenditure share on composite good $s$ by sector $t$. The parameter $(1 - \gamma_j^{st}) > 0$ is the elasticity of substitution between intermediate inputs $s$ from different countries $i$ in the production of the composite good.

The producer price index $p_j^t$ corresponding to [1], the product price index $r_j^{st}$ corresponding to [2], and the consumer price index $p_j^f$ corresponding to [3] become

$$p_j^t = \left( \frac{w_j^t}{\lambda_j^t} \right)^{\lambda_j^t} \prod_{s \in S} \left( \frac{r_j^{st}}{\lambda_j^{st}} \right)^{\lambda_j^{st}}$$

$$r_j^{st} = \left[ \sum_{i \in N} (p_i^{st} \tau_{ij}^{st})^{\gamma_j^{st}} \right]^{1/\gamma_j^{st}}$$

$$p_j^f = \prod_{s \in S} \left( \frac{r_j^{sf}}{\lambda_j^f} \right)^{\lambda_j^f}$$

where $r_j^{st}$ also comprises $r_j^{sf}$. It follows from Shephard’s Lemma

$$\pi_{ij}^{st} = \frac{\partial \ln(r_j^{st})}{\partial \ln(p_i^t)} = \frac{\partial \ln(r_j^{st})}{\partial \ln(\tau_{ij}^{st})} = \frac{(p_i^{st} \tau_{ij}^{st})^{\gamma_j^{st}}}{(r_j^{st})^{\gamma_j^{st}}}$$
The total differentials of the price indices are given by

\[
d \ln(p_{ij}^t) = \lambda_{ij}^t d \ln(u_j) + \sum_{s \in S} \lambda_{ij}^{st} \left[ \sum_{i \in N} \left( d \ln(p_{ij}^s) \pi_{ij}^{st} + \pi_{ij}^{st} d \ln(\tau_{ij}^{st}) \right) \right]
\]

(4)

\[
d \ln(r_{ij}^{st}) = \sum_{i \in N} \left( d \ln(p_{ij}^s) \pi_{ij}^{st} + d \ln(\tau_{ij}^{st}) \pi_{ij}^{st} \right)
\]

(5)

\[
d \ln(p_{ij}^{st}) = \sum_{s \in S} \lambda_{ij}^{st} \left[ \sum_{i \in N} \left( d \ln(p_{ij}^s) \pi_{ij}^{st} + \pi_{ij}^{st} d \ln(\tau_{ij}^{st}) \right) \right]
\]

(6)

From the balanced trade condition, we can infer the intermediate goods trade equation:

\[
x_{ij}^{st} = \pi_{ij}^{st} \lambda_j^{st} X_j^t
\]

(7)

where \(x_{ij}^{st} = (p_{ij}^s \pi_{ij}^{st}) q_{ij}^{st} \) is the value of intermediate inputs that sector \(t\) of country \(j\) buys from sector \(i\) of country \(s\). The input share \(\pi_{ij}^{st}\) gives

\[
\pi_{ij}^{st} = \frac{x_{ij}^{st}}{\sum_{k \in N} x_{ij}^{st}}
\]

and the total output \(X_j^t = \sum_{u \in S \cup \{f\}, k \in N} x_{jk}^{tu}\).

Total differential of the expenditure shares in country \(j\) gives

\[
d \ln(\pi_{ij}^{st}) = \gamma^{st} \left( d \ln(p_{ij}^s) + d \ln(\tau_{ij}^{st}) - d \ln(r_{ij}^{st}) \right)
\]

\[= \gamma^{st} \left( d \ln(p_{ij}^s) + d \ln(\tau_{ij}^{st}) \right) - \gamma^{st} \sum_{n \in N} \left( d \ln(p_{nj}^s) \pi_{nj}^{st} + d \ln(\tau_{nj}^{st}) \pi_{nj}^{st} \right)
\]

(8)

, while the total differential of the trade equation implies

\[
d(x_{ij}^{st}) = (\pi_{ij}^{st} \lambda_j^{st}) \times dX_j^t + \lambda_j^{st} X_j^t \times d(\pi_{ij}^{st})
\]

\[= (\pi_{ij}^{st} \lambda_j^{st}) \times \left( \sum_{u \in S \cup \{f\}, k \in N} d x_{jk}^{tu} \right) + \lambda_j^{st} X_j^t \times d(\pi_{ij}^{st})
\]

(9)

From this framework, we can directly relate to the network effects (in figure 1). We differentiate between two types of effects. One is demand-driven as in effect 3, where Vietnam’s input suppliers enjoy higher demand from Vietnamese producers. And the second is price-driven as in effects 1, 2 and 4. For demand-driven effects, we test the impact of the US-Vietnam tariff cut on the changes of trade flows \(dx_{ij}^{st}\). However, for price-driven effects, we test the effect on changes in input shares \(d \ln(\pi_{ij}^{st})\). Either the exporter \(s, i\)’s shares in the foreign markets increase if the price becomes more attractive, or it will lose market shares if the price becomes relatively high. If we look at the trade flows to examine price-driven effects, we will need to make sure that the changes in trade values are truly emerging because of price movements and not driven by the changes in total demand \(X_j^t\) facing the importers \(\{t, j\}\). To see how the effects manifest in the model, we simply replace the country indices \(i\) and \(j\) in equations 8 and 9 to either Vietnam or the US, depending on whether
the country is the importer or the exporter.

### 3.1 Substitution effect 1

Replacing the importer index \( j \) in equation 8 with "US" gives

\[
d\ln (\pi_{st,iUS}) = \frac{\gamma_{st} \left( d\ln (p_s^i) + d\ln (\tau_{st,iUS}) \right)}{\text{country-sector dummies}} - \gamma_{st} \left( d\ln (p_{VN}^i) + d\ln (\tau_{VN,iUS}) \right) \pi_{VN,iUS} - \sum_{n \neq VN} \left( d\ln (p_{n}^i) + d\ln (\tau_{n,iUS}) \right) \pi_{n,iUS}.\]

The substitution happens in the US product price \( d\ln (r_{US}) \) through the term \(-\gamma_{st} \left( d\ln (p_{VN}^i) + d\ln (\tau_{VN,iUS}) \right) \pi_{VN,iUS}\). On one hand, the tariff reduction within \( d\ln (\tau_{VN,iUS}) \) makes the price of Vietnamese inputs cheaper for the US producers. On the other hand, higher demand can also drive up Vietnamese producer prices \( d\ln (p_{VN}^i) \). Nevertheless, if there truly exists an increase in demand from the US, it must be that Vietnamese inputs are still relatively cheap despite some rising in producer prices. Therefore, we expect the net effect to be in favour of Vietnam and negative for non-Vietnamese producers.

By proxying both the change in trade cost \( d\ln (\tau_{VN,iUS}) \) and the change in Vietnamese producer price \( d\ln (p_{VN}^i) \) with the magnitude of the import tariff cut \( dtar_{VN,iUS} \), we infer the measurement of exposure

\[
\text{Substitution}_{US}^{st} = \pi_{VN,iUS}^{st} dtar_{VN,iUS}.
\]

Here, we need to clarify two issues. First, if there is a systematic correlation between the tariff reduction and the changes in non-tariff barriers, our estimate will pick up the net effect of these changes in trade costs. However, we have yet to find concrete evidence for any correlation between tariff and non-tariff adjustments (see section 2), and thus, the effects related to non-tariff barriers against Vietnam are likely captured by the sector dummies and the error terms. Second, in our model, the first-order approximation gives us the change of price \( d\ln (p_{VN}^i) \) linear in \( dtar_{VN,iUS} \) (see section 5.2), which supports our use of the tariff cut as the proxy for the change in price.

A direct translation from the input share equation \( d\ln (\pi_{iUS}) \) above gives us the diff-in-diff specification

\[
d\ln (\pi_{iUS}) = \beta_0 + \beta_1 \text{Substitution}_{US}^{st} + X_{iUS}^{st} \gamma + \mu_i^{st} + \varepsilon_{st,iUS},
\]

where Substitution\(_{US}^{st}\) is the exposure of a sector \( s \) in any country to the heightened competition in sector \( t \) of the US after the tariff cut (as defined above), \( \mu_i^{st} \) are sector- and country-specific dummies (with \( T \) indicating the sector groups specified in table 1), and \( X_{iUS}^{st} \) represents a set of
variables to control for initial characteristics of sector \( \{t, US\} \) in 2000 and other factors that are yet to be controlled by the dummies. We exclude Vietnam and the US from the set of exporting countries \( i \). The share of imports from non-Vietnamese producers will decline the most in the US sector where the competition is most fierce and the substitution within the US production is strongest. That is, \( \beta_1 \) is negative, and higher Substitution \( \text{Substitution}_{st^tUS} \) is associated with lower \( d\ln(\pi^t_{st^tVN,US}) \) for all \( \{s \in S \cup f, i \in N\} \).

The term \( \beta_1 \text{Substitution}_{st^tUS} \) will capture the average effect of \(-\gamma_{st^t} (d\ln(p^*_sVN) + d\ln(\tau^t_{st^tVN,US})) \pi^t_{st^tVN,US} \). Any deviation from the average is included in the error term.

The \( \{s, i, T\} \)-specific dummies \( \mu^t_{s,T^i} \) capture all the \( \{s, i, T\} \)-specific factors including changes in (i) the producer price \( d\ln(p^*_i) \), (ii) the trade costs \( d\ln(\tau^t_{st^t}) \) and (iii) the non-Vietnam part of the US product price \(-\gamma_{st^t} \sum_{i \neq VN} d\ln(p^*_i) + d\ln(\tau^t_{st^tij}) \pi^t_{st^tij} \). Notice that since our exposure measure is \( \{s, t\} \)-specific, we cannot use \( \{s, i, t\} \)-dummies to capture all the US-related elements on the \( \{t, US\} \)-side. However, we group sectors that we think are similar in terms of skill/labour requirement and technology development into \( T \) groups (as specified in the first column of table 1) and rely on \( \mu^t_{s,T^i} \) to capture the general trends within each group \( T \). That is, the dummies can capture any contemporaneous changes in the US sectors up to the \( T \) level. To further control for the importer \( t \)-related factors (especially the trend in technology progress), we include in \( X^t_{st^tUS} \) the lag of the dependent variable, the weighted average change in the US import tariffs \( \sum_{n \neq VN} d(\text{tar}^*_nUS) \pi^t_{nj} \), together with the initial year-2000 log-values and the 1995-2000 pre-trends of the following indicators: (i) total output \( X^t_{US} \), (ii) the composite-input share \( \lambda^t_{US} \), (iii) the share of domestic inputs in the production \( \text{Domshare}^t_{US} = \sum_s x^s_{st^tUS} X^t_{US} \), and (iv) the labour cost share \( \lambda^t_{US} \).

