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How Does Trade Respond to Anticipated Tariff Changes?

Evidence from NAFTA

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Abstract

Firms anticipate upcoming tariff changes by shifting their purchases to periods with lower costs. This paper shows that such anticipatory dynamics overstate the trade elasticity. Standard identification of the trade response to trade cost changes uses tariff variation from free trade agreements and assumes that trade flows equal their consumption. However, free trade agreements eliminate tariffs gradually through announced phaseouts. This allows firms to delay their purchases until tariff cuts are effective, while consuming their inventories. Indeed, during the North American Free Trade Agreement's staged tariff reductions, imports experienced sizable anticipatory slumps followed by libseralization bumps. To study the behavior of consumed imports, a measure is constructed that uses inventory-to-sales ratios to smooth the trade flows. Its application to the data yields that the annual trade-flow elasticity is 56 percent larger than the trade-consumption response and that the ratio of the long- to short-run elasticity increases from 2.3 with trade flows to 3.4 with consumed imports. The measure is validated through Monte Carlo simulations of an (s,S) ordering model that reproduces the observed trade pattern.

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How Does Trade Respond to Anticipated Tariff Changes? Evidence from NAFTA*

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1 Introduction

Most trade policy changes are announced before their implementation, giving firms the opportunity to shift their purchases to periods with lower costs.[1] In particular, Free Trade Agreements (FTAs) are usually put into effect gradually with scheduled phaseouts of the initial tariffs. In the case of the North American Free Trade Agreement (NAFTA), 96% of the tariff reductions were known at least one year in advance. The knowledge of future tariff reductions provides firms with strong incentives to schedule their imports accordingly. Using inventories in the meantime, firms can delay their purchases until the change is effective and then stock up. These anticipatory dynamics create a gap between the trade flows and their consumption. While gravity foundations of the trade elasticity do not distinguish between trade and its consumption, it is commonly estimated using variation in trade flows and tariffs from the FTAs. In this paper, we show that in the presence of anticipatory dynamics this distinction is consequential.

First, we document that in the early years of NAFTA, US imports from Mexico dropped strongly in anticipation and then overshot sharply right after the tariff reduction. Second, we propose a model-based measure of the consumption of imports. Its application to the data demonstrates that these dynamics cause the short run (annual) trade elasticity to be substantially smaller when using consumed imports — trade-consumption elasticity — rather than imports crossing the border — trade-flow elasticity. Third, we show that a $(\underline{s}\ \overline{s})$ ordering model reproduces the documented trade flow pattern and use Monte Carlo simulations to validate the consumption measure.

NAFTA with its gradual tariff phaseouts provides a clear case of anticipated trade policy changes. Among the goods that were not already tariff-free before NAFTA, 75% were scheduled to be phased-out gradually over up to 15 years. In fact, the original text of the agreement specified the exact schedule of tariff phaseouts at HS-8 product level, including the number of stages, the size and the date of each staged tariff reduction. While there was little time to anticipate the first round of tariff reductions,[2] in the following years, all the phaseout stages were scheduled to take place on January 1. Since

[1]Recently there have been numerous examples of anticipated trade policy changes. Imports of solar panels soared in the three months before the tariff safeguards took effect (Wall Street Journal Jan 03, 2018). Similarly, Iran stockpiled oil tankers during the six months before the actual lifting of export sanctions in January 2016 (The Economist Jan 23,2016).

[2]NAFTA was ratified by the US Congress only 40 days before coming into force on Jan 1, 1994.

all traded goods are storable to some extent, the certainty and knowledge of future tariff reductions provided firms with strong incentives to delay their purchases in advance of their implementation and then to stock up in their aftermath.

Indeed, we find strong evidence of *anticipatory slumps* and *liberalization bumps* in the response of trade flows to tariff cuts for US imports from Mexico of phased-out goods. We estimate these anticipatory dynamics by using a standard odds ratio or "tetrads" method (Head and Ries (2001), Head et al. (2010)) to construct trade flows, we then consider within-year growth rates of these. First, we find that in anticipation of an upcoming tariff reduction of 1%, imports dropped by a sizeable 6% in November and December relative to the middle of the year. Second, in the first few months after the tariff reduction, imports spiked by 12% with respect to the end of the previous year. The size of these high frequency reversals are large even in comparison to previously documented short-run (annual) estimates of the trade elasticity. This paper is the first to our knowledge to document how (1) firms anticipate tariff reductions during gradual phaseouts and (2) that the trade elasticity can be quite large even at high frequencies.

Importantly, we find that the anticipatory dynamics are increasing in the degree of product storability. This suggests that trade flows and their consumption might significantly diverge during these episodes. Unfortunately, the consumption or usage of imports is not observed, especially at the level of aggregation used in the estimation of trade elasticities. To make progress, we propose a novel measure of the consumption of imports that builds on monthly trade data and the assumption that a constant fraction of inventory holdings are used for consumption. A product-source country specific inventory-usage ratio is obtained by exploiting the fact that more storable goods are traded less frequently.[3] We validate the measure of consumption by demonstrating that (1) it eliminates the anticipatory slumps documented for NAFTA's phased-out goods, and (2) it is effective in replicating the actual consumption response in Monte Carlo simulations of a $(\underline{s}, \overline{s})$ ordering model.

With our measure of consumed imports in hand, we examine how the anticipatory dynamics lead to deviations between the trade-flow and the trade-consumption elasticities using annual data. Consistent with the smooth behavior of consumed imports around the tariff changes, the annual or short-run trade-consumption elasticity is smaller

[3]This relationship emanates from the existence of per shipment ordering costs that lead firms to trade off the frequency of orders against the costs of holding inventories.

than the trade-flow elasticity, dropping from 4.2 to 2.7. This deviation is driven by the phased-out goods, for which the estimated annual trade-flow elasticity is 7.4, while the trade-consumption elasticity is 2.9. As expected, these differences become less important when considering changes over longer horizons. In effect, the two long-run (7-year) elasticities are almost indistinguishable. A straightforward implication is that the ratio of the long- to short-run elasticities is significantly larger when considering the response of consumed imports, as it increases from 2.3 in the case of trade flows to 3.4. This indicates that the adjustment to trade liberalizations might be even more gradual than previously documented. These findings are important in light of the welfare implications of transitions in dynamic models of trade (Alessandria et al. (2021)). Finally, we show that the average estimates that pool over sample periods with gradual tariff reductions and that are used as an input for the welfare analysis of static models of trade can contain non-negligible deviations between the trade-consumption and trade-flow response.

This paper is related to three main strands of literature. In first place, we contribute to the empirical literature on the anticipatory effects of policy changes. When policy changes are implemented with lags, previous studies have shown that households increase their purchases in anticipation of upcoming local consumption sales tax hikes (Baker et al. (Forthcoming), Agarwal et al. (2017)) or gasoline tax rate increases (Coglianese et al. (2017)). In response to trade policy changes such evidence has been more scant. In the recent wave of US tariff hikes, the evidence of anticipation has been inconclusive. While Cavallo et al. (2019) find that two large US retailers stockpiled before the tariff increases, Fajgelbaum et al. (2020) find less support for this pattern in the overall trade flows. We show that when firms have ample time to anticipate tariff changes the response is similar to the one documented in the case of sales tax changes.

Second, we contribute to the literature on the estimation of the trade elasticity, the most important parameter in international trade (Arkolakis et al. (2012)). As a result of different estimation methods and samples, there is a wide range of estimates in the literature (Anderson and van Wincoop (2004), Hillberry and Hummels (2012)). Estimates based on cross-sectional data range from 4 to 6 (Feenstra (1994), Broda and Weinstein (2006), Simonovska and Waugh (2014), Caliendo and Parro (2015)), while studies using panel data tend to produce larger of estimates of around 7 to 11 (Head and Ries (2001), Romalis (2007)).[4] Although anticipatory dynamics and the deviations between trade flows and their consumption around the tariff reduction are less of a concern in the long run, we show these significantly affect the estimate of the short run or annual trade elasticity. It is well established that trade responds gradually to trade liberalizations (Baier and Bergstrand (2007), Jung (2012), Besedes et al. (2020)). As in Yilmazkuday (2019) and Boehm et al. (2020), our results indicate that the long run trade elasticity is twice as large as the short-run.[5] However, when using trade consumption this ratio increases significantly suggesting an even larger role for the gradual adjustment.

Finally, the paper contributes to the literature of the role of inventories in accounting for observed trade dynamics. Incorporating inventory decisions into standard models of trade has been successful in accounting for the fluctuations of trade flows in response to business cycle shocks (Alessandria et al. (2010b), Alessandria et al. (2011a)), as well as for trade and pricing dynamics in response to large devaluations (Alessandria et al. (2010a), Charnavoki (2017)) or the pricing dynamics following a credit crunch (Kim (2018)). Here, we use a similar model to reproduce the observed trade pattern around NAFTA's staged tariff reductions and validate our measure of the usage of imports.

The paper is organized as follows. Section 2 describes our methodological approach and documents the anticipation to NAFTA's staged tariff reductions. Section 3 proposes a measure of the consumption of imports and uses it to estimate the trade-flow and trade-consumption elasticities over different horizons. Section 4 introduces the $(\underline{s}, \overline{s})$ ordering model and describes the Monte Carlo simulations that validate the measure of trade consumption. Section 5 concludes.

2 Anticipation of NAFTA's Phaseouts

This section documents that in advance of NAFTA's staged tariff reductions, importers delayed their purchases and responded strongly after their implementation. First, we lay out our estimation approach. Second, we provide some background to NAFTA's tariff phaseouts and describe the dataset. Third, we present the results and provide evidence that the anticipatory response was strongest for goods that are relatively more storable.

[4] A notable exception is Boehm et al. (2020) who estimate a long run elasticity of around 2.

[5] Using price data, Gallaway et al. (2003) show similar deviations of the elasticity of substitution.

2.1 Estimation Approach

Our estimation of the trade elasticity in the short window around anticipated tariff reductions builds on a product-specific version of the gravity equation that emerges in a wide class of models of international trade.[6] Namely, imports M_{iczt} of good z by country i from country c in year t are described by:

$$M_{iczt} = A_{czt} B_{izt} \phi_{iczt}^{\varepsilon} \tag{1}$$

where A_{czt} captures the exporter-product-time specific variables (e.g. supply terms) and B_{izt} signifies the importer-product-time specific variables (e.g. demand terms), ϕ_{iczt} is the total trade cost and ε the trade elasticity, the object of our interest.[7] To identify ε we implement a ratio-type of estimation approach by considering a reference exporter c' and reference importer i' and taking the double difference of their trade flows, so that:[8]

$$\left(\frac{M_{iczt}}{M_{ic'zt}} \bigg/ \frac{M_{i'czt}}{M_{i'c'zt}} \right) = \left(\frac{\phi_{iczt}}{\phi_{ic'zt}} \bigg/ \frac{\phi_{i'czt}}{\phi_{i'c'zt}} \right)^{\varepsilon} \tag{2}$$

We formulate the total trade cost to take the following form:

$$\ln(\phi_{iczt}) = \ln(\tau_{iczt}) + D_{icz} + D_{izt} + D_{czt} + u_{iczt} \tag{3}$$

where $\tau_{iczt} \geq 1$ are applied tariff rates, D_{icz} time invariant bilateral measures of trade barriers such as distance, language or common borders, D_{izt} (D_{czt}) are importer (exporter) specific non-tariff trade barriers such as customs procedures, regulatory compliance or clearing lead times, and u_{iczt} is a random disturbance term that is assumed to be orthogonal to tariff rates. For notational simplicity, in what follows we denote the double difference of log trade flows as $m_{zt}^{DD} \equiv \ln \left(\frac{M_{iczt}}{M_{ic'zt}} / \frac{M_{i'czt}}{M_{i'c'zt}} \right)$ and do the same for the double difference of tariffs $\left(\ln \tau_{zt}^{DD} \equiv \ln \frac{\tau_{iczt}}{\tau_{ic'zt}} / \frac{\tau_{i'czt}}{\tau_{i'c'zt}} \right)$. Log transformations are noted in lower case. Substituting (3) into (2) and then taking log differences between the periods $t+h$

[6] In Section 3.4 we discuss the implications of our result for the interpretation of the trade elasticity.

[7] Head and Mayer (2014) provide the exact terms included in A and B for a wide class of benchmark models in international trade, including the Dixit and Stiglitz (1977) Krugman, Melitz (2003)-Chaney (2008) and Eaton and Kortum (2002) models and some of their extensions.

[8] The odds ratio or "tetrads" approach to estimate the trade elasticity or trade costs goes back to Head and Ries (2001) and different versions of it have been in Hallak (2006), Romalis (2007), Head et al. (2010) and Caliendo and Parro (2015), among others.

and t we obtain the following expression:

$$\Delta_h m_{zt}^{DD} = \varepsilon^h \left(\Delta_h \ln \tau_{zt}^{DD}\right) + \tilde{u}_{zt} \tag{4}$$

where $\tilde{u}_{zt} = \varepsilon(\Delta_h u_{iczt} - \Delta_h u_{ic'zt} - \Delta_h u_{i'czt} + \Delta_h u_{i'c'zt})$. Note that taking double differences eliminates all terms included in (3) except for the change in applied tariff rate. The trade elasticity ε now carries the superscript h in reference to the horizon at which it is estimated.

The main departure of our approach with respect to previous formulations is the inclusion of a time dimension that allows for a distinction of the trade elasticity at various horizons.[9] The distinction between short- and long-run trade elasticity is important given the previously documented delayed or gradual effects of trade policy changes (Baier and Bergstrand (2007), Jung (2012), Besedes et al. (2020)). In Section 3 we estimate (4) at various horizons using annual trade flows. For now, we are interested in the response of trade in the few months before and after anticipated tariff reductions. To fix the terminology, we define the short-run trade elasticity to refer to one-year changes as is common in the literature, while we consider the anticipatory dynamics to take place within less than a year. In Section 3 we argue that these anticipatory dynamics lead to deviations between trade flows and their usage that are consequential even when using annual data.

To study the trade pattern around the short window of time of tariff reductions we estimate two slightly modified versions of (4):

$$\Delta_{\overline{n}-\underline{n}} m_{z,t-1}^{DD} = \varepsilon^S \left(\Delta_1 \ln \tau_{zt}^{DD}\right) + D_z + \tilde{u}_{zt} \tag{5}$$

$$\Delta_{\overline{n}-\underline{n}} m_{zt}^{DD} = \varepsilon^B \left(\Delta_1 \ln \tau_{zt}^{DD}\right) + D_z + \tilde{u}_{zt} \tag{6}$$

where n indicates a sub-period of the year t and $\overline{n}$ is a sub-period after $\underline{n}$. The estimation equation (5) captures the response of within-year trade flows to an upcoming tariff change. Note that the dependent variable is the within-year $t-1$ growth between sub-periods $\underline{n}$ and $\overline{n}$ of m_{zt}^{DD}, while the tariff change is that of the upcoming year t relative to $t-1$. For example $\Delta_{10:12-4:9}\ m_{zt}^{DD}$ takes the log difference between the monthly average of

[9] In recent papers, Yilmazkuday (2019) and Boehm et al. (2020) also distinguish the short- and long-run response of trade to tariff changes.

m_{zt}^{DD} from April to September ($\underline{n}$) and the monthly average of m_{zt}^{DD} from October to December ($\overline{n}$). The anticipatory slump is quantified by ε^S and hence its positive value implies that imports drop in the months before an upcoming tariff reduction relative to a reference period in the year. We include product fixed effects D_z to account for product seasonalities that are not eliminated by the double difference of the trade flows.[10]

The estimation equation (6) captures the response of trade flows to the (annual) change in tariffs in the narrow time window between $\underline{n}$ in year $t-1$ and $\overline{n}$ in year t.[11] For example $\Delta_{1:4-11:12}\, m_{zt}^{DD}$ takes the log difference between the monthly average of $m_{z,t-1}^{DD}$ from November to December of the previous year ($\underline{n}$) and the monthly average of m_{zt}^{DD} from January to April ($\overline{n}$). Again, to control for seasonal effects we include product fixed effects. A large negative estimate of ε^B would indicate firms anticipating the upcoming tariff reduction by delaying their orders until the tariff reduction is implemented.

