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

Shafaat Y. Khan† and Armen Khederlarian‡

First Draft: September, 2018

This Draft: February, 2020

Click here for the latest version

Abstract

The anticipation to policy changes overstates the estimated elasticity of substitution, the most important parameter in international trade. Standard identification of this parameter uses tariff variation from Free Trade Agreements (FTA) and assumes that trade flows equal their consumption. However, FTAs eliminate tariffs gradually through announced phaseouts. This allows firms to delay their purchases until tariff cuts are effective while consuming their inventories. Indeed, during NAFTA's staged tariff reductions, imports experienced sizable *anticipatory slumps* followed by *liberalization bumps*. A trade model with inventories replicates these dynamics and illustrates that consumed imports provide unbiased estimates of the elasticity of substitution. We propose an empirical measure of consumed imports validated through Monte Carlo simulations. Application to the data shows that using imports instead of consumed imports overestimates the annual elasticity by 68%, the average elasticity by 16%, and increases the ratio of the long- to short-run response from 2 to 3.5.

JEL Classifications: F12, F13, F14

Keywords: Anticipation, Elasticity of Substitution, Inventories, NAFTA, Phaseouts

*We are greatly indebted to our advisor George Alessandria for invaluable discussions, guidance, and support throughout this project. We also are extremely grateful to Mark Bils, Yan Bai and Dan Lu for numerous comments and suggestions. Moreover, we would like to thank Mario Crucini, Alexandre Skiba, B. Ravikumar, George Schaur, Mostafa Beshkar, Ahmad Lashkaripour, Russel Hilberry, Michael Waugh, John Romalis, Lorenzo Caliendo, Kei Mu Yi, Carter Mix, Oscar Avila and seminar participants at the University of Rochester and conference participants at the ETSG 2018 (Warsaw), the Spring 2019 Midwest Macroeconomics Meetings (UGA), the Spring 2019 Midwest International Trade Meetings (IUB), the 2019 Economics Graduate Student's Conference (WashU) and Lisbon Meetings in Game Theory & Applications (LSEM).

†Shafaat Yar Khan, skhan37@worldbank.org, The World Bank

‡Armen Khederlarian, armen.khederlarian@gmail.com, University of Rochester

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 1 year in advance. We build on the insight that knowing future tariffs provides firms with incentives to delay their purchases until the reduction is effective. In the meantime, firms satisfy their demand by running down their inventories. Once the tariff reduction sets in, firms replenish their inventories by importing a large amount. This creates a gap between the import flows and the consumption of imported goods. The elasticity that is critical for welfare and policy analyses is informed by the latter. Because standard estimation approaches use variation in import flows and tariffs from the FTAs, these anticipatory dynamics are a potential source of bias.

First, we document that in the early years of NAFTA, US imports from Mexico dropped strongly in anticipation and overshot sharply right after the tariff reduction. Second, we propose a measure for the consumption of imports that reveals the elasticities in the presence of these anticipatory dynamics. Third, we apply our measure to the data and find that the documented anticipation causes substantial upward biases in the estimates of the average and the short run (annual) elasticities of substitution.

Most approaches to estimating the elasticity of substitution from changes in tariffs build on static models of trade. In doing so, two key assumptions are made. First, the tariff changes from FTAs are not anticipated. In fact, tariff eliminations from FTAs take multiple years after the agreements come into force. This gives firms ample time to anticipate them. Secondly, the goods are not storable and hence they are consumed in the period in which they are imported. However, in response to aggregate shocks, models in which imports and their consumption diverge have been very successful in accounting for the observed trade dynamics.[2] In this paper, we relax these assumptions by using the

[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]See Alessandria et al. (2010a,b), Charnavoki (2017)

estimation approach from a model in which firms incorporate the knowledge of future tariff cuts and in which goods are stored as inventories. We find that relaxing these assumptions reveals sizeable biases in the elasticity of substitution estimated using the standard approach.

In a trade model with inventories, anticipated tariff reductions lead to import declines before their implementation — *anticipatory slumps* — and a subsequent import rebound — *liberalization bumps*. During this period imports diverge from their consumption as importers run down their inventories. The ability of firms to use the information of tariff reductions hinges on the degree to which the goods can be held in inventories. Only if firms hold inventories, are they able to gain from delaying input purchases without disrupting their operations. Our model simulations show that when this is the case, these anticipatory dynamics lead to biases in the elasticity of substitution if import flows are used instead of their consumption. While the import flows display *slumps* and *bumps* around the time of the reduction, consumed imports have a smoother path. The consumption of imports identifies the preference parameter of the elasticity of substitution regardless of the anticipated nature of shock and the storability of the good.