### 3.2 Diversion effect 2

Rewriting equation 8 for the shares of Vietnam in non-US export destinations \( d\ln(\pi^t_{st^tVN,j}) \) gives

\[
\frac{\gamma_{st^t} (1 - \pi^t_{st^tVN,j}) d\ln(p^*_VN)}{\text{tariff exposure}} - \frac{\gamma_{st^t}}{i \neq VN} \sum_{i \neq VN} d\ln(p^*_i) \pi^t_{ij} + \frac{\gamma_{st^t}}{i \in N} d\ln(\tau^t_{st^tij}) - \frac{\gamma_{st^t}}{i \in N} \sum_{i \in N} d\ln(\tau^t_{st^tij}) \pi^t_{ij}.
\]

The effect is through the change of Vietnamese producer price \( d\ln(p^*_VN) \). And thus, we derive the exposure of sector \( \{s, VN\} \) to the trade cost shock as

\[
\text{Diversion}^t_{VN} = d\text{tar}^t_{VN,US}.
\]

We again proxy the change in price \( d\ln(p^*_VN) \) with the change in tariff \( d\text{tar}^t_{VN,US} \). We then estimate the diversion effect with the following specification

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\[
d \ln \pi_{i VN,j}^{st} = \beta_0 + \beta_2 \text{Diversion}_{i VN}^{st} + X_{i VN,j}^{st} \gamma + \mu_j^{St} + \varepsilon_{i VN,j}^{st}
\]

The term \(\beta_2 \text{Diversion}_{i VN}^{st}\) will capture the average effect in \(\gamma^{st}(1 - \pi_{i VN,j}^{st})d \ln(p_{i VN}^{st})\). Since we use \(d\text{tar}_{i VN,US}^{st}\) as the magnitude of the tariff cut, \(\beta_2\) is expected to be negative. A larger tariff reduction would lead to more diversion and more negatively affects the Vietnamese shares in non-US markets.

Our exposure measure is \(s\)-specific, meaning that we cannot use \(s\)-dummies and need to rely on the grouping of \(S\) groups according to the first column of Table 1 to account for the common trend in each group. We use the \(\{S,t,j\}\)-dummies \(\mu_j^{St}\) to capture \(S-, t-\) and \(j-\) specific factors within \(d \ln(p_{i VN}^{st})\), \(d \ln(\pi_{i VN,j}^{st})\) and \(d \ln(r_{i VN}^{st})\). We control further for changes in trade costs between Vietnam and its partners by including (within \(X_{i VN,j}^{st}\)) the actual import tariff change \(d\text{tar}_{i VN,j}^{st}\) and the initial year-2000 tariff level \(\text{tar}_{i VN,j}^{st}\) against Vietnam, as well as the average import tariffs \(\sum_{i \in N}(d\text{tar}_{i j}^{st})\pi_{i j}^{st}\) imposed by the export partners \(\{t,j\}\). To further control for other exporter \(s\)-related developments (particularly the technological progress that influences the producer price \(d \ln(p_{i VN}^{st})\)), we include in \(X_{i VN,j}^{st}\) the lag of the dependent variable together with the initial log-values and 1995-2000 pre-trends of the following indicators: (i) total output \(X_{i VN}^{st}\), (ii) the sector-specific export share \(\lambda_{i VN, exports}^{st} = \sum_{i \in N} x_{i VN,j}^{st} X_{i VN}^{st}\), (iii) the share of domestic inputs in the production \(\text{Domshare}_{i VN}^{st} = \sum_{i \in N} x_{i VN,VN}^{st} X_{i VN}^{st}\), and (iv) the labour cost share \(\lambda_{i VN}^{st}\).

One notable issue is the possibility of endogeneity due to Vietnam’s accession into WTO in 2007. There are potentially two complications. One, on the Vietnamese producer side, because of Vietnam’s granting MFN tariff rates to all WTO members, Vietnamese producers can enjoy cheaper foreign intermediate inputs, which may mitigate the upward pressure on Vietnamese prices due to higher final demand from the US. Two, on the demand side, other countries granting MFN status to Vietnam will help Vietnamese products to regain some competitiveness within these markets. However, since we are looking at the time frame 2000-2007, the accession in 2007 should have no immediate and big impact on our dependent variable \(d \ln \pi_{i VN,j}^{st}\). Even if the Vietnam’s WTO accession had created pre-2007 anticipation, we do include these post-WTO-accession tariff changes inside of \(X_{i VN,j}^{st}\). Furthermore, the dummies \(\mu_j^{St}\) will also control for the WTO-induced changes within sector groups \(S\) of Vietnam.

### 3.3 Upstream demand effect

From the trade flow equation [9], we have

\[
d x_{i VN}^{st} = \pi_{i VN}^{st} x_{i VN}^{st} \left( \sum_{u \in S \cup \{f\}} d x_{i VN,US}^{tu} \right) + \pi_{i VN}^{st} x_{i VN}^{st} \left( \sum_{u \in S \cup \{f\}, k \neq US} d x_{i VN,k}^{tu} \right) + X_{i VN}^{st} x_{i VN}^{st} d \left( \pi_{i VN}^{st} \right).
\]

We see that, \textit{ceteris paribus}, any increase in total US demand for Vietnamese products should induce a 1-1 increase in the imports of inputs by Vietnamese producers. Nevertheless, in the case
that there are adjustments in the usage of foreign intermediate inputs or the diversion effect 2, the 1-1 relationship does not hold. Anyhow, unless the increase in US demand is entirely offset by these changes, we should see a positive upstream demand for foreign inputs by Vietnamese sectors in the data.

The main source of effect 3 is from the changes in US demand \( \sum_{u \in S \cup \{ f \}} dx_{VN,US}^{tu} \). Approximately,

\[
dx_{VN,US}^{tu} = x_{VN,US}^{tu} \times d \ln x_{VN,US}^{tu} = x_{VN,US}^{tu} \times d \ln \left( \pi_{VN,US}^{tu} \lambda_{US}^{tu} X_{US}^{tu} \right) = x_{VN,US}^{tu} \times d \ln \left( \pi_{VN,US}^{tu} \right) + x_{VN,US}^{tu} d \ln X_{US}^{tu}\]

From the input share equations 8, we have

\[
d \ln \left( \pi_{VN,US}^{tu} \right) = \gamma^{tu} \left( 1 - \pi_{VN,US}^{tu} \right) \left( d \ln (p_{VN}^{t}) + d \ln (\tau_{VN,US}^{tu}) \right) + ...\]

The demand from the US depends on the relative price of Vietnamese products, which explains why our upstream effect is ultimately related on the shares of Vietnamese inputs in the US sectors. Proxying \( d \ln (p_{VN}^{t}) + d \ln (\tau_{VN,US}^{tu}) \) with \( d \text{tar}_{VN,US}^{t} \), we have the exposure of export line \( dx_{VN,US}^{tu} \) to the trade cost shock is \( x_{VN,US}^{tu} \times d \text{tar}_{VN,US}^{t} \). Summing up over the exports to all US sectors, we get the exposure measure

\[
\text{Upstream}_{iVN}^{st} = \left( \pi_{iVN}^{st} \lambda_{VN}^{st} \sum_{u \in S \cup \{ f \}} x_{VN,US}^{tu} \right) d \text{tar}_{VN,US}^{t}\]

We then estimate the upstream effect with the following specification

\[
dx_{iVN}^{st} = \beta_0 + \beta_3 \text{Upstream}_{iVN}^{st} + X_{iVN}^{st} \gamma + \mu_{iVN}^{stT} + \varepsilon_{iVN}^{st}.\]

The \( \mu_{iVN}^{stT} \) dummies capture the \( \{ s, i \} \)- and group \( T \)-specific factors within the non-US demand term \( \pi_{iVN}^{st} \lambda_{VN}^{st} \left( \sum_{u \in S \cup \{ f \}, k \neq US} dx_{VN,k}^{tu} \right) \) and the changes in Vietnamese production \( X_{VN}^{st} \lambda_{VN}^{st} \) and the dependent variable, together with the initial values and pre-trends for the total output and the usage of domestic inputs, labour and sector-specific inputs in the production (as specified in the specification of the substitution effect 1). The error terms will capture non-Vietnamese factors within the US demand for Vietnamese inputs \( \pi_{iVN}^{st} \lambda_{VN}^{st} \left( \sum_{u \in S \cup \{ f \}} dx_{VN,US}^{tu} \right) \) and any \( t \)-factors that are yet to be picked up by either the dummies or the control set.

As with effect 2, we need to address the possibility of endogeneity due to Vietnam’s accession into WTO in 2007. First, because of Vietnam’s granting MFN tariff rates to all WTO members, Vietnamese producers can enjoy lower prices of foreign inputs and may import more from overseas
as a result. This effect will be manifested through \( d\left(\pi_{st}^{i VN}\right) \). Second, Vietnam is granted MFN status by all WTO members, which creates a boost in foreign demand for Vietnamese products. This effect is integrated in \( \left(\sum_{u \in S \cup \{f\}, k \neq US} dx_{V N,k}^{tu}\right) \). Nevertheless, since our 2007 tariff data are post-WTO-accession and \( X_{st}^{i VN} \) coupled with \( \mu_{sT}^{i} \) should sufficiently control for confounding effects, such endogeneity is not a concern. Moreover, the full effect of the accession may take time to become fully realised, not immediately in 2007.

3.4 Downstream price effect 4

Rewriting the input-share equation with US as the exporter gives us

\[
\frac{d \ln(p_{US}^{st})}{\text{tariff exposure}} = \gamma^{st}(1 - \pi_{US,j}^{st}) \frac{d \ln(p_{US}^{s})}{\text{country-sector dummies}} - \gamma^{st} \sum_{i \neq US} d \ln(p_{i}^{s}) \pi_{ij}^{st} + \gamma^{st} \left[ d \ln(\tau_{US,j}^{st}) - \sum_{i \in N} d \ln(\tau_{ij}^{st}) \pi_{ij}^{st} \right].
\]

Further rewriting the producer price equation yields

\[
\frac{d \ln(p_{US}^{s})}{\text{the exposure}} = \sum_{k \in S} \lambda_{US}^{ks} \pi_{VN,US}^{ks} \left( d \ln(p_{VN}^{k}) + d \ln(\tau_{VN,US}^{ks}) \right) + \lambda_{US}^{s} d \ln(w_{US}) + \sum_{k \in S} \lambda_{US}^{ks} \sum_{n \neq VN} \left( d \ln(p_{n}^{k}) \pi_{n,US}^{ks} + \pi_{n,US}^{ks} d \ln(\tau_{n,US}^{ks}) \right)\]

sector dummies & control variables

We see that the shares of imports coming out of the US depend on the US producer prices, which in turn are influenced by their input prices. Effect 4 comes through the term \( \left( d \ln(p_{VN}^{k}) + d \ln(\tau_{VN,US}^{ks}) \right) \). On one hand, lower import tariffs make Vietnamese inputs cheaper for the US producers. On the other hand, more demand from the US also pushes up wages and producer prices in Vietnam. Again by proxying \( \left( d \ln(p_{VN}^{k}) + d \ln(\tau_{VN,US}^{ks}) \right) \) with the magnitude of the US tariff reduction against Vietnamese inputs, we derive the measure of effect 4 as

\[
\text{Downstream}_{US}^{s} = \sum_{k \in S} \lambda_{US}^{ks} \pi_{VN,US}^{ks} d \tau_{VN,US}^{k}
\]

, which is a summation over all US-Vietnam tariff changes weighted by the reliance of this US sector on Vietnamese intermediate inputs in 2000. Note that this is a weighted sum over Vietnamese non-
service sectors.