2.2 NAFTA's Tariff Phaseouts

NAFTA was signed by the three executives of the United States, Canada and Mexico in December 1992 after a lengthy negotiation. It took another year to be approved by legislators in the three countries. The US Congress ratified it on November 20, 1993, and US President Clinton signed it into law on December 8. NAFTA finally came into force on January 1, 1994. The agreement incorporated Mexico to the preferential FTA. Canada and the United States signed in 1988, and brought a major elimination of tariffs for trade with Mexico. By then, Canadian-US tariffs had mostly been removed. As a result of these tariff reductions, Mexico's share over total US imports almost doubled between 1994 and 1999. Because NAFTA was one of the first major preferential FTA and its tariffs reductions undercut the Most-Favored-Nation (MFN) rates, NAFTA has been widely studied to evaluate the gains from trade and, hence, to estimate the trade elasticity.[12]

[10] Results are robust to using more aggregate (less restrictive) seasonal fixed effects.

[11] Only for this specification we have used $\ln(1 + M_{icztn\overline{n}})$, so that we maintain all observations for which we estimate the anticipatory decline.

[12] See for example Kruegger (1999), Head and Ries (2001), Fukao et al. (2003), Romalis (2007), Kehoe and Ruhl (2013), Caliendo and Parro (2015).

Table 1: Phaseout Categories of HS-8 Goods Imported to US from Mexico

	1993			1999		
Classes	Number Goods	Scheduled Tariff	Import Share	Number Goods	Median Tariff	Import Share
A - 1 stage	438	5.5%	15.4%	367	0%	13.9%
B - 5 stages	760	9.0%	9.1%	695	0%	9.8%
C - 10 stages	641	6.5%	3.3%	498	2.6%	3.3%
C+ - 15 stages	68	19.0%	0.5%	66	10.4%	0.7%
D - Zeroed by 1993	4,814	0.01%	62.0%	4,249	0%	36.8%
Unclassified	264	0.9%	9.7%	1,920	0.0%	35.6%
TOTAL	6,985	2.2%	100%	7,772	0.3%	100%

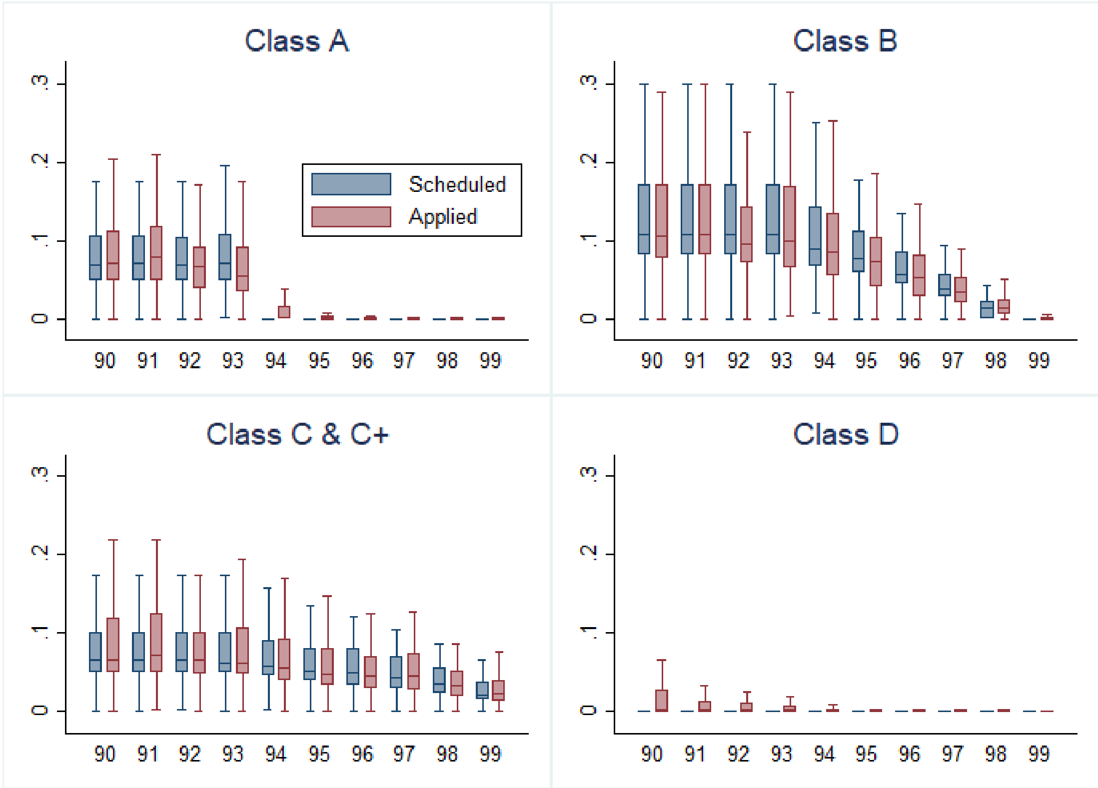
Some of the tariff cuts took place immediately on January 1, 1994 and the rest were scheduled to be phased out gradually over various stages of tariff reductions. Step reductions took place on January 1 for up to 15 years. In fact, 96% of NAFTA's tariff reductions were known at least one year in advance. Broadly, goods were classified into 5 categories, with class A to be immediately zeroed, classes B, C and C+ to be phased out over 5, 10 and 15 years and class D, goods with zero tariffs before NAFTA, to remain at zero. The annual distribution of US tariffs on imports from Mexico for each of these phaseout categories over the 1990s is illustrated in Figure 1.[13] As can be seen in Table 1, most of the HS-8 goods were already zeroed by 1993, providing little variation to estimate elasticities. Among those that were non-zero by 1993, around three quarters were scheduled to be phased out, while the rest became tariff-free the day NAFTA came into force. Given that there was considerable uncertainty regarding whether NAFTA would become effective, it is unclear that the latter reductions could have been anticipated.[14] But once signed, scheduled reductions of class B, C and C+ goods were certainly anticipated to become effective.[15] Before we document that indeed importers internalized this knowledge and anticipated upcoming tariff reductions during the early years of NAFTA, we describe our methodological approach to identifying anticipation in the next subsection.

[13]Although most tariffs were eliminated in equal annual stages, some schedules differed in the number of years with rate reductions and the size of each reduction. Because of this and different amount of goods per phaseout class, the median scheduled tariff rates declined non-monotonically during the 1990s.

[14]Given how the voting went, there was little political agreement in the US on NAFTA.

[15]We cannot ascertain at which degree agents internalized these scheduled reductions. However, a correlation of 87.42% between scheduled rates and applied duties at HS-8 level for goods that were phased out indicates that the scheduled reductions indeed materialized.

Figure 1: HS8 US Tariffs on Mexican Imports



Note: Applied tariffs are from US Census Bureau and scheduled tariffs from the US ITC. Classification of HS-8 products into phaseout categories uses NAFTA's original text. The line in the boxes is the median and the lower and upper bound of the boxes are the 25th and 75th percentile, respectively. The lower and upper adjacent lines (extremes) are the minimum and maximum, respectively (excluding outliers).

2.3 Data

Our empirical study of the anticipatory dynamics during NAFTA's staged tariff reductions focuses on US imports from Mexico during the 1990s.[16] We follow Romalis (2007) in the implementation of the estimation approach described above. The reference importer (i') is the aggregate of 12 countries of the European Union (EU12).[17] The reference exporter is an aggregate of 137 countries - rest of the world (RoW) - with which neither the United States nor the EU12 established a preferential FTA during 1990-1999.[18] Because the EU-12 did not have an FTA with Mexico nor with any of the reference exporters during our sample period, the only relevant tariff changes are the ones pertaining to the

[16]Similar results hold for US imports from Canada and are available upon request.

[17]These are Austria, Belgium, France, Finland, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Spain, and Portugal.

[18]See the list of 137 countries in Table D.1 of the Appendix.

United States (i) so that $\ln \tau_{zt}^{DD} = \ln(\tau_{US,Mex,z,t}/\tau_{US,RoW,z,t})$. However, the choice of EU12 restricts our sample period to 1990 to 1999, since in 2000 the European Union and Mexico signed an FTA. The large group of reference exporting and importing countries allows to circumvent the lumpiness in monthly HS-6 trade flows. Because our identification of the anticipatory effects relies on the variation in monthly trade flows, the relevant observations are those HS-6 with non-zero trade flows between sub-periods of the 4 directions to obtain growth rates. This reduces the sample size while also selecting the sample towards those goods that are more frequently traded. In Section 2.5 we dig deeper into this sample selection. We find that anticipatory effects are stronger for less frequently traded goods suggesting that the sample selection is more likely to undermine our results.

We obtain monthly US trade flows and applied tariff rates from the US Census Bureau and European trade flows are obtained from Eurostat. Trade flows are aggregate at the most disaggregate HS-6 product level available and measured as the CIF (Customs, Insurance and Freight) value of imports for consumption, which disregards imports for re-export purpose and includes insurance and freight charges. Tariffs are defined as the applied tariff rates, that is, the ratio of duties over the freight-on-board (FOB) value of imports.[19] We obtain the classification of HS-8 goods into their corresponding phaseout category from the original NAFTA text. To classify HS-6 products into their phaseout category we take the trade weight of its HS-8 products and pick the largest category to be the one corresponding to the HS-6 classification. The characteristics of the resulting sample by HS-6 phaseout category are very similar to the original at HS-8 level and reported in Table 2.

Table 2: Sample Characteristics at HS6 Level

Categories	HS6 Goods	HS6-Year	%	Mexico's Import Share 1990-1993	Median Duty 1993
Phased-out	451	5,283	16.5%	12.3%	7.7 %
Class A	129	1,541	4.8%	14.0%	6.5%
Non NAFTA	2,274	15,182	78.7%	73.6%	0.2 %
TOTAL	2,854	32,006	100%	0.8%	

[19]We drop observations at HS10, month, country of origin, district of entry level - the most disaggregate level available in census data - when applied duties are larger than 100%. These are outliers that were not subject MFN nor NAFTA rate provisions. Results are not sensitive to this choice.

2.4 Baseline Results

We now discuss the results of estimating (5) and (6) reported in Table 3. Panel A presents the elasticity estimates distinguishing the goods that were phased out and those that were not. To obtain this, we interact τ_{zt}^{DD} with an indicator variable that is one if the HS-6 good belongs to phaseout categories B, C or C+. The first three columns report the estimates of ε^S from (5) with different sub-periods $\underline{n}$ and $\overline{n}$. The first column shows that in anticipation of an upcoming tariff reduction of 1 percentage point (pp), imports fell by a substantial 6% in the last two months relative to the middle of the year. The last three columns report the estimates of ε^B from (6). In the trimester after the tariff reduction, a 1 percentage tariff reduction is associated with a 12% increase in imports relative to the two months before the tariff reduction. Both, the slump and bump in trade flows around the time of the tariff reduction, are quantitatively stronger as we consider the sub-period closer to the tariff reduction, moving from column 3 to 1 and 6 to 4. In Table D.2 of the Appendix we report that these results are unchanged when we consider different choices of product/industry fixed effects that control for seasonality.

The second row of Panel A indicates that goods which were not scheduled to be phased out did not experience any significant fluctuations in their trade flows around the short window of tariff changes. Panel B of Table 3 reports the results of estimating (5) and (6) for all goods irrespective of their phase out category. There is no significant slump in advance of upcoming tariff reductions, but a significant bump in its aftermath.

Overall, these results show that for goods on which tariffs were phased-out, US imports from Mexico first *slumped* and then *bumped* in the short window around the tariff reductions. In Section 4 we show that this pattern is consistent with a $(\underline{s}, \overline{s})$ ordering model in which tariff reductions are anticipated and firms use up their inventories to attend their demand for inputs while delaying their orders. In the next subsection we provide suggestive evidence of this mechanism by exploring the interaction between the anticipatory dynamics and the degree of storability of a good.

Table 3: Anticipatory Slumps & Bumps

Dep. Var.:	$\Delta_{\underline{n}:\overline{n}} m^{DD}_{z,t-1}$			$\Delta_{\underline{n}:\overline{n}} m^{DD}_{z,t}$		
	Slump	Slump	Slump	Bump	Bump	Bump
$\overline{n}$	11:12	11:12	10:12	1:4	1:3	1:4
$\underline{n}$	4:8	4:10	4:9	11:12	11:12	10:12
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Phaseout Categories						
$\mathbf{1}\{Phased\}\Delta\tau^{DD}_{z,t}$	6.1***	4.6***	4.1***	-12.2**	-9.2**	-7.6**
	(2.1)	(1.3)	(1.5)	(4.5)	(4.0)	(3.1)
$\mathbf{1}\{Other\}\Delta\tau^{DD}_{z,t}$	-1.6	-1.0	-0.2	-5.3*	-4.5	-5.8
	(2.8)	(2.3)	(2.4)	(2.8)	(2.7)	(2.6)
Panel B: All Goods						
$\Delta\tau^{DD}_{z,t}$	0.7	0.7	1.1	-7.4***	-5.9**	-6.3***
	(1.5)	(1.4)	(1.7)	(2.5)	(2.4)	(2.2)
HS6 FE	✓	✓	✓	✓	✓	✓
N	6023	6285	7076	7014	7014	8323
Adj R2	0.075	0.103	0.087	0.26	0.237	0.257

Note: Estimates are obtained using (5) (columns 1 to 3) and (6) (columns 4 to 6). Estimates in Panel A separate between the effect of $\Delta\tau^{DD}_{zt}$ for good's whose tariffs were phased-out (class B,C,C+) and the rest. Standard errors, in parentheses, are clustered at HS-2 product level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

2.5 Anticipation and Storability

Measuring storability for a wide range of products is not a straightforward task and no off-the-shelf measure is readily available. To make progress we follow Alessandria et al. (2010a) and proxy it by considering the lumpiness of a goods' trade flows.[20] In the model we present in section 4, more storable goods with lower depreciation rates are characterized higher inventory-sales ratios and more infrequent orders. We build on this insight and relate the goods inventory intensity with its observed trade lumpiness.[21] We measure trade lumpiness using the Herfindahl–Hirschman index of monthly concentration of the annual imports, calculated as follows:

$$HH_g = \sum_{m=1}^{12} \left(\frac{v(g,m)}{\sum_m^{12} v(g,m)} \right)^2 \tag{7}$$

[20] Alessandria et al. (2010a) also use a direct measure of a product's physical depreciation and obsolescence rate but only for a limited number of goods and at more aggregate levels than HS-6.

[21] Lumpiness in trade flows can be explained by lumpiness of demand or the usage of inventories. We take the second view. The importance of inventories in international trade has been widely documented as we emphasized in the introduction.

where $v(g,m)$ is the value of US imports of good g in month m.[22] HH_g is defined over the interval $[1/12, 1]$. For $HH_g = 1/12$, g is traded equally every month of the year, and, for $HH_g = 1$, g is traded in only one month of the year. For this measure, we define goods at the most disaggregate level (HS-10 product, district of entry and source country) and consider HH_g in the second year g enters our sample.[23] Then we take the median HH_g at HS 6-digit level to obtain HH_z.

To study the link between a products' degree of storability and the anticipatory dynamics we estimate (5) with the interaction of τ_{zt}^{DD} and the measure of the products HH index, HH_z, and an indicator for whether the product was phased-out as above. We also include the squared term of the HH index given that is important in capturing the interaction. Figure 2 shows the anticipatory slump in response to a 1% drop in tariffs at different percentiles of the HH Index for phased-out goods.[24] The total response of imports is calculated as $\Delta_{11:12-3:10} m_{z,t}^{DD} = \hat{\sigma}_0^S \times \Delta\tau_{zt}^{DD} + \hat{\sigma}_1^S \times \Delta\tau_{zt}^{DD} \times HH_z + \hat{\sigma}_2^S \times \Delta\tau_{zt}^{DD} \times HH_z^2$. Between the 20th and 70th percentile of the HH index the decline in imports before the tariff change is increasing. The anticipatory elasticity peaks at a value of around 10 at the 70th percentile. Moreover, precision increases over the x-axis, until the 70th percentile. Afterwards, the response is imprecise.[25] We also estimate (5) and (6) with a τ_{zt}^{DD} interacted with an indicator variable that takes the value of one if the good was phased-out and above the median HH_z, i.e. it is relatively more storable. Consistent with the results of the continuous measure of storability, the results reported in Table D.3 of the Appendix suggest that baseline results in Table 3 are driven by the goods which are more storable.