The implementation of NAFTA with 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.[3] While there was little time to anticipate the first round of tariff reductions,[4] in the following years, all the phaseout stages were scheduled to take place on January 1$^{\text{st}}$ every year, allowing importers to anticipate them. Because elasticities are generally estimated at the annual calendar frequency, the existence of anticipatory *slumps* and liberalization *bumps* around the beginning of the year would cause the trade elasticity (import flows) to exceed the elasticity of substitution (consumption of imports).

Indeed, we find that the data on US imports from Mexico contains strong evidence of anticipation to tariff cuts for the phased-out goods. We estimate anticipatory elasticities by considering within-year growth rates of import flows in response to upcoming tariff changes. We use a standard double-difference approach to construct trade flows free of exporter- and importer-specific factors (Romalis (2007), Head and Ries (2001), Caliendo

[3]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.

[4]NAFTA was ratified by the US Congress only 40 days before coming into force on Jan 1$^{\text{st}}$, 1994.

and Parro (2015)). We find that in anticipation of an upcoming tariff reduction of 1 percentage point (pp), imports experienced a sizeable 6% anticipatory trade *slump* in November and December relative to the middle of the year. In the first few months after the tariff reduction, imports experience a notable liberalization *bump* of 12% with respect to the end of the year. The size of these *slumps* and *bumps* are large even in comparison to previously documented short-run (annual) estimates of the trade elasticity. Our paper is the first to illustrate how (1) firms anticipate tariff reductions during gradual phaseouts and (2) that the trade elasticity can be large even in the short-run. We also find that the degree of anticipation is increasing in the storability of the good.

In contrast with the standard assumption on the elasticity identification, this trade pattern suggests that imports and their consumption diverge during these episodes. Unfortunately the consumption of imports is not observed, especially at the level of aggregation used in the estimation of the elasticity of substitution. To overcome this lack of data, we introduce a measure for the consumption of imports. The key ingredients of the consumption measure are high-frequency monthly trade data and inventory-sales ratios. In particular, we assume that a fraction of current inventory holdings is used for consumption. The inventory-sales ratio is obtained at the product, source and destination level by building on the relationship between the inventory-sales ratio and the lumpiness of imports. Hence the process for consumption of imports only requires monthly trade flows and can be implemented at the same aggregation level of the trade flows. We test the validity of the measure by demonstrating that (1) it is as effective as the consumption of imports in the model simulations, and (2) it eliminates the anticipation documented in the data for NAFTA's phased-out goods.

Next, we apply our measure of consumed imports to estimate the elasticity of substitution. We estimate the average (cross-sectional) elasticity as well as the dynamic short-run and long-run elasticities. Using our measure of consumption of imports instead of actual imports, we find a significantly lower average elasticity. The difference is driven by the phased-out goods, for which we documented significant anticipatory *slumps* and liberalization *bumps*. When we use consumption of imports instead of actual imports, the aggregate static elasticity of substitution across different country-varieties drops by 16% from 8.9 to 7.7. For the phased-out goods in particular, we find a bigger drop of 21%. Moreover, consistent with the inventory mechanism, the bias in the aggregate estimate is driven by the capital and the intermediate goods which are more storable.

To study the behavior of the bias in the short- and long-run we apply an Error-Correction Mechanism (ECM) model as in Gallaway et al. (2003). The short-run (annual) elasticity, based on the variation in import flows, is estimated to be 4.2. Whereas when we use the consumption of imports, the short-run elasticity falls to 2.5, eliminating a bias of 68%. This bias is again driven by the goods which experienced gradual phaseouts. As expected, the effects of the documented anticipatory dynamics become negligible in the long-run. Using the consumption of imports instead of the import flows, we find that the ratio of long- to short-run elasticity rises from 2 to 3.5. Moreover, after removing the bias in the annual response, the long- and short-run elasticities becomes statistically different from one another. We also find that the long-run adjustment horizon increases from 4 to 7 years. This suggests that using raw import flows causes an understatement of the dynamic adjustment of consumed imports. While the anticipatory *slump* is always present, the liberalization *bump* after the tariff reduction loses its importance in the long-run. In essence, using raw import flows as a proxy for consumed imports causes an overestimation of the annual response and an underestimation of the gradualness and duration of the response.