Consequently, we estimate the effect of the US sectoral exposure indicator \( \text{Downstream}^t_{US} \) on the shares of US products in intermediate inputs used by all other non-Vietnam non-US countries with the specification

\[
d\ln \pi_{USj}^t = \beta_0 + \beta_4 \text{Downstream}^t_{US} + X^t_{USj} \gamma + \mu^t_j + \varepsilon^t_{USj}
\]

If the US producers import more from Vietnam, it must be that Vietnamese goods are relatively cheap despite some increase in producer prices after the trade agreement. That is, we expect the effect of the tariff reduction on \( (d\ln(p^t_{VN}) + d\ln(\tau^t_{VN,US})) \) to be negative, which leads to a decrease in \( d\ln(p^t_{US}) \). The lower price \( p^t_{US} \) then induces an increase in \( d\ln(\pi^t_{US,j}) \) with a magnitude of \( \gamma^t (1 - \pi^t_{US,j}) \). Or that, \( \beta_4 \text{Downstream}^t_{US} \) will capture the average effect of \( \gamma^t (1 - \pi^t_{US,j}) \left[ \sum_{k \in S} \lambda^k_{US} \pi^k_{VN,US} \left( d\ln(p^k_{VN}) + d\ln(\tau^k_{VN,US}) \right) \right] \). Similar to the diversion effect, we control for the other elements in the above equations of \( d\ln(\pi^t_{US,j}) \) and \( d\ln(p^t_{US}) \) with the country-sector dummies \( \mu^t_j \) and the control set \( X^t_{USj} \) (which includes (i) the lag of the dependent variable, (ii) initial values and changes in tariffs against imports out of the US, (iii) the average change in tariffs imposed by the importers against all suppliers, and (iv) the initial values and the pre-trends of the US sectoral production).

A potential source of confounding factors is the accession of China into WTO in 2001. In our case, this Chinese effect is seen in the equation of \( d\ln(p^t_{US}) \), which can be rewritten to include the component \( \sum_{k \in S} \lambda^k_{US} \pi^k_{VN,US} \left( d\ln(p^k_{VN}) + d\ln(\tau^k_{VN,US}) \right) \). Given that the changes in trade cost \( d\ln(\tau^k_{VN,US}) \) is minimal, we control for this Chinese effect by further including the variable \( \sum_{k \in S} \lambda^k_{US} \pi^k_{CN,US} \), which indicates the reliance of a US sector to Chinese imports in 2000. We are not concerned by this Chinese effect in the other three network effects because (i) there was no major change in the economic tie between Vietnam and China at the time and (ii) the heterogeneity in trade flows out of China is captured by the dummies.

4 Estimation results

All trade values after 2000 are redenominated in 2000 US dollars by using the US GDP deflator\(^{15}\). Three further issues with the data need to be emphasized. First, since we look at the changes in trade flows and in shares of intermediate inputs, we drop all export lines with zero trade flows in 2000. That is, we only look at the intensive margin of pre-established trade links. Second, we only include the Vietnamese sectors with which the US import tariffs are available in table 1\(^\text{II}\). When we look at the trade flows out of the US in the downstream price effect 4, we also include only the US non-service sectors because there are no data on tariffs imposed against US services. Nevertheless, we do include service sectors from the trade partners of Vietnam and the US because changes in

\(^{15}\text{see https://fred.stlouisfed.org/series/GDPDEF}\)
tariffs against them will be captured by our country-sector dummies. Three, in the case of the upstream effect 3, we do not look at the trade flows into Vietnam to serve the final demand. This effect stems from the higher US demand for Vietnamese products, and thus, the import flows for final consumption in Vietnam are irrelevant. For the other three effects, we do look at the imports for consumption.

In our specifications, despite the inclusion of country-sector dummies and the group of variables that account for pre-trends and initial sectoral characteristics, it is possible that some contemporaneous factors in Vietnam and the US are not perfectly captured. That is, the residuals may be correlated. Hence, we always cluster the standard errors at the level of Vietnam’s and the US’ sectors. One potential problem is that we have small numbers of clusters. In fact, since we limit the sample to only the manufacturing sectors of Vietnam and the US, the number of cluster is 18. One solution is to compute the $p-$value according to the $t-$distribution with the degree of freedom $G - k$ (where $G$ is the number of clusters and $k$ the number of cluster-invariant control variables), which will give us a much wider confidence interval than a standard normal distribution. This is how we infer from the results. All the $p-$values are computed based on this inference with the $t-$distribution.

<table>
<thead>
<tr>
<th>Clusters</th>
<th>2004</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>32373</td>
<td>15139</td>
</tr>
<tr>
<td>adj. R-sq</td>
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<td>0.121</td>
</tr>
</tbody>
</table>

Table 2: Network effects - baseline estimation results

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th></th>
<th>2007</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Substitution</td>
<td>$-32.13^{**}$</td>
<td>(14.50)</td>
<td>$-41.69^*$</td>
<td>(21.67)</td>
</tr>
<tr>
<td>Substitution $ \times$ Mean of weights</td>
<td>$-0.252%$</td>
<td></td>
<td>$-0.327%$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diversion</td>
<td>$-0.0171^{***}$</td>
<td>(0.00558)</td>
<td>$-0.0222^{**}$</td>
<td>(0.00913)</td>
</tr>
<tr>
<td>Diversion</td>
<td>$-1.71%$</td>
<td></td>
<td>$-2.22%$</td>
<td></td>
</tr>
<tr>
<td>Upstream</td>
<td></td>
<td></td>
<td>$0.00606$</td>
<td>(0.0900)</td>
</tr>
<tr>
<td>Upstream $ \times$ Mean of weights</td>
<td>$-0.000$</td>
<td></td>
<td>$0.006$</td>
<td></td>
</tr>
<tr>
<td>Downstream</td>
<td>$53.79$</td>
<td>(57.23)</td>
<td>$240.0^{***}$</td>
<td>(69.44)</td>
</tr>
<tr>
<td>Downstream $ \times$ Mean of weights</td>
<td>$0.325%$</td>
<td></td>
<td>$1.442%$</td>
<td></td>
</tr>
</tbody>
</table>

Note: t statistics in parentheses; * $p<0.10$, ** $p<0.05$, *** $p<0.01$. The $p-$values are computed based on the $t-$distribution with the degree of freedom equal to the cluster size minus the number of cluster-invariant variables. The rows with $\times$ Mean of weights indicate the average economic impacts. Fixed-effect estimator is used to control for the country-sector dummies. For all four effects, we control for the lag of the dependent variable, together with pre-2000 growth rates and 2000 initial characteristics of Vietnamese and American sectors, including (i) total outputs, (ii) the share of domestic inputs and (iii) the share of value added in each unit of output. We further control for any changes in trade costs that are not related to the US-Vietnam trade agreement. With effects 1 and 3 where the exposure is on the importer side, we control for the pre-trends in the usage of intermediate inputs in the production of Vietnam and the US. With effects 2 and 4 where the exposure is on the exporter side, we control for the pre-trends in the export patterns of Vietnamese and American intermediate inputs across all countries. For the upstream effect, the average economic impact is denominated in millions of 2000 US dollars.

16When the number of clusters is less than approaching the infinity, which is arguably less than 42, the estimates of the standard errors can be biased downward and we tend to over-reject the null hypotheses (Angrist and Pischke, 2009).
Table 3: Descriptive summary of the weights in the exposure measures, 1st-step propagation

<table>
<thead>
<tr>
<th>Effect</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>25th percentile</th>
<th>50th percentile</th>
<th>75th percentile</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substitution</td>
<td>0.000079</td>
<td>0.000187</td>
<td>0.000000</td>
<td>0.000001</td>
<td>0.000006</td>
<td>0.000029</td>
<td>0.000863</td>
</tr>
<tr>
<td>Upstream</td>
<td>0.008559</td>
<td>0.126097</td>
<td>0.000000</td>
<td>0.000013</td>
<td>0.000077</td>
<td>0.000706</td>
<td>8.717491</td>
</tr>
<tr>
<td>Downstream</td>
<td>0.000060</td>
<td>0.000086</td>
<td>0.000002</td>
<td>0.000005</td>
<td>0.000016</td>
<td>0.000129</td>
<td>0.000299</td>
</tr>
</tbody>
</table>

Note: The mean of each weight is used to make inference about the average economic impact of the corresponding effect. The weights are calculated by summing up all the tariff-unrelated parts of the exposure measures. For example, suppose an exposure equal to \( \sum_{s \in S} \omega_s \text{tariff}_{Y,N,US} \), the weight is then \( \sum_{s \in S} \omega_s \). (The weight \( \times \) the point estimate) indicates the total economic impact given a universal tariff reduction of 1 percentage point against every sector \( s \in S \).

Table 4: Summary of the estimated changes in market shares, 2000-2007

<table>
<thead>
<tr>
<th>Effect</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>25th percentile</th>
<th>50th percentile</th>
<th>75th percentile</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substitution</td>
<td>-0.02%</td>
<td>0.14%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>-0.001%</td>
<td>-0.0015%</td>
<td>-4.59%</td>
</tr>
<tr>
<td>Diversion</td>
<td>-0.05%</td>
<td>0.19%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>-0.01%</td>
<td>-0.03%</td>
<td>-2.92%</td>
</tr>
<tr>
<td>Downstream</td>
<td>0.56%</td>
<td>2.17%</td>
<td>0.00%</td>
<td>0.04%</td>
<td>0.11%</td>
<td>0.35%</td>
<td>51.07%</td>
</tr>
</tbody>
</table>

Note: The estimated changes in market shares are computed based on the point estimates, the exposure measures and the initial 2000 input shares (see below).