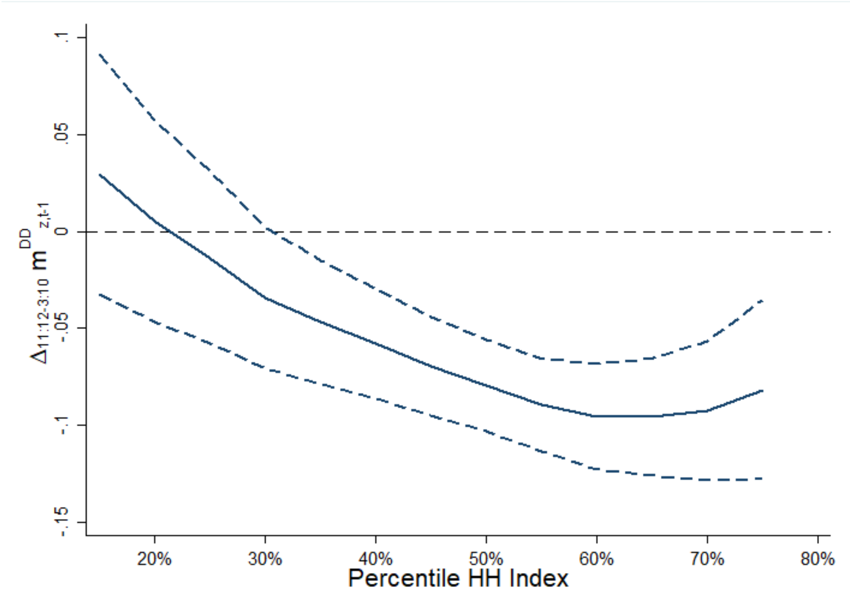
[22] Alternatively we could have used number of shipments. This doesn't change the results.

[23] To achieve variation in the HH index it is necessary to consider it at very disaggregate levels. We take the second year to eliminate the bias coming from the month it was first imported. We exclude US imports from Canada and Mexico to forego possible endogeneity in the frequency of trade and the preferential tariff rates from NAFTA. The distribution of the HH index is reported in Figure D.1 in the Appendix. Results are robust to including averages over more than the second year and including Canada and Mexico.

[24] Table D.4 of the Appendix reports the corresponding point estimates.

[25] The results are similar when we consider $\Delta_{11:12-5:10} m_{z,t}^{DD}$ or $\Delta_{10:12-4:9} m_{z,t}^{DD}$ and are reported in Figure D.2 of the Online Appendix.

Figure 2: Anticipation and Storability



Note: The yaxis corresponds to the predicted change in imports ($\Delta_{\overline{n}-\underline{n}} m^{DD}_{z,t-1}$) between November and December ($\overline{n} = 11/12$) relative to the previous 8 months of the year ($\underline{n} = 3/10$) of phased-out goods due to an upcoming tariff reduction of 1% ($\Delta\tau^{DD}_{zt} = -0.01$). It is estimated from $\Delta_{\overline{n}-\underline{n}} m^{DD}_{z,t-1} = \sigma^S_0\ \Delta\tau^{DD}_{zt} + \sigma^S_1\ \Delta\tau^{DD}_{zt} \times HH_z + \sigma^S_2\ \Delta\tau^{DD}_{zt} \times HH^2_z + D_z + u_{z,t,n-n'}$ with all variables interacted with an indicator variable of the products phaseout category. It is calculated as $\hat{\sigma}^S_0 \times \Delta\tau^{DD}_{zt} + \hat{\sigma}^S_1 \times \Delta\tau^{DD}_{zt} \times HH_z + \hat{\sigma}^S_2 \times \Delta\tau^{DD}_{zt} \times HH^2_z$ at different percentiles of the HH Index. The point estimates are reported in Table D.4 of the Appendix. The distribution of the HH index can be seen in Figure D.1 of the Appendix. Its calculation is described in 2.5. The dashed lines are the 90% confidence interval, calculated using the delta method.

To summarize, the results of this section document that imports of the products that were phased-out fell significantly in advance of tariff reductions and rebounded sharply afterwards. Importantly, this effect was strongest for goods that are more intensively held as inventories. These results suggest that during the window around tariff reductions imports and their consumption diverged. Unfortunately, we cannot test this hypothesis because neither inventory nor consumption data are available at the level of disaggregation of the trade data. In the next section, we propose a proxy measure of the usage of imports and find that the choice of trade or its usage affects the trade elasticity even at the annual frequency due to the anticipatory dynamics.

3 Trade-Consumption Elasticity

In the previous section we showed that in advance of NAFTA's staged tariff reductions, US imports from Mexico experienced sizeable *anticipatory slumps* and *liberalization bumps* thereafter. These dynamics are consistent with a model in which importing firms anticipate tariff reductions by delaying their input orders and attend to their demand using inventories. This suggests that trade flows and their actual usage might deviate substantially when tariff changes are anticipated.[26] In this section, we provide evidence that this was indeed the case and that the deviation between trade flows and their usage around the time of the tariff reductions is especially consequential in the estimation of short-run (annual) trade elasticities. First, we propose a parsimonious measure of the consumption of imports. Second, we estimate elasticities with annual trade flows and our trade consumption flows. Third, we consider several alternative formulations of the measure of import consumption to show robustness of our baseline results. Finally, we discuss the implications of the results.

3.1 Measure of the Consumption of Imports

A difference between import flows and their consumption can arise due to fluctuations in inventory holdings. However, neither the imports consumed nor their inventories are generally observed, especially at the disaggregated product and country of origin level at which trade data is used in the trade elasticity estimation. To make progress, we propose a measure of consumption of imports that is based on (1) the law of motion for inventories; and (2) a constant product and origin country specific inventory-usage ratio.

The starting point of our measure is the standard law of motion of inventories according to which the end-of-period inventory holdings are given by:

$$\tilde{s}_{icz,n} = \tilde{s}_{icz,n-1} + m_{icz,n} - \tilde{q}_{icz,n} \tag{8}$$

where i denotes the destination and c the source country, n denotes the month and z is a HS-6. The tilde on top of inventory holdings, $\tilde{s}$, and consumption of imports, $\tilde{q}$, indicates that they are imputed. Monthly imports, m, are the observable monthly trade flows.

[26] Alessandria et al. (2010a), Alessandria et al. (2010b), Alessandria et al. (2011a) and Charnavoki (2017) provide evidence on how in the face of large devaluations or business cycle shocks trade flows and their consumption can diverge significantly at high frequencies.

We begin by assuming an initial inventory level and then roll (8) forward to obtain the series.[27] The crucial step lies in the estimation of consumption process, $\tilde{q}$. Rather than assuming that goods crossing the border are immediately used, we assume that firms use a constant fraction of available goods at hand,

$$\tilde{q}_{icz,n} = \frac{\tilde{s}_{icz,n-1} + m_{icz,n}}{k_{cz}} \tag{9}$$

The right hand side of (9), establishes that a constant fraction $1/k_{cz}$ of current inventory holdings, $\tilde{s} + m$, is used for consumption. Note that the constant fraction k_{cz} is product and country of origin specific. This is because the inventory-usage depends on product characteristics such as the depreciation rate as well as the source country specific aspects such as the fixed cost of ordering or the shipping lag. We obtain k_{cz} by exploiting its relationship with the lumpiness of trade. Intuitively, a high inventory-sales ratio is associated with less frequent shipments. We calculate the inventory-usage as the inverse of HH index of the monthly concentration of annual imports as in Section 2.5 with the exception that here k is country specific as well.[28]

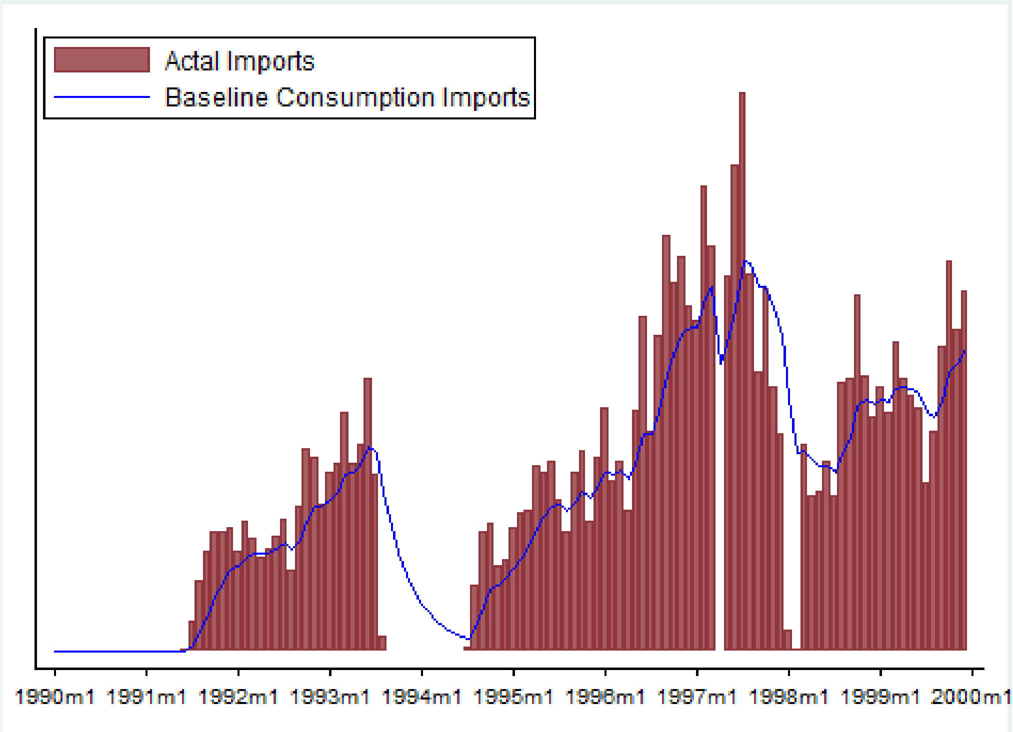
Figure 3 illustrates the behavior of our baseline measure in the case of vehicles used for transport of goods exported from Mexico to the United States. The time series of consumption of imports is much smoother than actual imports. First, imported goods are used even though they are not imported.[29] This can be observed in the abrupt halt in importing in the middle of 1994. During this gap in imports, our measure suggests a gradual running down of inventories. Second, the consumption mutes high frequency drops and rises. For example, in the months before January of 1997 only imports fell and then spiked, while the consumption of imports remained relatively stable. However, despite these high frequency differences, over the long run the consumption process tracks the import process.

[27]We set the inventory holdings in the first month of the first year to be the monthly average of imports in the first year multiplied by the inverse HH index (or inventory-usage ration). To make sure our results do not depend on this assumption, we exclude 1990 from the sample used in this section. Results are robust to including 1990 or assigning zero initial inventory holdings.

[28]In Section 3.3 we show that results are robust to alternative calculations of k.

[29]This is a convenient feature of the measure of consumption of imports in light of the problems associated with missing values due to trade lumpiness, especially at high frequencies (Silva and Tenreyro (2006)).

Figure 3: Example of our Baseline Measure



Note: The yaxis is in levels. The example here shown corresponds to HS6 code 870421, described as "Vehicles; compression-ignition internal combustion piston engine (diesel or semi-diesel), for transport of goods, (of a gvw not exceeding 5 tonnes)". Consumption of imports are calculated as in (9).

We validate our baseline measure of consumption by examining whether its response to the tariff reductions is smoother than the anticipatory dynamics of trade flows documented in Section 2. Table D.5 in the Appendix contains the results of estimating (5) when the corresponding measure of the consumed imports is used as the dependent variable. The anticipatory elasticity is economically negligible and statistically insignificant for phased-out goods, as it is for others. Consistent with the descriptive evidence above, our imputed consumption flow is relatively smooth in advance of the tariff reduction.

3.2 Trade Elasticity with Consumption of Imports

We now examine whether the anticipation we documented in Section 2 affect the trade elasticity estimate by distinguishing between trade flows and their consumption. We refer to the standard procedure that uses trade flows as the dependent variable as the trade-flow elasticity, and the estimate that uses the imputed consumption of imports described above as the trade-consumption elasticity. Precisely, we calculate the consumption of imports equivalent of the double difference trade flows as $\tilde{q}_{zt}^{DD} \equiv \ln\left(\frac{\tilde{q}_{US,MEX,z,t}}{\tilde{q}_{US,RoW,z,t}} / \frac{\tilde{q}_{EU,MEX,z,t}}{\tilde{q}_{EU,RoW,z,t}}\right)$, where $\tilde{q}_{i,c,z,t}$ is the summation of monthly flows from (9) to the annual frequency. The trade-flow and trade-consumption elasticities are then estimated following equation (4) derived in Section 2.1, providing an estimate at each horizon h.

Columns 1 and 2 of Table 4 report the results of estimating (4) with $h = 1$, i.e. the annual elasticities. Panel A shows the results of the average elasticities of all goods. There is a sizable difference of around 56% in the two elasticities. The estimate drops from 4.2 when using import flows to 2.7 when using consumed imports. Panel B suggests that this difference is driven almost entirely by the phased-out goods. For phased-out goods, the annual elasticity drops from 7.4 to 2.9. This is consistent with the strong anticipatory responses of phased-out goods found in Section 2.4. In contrast, non-phased-out goods yield similar estimates when using imports flows or consumption of imports. It is also noticeable that the estimated annual elasticity for the phased-out goods becomes almost equal to the one for the non-phased-out goods when considering the consumed imports.

Columns 3 to 8 estimate the two elasticities at longer horizons, with $h = 3, 5, 7$. Throughout the different specifications of h, the difference between the trade-flow and trade-consumption elasticity is now much smaller. In the case of the average over all goods (Panel A), the difference diminishes to only 8% after 7 years. The diminished difference between the two elasticities is also the case of the phased-out goods, although the trade-consumption elasticity remains 20% smaller. This permanent difference can be explained by the fact that as tariffs are fully phased-out the *liberalization bumps* dissipate, but the preceding *anticipatory slumps* remain in the denominator of the growth rates. Consistent with this explanation, the difference between the two elasticities disappears entirely in the case of non-phased-out goods.

Table 4: Trade-Flow vs. Trade-Consumption Elasticities over Time

	1-Year		3-Year		5-Year		7-Year	
Dep. Var.:	$\Delta_1 m_{z,t}^{DD}$	$\Delta_1 \tilde{q}_{z,t}^{DD}$	$\Delta_3 m_{z,t}^{DD}$	$\Delta_3 \tilde{q}_{z,t}^{DD}$	$\Delta_5 m_{z,t}^{DD}$	$\Delta_5 \tilde{q}_{z,t}^{DD}$	$\Delta_7 m_{z,t}^{DD}$	$\Delta_7 \tilde{q}_{z,t}^{DD}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: All Goods								
$\Delta_h \tau_{z,t}^{DD}$	-4.2***	-2.7***	-7.5***	-6.7***	-9.3***	-8.0***	-9.8***	-9.1***
	(1.2)	(0.8)	(1.2)	(1.1)	(1.3)	(1.3)	(1.5)	(1.5)
Difference		56%		12%		15%		8%
Panel B: Phaseout Categories								
$1\{$ *Phased* $\} \times \Delta_h \tau_{z,t}^{DD}$	-7.4***	-2.9**	-10.4***	-9.2***	-12.2***	-10.0***	-12.6***	-10.5***
	(2.1)	(1.3)	(1.8)	(1.6)	(1.8)	(1.7)	(2.2)	(2.1)
Difference		154%		13%		22%		20%
$1\{$ *Others* $\} \times \Delta_h \tau_{z,t}^{DD}$	-3.2**	-2.6***	-6.3***	-5.7***	-7.7***	-7.0***	-8.2***	-8.2***
	(1.3)	(0.9)	(1.4)	(1.3)	(1.7)	(1.7)	(1.9)	(2.0)
Difference		19%		11%		10%		0%
N	11,693	11,693	8,402	8,402	5,550	5,550	3,155	3,155
Adjusted R^2	0.002	0.001	0.009	0.010	0.018	0.017	0.026	0.025

Note: All estimates are obtained using (4). Odd columns use trade flows as dependent variable (m); and even columns use imputed consumed imports as dependent variable ($\tilde{q}$). The subscript h in the dependent variable, $\Delta_h \tau_{zt}^{DD}$, is 1 in columns 1 and 2 (1-year change), 3 in column 3 and 4 (3-year change) and so on. Estimates in Panel B separate between the effect of $\Delta_h \tau_{zt}^{DD}$ for good's whose tariffs were phased-out (class B,C,C+) and the rest. The difference is calculated as the difference between the estimate using m and $\tilde{q}$ over the estimate with $\tilde{q}$. Standard errors, in parentheses, are clustered at HS-6 level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A corollary of these findings is that the ratio of the long-run to short-run elasticity is much larger in the case of the trade-consumption.[30] In the specification with all goods, this ratio is 3.4 (9.1/2.7) for the trade-consumption elasticity, while it is 2.3 (9.8/4.2) for the trade-flow elasticity.[31] Again, the difference is driven by the phased-out goods (3.6 versus 1.7). These results suggest that the well documented gradual adjustment of trade after liberalization is even more pronounced once the anticipatory effects are removed.