The paper is organized as follows. Section 2 illustrates in which cases the standard estimation approaches may fail to identify the elasticity of substitution when using imports instead of their consumption. Section 3 briefly describes why NAFTA represents an ideal setting for this study and documents that for the goods that provide most variation in tariffs — phased-out goods — anticipation was strong. Section 4 describes our measure of consumed imports and shows that using actual imports instead of their consumption produces substantial upward biases in estimates of the elasticity of substitution. Section 5 concludes.

Related Literature

This paper mainly contributes to three strands of literature. In the first place, it contributes to the literature on the estimation of the elasticity of substitution which is the single most important parameter for the welfare and policy implications of 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 (Hillbery and Hummels (2012), Anderson and van Wincoop (2004)). Estimates based on cross-sectional variation tend to 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), Baier and Bergstrand (2007)). Our paper documents that during the implementation of FTAs, the existence of anticipatory slumps and bumps lead to upward biases in the estimated elasticity of substitution. These biases are especially relevant for estimates in the upper bound of the literature.

The difference in estimates using cross-sectional and panel data can not solely be explained by the existence of anticipatory effects. In effect, estimates based on annual cross-sectional variation in trade flows mute the gradualness in the response to trade liberalizations that has been shown to be consequential for the evaluation of welfare and policy (Alessandria et al. (2018)). Consistent with larger estimates from panel data, estimation strategies that distinguish between the short-run and the long-run elasticity yield long-run responses that are twice as large as the short-run response (Staiger (1995), Gallaway et al. (2003), Jung (2012), Yilmazkuday (2019)). Our paper illustrates that when accounting for the deviations between imports and its consumption especially in the short-run, the ratio of long- and short-run consumption response increases by 75% to 3.5.

Second, the paper contributes to the literature that highlights the role of inventories in accounting for observed short-run macroeconomic and trade dynamics. Alessandria et al. (2010a) explain how inventory adjustment largely accounts for the great trade collapse of 2008-2009. The inventory mechanism has also been applied to explain the response of trade to episodes of large devaluations (Alessandria et al. (2010b), Charnavoki (2017)) or the pricing dynamics following a credit crunch (Kim (2018)). We show that a model with inventories in which goods are ordered in infrequent large shipments, reproduces the anticipatory slumps and bumps in advance of tariff reductions observed during NAFTA's staged tariff phaseouts. In that sense, the paper provides further evidence of the importance of frictions in trade that lead to the presence of inventories, such as ordering costs (Kropf and Saure (2014)), delivery lags (Hummels and Schaur (2013)) and/or demand uncertainty (Bekes et al. (2017)).

Third, our paper illustrates that when policy changes are known in advance, anticipation can be strong. Most of the empirical literature of anticipation has studied the effect of announced consumption tax changes. Similar to the anticipatory effects documented here, purchases of goods that are storable rise in advance of sales tax hikes (Baker et al. (2018)) and during temporary exemptions (Agarwal et al. (2017)). As in our paper, Coglianese et al. (2017) show that in anticipation of increases in gasoline taxes, purchases spike, leading to an overestimated short-run demand elasticity. In the context of trade policy, the recent US trade policy changes have led importers to anticipate and stockpile goods which were affected by the different waves of tariff hikes (Cavallo et al. (2019), Fajgelbaum et al. (2019)). In contrast with the recent rise of protectionism, during NAFTA's gradual tariff phaseouts, there was ample time and certainty to anticipate the changes in tariffs. Nonetheless, anticipation might be relevant even when tariff changes are uncertain (Alessandria et al. (2019)).

2 Mechanism

In static models of trade, imports and their consumption are identical. Because goods are assumed to be non-storable, imports only respond to changes in tariffs once they are effective. However, in response to aggregate shocks, models in which imports crossing the border and their consumption diverge have been very successful in accounting for the observed trade dynamics. (Alessandria et al. (2010a), Alessandria et al. (2011a), Charnavoki (2017), etc.) In this section, simulations of a trade model with ($\underline{s}$,$\overline{s}$) inventory management model illustrate that, when tariff changes are anticipated, imports experience sizeable *anticipatory slumps* before and *liberalization bumps* after a tariff reduction. In the meantime imports and their consumption deviate, leading to an overestimated elasticity of substitution. We first describe how in static models of trade, difference-in-difference approaches identify the elasticity of substitution using imports. Secondly, we lay out a trade model with ($\underline{s}$,$\overline{s}$) inventory management in which forward looking firms decide the timing of their imports. We then use simulations of the model to show when the standard estimation approaches of the elasticity of substitution yield biases.