Table 5: Summary of the estimated changes in trade flows (millions of 2000 US dollars), 2000-2007

<table>
<thead>
<tr>
<th>Effect</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>25th percentile</th>
<th>50th percentile</th>
<th>75th percentile</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substitution</td>
<td>-2.59</td>
<td>64.61</td>
<td>0.00</td>
<td>-0.00004</td>
<td>-0.00199</td>
<td>-0.03090</td>
<td>-6423.01</td>
</tr>
<tr>
<td>Diversion</td>
<td>-0.23</td>
<td>3.44</td>
<td>0.00</td>
<td>-0.00071</td>
<td>-0.00305</td>
<td>-0.01874</td>
<td>-153.51</td>
</tr>
<tr>
<td>Upstream</td>
<td>0.13</td>
<td>2.64</td>
<td>0.00</td>
<td>0.00013</td>
<td>0.00086</td>
<td>0.00802</td>
<td>180.08</td>
</tr>
<tr>
<td>Downstream</td>
<td>1.52</td>
<td>31.78</td>
<td>0.00</td>
<td>0.00207</td>
<td>0.01526</td>
<td>0.12187</td>
<td>3809.26</td>
</tr>
</tbody>
</table>

Note: For the substitution, diversion and downstream effects, the estimated changes in trade flows are computed based on the estimated changes in market shares (summarised in table 4) and the initial 2000 trade flows. For the upstream effect, the changes are computed based on the point estimate and the exposure measure. See below for more details.
4.1 Horizontal propagation - Substitution effect

The first row of table 2 reports the estimates for effect 1. Besides the period 2000-2007, we do the same estimations for the period 2000-2004 with two purposes, (i) as a robustness check and (ii) to explore if the effects are time-varying. For both time periods, the estimates are negative and statistically significant. This confirms our expectation that the reduction in import tariffs would prompt US producers to replace foreign inputs with relatively cheaper Vietnamese ones. We also see that the effect deepens in the long run, with a larger magnitude in the sample of 2000-2007. Recall that exposure 1 is a weighted measurement, with the weights indicating the relative importance of Vietnamese inputs in the production in 2000. The term "Substitution × mean of weights" shows the average economic impact of effect 1, evaluated at the average value of all the weights. Given the exposure measure Substitution_{US}^{st} = π_{VN,US}^{st}d\text{tar}_{VN,US}^{st}, the weight is π_{VN,US}^{st}. Table 3 provides descriptive statistics of the weights from all exposure measures. We see that the weights are highly concentrated near zero, which reflects the role of Vietnam as a minor supplier to the US in 2000.

On average, a 1 percentage point of decrease in US import tariff against Vietnamese inputs from
any sector, say \( s \), would cause the share of inputs from sector \( s \) of all other countries to decrease by 0.33% between 2000 and 2007. Given the average tariff cut of about 23%, the economic impact is not small. Figure 6 shows the US sectors where the substitution with Vietnamese inputs is strongest and the suppliers who are most badly hit by the tariff shock. To determine which non-Vietnamese suppliers are most affected, we first compute the changes in input shares

\[
\hat{d} \pi_{it,US}^{st} = \exp \left( \ln \pi_{it,US}^{st} + \hat{\beta}_1 \text{Substitution}_{st,US} \right) - \exp(\ln \pi_{it,US}^{st})
\]

based on the point estimate \( \hat{\beta}_1 \) of 2000-2007 sample. To facilitate a comparison with the other three effects, we then translate these estimates into changes in trade values by computing

\[
\hat{d} \hat{x}_{it,US}^{st} = \hat{d} \hat{\pi}_{it,US}^{st} \lambda_{it,US} X_{it,US}.
\]

We display the country-sector pairs of the largest \( \hat{d} \hat{x}_{it,US}^{st} \) in figure 6.

In terms of input shares \( \hat{d} \hat{\pi}_{it,US}^{st} \) (summarised in table 4), the largest impact can be found in textiles demanded by the American producers and consumers, where the largest competitors of Vietnam are China, Mexico and countries not in the sample (or RoW). The 30%-point tariff cut against Vietnamese textiles causes a drop of 3.9 percentage point for the share of China’s textiles in US final consumption. It also causes an estimated decrease of 2.3 percentage point in the share of Mexico, and 1.2 percentage point for Italy and Canada. Significant impact can also found in the Mining sector, where the 20% tariff cut against Vietnam causes an estimated shrinkage of up to 1.6 percentage point for Canadian mining inputs in many sectors of the US.

Translated into trade values (see table 5 and figure 6), the biggest impact includes RoW Textiles’ loss of USD 6.4 billion, while the Chinese and Mexican Textiles sectors lose 5.5 and 3.2 billion respectively. The losses occur mostly in the trade flows from the largest suppliers. However, the average loss of all estimated \( \hat{d} \hat{x}_{it,US}^{st} \) is much smaller at 2.6 million.

### 4.2 Horizontal propagation - Diversion effect

Table 2 provides the evidence for this diversion effect. We find statistically significant estimates for both time period, and they are negative as expected. Furthermore, the effect strengthened in the long run where the point estimate for 2000-2007 is \(-0.0222\) as opposed to \(-0.0171\) for 2000-2004.

Recall that the exposure measure is the magnitude of the tariff cut itself. Hence, the point estimates are also the average economic effects. On average, a 1 percentage point decrease in US tariff against Vietnamese imports from a certain sector \( s \) could cause a decrease by 2.22% in the share of Vietnamese sector-\( s \) inputs elsewhere during 2000-2007.

Again, we determine the most affected trade linkages by first computing the implied changes in input shares

\[
\hat{d} \hat{\pi}_{VN,j}^{st} = \exp \left( \ln \pi_{VN,j}^{st} + \hat{\beta}_2 \text{Diversion}_{VN} \right) - \exp(\ln \pi_{VN,j}^{st})
\]

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and then translating them into trade values

\[ d\hat{x}^t_{VN,j} = d\hat{\pi}^t_{VN,j} \lambda_j^t X_j^t. \]

The sector-country pairs of the largest \( d\hat{x}^t_{VN,j} \) are shown in figure 7.

In terms of market shares (see table 4), sectors with the largest decreases are Electrical, Petroleum, Mining, Manufacturing n.e.c and Basic Metals. The biggest estimated drop is 2.9%, found with the Electrical exports to the Thai Final Demand. We also see a decrease of 1.5-2.0 percentage point in the shares of Electrical in other Thai sectors. The shares of Vietnamese Petroleum decrease with a magnitude of 2-2.2 percentage point in many Cambodian sectors. And an estimated reduction of 1.5-2.0 percentage point is found in the shares of Vietnamese Mining inputs in Australia and Singapore.

In terms of trade values (figure 7), the picture of the most affected trade linkages looks quite different. Despite the shares of Vietnamese Textiles in non-US markets do not decrease much,
their values are large. Moreover, the diversion effect occurs mostly with the consumption goods. Specifically, the exports from Textiles to Japan, Germany and Row’s Final Demand decrease by 145, 139 and 129 million respectively. The diversion concentrates in the exports out of a number of large Vietnamese sectors, but the average $d\hat{x}_{VN,j}$ is only 230 thousand.

4.3 Vertical propagation - Upstream effect

We find evidence for the effect in the long run. The estimate is positive as expected. On average, a 1 percentage point of US tariff cut against sector $\{s, VN\}$ induces an increase of 6 thousand US dollars in imports by this sector from each foreign supplier during 2000-2007. The weights summarised in table $3$ are the imports of foreign inputs by the Vietnamese producers to meet the US demand \( \left( \pi_{iVN}^{st} \lambda_{iVN}^{st} \sum_{u \in S \cup \{f\}} x_{VN,US}^{st} \right) \) in 2000.

Figure $8$ displays the country-sector pairs from the largest estimated increases in trade flows $d\hat{x}_{iVN}^{st} = \hat{\beta}_3 \text{Upstream}_{i, VN}^{st}$. 

Figure 8: Most affected trade links in upstream effect 3, in trade values
Computer equipments, Manufacturing n.e.c and Textiles are the three sectors of Vietnam that see highest increases in demand for foreign inputs. Most affected trade partners are major Asian producers, namely Japan, South Korea, Taiwan and Singapore. Particularly, the 60% tariff cut induces Vietnamese Computer producers to import USD 86 million more of Japanese Computer equipments and USD 36 million more from Singapore. The 30% tariff cut in Textiles also induces Vietnamese Textiles producers to import an estimate of USD 180 million of Textiles materials from South Korea and USD 164 million more from Taiwan. In Manufacturing n.e.c, we see estimates of 15.5 million and 14 million US dollars of Textiles inputs also from South Korea and Taiwan. In general, these four Asian countries enjoy significant benefits from the US-Vietnam trade deal through the demand effect, which is not surprising given that they are known to be major partners of all Vietnamese sectors. Aside from the main suppliers of these major Vietnamese sectors, the estimated increases in import flows are not as large. The increases with values higher than 1 million dollars account for 1.5% of all estimated $\hat{d}x_{i,VN}$. The mean estimate is 130 thousand.

4.4 Vertical propagation - Downstream effect

We show in figure the country-sector pairs of the largest estimated increases in export values out of the US

$$d\hat{x}_{US,j} = d\hat{x}_{US,j}x_j$$

, where the changes in input shares are

$$d\hat{\pi}_{US,j} = \exp\left(\ln{\pi_{US,j}} + \beta_4\text{Downstream}_{US}\right) - \exp\left(\ln{\pi_{US,j}}\right)$$

We see the effect is detected only in the long run. On average, a 1%-point of tariff drop against all Vietnamese sectors aggregately helps the US producers to increase their input market shares by nearly 1.5% in the long run. In terms of input shares (summarised in table), the US Textile and Petroleum producers gain the most, with 5-50% points of market shares in many export destinations. These exceptionally large gains are due to the fact that these sectors are dominant suppliers to many sectors in Costa Rica, Canada and Mexico. However, they account for only 1.6% of all estimated $\hat{x}_{US,j}$. In fact, the average estimated gain in shares for the entire 2000-2007 sample is 0.5 percentage point, which is reasonable given that Vietnam is still a small supplier despite the high growth rate in exports.

Translated into values, as seen in figure the largest gains are found in the exports of Textiles, Petroleum, Vehicles and Manufacturing n.e.c. towards mostly Final Demand of the largest partners, including Canada, Mexico, Japan, RoW, Britain and Germany. The biggest numbers are with Textiles to Mexican consumption at 3.8 billion, to Mexican Textiles at 1.9 billion and to Canadian consumption at 1.8 billion. Nevertheless, the average gain is a much smaller 1.5 million (see table).
4.5 Summary

This section has provided evidence for all four network effects. Nevertheless, we observe the upstream effect 3 and the downstream effect 4 only in the long run with the 2000-2007 sample. In general, the largest impact is on the US side with the estimated total changes in trade values between the US and its (non-Vietnam) trading partners much larger than the changes found on the (non-US) trade links connected to Vietnam. Textiles stands out as the most impacted sector in all four effects, which reflects its central role in driving Vietnam’s exports at the time. Our results also survive a number of robustness checks, including redoing the analysis with different years and controlling more rigorously for the impact of the trade cost shock on wages (see appendix A).
5 Domestic propagation and the indirect cross-border transmission of shock

We have so far seen evidence for the propagation of shock along the foreign trade links directly connected to Vietnam and the US. Nevertheless, the vertical propagation can also occur along the domestic input-output linkages of the two countries. That is, Vietnamese sectors use more inputs from other domestic suppliers, and the US sectors gain market shares within their home economy. These domestic effects closely resemble the transmission of supply and demand shocks along the US production linkages in Acemoglu, Akcigit and Kerr (2015). Their existence is only possible in a world with fragmented domestic production networks. In this section, we will test for the existence of domestic effects and contrast them to the cross-border propagation from section 4.