[30]In a previous versions we made this point by estimating short- and long-run elasticities using the restricted and unrestricted error-correction model as in Gallaway et al. (2003). The results are very similar to the ones presented here and are reported in Section A of the Appendix.

[31]The long-run to short-run ratio of 2.3 in the case of the trade-flow elasticity is in line with previous estimates of time-varying trade elasticities. Using a structural VAR Yilmazkuday (2019) estimates it to be slightly below 2, while Boehm et al. (2020) estimates it to be slightly above 2 using panel data and an instrumental variable approach.

Finally, we estimate the average trade-flow and trade-consumption elasticities as:

$$y_{zt}^{DD} = \varepsilon \tau_{z,t}^{DD} + D_z + D_t + u_{zt} \tag{10}$$

This specification is the same as in Romalis (2007) with the exception that we use $y_{zt}^{DD} = m_{zt}^{DD}$ to obtain the trade-flow elasticity and $y_{zt}^{DD} = \tilde{q}_{zt}^{DD}$ to estimate the trade-consumption elasticity. Product and year fixed effects are included to account for relative shipment costs to the US and the EU12. Note that this cross-sectional or pooled approach is the most common in the literature and is usually interpreted as the long run elasticity.[32]

Table 5 reports the results.[33] Panel A shows that for the average of all goods, the trade elasticity drops from 8.9 to 7.7 when consumed imports are used instead of imports.[34] This implies a considerable difference of 16%. Not surprisingly, Panel B shows that this is also driven by the phased-out goods, for which the difference is 21%. Note that the difference in the average elasticities is larger than the ones documented for the long run or 7-year elasticities. We view this as being driven by the fact that the average elasticities are the outcome of averaging over the elasticities at all horizons h in (4) and hence assign more weight to the anticipatory slumps than the long run elasticities.

3.3 Robustness

The results described above are robust to several alternative choices in the measurement of consumed imports. All results are reported in Table 6.

One Period Time to Market Lag. - Under the baseline measure, once imports are received at the destination, they are immediately available for consumption. If instead there are lags in domestic deliveries or lead times to market the imported goods, current imports would be unavailable for consumption or usage. The process that assumes a one

[32] See Eaton and Kortum (2002), Simonovska and Waugh (2014) or Caliendo and Parro (2015).

[33] We delete the first year of our sample since our measure does not generate sales in the first month of the sample and makes our assumption on the initial inventory holdings more relevant. This does not affect the results.

[34] Our estimate using import flows is below that obtained by Romalis (2007), who obtains 10.9. This is most likely from the fact that we exclude 1989 and 1990 from our sample period. In fact as we exclude earlier years from our sample the estimate falls, suggesting that the early years with less trade contribute towards larger elasticity estimates.

Table 5: Average Trade-Flow vs. Trade-Consumption Elasticities

Dep. Var. :	(1) $m_{z,t}^{DD}$	(2) $\tilde{q}_{z,t}^{DD}$	Difference
Panel A: All Goods			
$\tau_{z,t}^{DD}$	-8.9***	-7.7***	16%
	(1.1)	(1.1)	
Panel B: Phaseout Categories			
$1\ \{$ *Phased* $\} \times \tau_{z,t}^{DD}$	-13.2***	-10.9***	21%
	(1.6)	(1.6)	
$1\ \{$ *Others* $\} \times \tau_{z,t}^{DD}$	-6.6***	-6.0***	10%
	(1.4)	(1.3)	
Year FE	✓	✓	
HS6 FE	✓	✓	
Observations	15,153	15,153	

Note: All estimates are obtained form equation 10 and by varying the dependent variable. Column 1 uses imports and column 2 uses our baseline measure of consumption of imports. Estimates in Panel B separate between the effect of τ_{zt}^{DD} for good's whose tariffs were phased-out (class B,C,C+) and the rest. Standard errors, in parentheses, are clustered at HS-6 level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

period lag in the reception and consumption of imports has the following representation:

$$\tilde{q}_{icz,n} = \frac{\tilde{s}_{icz,n-1}}{k_{cz}} \tag{11}$$

The results of estimating (4) for $h = 1$ and $h = 7$ under this version of $\tilde{q}$ are contained in columns 3 and 4 of Table 6. The estimates are very similar to the baseline results.

Different Inventory-Sales Ratios. - In the baseline measure we use a different inventory-sales ratio, k_{cz}, for different exporter countries c, but not for the different destination countries i. To check whether our results are sensitive to this lack of data we impose a common k_z across all four directions of trade in our baseline measure. Again, as can be seen in columns 5 and 6, the estimates are very similar to the baseline results. Results are also robust to calculating k_{cz} using the average over HS10-district of entry HH indexes or different levels of aggregation of the HH index.

Demand Shock. - In our baseline we assume that the usage of inputs is a constant fraction of inventory holdings. Here, we extend the baseline measure of $\tilde{q}$ by including a demand shock, ν_{iczt}. Under this extension the consumption of imports takes the following form:

$$\hat{q}_{icz,t} = \underbrace{\frac{\tilde{s}_{icz,t} + m_{z,t}}{k_{icz}}}_{\text{expected}} + \underbrace{\frac{m_{icz,t+1}}{k_{icz}} - \mathbb{E}_t(m_{icz,t+1})}_{\text{shock } (\nu_{iczt})} \tag{12}$$

$$\tilde{q}_{icz,t} = \min\left[\hat{q}_{icz,t},\ \tilde{s}_{icz,t-1} + m_{icz,t}\right] \tag{13}$$

The first term on the right hand side of (12) is our baseline measure. The second term on the right hand side is the shock component of $\hat{q}$. The demand shock assumes that next period's import volume reveals information about the contemporaneous demand shock. We model it as the deviation between actual monthly imports and its expected value the period before. In other words, we infer a favorable contemporaneous demand shock if we observe orders higher than the good's average imports. This requires the existence of a delivery lag between purchase orders and reception of imports of one month, so that the consumption of imports cannot exceed contemporaneous inventory holdings as reflected in (13). We divide m_{t+1} by k to account for the fact that purchase orders are intended to satisfy consumption for an average k periods and calculate $\mathbb{E}_t m_{t+1}$ by taking the average of imports of the previous year, i.e. $1/12 \sum_{i=-11}^{0} m_{t+i}$. Results are similar if we use the previous 6 months or the year before and after t.

The result of estimating (4) using this alternative measure of the consumed imports is reported in column 7 and 8 of Table 6. The long-run estimate (7-year change) for all goods (Panel A) indicates a slightly larger drop of 15% relative to the one using trade flows (column 2) than our baseline (8%). Again it is driven by phased-out goods (Panel B). The short run (annual) elasticity estimates drop much more under this formulation of consumed imports than under the benchmark. Although phased-out goods display a much larger effect, other goods' trade-consumption elasticity is now also smaller than their trade-flow elasticity, albeit not statistically different.

Table 6: Robustness: Alternative Measures of Consumed Imports

	Trade Flows		Time to Market		Inventory-Usage		Demand Shock	
	1-Year	7-Year	1-Year	7-Year	1-Year	7-Year	1-Year	7-Year
Dep. Var.:	$\Delta_1 m_{z,t}^{DD}$	$\Delta_7 m_{z,t}^{DD}$	$\Delta_1 \tilde{q}_{z,t}^{DD}$	$\Delta_7 \tilde{q}_{z,t}^{DD}$	$\Delta_1 \tilde{q}_{z,t}^{DD}$	$\Delta_7 \tilde{q}_{z,t}^{DD}$	$\Delta_1 \tilde{q}_{z,t}^{DD}$	$\Delta_7 \tilde{q}_{z,t}^{DD}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: All Goods								
$\Delta_h \tau_{z,t}^{DD}$	-4.2***	-9.8***	-2.6***	-8.6***	-2.9***	-9.3***	-1.6***	-8.5***
	(1.2)	(1.5)	(0.8)	(1.5)	(0.8)	(1.5)	(0.6)	(1.5)
Difference			66%	14%	46%	6%	170%	15%
Panel B: Phaseout Categories								
1 { *Phased* } $\times \Delta_h \tau_{z,t}^{DD}$	-7.4***	-12.6***	-2.3	-10.0***	-3.4**	-10.9***	-1.8	-9.5***
	(2.1)	(2.2)	(1.5)	(2.1)	(1.4)	(2.1)	(1.1)	(2.1)
Difference			216%	26%	118%	16%	310%	32%
1 { *Others* } $\times \Delta_h \tau_{z,t}^{DD}$	-3.2**	-8.2***	-2.6***	-7.8***	-2.8***	-8.3***	-1.5**	-7.9***
	(1.3)	(1.9)	(1.0)	(2.0)	(1.0)	(2.0)	(0.7)	(2.1)
Difference			20%	6%	15%	-1%	111%	4%
N	11,693	3,155	11,650	3,139	11,693	3,155	11,693	3,155
Adjusted R^2	0.002	0.025	0.001	0.019	0.002	0.025	0.001	0.021

Note: All estimates are obtained using (4). The first two columns use trade flows as dependent variable (m); the rest use alternative measures of the imputed consumed imports as dependent variable ($\tilde{q}$). The calculation of the alternative measures of consumed imports is described in Section 3.3. The subscript h in the dependent variable, $\Delta_h \tau_{zt}^{DD}$, is 1 in odd columns (1-year change) and 7 in even columns (7-year change). Estimates in Panel B separate between the effect of $\Delta_h \tau_{zt}^{DD}$ for good's whose tariffs were phased-out (class B,C,C+) and the rest. The difference is calculated as the difference between the estimate using m and $\tilde{q}$ over the estimate with $\tilde{q}$. Standard errors, in parentheses, are clustered at HS-6 level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

3.4 Discussion

The interpretations of the trade elasticity can be broadly classified into two classes, depending on the underlying microfoundation of the gravity equation (Arkolakis et al. (2012)): (1) demand-side models in which the trade elasticity relates to the elasticity of substitution (Armington (1969), Anderson (1979), Dixit and Stiglitz (1977)); and (2) supply-side models in which it is the inverse measure of productivity dispersion (Eaton and Kortum (2002), Melitz (2003), Chaney (2008)). Both interpretations abstract from the distinction between imports and their consumption, implicitly assuming that imported goods are immediately consumed and/or that potential deviations do not matter in the long run. Given that the results of this Section show only small differences in the long run trade-flow and trade-consumption elasticities, their welfare implications might be less important in static models of trade.[35]

However, our results become more important when viewed through the lens of dynamic trade models in which trade adjusts gradually to tariff changes. In models with sunk costs of exporting (Alessandria and Choi (2014)) the short-run trade response to trade cost changes is dominated by the intensive margin or the elasticity of substitution (demand-side); and the long-run is dominated by the elasticity of the extensive margin or firm entry (supply-side). Importantly, in this class of models, welfare gains that account for the transition can be very different from the steady state welfare change (Alessandria et al. (2021)). Our results indicate that at an even shorter horizon, the trade-flow response is dictated by inventory considerations leading to an overestimation of the short run intensive margin response. In that sense, our findings and their implication for the ratio of the long-run to short-run trade elasticity are important for the quantification of welfare gains in such models.

4 Monte Carlo Simulations of $(\underline{s}, \overline{s})$ Ordering Model

This section lays out a standard $(\underline{s},\overline{s})$ inventory model that captures the dynamics documented in Section 2. In this model, the trade elasticity is only related to the intensive margin adjustment, i.e. the elasticity of substitution.[36] The goal is to show how the estimated intensive margin adjustment is affected by firms' high frequency inventory decisions. The mechanism we present has no implications for the long-run adjustment to trade cost changes and, therefore, we abstract from modelling the deviations between the short- and long-run response documented in Section 3.[37] We proceed as follows. First, we describe the model. Second, we show how it can reproduce the trade flow pattern around NAFTA's tariff reductions. Third, we demonstrate through Monte Carlo simulations that our measure of consumed imports effectively estimates the true trade-consumption

[35] A subtle implication of our findings is that elasticity estimates using data pooled over several years may understate the actual long run elasticity.

[36] This is only approximately correct because, as tariffs decline and firms' revenues expand, retailers re-optimize their ordering schedule and order more frequently. This leads to a decline in the inventory holding costs and a pass-through of tariffs to consumer prices larger than one. However, this mechanism is quantitatively less important.

[37] In addition to models with sunk costs of exporting, other mechanisms that generate gradual adjustment to trade liberalizations include market penetration costs (Arkolakis (2010), Drozd and Nosal (2012)), the persistence of shocks (Ruhl (2008)) or distributional capital (Crucini and Davis (2016)).

elasticity in the model.

4.1 Model Description

We consider the partial equilibrium problem of a monopolistically competitive retailer that decides when to order a homogeneous storable good and how to price its variety as in Alessandria et al. (2010a). In advance of an upcoming tariff reduction, the retailer delays its purchases to when the good is cheaper, while in the meantime it continues to satisfy its demand by running down its inventories.[38]

Retailers hold inventories for two reasons. First, in addition to the per unit cost $\omega_t = \omega(1 + \tau_t)$, ordering implies a fixed shipment cost f, causing firms to economize on it by ordering infrequently and in large shipments.[39] Second, retailers face demand uncertainty and a one period delivery lag, leading to precautionary inventory holdings. However, holding inventories is costly, since goods depreciate at the rate δ and the future is discounted at β. Under this setup, retailers' purchases are lumpy as they run down their stocks to $\underline{s}$ and then replenish it up to $\overline{s}$.

Retailer j faces the following demand c_{jt} for its variety:

$$c_{jt} = e^{\nu_{j,t}} p_{jt}^{-\sigma} \tag{14}$$

where p_{jt} denotes the retailer's sales price and $\nu_{jt} \sim^{iid} N(0, \sigma_\nu^2)$ its demand shock, assumed to be i.i.d. over time.[40] The response of consumption to changes in prices is dictated by the elasticity of substitution, σ. Note that demand c_{jt} is not necessarily equal to actual sales. This is because (1) purchases, m_{jt}, are irreversible, $m_{jt} \geq 0$; and (2) the one period delivery lag implies that sales can never exceed current inventory holdings, so that:

$$q_{jt} = \min[e^{\nu_{jt}} p_{jt}^{-\sigma}, s_{jt}] \tag{15}$$

[38]The choice to model the anticipatory dynamics as those of a firm's inventory decisions as opposed to that of a consumer's durable purchases is justified by the fact that international trade is dominated by trade in intermediate goods. Moreover, using the Broad Economic Categories classification, Table D.6 of the Appendix demonstrates that the results of Section 3 are driven by non-consumer goods.

[39]By setting the purchase price to be a constant we assume that exporters are perfectly competitive, so that the pass-through (to retailers) of the tariff reduction is complete. This is consistent with the fact that we do not observe any significant movements in unit values in advance of NAFTA's tariff reductions when estimating (5) using unit values as the dependent variable. See Table D.9 of the Appendix.

[40]The iid demand shock allows for some variation in the anticipation to a tariff reduction. With perfectly correlated demand shocks all firms would respond equally to the incentives of anticipating the demand shock.

Assuming the goods only depreciate in the warehouse, the law of motion for the inventories is:

$$s_{j,t+1} = (1-\delta)[s_{jt} - q_{jt}] + m_{jt} \tag{16}$$

A firm's problem is the following. At the beginning of each period it observes its inventory holdings, s_{jt}, and its level of demand, and then decides (1) the price of its good and (2) whether to import or not, and, if so, how much. Formally, denote the firm's value of adjusting inventories by $V^a(s, \nu)$ and of not adjusting by $V^n(s, \nu)$.[41] Every period, retailers optimize by choosing $V(s, \nu) = \max\{V^a(s, \nu), V^n(s, \nu)\}$, where

$$\begin{aligned} V^a(s, \nu) &= \max_{p, m>0} q(p, s, \nu)p - \omega m - f + \beta EV[s', \nu'] \\ V^n(s, \nu) &= \max_{p} q(p, s, \nu)p + \beta EV[s', \nu'] \end{aligned} \tag{17}$$

are subject to (16) and (15). Solving for the optimal policies generates an ($\underline{s}$,$\overline{s}$) policy of ordering in which purchases are a function of current inventory holdings and the demand shock, i.e. $m = m(s, \nu)$. Similarly, the pricing schedule is characterized by a constant markup over the marginal value of an additional unit of inventory, $p = \frac{\theta}{\theta-1}V_s(s, \nu)$. In contrast with the different models that microfound the gravity equation, demand for the good, q_{jt}, can be satisfied using inventories. Moreover, because firms optimize the timing of their purchases, m_{jt}, will respond to the incentives of anticipated tariff reductions.

Before we simulate the model under a wide range of parameter values, we show that to reproduce the trade flow pattern observed during NAFTA's staged tariff reductions, two ingredients are required. First, the tariff reduction has to be anticipated. Second, the inventory-usage ratio has to be non-negligible.[42] The first three panels of Figure 4 show the aggregate response of imports and their consumption of an industry. Only in the benchmark case (Panel A), in which the equilibrium amount of inventories is worth 2.2 months of sales and the tariff reduction is known in advance, there is a significant *anticipatory slump* and *liberalization bump*.[43] The lower right panel illustrates that the

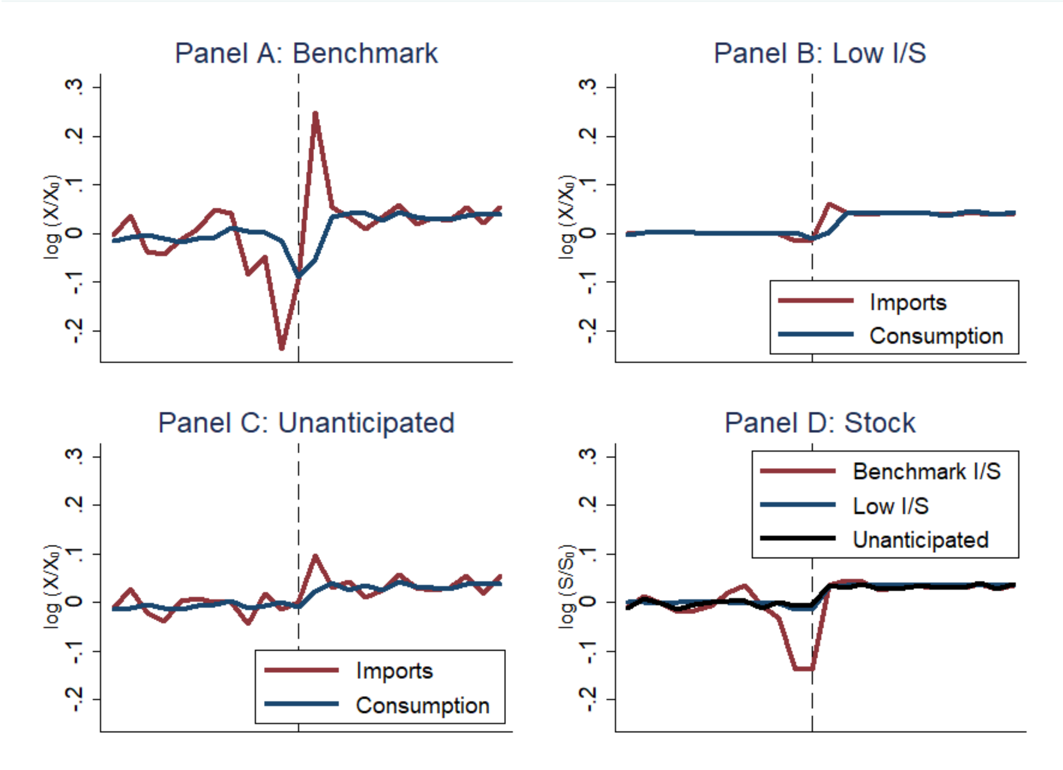
[41] For simplicity, we drop the firm subscript j from here on.

[42] In Section C of the Appendix we show that for an individual retailer that does not face demand uncertainty there is a closed form expression of the anticipatory drop in imports. Indeed, the drop is increasing in the equilibrium inventory-sales ratio and the upcoming tariff cut.

[43] The parameter values and moments corresponding to the three simulations of Figure 4 are in Table D.7 of the Appendix. The parameter values of the benchmark case and unanticipated shock are reported in the first row. The low I/S calibration is reported in the second column.

fluctuations in trade flows of the benchmark case are accompanied by a drop in inventories in the run-up to the tariff reduction. It is the use of inventories that allows for the relatively smooth response of consumption of imports in the benchmark case.

Figure 4: Impulse Response Function of Aggregate Variables in the 3 Simulations



Note: In all four panels the yaxis is log changes with respect to the average level of the corresponding variable in the first 12 months of the simulation. Panel A are aggregate consumption and imports from the simulations under the benchmark calibration reported in the first row of Table D.7 of the Appendix. Panel B illustrates the response under the calibration with a low equilibrium inventory-sales reported in the second row of Table D.7. Panel C plots the response under the benchmark calibration when the tariff reduction is unanticipated. Panel D shows the response of end of period stock holdings for all three simulations.

4.2 Monte Carlo Simulations

The goal of the Monte Carlo simulations is to validate the measure of consumed imports described in Section 3.1 by considering how effective it is in replicating the actual consumption of imports in the model. To do so we perform simulations under a wide range of parameter values. Each simulation includes 2,000 firms over 48 periods. In all simulations, firms receive two types of shocks: (1) a periodic i.i.d. demand shock; and (2) an anticipated permanent decrease in the tariff rate τ of 1 pp in period 25.[44] In addition to a benchmark calibration and a low inventory-sales ratio calibration, we simulate the model under another 50 different calibrations described in Table D.7 of the Appendix. We focus on varying the parameters that determine the equilibrium inventory-usage ratio, since these are the ones determining the dynamics around the tariff reductions. Namely, we vary $f, \delta, \beta, \sigma_\nu$ one-by-one while holding constant the other three parameters at their benchmark value. We also assess the sensitivity to the depreciation rate when $f = 0$ and inventory holdings are only due to the precautionary motive. The elasticity of substitution is set to 4 in all simulations.

The implementation of the model equivalent of the measure of the consumption in (9) is straightforward. In each of the 52 simulations we set k to be the average inventory sales ratio of the first year. The main difference with respect to (9) is that in the model, contemporaneous orders only become available for consumption in the next period. Hence, in the model simulations, m_t drops out of (9). To study how anticipatory dynamics lead to deviations between the trade-flow and the trade-consumption elasticities when using annual data we estimate the following equation for each one of the 52 simulations:

$$\ln(y_{jt}) = \sigma \ln(1 + \tau_t) + u_{jt} \tag{18}$$

where the dependent variable $y_{jt} = \{m_{jt}, q_{jt}, \tilde{q}_{jt}\}$ is aggregated at firm level to the annual frequency. Using m_{jt} as the dependent variable estimates the trade-flow elasticity, using q_{jt} the true trade-consumption elasticity and $\tilde{q}_{jt}$ the trade-consumption elasticity under the measure of consumption in (9).

The deviation between the trade-flow and the trade-consumption increases in the degree of anticipation to the tariff reduction. Similar to the estimation equation (5) of Section 2 we estimate the *anticipatory slump* as:

$$\ln(m_{jt,11:12}/m_{jt,4:8}) = \varepsilon^S \ln(1 + \tau_{t+1}) + u_{jt} \tag{19}$$

where ε^S captures the elasticity of the end of the year import decline in response to the

[44]The model is solved using a shooting algorithm where importers solve their problems backwards starting from a new steady state. We first simulate 2,000 firms over 5,000 periods using their initial policy functions so that we can initiate the distribution of firms at the stationary inventory holdings distribution.

upcoming tariff reduction.

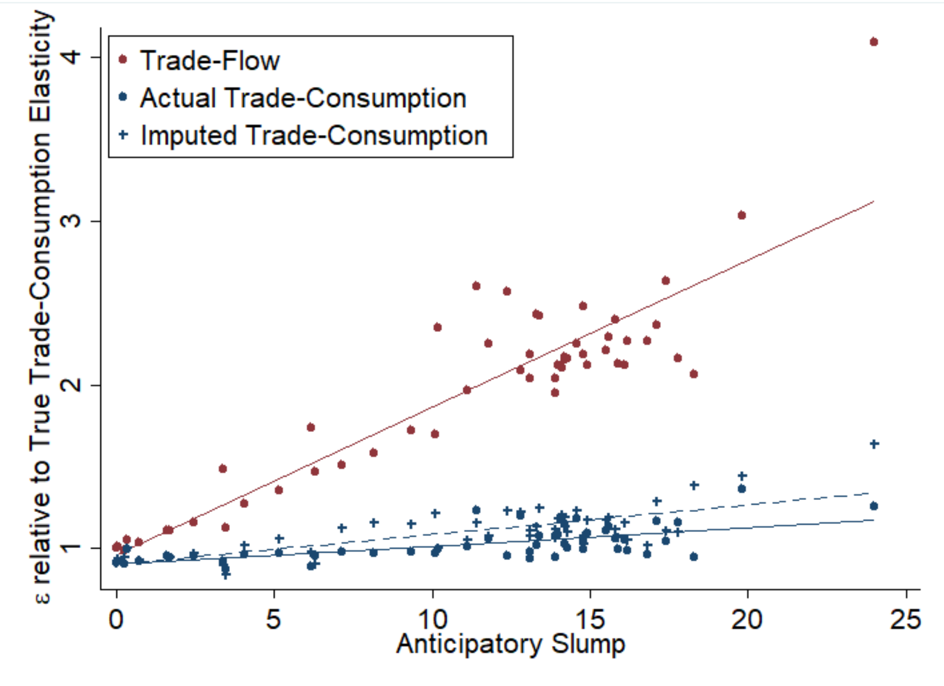
Figure 5 illustrates the main results of the simulations. On the y-axis it plots the elasticity estimates of σ when using the year before and after the change in tariffs relative to the one when using consumed imports (q_{jt}) in the years 1 and 4, i.e. those without the *slump* and *bump*. Note that when using years 1 and 4 the elasticity of imports and consumed imports are identical.[45] The estimate of ε^S of each simulation is shown on the x-axis.[46] There are three main findings.[47] First, the trade-consumption elasticity in the two years around the tariff reduction is almost identical to the trade-consumption elasticity using years 1 and 4 (blue line) for any degree of anticipation. This indicates that the slumps and bumps of trade flows are absent in the response of consumed imports as these adjust immediately and uniformly to the tariff reduction. Second, the deviation between the trade-flow elasticities (red dots) and the trade-consumption elasticities (blue dots) is substantial even when the anticipatory slump is within reasonable values of 5 and 10, as during NAFTA's staged tariff reductions. Third, the trade-consumption elasticity when using our measure of consumed imports (blue crosses) is very close to the actual trade-consumption elasticity for the entire range of anticipatory elasticities (and calibrations of the model). Hence, the performance of our measure of consumption within this framework supports the empirical results of Section 3.2. Altogether, these findings indicate that even when using annual trade flows, in the presence of anticipatory dynamics, trade and their consumption can deviate substantially, with important implications for the estimation of the short-run intensive margin adjustment to trade cost changes.

[45] Note that this approach to side stepping the bias requires knowledge about the existence of anticipation. In contrast, using q_{jt} does not require information about the existence of anticipation.

[46] If instead the x-axis was the equilibrium inventory-sales ratio, Figure 5 would look very similar.

[47] Table D.8 illustrates the three findings with the point estimates of three specific calibrations.

Figure 5: Monte Carlo Simulations: Trade vs. Trade-Consumption Elasticities



Note: Dots and crosses correspond to the elasticity estimates of (18) (y-axis) and (19) (x-axis) for each of the 52 simulations. Parameter values for the 52 simulations are reported in Table D.7. The elasticity estimate in the y-axis are relative to the true trade-consumption elasticity, i.e. the estimate that excludes the consumed imports during the two years around the tariff reduction. The red dots and line (lines are linear fit) uses trade flows as dependent variable in (18); the blue dot and line uses actual consumption; and the blue dots and dashed line uses our measure of consumed imports.

5 Conclusions

This paper makes three contributions. First, it shows that firms' optimal ordering behavior in response to NAFTA's staged tariff phaseouts leads to *slumps* and *bumps* in trade flows. Second, it provides a method to estimate the underlying consumption process of imports that is validated through Monte Carlo simulations of a standard model of trade extended with $(\underline{s},\overline{s})$ inventory management. Applied to the data, the consumption measure does not exhibit anticipatory effects. Third, using the measure of consumed imports, it suggests that the documented anticipatory dynamics are consequential even in the annual data. The short-run (annual) trade elasticity is more than 50% larger when using trade flows instead of trade-consumption, whereas the long-run response is unaffected. These findings imply that the adjustment to tariff changes is even slower than captured by raw trade flows.

There are several insights from this paper that open up interesting future research avenues. The consumption of imports process we propose is easily implementable since it requires only high-frequency trade data and estimates of the inventory-sales ratios. However, its necessity arises only due to the lack of data on inventories (consumption of imports) at the same level of aggregation at which elasticities are estimated. Although Alessandria et al. (2011a) have shown similar dynamics with inventory data for the automotive industry, our paper illustrates that incorporating inventory data is important to fully understand the response of trade to liberalizations and that progress can be made once more disaggregate inventory data becomes available.

Moreover, in the episode studied in this paper, the implementation of the tariff reductions was certain to take place. Nonetheless, the anticipatory effects we document here are potentially sizable even when the policy change is uncertain. In fact, during the annual renewal of China's MFN status in the 1990s, US imports from China rose systematically before the US Congress approved the renewal in anticipation of higher future tariffs (Alessandria et al. (2019)). In that sense, besides the uncertainty surrounding the current rise of protectionism, our paper provides a mechanism to understand the stockpiling in advance of events such as Brexit and a way to study the consumption response of imported goods in this context.

References

Agarwal, Sumit, Nathan Marwell, and Leslie McGranahan, "Consumption Responses to Temporary Tax Incentives: Evidence from State Sales Tax Holidays," *American Economic Journal: Economic Policy*, 2017, *9(4)*, 1–27.

Alessandria, George and Horag Choi, "Establishment Heterogeneity, Exporter Dynamics, and the Effects of Trade Liberalization," *Journal of International Economics*, 2014, pp. 207–223.

_ , _ , and Kim J. Ruhl, "Trade Adjustment Dynamics and the Welfare Gains from Trade," *Journal of International Economics*, 2021, *Forthcoming.*

_ , Joseph Kaboski, and Virgiliu Midrigan, "Inventories, lumpy trade, and large devaluations," *American Economic Review*, 2010a, *100(5)*, 2304–2339.

_ , _ , and _ , "The Great Trade Collapse of 2008-09: An Inventory Adjustment?," *IMF Economic Review*, 2010b, *58*, 254–294.

_ , _ , and _ , "US Trade and Inventory Dynamics," *American Economics Review*, 2011a.

_ , Shafaat Y. Khan, and Armen Khederlarian, "Taking Stock of Trade Policy Uncertainty: Evidence from China's Pre-WTO Accession," *NBER working paper No. 25965*, 2019.

Anderson, James, "A theoretical foundation for the gravity equation," *American Economic Review*, 1979, *69(1)*, 106–116.

_ and Eric van Wincoop, "Trade Costs," *Journal of Economic Literature*, 2004, *42(3)*, 691–751.

Arkolakis, Costas, "Market Penetration Costs and the New Consumers Margin in International Trade," *Journal of Political Economy*, 2010, *118(6)*, 1151–1199.

_ , Arnaud Costinot, and Andrés Rodríguez-Clare, "New Trade Models, Same Old Gains?," *American Economic Review*, 2012, *102(1)*, 94–130.

Armington, Paul S., "A Theory of Demand for Products Distinguished by Place of Production," *Staff Papers - International Monetary Fund*, 1969, *16(1)*, 159–178.

Baier, Scott L. and Jeffrey Bergstrand, "Do free trade agreements actually increase members international trade?," *Journal of International Economics*, 2007, *71(1)*, 72–95.

Baker, Scott, Lorenz Keung, and Stephanie Johnson, "Shopping for Lower Sales Tax Rates," *American Economic Journal: Macroeconomics*, Forthcoming.

Besedes, Tibor, Tristian Kohl, and James Lake, "Phase Out Tariffs, Phase In Trade?," *Journal of International Economics*, 2020, *127.*

Boehm, Christoph, Andrei Levchenko, and Nitya Pandalai-Nayar, "The Long and (Short) Run of Trade Elasticities," *Working Paper*, 2020.

Broda, Christian and David E. Weinstein, "Globalization and the Gains from Variety," *The Quarterly Journal of Economics*, 2006, *121(2)*, 541–585.

Caliendo, Lorenzo and Fernando Parro, "Estimates of the Trade and Welfare Effects of NAFTA," *The Review of Economic Studies*, 2015, *82(1)*, 1–44.

Cavallo, Alberto, Gita Gopinath, Brent Neiman, and Jenny Tang, "Tariff Passthrough at the Border and at the Store: Evidence from US Trade Policy," *NBER WP*, 2019.