Furthermore, the existence of a domestic transmission of shock within the Vietnamese input-output linkages will enable an indirect channel of upstream propagation. In the baseline estimation of cross-border shock transmission, we find evidence for the effect where Vietnamese producers use more intermediate inputs to serve higher demand from the US. Nevertheless, there may also be an indirect channel in which Vietnamese suppliers use more inputs but to meet higher demand from their Vietnamese customers who then export more to the US. On the downstream side, we can also anticipate an indirect effect where the US producers gain competitiveness not only because they use lower-priced Vietnamese inputs but also because they use more domestic inputs from other US producers, who themselves gain pricing advantage by importing cheaper Vietnamese inputs. The indirect effect occurs through the domestic input-output linkages of the US economy.
5.1 Domestic propagation

5.1.1 Upstream effect

Rewrite the trade equation for input flows between Vietnamese sectors gives

\[ dx_{VN,VN}^{st} = \pi_{VN,VN}^{st} \lambda_{VN}^{st} \left( \sum_{u \in S \cup \{f\}} dx_{VN,US}^{tu} \right) + X_{VN}^{lt} d \ln \pi_{VN,VN}^{st} \]

\[ + X_{VN}^{lt} d \ln \lambda_{VN}^{st} + \pi_{VN,VN}^{st} \lambda_{VN}^{st} \left( \sum_{u \in S \cup \{f\}, k \neq US} dx_{VN,k}^{tu} \right). \]

The upstream propagation is due to the Vietnamese buyers’ exposure to the higher US demand. One key difference to the cross-border upstream effect is that the Vietnamese seller side is also directly exposed to the shock in the same manner of the diversion effect 2. Thus, we need to control for the domestic diversion (to avoid the complication from possibly systematic correlation between the exposure measures). The exposure measures are similar to the cross-border exposures 2 and 3. We replace the seller country index \( i \) to \( VN \) in the case of upstream propagation, and the buy index \( j \) to \( VN \) in the case of diversion effect. Subsequently, we have the following measures

\[ \text{Upstream}^{st}_{VN,VN} = \left( \pi_{VN,VN}^{st} \lambda_{VN}^{st} \sum_{u \in S \cup \{f\}} x_{VN,US}^{tu} \right) dt\alpha_{VN,US}, \]

\[ \text{Diversion}^{st}_{VN} = X_{VN}^{lt} dt\alpha_{VN,US}^{st} \]

We test the domestic upstream propagation with the specification

\[ dx_{VN,VN}^{st} = \beta_0 + \beta_3 \text{Upstream}^{st}_{VN,VN} + X^{st} \gamma + \mu^{st} + \varepsilon_{VN,VN}^{st}, \]

where \( X^{st} \) further includes Diversion\( ^{st}_{VN} \) in addition to the set of controls specified in the case of the cross-border effect 3.
5.1.2 Downstream effect

On the US side, rewrite the input share equation but with the US sectors as both suppliers and customers,

\[
\frac{d \ln(\pi_{US,US}^st)}{d \ln(p_{US}^s)} = \gamma_{US}^st \left(1 - \pi_{US,j}^st\right) \frac{d \ln(p_{US}^s)}{d \ln(p_{VN}^s)}
\]

\[\text{Downstream propagation}\]

\[-\gamma_{US}^st \left(d \ln(p_{VN}^s) + d \ln(\tau_{VN,US}^st)\right) \pi_{VN,US}^st \]

\[\text{Substitution effect}\]

\[-\gamma_{US}^s \sum_{i \neq US,VN} d \ln(p_{i}^s) \pi_{ij}^st + \gamma_{US}^s \left[d \ln(\tau_{US,j}^st) - \sum_{i \neq VN} d \ln(\tau_{i,j}^st) \pi_{i,j}^st\right].\]

The downstream propagation is due to the US sellers’ exposure to Vietnamese inputs. Since the buyer side is also directly exposed to the tariff shock, we need to control for the substitution effect in which the US buyers substitute domestic US inputs with lower-priced Vietnamese ones. Following the specifications of the cross-border effects, we have the domestic US measures

\[
\text{Downstream}_{US}^s = \sum_{k \in S} \lambda_{US}^{ks} \pi_{VN,US}^{ks} dtar_{VN,US}^k, \]

\[
\text{Substitution}_{US}^s = \pi_{VN,US}^st dtar_{VN,US}^s
\]

and the estimation equation

\[
\frac{d \ln(\pi_{US,US}^st)}{d \ln(p_{US}^s)} = \beta_0 + \beta_1^s \text{Downstream}_{US}^s + X^s \gamma + \mu^s + \varepsilon_{US,US}^st
\]

, where \(X^s\) includes \(\text{Substitution}_{US}^s\) in addition to the control variables specified in the case of cross-border downstream propagation 4.

5.2 Indirect propagation through domestic production linkages

5.2.1 Upstream effects

Rewriting the trade equation shows us

\[
d_{x_{i,VN}}^st = \pi_{i,VN}^st \lambda_{VN}^st \left(\sum_{u \in S \cup \{f\}} dx_{VN,US}^tu\right) + \pi_{i,VN}^st \lambda_{VN}^st \left(\sum_{u \in S} dx_{VN,VN}^tu\right)
\]

\[\text{Direct effect - US demand}\]

\[+ \pi_{i,VN}^st \lambda_{VN}^st dx_{VN,VN}^tf + \pi_{i,VN}^st \lambda_{VN}^st \left(\sum_{u \in S \cup \{f\}, k \neq VN,US} dx_{VN,k}^tu\right) + X^t_{VN} d\left(\pi_{i,VN}^st \lambda_{VN}^st\right).
\]

\[\text{Indirect effect - Domestic demand}\]
We see the direct effect due to the increase of export flows to the US \(\sum_{u \in S \cup \{f\}} dx_{VN,US}^{tu}\) and the indirect effect coming from the increase of domestic product flows \(\sum_{u \in S} dx_{VN,VN}^{tu}\). Sector \{t, VN\} may use more intermediate inputs from \{s, i\} not only because it needs to export to the US but also because it needs to supply to sector \{u, VN\}, who itself increases the production to meet a higher US demand. Notice that we can again write each \(dx_{VN,VN}^{tu}\) (for all \(s \in S\)) in terms of the US demand and domestic demand:

\[
\begin{align*}
\sum_{u \in S} dx_{VN,VN}^{tu} &= \pi_{VN,VN}^{tu} \lambda_{VN}^{tu} \left( \sum_{k \in S \cup \{f\}} dx_{VN,US}^{uk} + \sum_{k \in S} dx_{VN,VN}^{uk} \right) + \ldots \tag{US demand} \\
&= \pi_{VN,VN}^{tu} \lambda_{VN}^{tu} \left( \sum_{k \in S} dx_{VN,VN}^{uk} \right) + \ldots \tag{Domestic demand}
\end{align*}
\]

Continue in this manner to fully expand the term \(\sum_{u \in S} dx_{VN,VN}^{tu}\) and focus only on the components related to Vietnam’s domestic production and the US demand, we see:

\[
\sum_{u \in S} dx_{VN,VN}^{tu} = \left( \sum_{h=1}^{\infty} \Pi_{VN}^{ht} \right) \cdot \text{USdemand} + ...
\]

where \(\Pi_{VN}\) is the matrix containing all domestic input shares of Vietnam:

\[
\Pi_{VN} = \begin{bmatrix}
    a_{11} & a_{12} & a_{13} & \ldots \\
    a_{21} & a_{22} & a_{23} & \ldots \\
    \vdots & \vdots & \ddots & \vdots \\
    a_{SS} & & & &
\end{bmatrix}
\]

with \(a_{mn} = \pi_{V_{N},VN}^{mn} \lambda_{VN}^{mn}\) (\(m, n \in S\)). \text{USdemand} is a column vector containing the changes in US demand for Vietnamese products \(\left\{ \sum_{u \in S \cup \{f\}} dx_{VN,US}^{tu} \right\}_{t \in S}\), and \((\cdot)_t\) indicates the \(t^{th}\) row of the matrix.

Further denote \(I\) as an identity matrix of size \(S \times S\). We can rewrite the trade equation \(dx_{i,VN}^{st}\) above as:

\[
\begin{align*}
dx_{i,VN}^{st} &= \pi_{i,VN}^{st} \lambda_{VN}^{st} \left( \left( I + \sum_{h=1}^{\infty} \Pi_{VN}^{ht} \right) \cdot \text{USdemand} \right) + \ldots \\
&= \pi_{i,VN}^{st} \lambda_{VN}^{st} \left( (I - \Pi_{VN})^{-1} \right) \cdot \text{USdemand} + \ldots
\end{align*}
\]
The matrix \((I - \Pi_{VN})^{-1}\) is the Leontief inverse for the Vietnamese economy. Proxying the increase of US demand \(\left( \sum_{u \in S \cup \{f\}} x_{VN,US}^{tu} \right)\) by the weighted tariff adjustment \(\left( \sum_{u \in S \cup \{f\}} x_{VN,US}^{tu} \right) d\text{tar}_{VN,US}^k\), we derive the exposure measure that combines both direct and indirect effects as

\[
\text{Upstream}_{i,VN}^t = \left( (I - \Pi_{VN})^{-1} \right)_t \cdot \text{DemandShock}
\]

, where \text{DemandShock} is a column vector of \(\left\{ \left( \sum_{u \in S \cup \{f\}} x_{VN,US}^{ku} \right) d\text{tar}_{VN,US}^k \right\}_{k \in S}\).