Chaney, Thomas, "Distorted Gravity: The Intensive and Extensive Margins of International Trade," *American Economic Review*, 2008, *98(4)*, 1707–1721.

Charnavoki, Valery, "Retail Sales of Durable Goods, Inventories and Imports after Large Devaluations," 2017.

Coglianese, John, Lucas Davis, Lutz Kilian, and James Stock, "Anticipation, Tax Avoidance, and the Price Elasticity of Gasoline Demand," *Journal of Applied Econometrics*, 2017.

Crucini, Mario and Jonathan Davis, "Distribution capital and the short- and long-run import demand elasticity," *Journal of International Economics*, 2016, *100(C)*, 203–219.

Dixit, Arvind K. and Joseph Stiglitz, "Monopolistic Competition and Optimum Product Diversity," *American Economic Review*, 1977, *67(3)*, 297–308.

Drozd, Lukasz A. and Jaromir B. Nosal, "Understanding International Prices: Customers as Capital," *American Economic Review*, 2012, *102(1)*, 364–395.

Eaton, Joanthan and Samuel Kortum, "Technology, Geography, and Trade," *Econometrica*, 2002, *70(5)*, 1751–1779.

Engel, Charles and Jian Wang, "International trade in durable goods: Understanding volatility, cyclicality, and elasticities," *Journal of International Economics*, 2011, *83(1)*, 37–52.

Fajgelbaum, Pablo, Pinelopi Goldberg, Patrick Kennedy, and Amit Khandelwal, "The Return to Protectionism," *Quarterly Journal of Economics*, 2020, *135.*

Feenstra, Robert C., "New Product Varieties and the Measurement of International Prices," *The American Economic Review*, 1994, *84(1)*, 157–177.

Fukao, Kyoji, Toshihiro Okubo, and Robert M. Stern, "An econometric analysis of trade diversion under NAFTA," *The North American Journal of Economics and Finance*, 2003, *14(1)*, 3–24.

Gallaway, Michael P., Christine A. McDaniel, and Sandra A. Rivera, "Short-run and Long-run Industry level Estimates of U.S. Armington Elasticities," *The North American Journal of Economics and Finance*, 2003, *14(1)*, 49–68.

Hallak, Juan C., "Product Quality and the Direction of Trade," *Journal of International Economics*, 2006, *68(1)*, 238–265.

Head, Keith and John Ries, "Increasing Returns versus National Product Differentiation as an Explanation for the Pattern of U.S.-Canada Trade," *American Economic Review*, 2001, *91(4)*, 858–876.

_ **and Thierry Mayer**, "Gravity Equations: Workhorse, toolkit, cookbook," *Handbook of International Economics*, 2014, *4*, 131–195.

_ **, John Ries, and Thierry Mayer**, "The erosion of colonial trade linkages after independence," *Journal of International Economics*, 2010, *81(1)*, 1–14.

Hillberry, Russel and David Hummels, "Trade Elasticity Parameters for a Computable General Equilibrium Model," *Dixon and Jorgenson (eds) Handbook of Computable General Equilibrium Modeling, Elsevier*, 2012.

Jung, Benjamin, "Gradualism and dynamic trade adjustment: Revisiting the pro-trade effect of free trade agreements," *Economic Letters*, 2012, *115*, 63–66.

Kehoe, Timothy and Kim Ruhl, "How Important is the New Goods Margin in International Trade," *Journal of Political Economy*, 2013, *121(2)*, 358–392.

Kim, Ryan, "The Effect of the Credit Crunch on Output Price Dynamics: The Corporate Inventory and Liquidity Management Channel," 2018.

Kruegger, Anne O., "Trade Diversion and Trade Creation under NAFTA," *Latin American Econometric Society Meeting, Cancun, Mexico*, 1999.

Melitz, Marc, "The Impact of Trade on Intra-industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 2003, *71(6)*, 1695–1725.

Romalis, John, "NAFTA's and CUSFTA's Impact on International Trade," *Review of Economics and Statistics*, 2007, *89(3)*, 416–435.

Ruhl, Kim, "The International Elasticity Puzzle," *University of Texas-Austin mimeo*, 2008.

Silva, J.M.C. Santos and Silvana Tenreyro, "The Log of Gravity," *The Review of Economics and Statistics*, 2006, *88(4)*, 641–658.

Simonovska, Ina and Michael Waugh, "The Elasticity of Trade: Estimates and Evidence," *Journal of International Economics*, 2014, *92(1)*, 34–50.

Yilmazkuday, Hakan, "Estimating the Trade Elasticity over Time," *Economics Letters*, 2019, *183.*

Appendix

A Dynamic Elasticities Using the Error-Correction Mechanism Method

Here we examine whether the documented anticipation affects the estimated dynamic elasticities using Error-Correction Mechanism (ECM) model instead of local projections as in Section 3.2. To do so, we use the ratio-type trade flows described in Section 2.1 and distinguish between the response of trade flows and trade consumption using annual data. The results of using the ECM method are very similar to the baseline results.

Precisely, we generalize (10) by applying an unrestricted Error-Correction Mechanism (ECM) model that estimates the short- and long-run response by considering:

$$\Delta y_{zt}^{DD} = \sigma^{SR}\ \Delta\tau_{zt}^{DD} + \sigma^{LR}\ \tau_{z,t-1}^{DD} + \alpha\ y_{z,t-1}^{DD} + \delta_t + \delta_z + u_{zt} \tag{20}$$

where $\Delta y_{z,t}^{DD} = y_{z,t}^{DD} - y_{z,t-1}^{DD}$.[48] Short-run or one-year elasticity is denoted by σ^{SR} and $-\sigma^{LR}/\alpha$ denotes the long-run elasticity.[49] This formulation generalizes (10) by relaxing the assumptions $\sigma^S = \sigma^L$ and $\alpha = -1$. We consider both the imports flows and their consumption as dependent variables to highlight the difference between trade-flow elasticity and trade-consumption elasticity.

In Table D.10 we report the short-run and long-run elasticities from (20). Panel A reports estimates for all goods. There is a sizeable bias in the short-run elasticity, of around 68%. The estimate drops from 4.2 when using import flows to 2.5 when using our measure of consumption of imports. Also note that both of these estimates are similar to the one obtained in the baseline approach using (4). Panel B shows that the bias is driven by a largely overestimated short-run elasticity for phased-out goods. For these goods, the short-run elasticity with import flows is around 250% larger than the one estimated using the consumption of imports, dropping from 7.1 to 2.9. These results are consistent with the strong anticipatory responses of phased-out goods found in Section 2.4. In contrast, non-phased-out goods yield similar estimates when using imports flows or consumption

[48] This assumes that imports and tariffs have order of integration 1 and are co-integrated.

[49] In a restricted version, one would add a lag of the dependent term to (10). That would impose the restriction $\sigma^{SR} = \sigma^{LR}$. Results are similar using the restricted version and reported in Table D.11.

of imports. It is also noticeable that the estimated short-run elasticity for the phased-out goods becomes almost equal to the one for the non-phased-out goods once we control for the anticipatory effects.

We now discuss the effect of anticipatory dynamics on the long-run elasticity. Anticipation to upcoming tariff cuts causes firms to delay their imports to right after the tariff reduction. This does not affect the long-run response, which is governed by longer-run dynamics such as firm entry or gradual adjustment in consumer habit stock. In effect, Table D.10 shows that our measure of consumption of imports yields an almost identical long run trade-flow and trade-consumption elasticity of around 9.7 and 9.2, respectively.

Given the differential short run and long run bias from anticipatory effects, correcting for it implies a larger role for the size. The ratio of long- to short-run elasticity is an important feature of dynamic models of trade.[50] Table D.10 shows that long-run trade elasticity is 2.3 times the short-run. This is in line with the estimates of this ratio found in the literature (Gallaway et al. (2003), Baier and Bergstrand (2007), Jung (2012) and Yilmazkuday (2019)). However, using the consumption of imports increases the ratio of long- to short-run elasticity by 75% to around 3.7.

Moreover, the full adjustment to the long run response takes longer using the consumption response. In Figure D.3 we plot the dynamic response of import flows and import consumption to a 1 percentage point permanent tariff reduction. The elasticity grows with the distance between periods. Although the bias becomes relatively less important over time, a small bias persists. However, a notable feature of the plot is the speed with which imports adjust to their long-run value. While import flows show a convergence time of 4 years, import consumption takes around 7 years to converge to its long-run value. This is line with the estimated speed of adjustment parameter, α, reported in Table D.10. In Figure D.4 we report the dynamic response for the phased-out goods. There are two major differences. First, the reduction in short-run elasticity is bigger. Second, because of a larger anticipatory dip for phased-out goods, even the long-run elasticity has a bigger bias of around 17%.

This section shows how using an alternative method of estimating dynamic elasticities yields very similar results to those in Section 3.2. The difference between ECM trade-flow and trade-consumption elasticities is very similar in magnitude to the ones estimated

[50] See for example Arkolakis (2010), Engel and Wang (2011), Crucini and Davis (2016), Alessandria et al. (2021).

using local projections method. Therefore, the findings here provide further evidence that using trade flows leads to biased estimates of short-run trade-consumption elasticity and the dynamic response of consumed imports.

B Anticipatory Effects in Exporter Prices

In the model of Section 4 we assume that exporters are perfectly competitive and that the purchase price, ω is exogenous and constant.[51] In reality, however, it could be the case that when suppliers observe a temporary drop in their sales, they offer discounts countervailing the incentives of anticipation to tariff reductions. Similarly, it could be that the drop in utilization of shipment infrastructure results in a price drop from lower transportation costs.

We test this by considering how Mexican unit values including shipping costs responded to the upcoming tariff reduction in line with our approach of Section 2. To control for confounding in Mexican export prices at HS-6 level we take the ratio of the unit values of imports to the US and EU12. Additionally, we considered unit values of Mexican alone and the overall result does not change. Unit values are calculated using CIF value to take into account changes in shipping costs that would be consistent with a story of less congestion and lower shipping costs due to the drop in demand in advance of a tariff reduction. Next, we take within-year growth rates between sub-periods $\overline{n}$ and $\underline{n}$ and estimate the following equation:

$$\Delta_{\overline{n}:\underline{n}} UV^{D}_{z,t-1} \equiv \log\left(\frac{UV^{Mex,US}_{z,t,\overline{n}}}{UV^{Mex,EU12}_{z,t,\overline{n}}} \Big/ \frac{UV^{Mex,US}_{z,t,\underline{n}}}{UV^{Mex,EU12}_{z,t,\underline{n}}} \right) = \sigma^{A,UV} \Delta\tau^{D}_{z,t} + \delta_z + u_{z,t} \tag{21}$$

$\sigma^{A,UV}$ is the anticipatory elasticity of unit values to an upcoming tariff change, defined as $\Delta\tau^{D}_{z,t} = \frac{\ln(1+\tau^{MEX,US}_{z,t})}{\ln(1+\tau^{RoW,US}_{z,t})} \Big/ \frac{\ln(1+\tau^{MEX,US}_{z,t-1})}{\ln(1+\tau^{RoW,US}_{z,t-1})}$. This estimation equation is very similar to 5, except that we take only a reference importing country. We restrict the sample to the sample considered in Table 3, in which we found anticipatory effects in phased-out goods using the triple difference approach. Calculating unit values further restricts the sample since quantities are generally less available than values. Results are reported in Table D.9. Neither in the aggregate, nor for phased-out goods, do we observe any significant

[51] In the model, introducing an ad-hoc supply elasticity dampens the *anticipatory slump* only slightly and the results of section 4.2 are unchanged.

movement in unit values before an upcoming tariff change.

C Analytical Expression of the Anticipatory Slump

This section describes and solves an inventory model with stockout avoidance motive. The purpose of here is to find analytical expressions displaying anticipatory effects. We set the fixed ordering costs to zero. This makes it optimal for firms to order every period. However, due to uncertainty and a delivery lag, they hold inventories and target a base inventory level. Firms solve,

$$\begin{aligned} V(s,\eta) &= \max_{p,i} \eta p^{1-\sigma} - \omega i + \beta EV(s') \\ s.t. \quad s' &= (1-\delta)(s+i-q)\ , \qquad \eta p^{-\sigma} \leq s \end{aligned}$$

where every period firms choose their price and orders. The demand function, $q = p^{-}$, is plugged in the problem above. The iid demand shock is denoted by η. There are two constraints. First constraint imposes the law of motion of inventories. Second condition imposes the delivery lag i.e. sales are restricted by beginning-period inventories. The first-order-conditions are as follows

$$p = \frac{\sigma}{\sigma-1}\left(\Upsilon + \beta(1-\delta)\frac{\partial EV(s',\eta')}{\partial s'}\right) \tag{I}$$

$$\omega = \beta(1-\delta)\frac{\partial EV(s')}{\partial s'} \tag{II}$$

Here the Lagrangian multiplier for the second constraint is denoted by Υ. If sales are strictly less than the beginning-period inventories then $\Upsilon = 0$ and $p = \sigma\omega/(\sigma-1)$. On the other hand, if sales are restricted by inventories due to a high demand shock, then $p = \sigma(\omega+\Upsilon)/(\sigma-1)$. The critical level of demand shock is,

$$\bar{\eta}(s) = s\left(\frac{\sigma}{\sigma-1}\omega\right)^{\sigma}$$

If $\eta \geq \bar{\eta}(s)$, then firms stockout and hence charge a higher price. Going forward, we will denote the purchase needed to achieve base inventory by $i_0 = s + i(s,\eta) - \eta p^{-\sigma}$. Purchases, $i(s,\eta)$, will be adjusted so that firms begin next period with the base inventory level, denoted by s_0. Using $s' = s_0 = i_0(1-\delta)$, the optimal ordering function is given by,

$$i(s,\eta) = \begin{cases} i_0 + \eta \left(\frac{\sigma}{\sigma-1}\omega\right)^{-\sigma} - s & \text{if } \eta < \bar{\eta}(s) \\ i_0 & \text{if } \eta \geq \bar{\eta}(s) \end{cases} \tag{22}$$

To find an expression for i_0 we use (II) and the expression for $EV(s)$.

$$\begin{aligned} EV(s) = & \int_{\eta<\bar{\eta}(s)} \left[\eta \left(\frac{\sigma}{\sigma-1}\omega\right)^{1-\sigma} - \omega i_0 \eta \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} \omega^{1-\sigma} + \omega s\right] dF(\eta) \\ & + \int_{\eta\geq\bar{\eta}(s)} \left[\eta^{1/\sigma} s^{(\sigma-1)/\sigma} - \omega i_0\right] dF(\eta) + \beta EV[(1-\delta)i_0] \\ = & \left(\frac{\sigma\omega}{\sigma-1}\right)^{1-\sigma} \frac{1}{\sigma}\Psi_1(s) + s^{(\sigma-1)/\sigma}\Psi_2(s) - \omega i_0 + F(\bar{\eta}(s))\omega s + \beta EV[(1-\delta)i_0] \end{aligned} \tag{23}$$

$$\begin{aligned} \Psi_1(s) &= \int_{\eta<\bar{\eta}(s)} \eta \; dF(\eta) \\ \Psi_2(s) &= \int_{\eta\geq\bar{\eta}(s)} \eta^{1/\sigma} \; dF(\eta) \end{aligned}$$

To obtain an analytical form, we assume η is drawn from a pareto distribution with parameter α. This implies,

$$\begin{aligned} \Psi_1(s) &= \frac{\alpha}{\alpha-1}\left[1 - \bar{\eta}(s)^{1-\alpha}\right] \\ \Psi_2(s) &= \frac{\alpha\sigma}{\alpha\sigma-1}\left[\bar{\eta}(s)^{(1-\alpha\sigma)/\sigma}\right] \end{aligned}$$

To obtain the steady-state base inventory level, we use (II) and set $\partial EV(s')/\partial s' = \omega/[\beta(1-\delta)]$. This gives the following expression by setting $s' = s_0$ in (23),

$$s_0 = \left(\frac{\sigma}{\sigma-1}\omega\right)^{-\sigma} (\alpha\sigma-1)^{-1/\alpha} \left[\frac{1-\beta(1-\delta)}{\beta(1-\delta)}\right]^{-1/\alpha} \tag{24}$$

The optimal purchases are given by substituting $s_0 = i_0(1-\delta)$ and (24) in (22).

Having solved for the steady-state decision rules analytically, we derive the analytical form of the non-stationary ordering policy when tariff changes (ω) are anticipated. To do this, we start from (23) after imposing the pareto distribution for the demand shock.

$$
\begin{aligned}
EV(s) =& \frac{\alpha}{\alpha-1}\frac{1}{\sigma}\left(\frac{\sigma\omega}{\sigma-1}\right)^{1-\sigma} - \left(\frac{\sigma}{\sigma-1}\right)^{-\alpha\sigma}\frac{1}{(\alpha\sigma-1)}\omega^{1-\alpha\sigma}s^{1-\alpha} \\
&+ \omega s - \frac{\omega s_0}{1-\delta} + \beta EV(s')
\end{aligned}
$$

Fixing s', we get the following expression for the derivative

$$
\frac{EV(s)}{\partial s} = \left(\frac{\sigma}{\sigma-1}\right)^{-\alpha\sigma}\frac{1}{\alpha\sigma-1}\omega^{1-\alpha\sigma}s^{-\alpha} + \omega
$$

We move this forward one period to obtain $EV(s')/\partial s'$ and equate it to $\omega/[\beta(1-\delta)]$ as in (II). This outputs the following functional form for next period's target inventory level if firms expect ω to change to ω',

$$
s' = \left(\frac{\sigma\omega'}{\sigma-1}\right)^{-\sigma}(\alpha\sigma-1)^{-1/\alpha}\left(\frac{(\omega/\omega')-\beta(1-\delta)}{\beta(1-\delta)}\right)^{-1/\alpha} \tag{25}
$$

This expression is similar to the one in (24). The only difference is that in the last parenthesis, 1 is replaced with ω/ω' i.e. change in purchase price. If in the next period tariffs are set to fall i.e. $\omega > \omega'$ then the beginning period inventories next period will be lower than the new steady-state level. This translates into smaller order in the period before the tariff fall i.e. *anticipatory slump.*

D Tables and Figures

Table D.1: Reference Exporter Countries

Afghanistan	Gabon	Norfolk Is	Angola	Gambia, The	Korea, DPR
Antigua Barbuda	Ghana	Norway	Argentina	Greenland	Oman
Aruba	Grenada Is	Pakistan	Australia	Guatemala	Palau
Bahamas	Guinea	Panama	Bahrain	Guinea-Bissau	Papua New Guinea
Bangladesh	Guyana	Paraguay	Barbados	Haiti	Peru
Belize	Honduras	Philippines	Benin	Hong Kong, SAR China	Pitcairn Is
Bermuda	India	Qatar	Bhutan	Indonesia	Rwanda
Bolivia	Iran, Islamic Rep	Samoa	Botswana	Jamaica	Saudi Arabia
Brazil	Japan	Senegal	Brunei	Kenya	Seychelles
Burkina Faso	Kiribati	Sierra Leone	Burundi	Korea, Rep	Singapore
Cambodia	Lao PDR	Solomon Is	Cameroon	Lesotho	Somalia
Cabo Verde	Liberia	Sri Lanka	Cayman Is	Libya	St Kitts and Nevis
Central African Republic	Macao	St Lucia Is	Chad	Madagascar	St Vincent & Grenadines
Chile	Malawi	Sudan	China	Malaysia	Suriname
Christmas Is	Maldive Is	Swaziland	Cocos Is	Mali	Eswatini
Colombia	Marshall Is	Taiwan, China	Comoros	Mauritania	Tanzania
Congo, Dem. Rep.	Mauritius	Thailand	Congo, Rep.	Mongolia	Togo
Cook Is	Montserrat Is	Tonga	Costa Rica	Mozambique	Trinidad & Tobago
Cote d'Ivoire	Namibia	Tuvalu	Cuba	Nauru	Uganda
Djibouti	Nepal	United Arab Em	Dominica Is	Netherlands Ant	Uruguay
Dominican Rep	New Caledonia	Venezuela, RB	Ecuador	New Zealand	Vietnam
El Salvador	Nicaragua	Yemen, Rep.	Equatorial Guinea	Niger	Zambia
Ethiopia	Nigeria	Zimbabwe	Fiji	Niue	

Table D.2: Anticipatory Slumps & Bumps - Fixed Effects Robustness

Dep. Var.:	$\Delta_{\underline{n}:\overline{n}} m^{DD}_{z,t-1}$			$\Delta_{\underline{n}:\overline{n}} m^{DD}_{zt}$		
	Slump	Slump	Slump	Bump	Bump	Bump
$\overline{n}$	11:12	11:12	11:12	1:4	1:4	1:4
$\underline{n}$	4:8	4:8	4:8	11:12	11:12	11:12
$\mathbf{1}\{Phased\}\Delta\tau^{DD}_{zt}$	6.1***	4.0**	4.9***	-11.7**	-8.9**	-13.1***
	(2.10)	(1.93)	(1.77)	(4.67)	(3.43)	(4.58)
$\mathbf{1}\{Others\}\Delta\tau^{DD}_{zt}$	-1.6	-1.7	-1.4	-2.7	1.5	-1.5
	(2.76)	(2.53)	(2.48)	(2.77)	(2.54)	(3.34)
Year FE				✓	✓	✓
HS6 FE	✓			✓		
HS4 FE		✓			✓	
SITC FE			✓			✓
N	6023	6307	6176	7014	7421	7251
adj. R^2	0.075	0.045	0.066	0.266	0.140	0.209

Note: Estimates are obtained from (5) and (6) using different levels of aggregation of the industry/product specific seasonalities (fixed effects). Estimates separate between the effect of $\Delta\tau^{DD}_{zt}$ for good's whose tariffs were phased-out (class B,C,C+) and the rest. Standard errors, in parentheses, are clustered at HS-2 product level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.3: Anticipatory Slumps & Bumps - Storability

Dep. Var.:	$\Delta_{\underline{n}:\overline{n}} m^{DD}_{z,t-1}$			$\Delta_{\underline{n}:\overline{n}} m^{DD}_{z,t}$		
	Slump	Slump	Slump	Bump	Bump	Bump
$\overline{n}$	11:12	11:12	10:12	1:4	1:3	1:4
$\underline{n}$	4:8	4:10	4:9	11:12	11:12	10:12
$\mathbf{1}\{HH_z > \text{Med}(HH_z)\}\mathbf{1}\{\textit{Phased}\}\Delta\tau^{DD}_{zt}$	7.1**	5.8***	4.9***	-17.0**	-12.7*	-11.5**
	(2.75)	(1.99)	(1.63)	(7.45)	(6.64)	(5.79)
$\mathbf{1}\{\textit{Other}\}\Delta\tau^{DD}_{zt}$	-0.8	-0.6	0.1	-2.5	-1.3	-2.9
	(2.22)	(2.00)	(2.06)	(2.55)	(2.59)	(2.43)
HS6 FE	✓	✓	✓	✓	✓	✓
Year FE				✓	✓	✓
N	6023	6285	7076	7014	7014	8323
Adj R2	0.08	0.10	0.09	0.27	0.24	0.26

Note: Estimates are obtained from a modified version of (5) and (6) in which τ^{DD}_{zt} is interacted with an indicator variable of the products' phaseout category and if it is above the median HH_z . The HH_z is the lumpiness of imports given by the HH index of concentration of imports over the year and proxies the products' degree of storability. A high HH index is associated with high storablity. Standard errors, in parentheses, are clustered at HS-2 product level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.4: Anticipatory Slumps & Bumps - Storability Interaction

Dep. Var.:	$\Delta_{\overline{n}:\underline{n}} m^{DD}_{z,t-1}$		
	Slump	Slump	Slump
$\overline{n}$	11:12	11:12	10:12
$\underline{n}$	4:8	4:10	4:9
Panel A: All Goods			
$\Delta\tau^{DD}_{zt}$	-42.4***	-22.8	-25.7*
	(14.05)	(13.70)	(13.64)
$\Delta\tau^{DD}_{zt} \times HH_z$	280.0***	157.5*	174.1**
	(92.18)	(84.61)	(85.67)
$\Delta\tau^{DD}_{zt} \times HH^2_z$	-415.6***	-244.1*	-266.7**
	(156.46)	(129.00)	(133.89)
Panel B: Phaseout Goods			
$\Delta\tau^{DD}_{zt}$	-53.4***	-71.0***	-78.0***
	(18.27)	(22.33)	(25.74)
$\Delta\tau^{DD}_{zt} \times HH_z$	372.6***	478.6***	518.5***
	(99.47)	(138.39)	(173.83)
$\Delta\tau^{DD}_{zt} \times HH^2_z$	-573.8***	-710.3***	-775.6***
	(132.29)	(215.61)	(293.30)
HS6 FE	✓	✓	✓
Observations	7076	6453	6285
Adjusted R^2	0.09	0.12	0.10

Note: Estimates are from (5) using different time horizons in the within year growth rate. Estimates from this Table are used in the construction of Figure 2 which indicates that a tariff reduction of 1% generates stronger anticipatory slump for goods with higher HH index, that is, that are lumpier (more storable). Standard errors, in parentheses, are clustered at HS-2 level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.5: Empirical Validation of the Imputed Consumption of Imports

US Imports from Mexico	Dep. Var.:	$\Delta_{\overline{n}:\underline{n}}\tilde{q}^{DD}_{z,t-1}$		
		Slump	Slump	Slump
	$\overline{n}$	11:12	11:12	10:12
	$\underline{n}$	4:8	4:10	4:9
Panel A: All Goods				
$\Delta\tau^{DD}_{zt}$		0.2	0.6	0.3
		(0.50)	(0.68)	(0.41)
Panel B: Phaseout Categories				
1 { *Phased* } $\times\ \Delta\tau^{DD}_{zt}$		0.8	0.5	0.8
		(0.97)	(1.17)	(0.76)
1 { *Others* } $\times\ \Delta\tau^{DD}_{zt}$		0.0	0.6	0.0
		(0.76)	(1.01)	(0.74)
HS6 FE		✓	✓	✓
Observations		6023	6269	7076

Note: Estimates are obtained from (5) using different within-year periods to construct the growth rate of trade between $\underline{n}$ and $\overline{n}$. In contrast with estimates reported in Table 3, here we use our baseline measure of consumption of imports from (9) as the dependent variable. We restrict the sample to be the same as in that of estimating with $\Delta_{\overline{n}-\underline{n}}m^{DD}_{zt}$. Standard errors, in parentheses, are clustered at HS-2 product level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.6: Durable vs. Non-Durable Goods

	1-Year		3-Year		5-Year		7-Year	
Dep. Var.:	$\Delta_1 m^{DD}_{z,t}$	$\Delta_1\tilde{q}^{DD}_{z,t}$	$\Delta_3 m^{DD}_{z,t}$	$\Delta_3\tilde{q}^{DD}_{z,t}$	$\Delta_5 m^{DD}_{z,t}$	$\Delta_5\tilde{q}^{DD}_{z,t}$	$\Delta_7 m^{DD}_{z,t}$	$\Delta_7\tilde{q}^{DD}_{z,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1 { *Non-Durables* } $\times\Delta_h\tau^{DD}_{zt}$	-7.12***	-4.27***	-10.7***	-8.65***	-10.1***	-7.55***	-9.77***	-9.12***
	(1.82)	(1.15)	(1.75)	(1.62)	(2.19)	(2.17)	(2.93)	(2.75)
Difference		67%		24%		34%		7%
1 { *Durables* } $\times\Delta_h\tau^{DD}_{zt}$	-2.13	-1.43	-5.36***	-5.38***	-8.83***	-8.22***	-9.80***	-9.05***
	(1.34)	(0.95)	(1.44)	(1.38)	(1.58)	(1.59)	(1.70)	(1.72)
Difference		.%		-0%		7%		8%
N	11488	11488	8280	8280	5516	5516	3155	3155
Adjusted R^2	0.002	0.002	0.009	0.010	0.017	0.017	0.025	0.025

Note: All estimates are obtained using (4) and interacting $\Delta_h\tau^{DD}_{zt}$ with an indicator variable for the goods Broad Economics Categories (BEC) classification into a durable or non-durable good. Durables include industrial supplies (BEC-2), fuels and lubricants (BEC-3) capital goods (BEC-4), and transport equipment (BEC-5); non-durables include food and beverages (BEC-1), consumer goods (BEC-6) and goods not specified elsewhere (BEC-7). Standard errors, in parentheses, are clustered at HS-6 level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.7: Parameters and Moments of the Simulations

Varied Parameter		f	σ_ν	δ	β	monthly I/S	HH Index	Fixed Cost over Rev.
Benchmark		0.05	0.6ˆ2	0.025	0.96ˆ(1/12)	2.17	0.20	1.92%
Low I/S		0.001	0.6ˆ2	0.1	0.96ˆ(1/12)	1.44	0.09	0.10%
f	1	0.001	0.6ˆ2	0.025	0.96ˆ(1/12)	1.75	0.09	0.09%
f	2	0.005	0.6ˆ2	0.025	0.96ˆ(1/12)	1.74	0.10	0.40%
f	3	0.01	0.6ˆ2	0.025	0.96ˆ(1/12)	1.78	0.12	0.69%
f	4	0.02	0.6ˆ2	0.025	0.96ˆ(1/12)	1.89	0.15	1.06%
f	5	0.03	0.6ˆ2	0.025	0.96ˆ(1/12)	1.98	0.16	1.41%
f	6	0.04	0.6ˆ2	0.025	0.96ˆ(1/12)	2.06	0.18	1.68%
f	7	0.06	0.6ˆ2	0.025	0.96ˆ(1/12)	2.12	0.21	2.16%
f	8	0.075	0.6ˆ2	0.025	0.96ˆ(1/12)	2.31	0.23	2.47%
f	9	0.1	0.6ˆ2	0.025	0.96ˆ(1/12)	2.47	0.26	2.91%
f	10	0.15	0.6ˆ2	0.025	0.96ˆ(1/12)	2.77	0.31	3.57%
δ	11	0.05	0.6ˆ2	0.01	0.96ˆ(1/12)	2.68	0.26	1.30%
δ	12	0.05	0.6ˆ2	0.02	0.96ˆ(1/12)	2.28	0.21	1.76%
δ	13	0.05	0.6ˆ2	0.03	0.96ˆ(1/12)	2.08	0.19	2.08%
δ	14	0.05	0.6ˆ2	0.04	0.96ˆ(1/12)	1.97	0.17	2.35%
δ	15	0.05	0.6ˆ2	0.05	0.96ˆ(1/12)	1.87	0.16	2.61%
δ	16	0.05	0.6ˆ2	0.075	0.96ˆ(1/12)	1.69	0.13	3.24%
δ	17	0.05	0.6ˆ2	0.1	0.96ˆ(1/12)	1.58	0.12	3.65%
δ	18	0.05	0.6ˆ2	0.15	0.96ˆ(1/12)	1.43	0.10	4.42%
δ	19	0.05	0.6ˆ2	0.25	0.96ˆ(1/12)	1.28	0.09	5.02%
δ, $f = 0$	20	0.05	0.6ˆ2	0.3	0.96ˆ(1/12)	1.24	0.09	5.07%
δ, $f = 0$	21	0	0.6ˆ2	0.01	0.96ˆ(1/12)	1.95	0.09	0.00%
δ, $f = 0$	22	0	0.6ˆ2	0.02	0.96ˆ(1/12)	1.78	0.09	0.00%
δ, $f = 0$	23	0	0.6ˆ2	0.03	0.96ˆ(1/12)	1.69	0.09	0.00%
δ, $f = 0$	24	0	0.6ˆ2	0.04	0.96ˆ(1/12)	1.63	0.09	0.00%
δ, $f = 0$	25	0	0.6ˆ2	0.05	0.96ˆ(1/12)	1.58	0.09	0.00%
δ, $f = 0$	26	0	0.6ˆ2	0.075	0.96ˆ(1/12)	1.5	0.09	0.00%
δ, $f = 0$	27	0	0.6ˆ2	0.1	0.96ˆ(1/12)	1.44	0.09	0.00%
δ, $f = 0$	28	0	0.6ˆ2	0.15	0.96ˆ(1/12)	1.35	0.09	0.00%
δ, $f = 0$	29	0	0.6ˆ2	0.25	0.96ˆ(1/12)	1.25	0.08	0.00%
δ, $f = 0$	30	0	0.6ˆ2	0.3	0.96ˆ(1/12)	1.19	0.08	0.00%
σ_ν	31	0.05	0.3ˆ2	0.025	0.96ˆ(1/12)	2.07	0.20	1.88%
σ_ν	32	0.05	0.4ˆ2	0.025	0.96ˆ(1/12)	2.06	0.19	2.03%
σ_ν	33	0.05	0.45ˆ2	0.025	0.96ˆ(1/12)	2.08	0.19	2.03%
σ_ν	34	0.05	0.5ˆ2	0.025	0.96ˆ(1/12)	2.11	0.19	2.01%
σ_ν	35	0.05	0.55ˆ2	0.025	0.96ˆ(1/12)	2.14	0.20	1.98%
σ_ν	36	0.05	0.65ˆ2	0.025	0.96ˆ(1/12)	2.22	0.20	1.88%
σ_ν	37	0.05	0.7ˆ2	0.025	0.96ˆ(1/12)	2.25	0.20	1.83%
σ_ν	38	0.05	0.75ˆ2	0.025	0.96ˆ(1/12)	2.28	0.20	1.82%
σ_ν	39	0.05	0.8ˆ2	0.025	0.96ˆ(1/12)	2.35	0.21	1.72%
σ_ν	40	0.05	0.9ˆ2	0.025	0.96ˆ(1/12)	2.45	0.21	1.65%
β	41	0.05	0.6ˆ2	0.025	0.9ˆ(1/12)	2.09	0.19	2.10%
β	42	0.05	0.6ˆ2	0.025	0.91ˆ(1/12)	2.1	0.19	2.08%
β	43	0.05	0.6ˆ2	0.025	0.92ˆ(1/12)	2.11	0.19	2.05%
β	44	0.05	0.6ˆ2	0.025	0.93ˆ(1/12)	2.13	0.19	2.02%
β	45	0.05	0.6ˆ2	0.025	0.94ˆ(1/12)	2.14	0.19	2.00%
β	46	0.05	0.6ˆ2	0.025	0.95ˆ(1/12)	2.15	0.19	1.96%
β	47	0.05	0.6ˆ2	0.025	0.97ˆ(1/12)	2.19	0.20	1.90%
β	48	0.05	0.6ˆ2	0.025	0.98ˆ(1/12)	2.2	0.20	1.87%
β	49	0.05	0.6ˆ2	0.025	0.99ˆ(1/12)	2.22	0.20	1.83%
β	50	0.05	0.6ˆ2	0.025	0.995ˆ(1/12)	2.23	0.20	1.82%