### 5.2.2 Downstream effects

We again examine the input share equation

\[
d \ln(p_{US}^s) = \sum_{k \in S} \lambda_{US}^{ks} \pi_{VN,US}^{ks} \left( d \ln(p_{VN}^k) + d \ln(\tau_{VN,US}^{ks}) \right)
\]

\[
+ \sum_{k \in S} \left[ \lambda_{US}^{ks} \pi_{US}^{ks} d \ln(p_{US}^k) \right]
\]

\[
+ \lambda_{US}^s d \ln(w_{US}) + \sum_{k \in S} \lambda_{US}^{ks} \left[ \sum_{n \neq VN,US} (d \ln(p_n^k) \pi_{n,US}^{ks} + \pi_{n,US}^{ks} d \ln(\tau_{n,US}^{ks})) \right].
\]

The producer price of sector \(\{s,US\}\) is affected by the tariff shock not only directly through the prices of Vietnamese inputs \(\left\{ d \ln(p_{VN}^k) + d \ln(\tau_{VN,US}^{ks}) \right\}_{k \in S}\) but also indirectly through the prices of domestic suppliers \(\left\{ d \ln(p_{US}^k) \right\}_{k \in S}\). Each term \(d \ln(p_{US}^k)\) can be expressed in terms of Vietnamese prices and US producer prices in a similar manner, leading to a full expansion of

\[
\sum_{k \in S} \left[ \lambda_{US}^{ks} \pi_{US}^{ks} d \ln(p_{US}^k) \right] = \left( \sum_{h=1}^{\infty} (\Pi_{US}')^h \right)_s \cdot \text{VNprices} + ...
\]

, where \(\Pi_{US}\) is a matrix of all domestic input shares \(\left\{ \pi_{US,US}^{mn} \lambda_{US}^{mn} \right\}_{m,n \in S}\), defined similarly to the \(\Pi_{VN}\) above, \text{VNprices} is a column vector of all Vietnamese price terms \(\left\{ \sum_{k \in S} \lambda_{US}^{ks} \pi_{VN,US}^{ks} \left( d \ln(p_{VN}^k) +
\right) \right\}_{k \in S}\).
\( d \ln(p_{US}^s) \) \( s \in S \), and \( (\cdot)_s \) is the \( s^{th} \) row of the matrix. Thus, we can write the equation of \( d \ln(p_{US}^s) \) above into

\[
d \ln(p_{US}^s) = (I)_s \cdot VNprices + \left( \sum_{h=1}^{\infty} (\Pi'_{US})^h_s \right) \cdot VNprices + ...
\]

Direct effect

\[
= \left( (I - \Pi'_{US})^{-1} \right)_s \cdot VNprices + ...
\]

Indirect effect

By proxying \( \sum_{k \in S} \lambda_{US}^k \pi_{VN,US}^k (d \ln(p_{VN}^k) + d \ln(\tau_{VN,US}^k)) \) with \( \left( \sum_{k \in S} \lambda_{US}^k \pi_{VN,US}^k d.tar_{VN,US}^k \right) \), we derive an exposure measure that combines both the direct and the indirect effects

\[
\text{Downstream}^s_{US} = \left( (I - \Pi'_{US})^{-1} \right)_s \cdot \text{SupplyShock}
\]

where \text{SupplyShock} is a vector of \( \left\{ \sum_{k \in S} \lambda_{US}^k \pi_{VN,US}^k d.tar_{VN,US}^k \right\} s \in S \).

## 5.3 Estimation results

We find strong evidence for the domestic propagation in both Vietnam and the US (table 6). The domestic upstream propagation in Vietnam is sizeable. Evaluated at the mean of the weights in the exposure measures, every 1 percentage point of US tariff reduction induces an increase of 2.363 million USD in demand for inputs from each domestic supplier. Computing the estimated changes in total input values in table 7, we see that the average increase of input values along a domestic link is 17.8 million. Largest estimated increases for domestic input flows include Textiles to Textiles (2.1 billion), Agriculture to Food (1.25 billion), Retail to Textiles (970 million), Computer equipments to Computer (590 million), and Food to Food (220 million). The propagation occur mainly along the linkages to sectors Textiles and Manufacturing n.e.c., Computer equipments and Mining.

On the US side, every 1 percentage of tariff cut against all Vietnamese sectors aggregate induces a growth rate of 0.254% in domestic market shares. Given that the shares of domestic suppliers in the US production are around 80%, we see a large total increase in market shares and input values with the domestic propagation. From table 7 we see that the average total increase of market share is 1.73% within the US. In terms of values, the average increase across sectoral linkages is 115 million. The downstream propagation occurs mostly along the links to Final Demand, which is consistent with what we see in the case of cross-border effect.

The rows "direct + indirect" report the estimates where we account for the indirect propagation due to domestic linkages of Vietnam and the US. We see from table 7 that the average aggregate effects are larger than when we consider the direct propagation alone, which is a result that we should expect. Nevertheless, the additional increases in trade values along the trade links are not substantial.
Table 6: Estimation results, domestic propagation and indirect cross-border effects, 2000-2007

<table>
<thead>
<tr>
<th></th>
<th>$d \ln \pi_{US}^{d}$</th>
<th>$d \ln \pi_{US,j}^{d}$</th>
<th>$d \ln \pi_{VN, VN}^{d}$</th>
<th>$d \ln \pi_{VN, US}^{d}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic VN upstream</td>
<td>2.989** (1.135)</td>
<td>2.363</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic US downstream</td>
<td>42.32*** (14.42)</td>
<td>0.254%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct+Indirect cross-border upstream</td>
<td>0.560*** (0.080)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct+Indirect cross-border downstream</td>
<td>220.38*** (62.80)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Clusters | 18 | 18 | 18 | 18  
N | 546 | 612 | 12948 | 35249  
adj. R-sq | 0.401 | 0.219 | 0.099 | 0.206  

Note: *p<0.10 **p<0.05 ***p<0.01. The p−values are computed based on the t-distribution with the degree of freedom equal to the cluster size minus the number of cluster-invariant variables. The average economic impact is per 1 percentage point of US tariff reduction against Vietnam.

Table 7: Estimated changes in market shares (%) and trade values (in millions of 2000 USD)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>25th percentile</th>
<th>50th percentile</th>
<th>75th percentile</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic VN upstream</td>
<td>17.80</td>
<td>120.44</td>
<td>0.00</td>
<td>0.04</td>
<td>0.32</td>
<td>3.33</td>
<td>2189.19</td>
</tr>
<tr>
<td>Domestic US downstream</td>
<td>1.73%</td>
<td>2.77%</td>
<td>0.15%</td>
<td>0.33%</td>
<td>0.71%</td>
<td>1.34%</td>
<td>11.85%</td>
</tr>
<tr>
<td>Direct</td>
<td>0.13</td>
<td>2.64</td>
<td>0.0000</td>
<td>0.00013</td>
<td>0.00086</td>
<td>0.01</td>
<td>180.08</td>
</tr>
<tr>
<td>Direct + Indirect</td>
<td>0.14</td>
<td>2.68</td>
<td>0.0001</td>
<td>0.00032</td>
<td>0.00168</td>
<td>0.01</td>
<td>182.08</td>
</tr>
<tr>
<td>Direct</td>
<td>0.56%</td>
<td>2.17%</td>
<td>0.00%</td>
<td>0.04%</td>
<td>0.11%</td>
<td>0.35%</td>
<td>51.07%</td>
</tr>
<tr>
<td>Direct + Indirect</td>
<td>1.52</td>
<td>31.78</td>
<td>0</td>
<td>0.00207</td>
<td>0.01526</td>
<td>0.12187</td>
<td>3809.26</td>
</tr>
<tr>
<td>Cross-border upstream</td>
<td>0.77%</td>
<td>2.40%</td>
<td>0.00%</td>
<td>0.07%</td>
<td>0.20%</td>
<td>0.59%</td>
<td>53.62%</td>
</tr>
<tr>
<td>Cross-border downstream</td>
<td>2.17</td>
<td>37.83</td>
<td>0.00</td>
<td>0.004</td>
<td>0.028</td>
<td>0.216</td>
<td>4188.89</td>
</tr>
</tbody>
</table>
Figure 11: Estimated changes in trade values (2000-2007), direct vs. indirect propagation

**Upstream propagation - Vietnamese sectors' demand for intermediate inputs**

**Downstream propagation - Intermediate inputs produced by the US sectors**
Given that the number of cross-border linkages is much larger than the number of domestic sectoral links, we combine the increases in trade values across the trading partners of Vietnam and the US to facilitate the comparison between the domestic and cross-border effects. Figure 11 shows the estimated total increases in intermediate inputs demanded by Vietnamese sectors and the total gains by the US sectors. We see that the domestic effect dominates the upstream propagation, with the estimated demand for domestic inputs by the Vietnamese producers much higher than the demand for foreign inputs. On the downstream side, we see that the increases in US exports are more on par with the estimated domestic sales, showing that the cross-border spillover is a significant part in the transmission of shock along the global production network.

6 2nd-step propagation: Preliminary results

This section is to be completed. Here, we show our preliminary results. The paper so far has found evidence for the propagation of the tariff shock to direct suppliers and customers of Vietnam and the US. This propagation might have continued one more step upstream and downstream towards the trade partners of these suppliers and customers. Thus, we further explore the following network effects (as shown in figure 12)

(i) Upstream demand effect 5: non-Vietnamese suppliers import less intermediate inputs because of losing market shares in the US (due to the substitution effect 1)

(ii) Upstream demand effect 6: Suppliers of Vietnam import more intermediate inputs to meet a higher demand from Vietnam (as tested in the demand effect 3)
(iii) Downstream price effect 7: non-US customers lose competitiveness and market shares because of losing low-priced Vietnamese inputs (caused by the diversion effect 2)

(iv) Downstream price effect 8: Customers of the US gain competitiveness and market shares because of importing lower-priced US inputs (due to the price effect 4)

6.1 Upstream demand effects

The nature of effects 5 and 6 is similar to the upstream demand effect 3. We devise the following diff-in-diff specification to test the propagation

\[ dx_{ij}^{st} = \beta_0 + \beta_5 \text{Upstream5}_{ij} + \beta_6 \text{Upstream6}_{ij} + X_{ij}^{st} \gamma + \mu_{ij}^T + \varepsilon_{ij} \]

, which is a direct translation of the trade equation 9 for the export flow from any sector \( s \) of country \( i \) to a sector \( t \) of country \( j \) (where \( \{t, j\} \) is a direct supplier of either Vietnam or the US)

\[
dx_{i,j}^{st} = \pi_{i,j}^{st} \lambda_j^{st} \left( \sum_{u \in S \cup \{f\}} dx_{j,u,US}^{tu} \right) + \pi_{i,j}^{st} \lambda_j^{st} \left( \sum_{u \in S \cup \{f\}} dx_{j,u,VN}^{tu} \right)
\]

exposure to the substitution effect 1

\[
+ \pi_{i,j}^{st} \lambda_j^{st} \left( \sum_{u \in S \cup \{f\}, k \neq US, VN} dx_{j,k}^{tu} \right) + X_j^d \left( \pi_{i,j}^{st} \lambda_j^{st} \right)
\]

control variables

We see the upstream effect 5 within the change of the US demand for \( \{t, j\} \)'s goods, or

\[
dx_{j,US}^{tu} \approx x_{j,US}^{tu} \times d \ln x_{j,US}^{tu} = x_{j,US}^{tu} \left( d \ln \pi_{j,US}^{tu} + d \ln \lambda_{US}^{tu} + d \ln X_{US}^u \right)
\]

, where the exposure of \( d \ln \pi_{j,US}^{tu} \) to the tariff shock is \( \text{Substitution}_{US}^{tu} \). Hence, the propagation is proxied by the exposure measure

\[
\text{Upstream5}_{ij} = \pi_{i,j}^{st} \lambda_j^{st} \sum_{u \in S \cup \{f\}} \left( x_{j,US}^{tu} \times \text{Substitution}_{US}^{tu} \right).
\]

The demand effect 6 is seen in the export growth of any sector \( t \) in country \( j \) to a sector \( u \) in Vietnam, or \( dx_{j,VN}^{tu} \), whose exposure to the tariff shock is \( \text{Upstream}_{j,VN}^{tu} \). Thus, the exposure measure is

\[
\text{Upstream6}_{ij} = \pi_{i,j}^{st} \lambda_j^{st} \sum_{u \in S} \text{Upstream}_{j,VN}^{tu}.
\]

We include in \( X_{ij}^{st} \) a similar set of control variables as in the specification of the upstream effect 3, but instead of Vietnam, we compute these variables for each of the importers. The standard errors are clustered at the \( \{t, j\} \)-level.
6.2 Downstream price effects

The nature of effects 7 and 8 is similar to the downstream price effect 4. We test the propagation with the diff-in-diff specification

\[ d \ln \pi_{ij}^s = \beta_0 + \beta_7 \text{Downstream7}_i + \beta_8 \text{Downstream8}_i + X_{ij}^s \gamma + \mu_{ij}^s + \varepsilon_{ij}^s \]

, which is translated from the input share equation [8] for the share of inputs s from country i in the production of sector t in country j (where \{s, i\} is a direct customer of either Vietnam or the US)

\[
d \ln(\pi_{ij}^s) = \gamma_{ij}^s (1 - \pi_{ij}^s) d \ln(p_i^s) \]

\[
\gamma_{ij}^s \sum_{n \in N \setminus \{i\}} \left( d \ln(p_n^s) \pi_{nj}^s \right) + \gamma_{ij}^s d \ln(\tau_{ij}) - \gamma_{ij}^s \sum_{n \in N} \pi_{nj}^s d \ln(\tau_{nj})
\]

where

\[
d \ln(p_i^s) = \sum_{k \in S} \pi_{VN,i}^k \lambda_i^k d \ln(p_{VN}^k) + \sum_{k \in S} \pi_{US,i}^k \lambda_i^k d \ln(p_{US}^k)
\]

exposure to diversion effect 2

\[
+ \lambda_i^s d \ln(w_i) + \sum_{k \in S} \lambda_i^k \left[ \sum_{n \in N \setminus \{US,VN\}} \pi_{ni}^k d \ln(p_n^k) + \sum_{n \in N} \pi_{ni}^k d \ln(\tau_{ni}^k) \right]
\]

dummies & control variables

The exposure of the Vietnamese producer price \(d \ln(p_{VN}^k)\) to the tariff shock is Diversion\(_{VN}\)^k. Hence, the downstream effect 7 is proxied by the exposure measure

\[ \text{Downstream7}_i^s = \sum_{k \in S} \pi_{VN,i}^k \lambda_i^k \text{Diversion}_{VN}^k. \]

We have proxied for the exposure of the US producer price \(d \ln(p_{US}^k)\) to the shock with Downstream\(_{US}\)^k, and therefore the downstream exposure 8 is

\[ \text{Downstream8}_i^s = \sum_{k \in S} \pi_{US,i}^k \lambda_i^k \text{Downstream}_{US}^k. \]
$X_{ij}^{st}$ includes the same set of control variables as in the estimation of downstream effect 4, but instead of the US, these variables are computed for each exporter. And we cluster the standard errors at the \{s, i\}-level.

### 6.3 The estimation results

Table 8 reports the point estimates of all four 2nd-step effects. The odd columns are results with trading in services and the even columns are without. We do not find evidence for the propagation further along the supply chains, which is not surprising given the very small weights of the exposure measures (see table 9). The weights reflect the small role of Vietnam as a supplier of intermediate inputs in the global supply chains. In our 1st-step estimation, the largest estimated impact is concentrated on a certain number of major trade partners and mostly found in the flows of consumption goods. This can explain why the propagation stops at the 1st-step.

#### Table 8: The estimates for the 2nd-step propagation

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2007</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$dx_{ij}^{st}$</td>
<td>$dln \pi_{ij}^{st}$</td>
<td>$dx_{ij}^{st}$</td>
<td>$dln \pi_{ij}^{st}$</td>
<td>$dx_{ij}^{st}$</td>
<td>$dln \pi_{ij}^{st}$</td>
</tr>
<tr>
<td>Upstream 5</td>
<td>221.7</td>
<td>234.7</td>
<td>434.5</td>
<td>489.2</td>
<td>(231.1)</td>
<td>(250.2)</td>
</tr>
<tr>
<td></td>
<td>(231.1)</td>
<td>(250.2)</td>
<td>(426.3)</td>
<td>(477.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upstream 6</td>
<td>-57.97</td>
<td>-68.56</td>
<td>185.4</td>
<td>202.3</td>
<td>(89.78)</td>
<td>(99.86)</td>
</tr>
<tr>
<td></td>
<td>(89.78)</td>
<td>(99.86)</td>
<td>(187.6)</td>
<td>(213.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downstream 7</td>
<td>0.226</td>
<td>0.0812</td>
<td>-0.357</td>
<td>-0.152</td>
<td>(0.174)</td>
<td>(0.182)</td>
</tr>
<tr>
<td></td>
<td>(0.174)</td>
<td>(0.182)</td>
<td>(0.371)</td>
<td>(0.388)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downstream 8</td>
<td>920.5</td>
<td>672.5</td>
<td>-38.99</td>
<td>59.56</td>
<td>(714.7)</td>
<td>(732.1)</td>
</tr>
<tr>
<td></td>
<td>(714.7)</td>
<td>(732.1)</td>
<td>(993.7)</td>
<td>(948.0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Clusters</th>
<th>N</th>
<th>adj. R-sq</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2045</td>
<td>1935714</td>
<td>0.009</td>
</tr>
<tr>
<td></td>
<td>1178</td>
<td>679676</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>2034565</td>
<td>0.068</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>679594</td>
<td>0.062</td>
</tr>
<tr>
<td></td>
<td>2045</td>
<td>1941030</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td>1178</td>
<td>680232</td>
<td>0.017</td>
</tr>
<tr>
<td></td>
<td>1993</td>
<td>2040433</td>
<td>0.071</td>
</tr>
<tr>
<td></td>
<td>1153</td>
<td>680179</td>
<td>0.063</td>
</tr>
</tbody>
</table>

Note: t statistics in parentheses; * p<0.10 ** p<0.05 *** p<0.01. The p-values are computed based on the t-distribution with the degree of freedom equal to the cluster size minus the number of cluster-invariant variables.

Table 9: Descriptive summary of the weights in the exposure measures, 2nd-step propagation

<table>
<thead>
<tr>
<th>Effect</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>25th percentile</th>
<th>50th percentile</th>
<th>75th percentile</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream 5</td>
<td>0.0000008</td>
<td>0.000274</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.150042</td>
</tr>
<tr>
<td>Upstream 6</td>
<td>0.000018</td>
<td>0.002166</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>1.608319</td>
</tr>
<tr>
<td>Downstream 7</td>
<td>0.000301</td>
<td>0.001604</td>
<td>0.000000</td>
<td>0.000015</td>
<td>0.000045</td>
<td>0.000149</td>
<td>0.042841</td>
</tr>
<tr>
<td>Downstream 8</td>
<td>0.000000</td>
<td>0.000001</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000016</td>
</tr>
</tbody>
</table>
7 Conclusion

As a result of increasingly fragmented global value chains, the fate of one country is not only in its own hand any more but greatly influenced by the well-being of its trade partners. In this paper, we provide strong evidence for a transnational propagation of shock on a global scale. Using the 2001 US-Vietnam trade agreement as the source of exogenous trade cost shock, we document a significant impact of the US import tariff reduction against Vietnam on the trade links between Vietnam, the US and their largest trade partners.

Our study is a natural complement to the current strand of literature that typically examines the role of input-output linkages in the transmission of shocks within a country. Our paper is also related to the literature on trade models in which a cross-border transmission along the input-output linkages is visible but empirical testing is still in scarcity.

Among our contributions, we have a unique position to offer a perspective on the scope of cross-border versus domestic transmission. Further exploration is ongoing, but our current results indicate a strong increase in demand for intermediate inputs from domestic suppliers by the Vietnamese producers, while the increase in demand for foreign inputs is much smaller. In the case of downstream propagation, we find strong evidence for both the domestic and the cross-border transmission where the US producers gain market shares domestically and overseas.

REFERENCES


**Appendices**

A **Robustness checks for the direct network effects**

A.1 **Without any service sectors (both on the exporter and the importer sides)**

In the baseline estimations, our sample does not include the service sectors of Vietnam and the US but do include the services of the trade partners. As the first robustness check, we drop all trading of services from the sample, meaning that we exclusively look at the trade flows of goods. The estimates are reported in table 10. The results are robust, with the point estimates not far off from those in our baseline.
Table 10: Robustness check: excluding all service sectors

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>d ln π^st_j</td>
<td>d ln π^st_j</td>
<td>d ln π^st_j</td>
</tr>
<tr>
<td></td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>d ln π^st_j</td>
<td>d ln π^st_j</td>
<td>d ln π^st_j</td>
</tr>
<tr>
<td>dx^st_j</td>
<td>dx^st_j</td>
<td>dx^st_j</td>
</tr>
</tbody>
</table>

Substitution: -40.21*** -45.42**
(12.59) (21.33)
Substitution × Mean of weights: -0.285% -0.322%
(0.00525) (0.00832)

Diversion: -0.0198*** -0.0270***
-1.98% -2.70%

Upstream: -0.0117 0.707***
(0.0995) (0.111)
Upstream × Mean of weights: -0.000 0.006
Downstream: 84.67 267.8***
(60.94) (65.20)
Downstream × Mean of weights: 0.509% 1.601%

Clusters: 18 18 18 18 18 18 18 18
N: 17604 8019 9334 18587 17606 8113 9432 18536
adj. R-sq: 0.051 0.131 0.012 0.187 0.057 0.140 0.094 0.210

Note: t statistics in parentheses; * p<0.10 ** p<0.05 *** p<0.01. The p-values are computed based on the t-distribution with the degree of freedom equal to the cluster size minus the number of cluster-invariant variables.