Table D.8: Simulation Results for Three Calibrations

Dep. Var.:	m_{jt}	m_{jt}	q_{jt}	q_{jt}	$\tilde{q}_{jt}$	$\tilde{q}_{jt}$
	Imports	Imports	Consumption	Consumption	Proxy	Proxy
Years:	1 & 4	2 & 3	1 & 4	2 & 3	1 & 4	2 & 3
1{Benchmark} × τ_t	-4.4	-9.2	-4.1	-4.3	-3.9	-4.5
	(0.71)	(0.73)	(0.69)	(0.68)	(0.62)	(0.58)
1{Low I/S} × τ_t	-4.0	-4.5	-4.0	-3.9	-4.0	-3.9
	(0.27)	(0.28)	(0.31)	(0.32)	(0.27)	(0.27)
1{Unanticipated} × τ_t	-4.3	-4.7	-4.1	-4.2	-3.9	-4.0
	(0.71)	(0.73)	(0.69)	(0.68)	(0.62)	(0.59)
N	12000	12000	12000	12000	12000	12000
Adjusted R^2	0.087	0.100	0.110	0.110	0.118	0.113

Note: Estimates are obtained from estimation equation (18) varying the dependent variable and the sample period included. Columns 1 and 2 use annual imports as the dependent variable; columns 3 and 4 use annual consumption of imports or sales; and columns 5 and 6 use the proxy measure of consumption of imports described in Section 3.1. Tariff changes take place in the first month of the third year in the simulations. Hence odd columns are less affected by the bias from anticipation. Standard errors, in parentheses, are clustered at firm level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.9: Anticipatory Effects in Mexican Exporter Prices

US Imports Mexico	Dep. Var.:	$\Delta_{\overline{n}:\underline{n}} UV^D_{z,t-1}$		
		Fall	Fall	Fall
	$\overline{n}$	11:12	11:12	10:12
	$\underline{n}$	4:8	4:10	4:9
Panel A: All Goods				
$\Delta\tau^{DD}_{zt}$		0.18	0.20	0.61
		(1.04)	(0.81)	(0.76)
Panel B: Phaseout Categories				
1 { *Phased* } × $\Delta\tau^{DD}_{zt}$		-0.02	-0.31	0.54
		(1.22)	(0.94)	(0.86)
1 { *Others* } × $\Delta\tau^{DD}_{zt}$		0.57	1.22	0.73
		(1.96)	(1.24)	(1.32)
HS6 FE		✓	✓	✓
Observations		4179	4457	4393
Adjusted R^2		0.07	0.07	0.04

Note: All estimates are obtained from estimating (21) for different time horizons of the within year growth rate $\Delta_{\overline{n}:\underline{n}}$. Unit values are calculated as the CIF value of exports over quantities. Standard errors, in parentheses, are clustered at HS-2 level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.10: Dynamic Elasticities - Unrestricted ECM

Dep. Var. :	m_{zt}^{DD}	$\tilde{q}_{zt}^{DD}$	Difference
Panel A: All Goods			
Short-run (σ^{SR})	-4.2***	-2.5***	68%
	(1.25)	(0.89)	
Long-run ($-\sigma^{LR}/\alpha$)	-9.7***	-9.2***	5%
	(1.52)	(1.62)	
Panel B: Phaseout Goods			
Short-run (σ^{SR})	-7.1***	-2.9**	145%
	(1.98)	(1.37)	
Long-run ($-\sigma^{LR}/\alpha$)	-14.0***	-12.0***	17%
	(2.18)	(2.28)	
Panel C: Non-Phaseout Goods			
Short-run (σ^{SR})	-2.7*	-2.2*	23%
	(1.98)	(1.37)	
Long-run ($-\sigma^{LR}/\alpha$)	-7.4***	-7.8***	-5%
	(1.83)	(2.00)	
Year FE	✓	✓	
HS6 FE	✓	✓	
N	11290	11290	
adj. R^2	0.345	0.314	

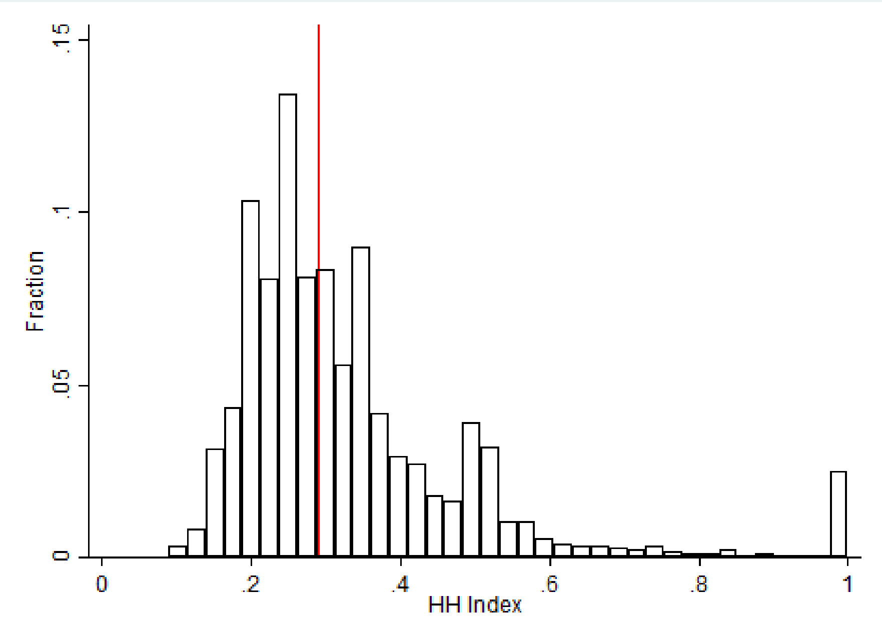
Note: All estimates are obtained form (20) and by varying the dependent variable. Columns one uses actual imports, while column two uses our baseline measure of consumption of imports, described in (9). Standard errors, in parentheses, are clustered at HS-6 level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.11: Dynamic Elasticities - Restricted ECM

Dep. Var. :	m_{zt}^{DD}	$\tilde{q}_{zt}^{DD}$	Difference
Panel A: All Goods			
Short-run (σ^{SR})	-6.2***	-3.9***	59%
	(1.25)	(0.78)	
Long-run ($-\sigma^{LR}/\alpha$)	-8.3***	-7.8***	6%
	(1.52)	(1.62)	
Panel B: Phaseout Goods			
Short-run (σ^{SR})	-9.6***	-5.00***	92%
	(1.98)	(1.37)	
Long-run ($-\sigma^{LR}/\alpha$)	-12.4***	-10.3***	20%
	(2.00)	(2.13)	
Panel C: Non-Phaseout Goods			
Short-run (σ^{SR})	-4.4***	-3.2***	37%
	(1.98)	(1.37)	
Long-run ($-\sigma^{LR}/\alpha$)	-6.0***	-6.5***	-8%
	(1.83)	(2.00)	
Year FE	✓	✓	
HS6 FE	✓	✓	
N	11290	11290	11290
11290			
Adjusted R^2	0.653	0.806	0.654
0.806			

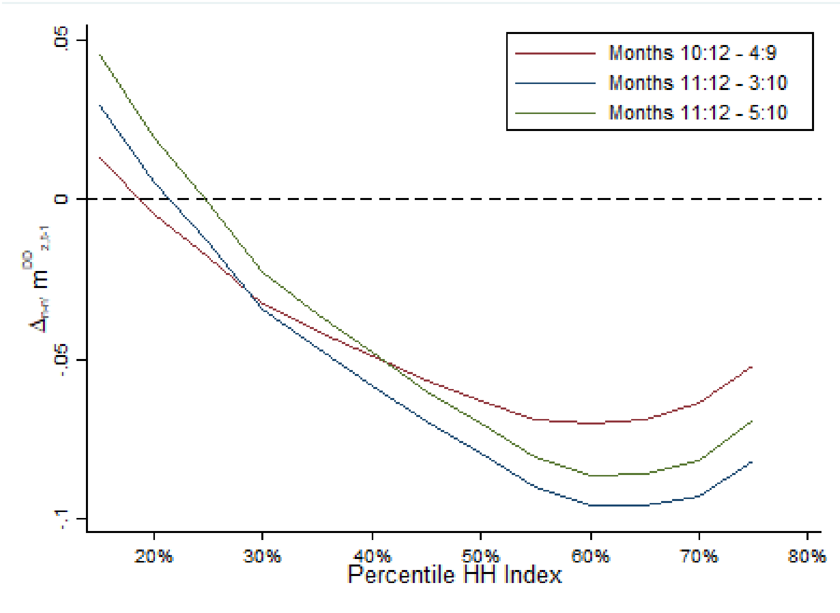
Note: All estimates are obtained form (20) and by varying the dependent variable. Columns one uses actual imports, while column two uses our baseline measure of consumption of imports, described in (9). Standard errors, in parentheses, are clustered at HS-6 level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure D.1: Distribution of the HH Index



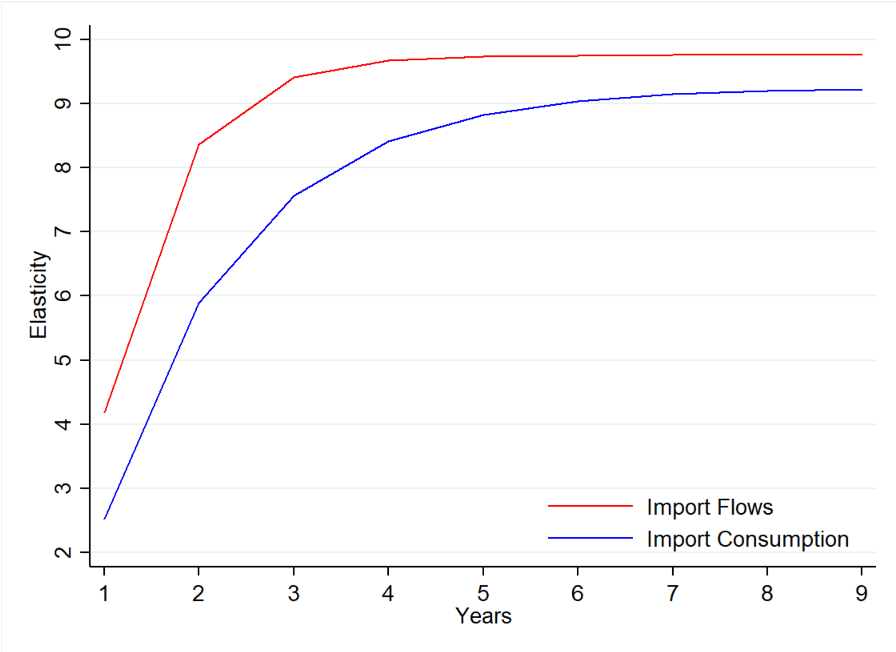
Note: This is the distribution over HH indexes calculated for each HS-6 good uses in Section 2.5. For each HS6 product the HH index is calculated taking the median HH index of annual imports of goods at HS-10, district of entry and source country level in the second year the good appears in the sample, excluding Canada and Mexico.

Figure D.2: Anticipation and Storability at different Sub-Periods



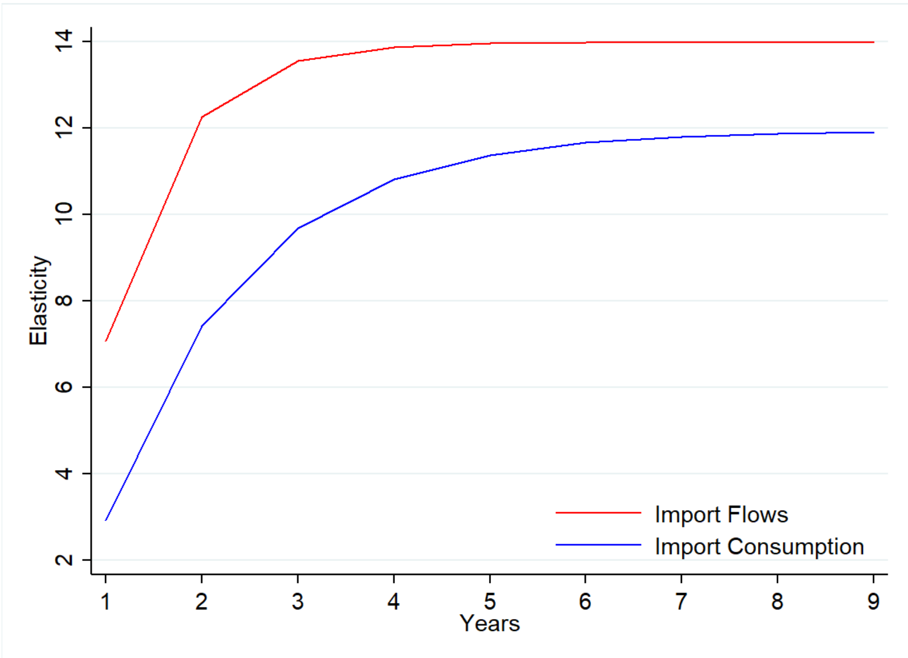
Note: The liness correspond to the predicted $\Delta_{n-n'} m^{DD}_{z,t-1}$ from estimating equation (5) for different values of $n = \underline{n}$ and $n' = \overline{n}$ given $\Delta\tau^{DD}_{zt} = -0.01$ at different percentiles of the HH Index. They capture how 2 varies under different within year horizons. It is calculated as $\hat{\sigma}^S = \hat{\sigma}^S_0 \times \Delta\tau^{DD}_{zt} + \hat{\sigma}^S_1 \times \Delta\tau^{DD}_{zt} \times HH_z + \hat{\sigma}^S_2 \times \Delta\tau^{DD}_{zt} \times HH^2_z$ at different percentiles of HH_z. The sample includes only HS-6 goods that were phased out. The estimation results with coefficients for $\sigma^S_{i=\{0,1,2\}}$, are reported in Table D.4 of the Appendix. The distribution of the HH index can be seen in Figure D.1. Its calculation is described in 2.5.

Figure D.3: Dynamic Elasticity - All HS6 Goods



Note: On the y-axis are the trade elasticity estimated obtained from (20). The sample includes all HS-6 goods. The red line uses actual imports as the dependent variable, while the blue line uses our baseline measure of consumption of imports, described in (9).

Figure D.4: Dynamic Elasticity - Phased-Out Goods



Note: On the y-axis are the trade elasticity estimated obtained from (20). The sample only includes HS-6 goods that were phased out. The red line uses actual imports as the dependent variable, while the blue line uses our baseline measure of consumption of imports, described in (9).