A.2 Re-weighting to account for the wage effects

In our second robustness check, we rescale the exposure measures as a way to account for the impact of the tariff shock on the Vietnamese producer prices. In the baseline specifications, we simply use dτ^s_{VN,US} to proxy for the change in the producer price d ln p^s_{VN}. Nevertheless, rewriting equation 4 tells us that the effect is through the change in wage, specifically

\[ d \ln (p^s_{VN}) = \lambda^s_{VN} d \ln (w^s_{VN} / a^s_{VN}) + \sum_{s \in S} \lambda^s_{VN} \left[ -d \ln (a^s_{VN}) + \sum_{i \in N} (d \ln (p^s_i)) \pi^s_{i,VN} + \pi^s_{i,VN} d \ln (\tau^s_{i,VN}) \right] \]

Given that the total wage payment is the total value of outputs minus the total imports of intermediate inputs, a first-ordered approximation shows us that the change in wage is linear in the changes of tariffs weighted by how important exporting to the US is for the Vietnamese economy. Our theoretical framework assumes perfect mobility of labour across sectors, and there is only one wage level for each country. However, in order to explore the direct impact of the tariff cut on the producer price of a sector, we look locally within each Vietnamese sector. That is, total differentiating the
total wage payment of a sector $t$

$w^t_{VN} L^t_{VN} = X^t_{VN} - \sum_{s \in S, s \neq VN} x^s_{i,VN}$

$= \left[ \sum_{u \in S \cup \{f\}} x^{tu}_{VN,US} + \sum_{u \in S \cup \{f\}, j \neq US} x^{tu}_{VN,j} \right] - \sum_{s \in S, s \neq VN} x^s_{i,VN}$

will give us $d \ln w^t_{VN}$ linear in $(w^t_{VN} L^t_{VN})^{-1} \sum_{u \in S \cup \{f\}} x^{tu}_{VN,US} \times d \ln x^{tu}_{VN,US}$. From the discussion with the upstream demand effect 3, we know that the change in the US demand for Vietnamese inputs $d \ln x^{tu}_{VN,US}$ is directly related to the change in tariff $d \ln(VN,US)$. Thus, we proxy the impact of $d \ln(VN,US)$ on the wage $d \ln w^t_{VN}$ and also on the price $d \ln(p^t_{VN})$ of sector $t$ with $(w^t_{VN} L^t_{VN})^{-1} \left( \sum_{u \in S \cup \{f\}} x^{tu}_{VN,US} \right) \times d \ln(VN,US)$. As a result, we have the rescaled exposure measures for the four network effects as follows:

$\text{Substitution}^{st}_{US, reweighted} = \pi^{st}_{VN,US} \left( 1 - \sum_{u \in S \cup \{f\}} \frac{x^{su}_{VN,US}}{w^s_{VN} L^s_{VN}} \right) d \ln(VN,US)$

$\text{Diversion}^{s}_{VN, reweighted} = \left( \sum_{u \in S \cup \{f\}} \frac{x^{su}_{VN,US}}{w^s_{VN} L^s_{VN}} \right) d \ln(VN,US)$

$\text{Upstream}^{st}_{VN, reweighted} = \left( \pi^{st}_{VN} \lambda^{st}_{VN} \sum_{u \in S \cup \{f\}} x^{tu}_{VN,US} \right) \left( 1 - \sum_{u \in S \cup \{f\}} \frac{x^{tu}_{VN,US}}{w^t_{VN} L^t_{VN}} \right) d \ln(VN,US)$

$\text{Downstream}^{s}_{US, reweighted} = \sum_{k \in S} \lambda^{ks}_{US} \pi^{ks}_{VN,US} \left( 1 - \sum_{u \in S \cup \{f\}} \frac{x^{ku}_{VN,US}}{w^k_{VN} L^k_{VN}} \right) d \ln(VN,US)$

The scaling $\left( 1 - \sum_{u \in S \cup \{f\}} \frac{x^{tu}_{VN,US}}{w^t_{VN} L^t_{VN}} \right)$ accounts for the idea that on one hand, the tariff reduction makes Vietnamese inputs cheaper for the US producers, but on the other hand, a higher demand from the US creates an upward pressure on the Vietnamese prices; and thus, the net effect is less than unity.

We redo the analysis both with and without the trading in services. The results (in tables 11 and 12) are robust except that we do not see a significant diversion effect in the long run with 2000-2007 sample. In terms of economic effects, the estimated changes in input shares and trade values are not significantly different from the ones obtained in our baseline results.
Table 11: Robustness check, reweighted exposures and with service sectors

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2007</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(1')</td>
<td>(2')</td>
<td>(3')</td>
<td>(4')</td>
</tr>
<tr>
<td>d\ln \pi_{\text{US}}^{st}</td>
<td>-35.84**</td>
<td>-46.59*</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dx_{\text{US}}</td>
<td>(16.16)</td>
<td>(23.69)</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>d\ln \pi_{\text{VN,j}}^{st}</td>
<td></td>
<td></td>
<td>0.00839</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dx_{\text{VN}}</td>
<td>(0.0336)</td>
<td>(0.0739)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substitution</td>
<td>-0.0797**</td>
<td></td>
<td>0.776***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diversion</td>
<td></td>
<td></td>
<td>(0.104)</td>
<td></td>
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<tr>
<td>Upstream</td>
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<td></td>
</tr>
<tr>
<td>Downstream</td>
<td>58.62</td>
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</tr>
<tr>
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<td>35318</td>
<td>32376</td>
<td>15257</td>
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<td>35249</td>
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<td>adj. R-sq</td>
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<td>0.106</td>
<td>0.012</td>
<td>0.176</td>
<td>0.060</td>
<td>0.095</td>
<td>0.099</td>
<td>0.206</td>
</tr>
</tbody>
</table>

Note: t statistics in parentheses; * p<0.10 ** p<0.05 *** p<0.01. The p-values are computed based on the t-distribution with the degree of freedom equal to the cluster size minus the number of cluster-invariant variables.

Table 12: Robustness check, reweighted exposures and with no service sectors

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2007</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
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<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(1')</td>
<td>(2')</td>
<td>(3')</td>
<td>(4')</td>
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<tr>
<td>d\ln \pi_{\text{US}}^{st}</td>
<td>-44.76***</td>
<td>-49.12*</td>
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<td></td>
</tr>
<tr>
<td>dx_{\text{US}}</td>
<td>(14.20)</td>
<td>(24.02)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d\ln \pi_{\text{VN,j}}^{st}</td>
<td></td>
<td></td>
<td>0.00239</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>dx_{\text{VN}}</td>
<td>(0.0354)</td>
<td>(0.0817)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Substitution</td>
<td>-0.0934**</td>
<td></td>
<td>0.789***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diversion</td>
<td></td>
<td></td>
<td>(0.114)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upstream</td>
<td>-0.0162</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Downstream</td>
<td>91.34</td>
<td></td>
<td></td>
<td></td>
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<tr>
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</tr>
<tr>
<td>N</td>
<td>17604</td>
<td>8019</td>
<td>9334</td>
<td>18587</td>
<td>17606</td>
<td>8113</td>
<td>9432</td>
<td>18536</td>
</tr>
<tr>
<td>adj. R-sq</td>
<td>0.056</td>
<td>0.110</td>
<td>0.012</td>
<td>0.186</td>
<td>0.060</td>
<td>0.093</td>
<td>0.093</td>
<td>0.210</td>
</tr>
</tbody>
</table>

Note: t statistics in parentheses; * p<0.10 ** p<0.05 *** p<0.01. The p-values are computed based on the t-distribution with the degree of freedom equal to the cluster size minus the number of cluster-invariant variables.
A.3 With 2003 and 2005 data

In the baseline estimation, we choose 2004 to check the short-term versus long-term aspect. To ensure that the estimates are consistent and have the expected signs over different years, we redo the analysis with the data from years 2003 and 2005. We use the baseline exposure measures, not the wage-adjusted ones from our previous robustness check. Tables 13 and 14 report the results. Overall, the estimates are of expected signs and not contradicting our baseline results except for the upstream estimate of 2000-2003 (see columns 3). The upstream estimate for 2000-2003 is negative, not positive as expected. It means that during the first two years after the BTA, a higher demand from the US was associated with a smaller increase in demand for foreign inputs. Together with the insignificant estimate for 2000-2004 and the increasingly positive estimates for 2000-2005 and 2000-2007, we see a short-term/long-term trend in which the upstream demand effect turns positive and increases over time. One explanation is that, in the short run, Vietnamese sectors pushed products to the US mainly by diverting exports away from non-US markets (which is evidenced by the diversion effect 2). Another contributor can be that the Vietnamese sectors with stronger demand from the US boosted the production mainly by sourcing more from the domestic suppliers. The positive cross-border upstream spillover can be detected only in the long run.

Table 13: Robustness check with the 2003 and 2005 data, with service sectors

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Substitution</td>
<td>-68.25***</td>
<td>-27.59**</td>
</tr>
<tr>
<td></td>
<td>(10.25)</td>
<td>(11.88)</td>
</tr>
<tr>
<td>Diversion</td>
<td>-0.0169***</td>
<td>-0.0141**</td>
</tr>
<tr>
<td></td>
<td>(0.00384)</td>
<td>(0.00616)</td>
</tr>
<tr>
<td>Upstream</td>
<td>-0.162**</td>
<td>0.464***</td>
</tr>
<tr>
<td></td>
<td>(0.0620)</td>
<td>(0.133)</td>
</tr>
<tr>
<td>Downstream</td>
<td>172.4***</td>
<td>44.96</td>
</tr>
<tr>
<td></td>
<td>(58.56)</td>
<td>(53.50)</td>
</tr>
<tr>
<td>Clusters</td>
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<td>18</td>
</tr>
<tr>
<td>N</td>
<td>32232</td>
<td>14918</td>
</tr>
<tr>
<td>adj. R-sq</td>
<td>0.069</td>
<td>0.130</td>
</tr>
</tbody>
</table>

Note: t statistics in parentheses; * p<0.10 ** p<0.05 *** p<0.01. The p-values are computed based on the t-distribution with the degree of freedom equal to the cluster size minus the number of cluster-invariant variables.

17The 2000-2005 point estimates are in line with the ones we obtained from the 2000-2004 sample. The results with 2000-2003 data are peculiar in the sense that we can also detect the downstream effect with this short-term sample. However, it is consistent with what we see from figures 2 and 3 where there is a temporary spike in the Vietnamese exports to the US in 2003. One explanation could be that there was some initial optimism or a stock of pre-orders that played out within the first 2 years after the BTA. Our diff-in-diff can pick up this short-term phenomenon if it is correlated with how deep the tariff cut is and how much a sector is exposed to the trade agreement.

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Table 14: Robustness check with the 2003 and 2005 data, with no service sectors

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>d\ln \pi_{st}^t</td>
<td>d\ln \pi_{VN,j}^t</td>
<td>d\pi_{US}^t</td>
</tr>
<tr>
<td>Substitution</td>
<td>-65.51***</td>
<td>-39.32***</td>
</tr>
<tr>
<td></td>
<td>(12.40)</td>
<td>(9.074)</td>
</tr>
<tr>
<td>Diversion</td>
<td>-0.0197***</td>
<td>-0.0181***</td>
</tr>
<tr>
<td></td>
<td>(0.00381)</td>
<td>(0.00587)</td>
</tr>
<tr>
<td>Upstream</td>
<td>-0.169**</td>
<td>0.465***</td>
</tr>
<tr>
<td></td>
<td>(0.0688)</td>
<td>(0.147)</td>
</tr>
<tr>
<td>Downstream</td>
<td>184.2***</td>
<td>66.69</td>
</tr>
<tr>
<td></td>
<td>(54.13)</td>
<td>(53.08)</td>
</tr>
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<td>Clusters</td>
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<tr>
<td>N</td>
<td>17511</td>
<td>7893</td>
</tr>
<tr>
<td>adj. R-sq</td>
<td>0.084</td>
<td>0.139</td>
</tr>
</tbody>
</table>

Note: t statistics in parentheses; * p<0.10 ** p<0.05 *** p<0.01. The p-values are computed based on the t-distribution with the degree of freedom equal to the cluster size minus the number of cluster-invariant variables.