2.1 Static Models of Trade

Most approaches to the identification of the elasticity of substitution are founded on an import demand equation that can be expressed as a gravity equation, where trade is a function of bilateral trade costs and destination specific aggregate variables.[5] Under this structure and some assumptions, taking a difference-in-difference approach identifies the elasticity of substitution. One assumption that has been widely overlooked in the literature is that identification requires imports to be immediately consumed. However, this assumption is likely to fail if importers (1) anticipate upcoming tariff reductions and (2) goods are storable so that firms can adjust the timing of their orders.

To illustrate how static models of trade identify the elasticity of substitution, without loss of generality we focus on an import demand from the Dixit-Stiglitz structure of CES preferences. According to this formulation, country i's consumption, q, of good z from country c is expressed as:

$$q_{iczt} = \left(\frac{(1+\tau_{iczt})p_{czt}}{P_{izt}}\right)^{-\sigma} Q_{izt} \tag{1}$$

where τ_{iczt} is the applied tariff levied on the imports of good z sourced from country c by country i. The exporter-specific price of the good is denoted by p_{czt}. P_{izt} and Q_{izt} are country i's price index and total consumption of good z. The elasticity of substitution across different varieties, σ, is the preference parameter of interest. In appendix A, we discuss the underlying preference structure behind this formulation. Importantly, the left hand side of (1) refers to consumption and not purchases of good z.

This demand equation contains exporter-specific (unit-price) term and a few importer-specific (aggregate demand) terms. To control for these terms, it is standard to take differences of (1) with respect to control country groups. Moreover, to overcome issues related to the measurement of quantities, (1) is expressed in values by multiplying both sides by p_{czt}, i.e. $v^q_{iczt} \equiv q_{iczt}p_{czt}$. [6] The following expression of consumption of imports, denoted by q^{DD}_{zt}, is obtained by taking a double-difference of (1) in terms of value with

[5] See for example Head and Ries (2001), Gallaway et al. (2003), Romalis (2007), Caliendo and Parro (2015), Feenstra et al. (2018), etc.

[6] See Hillbery and Hummels (2012)

respect to reference importer (i') and exporter (c'):[7]

$$\underbrace{\ln\left(\frac{v^q_{iczt}}{v^q_{ic'zt}}\Big/\frac{v^q_{i'czt}}{v^q_{i'c'zt}}\right)}_{q^{DD}_{zt}} = -\,\sigma \ln\left(\frac{1+\tau_{iczt}}{1+\tau_{ic'zt}}\Big/\frac{1+\tau_{i'czt}}{1+\tau_{i'c'zt}}\right) \tag{2}$$

To estimate σ from (2) the standard approach is to use trade flows, m, on the left hand side and cross-country variation in tariff levels from FTAs on the right hand side. On the one hand, data on the consumption of imports is generally not available at the same aggregation level at which tariffs are applied. On the other hand, FTAs are the natural workaround to the Most-Favored-Nation (MFN) clause that eliminates any cross-country variation in applied tariffs. Hence, the standard estimation equation of (1) is: [8]

$$\underbrace{\ln\left(\frac{v^m_{iczt}}{v^m_{ic'zt}}\Big/\frac{v^m_{i'czt}}{v^m_{i'c'zt}}\right)}_{m^{DD}_{zt}} = -\,\sigma \ln\left(\frac{1+\tau_{iczt}}{1+\tau_{ic'zt}}\Big/\frac{1+\tau_{i'czt}}{1+\tau_{i'c'zt}}\right) + u_{iczt} \tag{3}$$

In the context of FTAs assuming that $q^{DD}_{zt} = m^{DD}_{zt}$ might bias the estimate of the elasticity of substitution. This because the static structure of (1) precludes two empirically relevant facts. First, when tariffs are scheduled to be reduced long in advance, importers act on this knowledge by anticipating upcoming tariff reductions. Secondly, all traded goods are storable to some degree, allowing firms to use inventories without placing new orders until they stock out. In fact, if importers delay their purchases until the tariff reductions are effective, then imports might deviate from their consumption precisely at the time of the tariff reduction. In other words, the response of trade or trade elasticity overstates the response of consumption or elasticity of substitution. We argue that this divergence is especially relevant in the context of FTAs because FTAs are implemented through gradual tariff phaseouts, providing importers with ample time to anticipate the scheduled tariff reductions and adapt the timing of their orderings. In the model formulated below, the import demand equation is generalized to allow for these potential anticipatory dynamics.

[7] See appendix A in the Appendix for the derivation.

[8] This is the dependent variable in Romalis (2007).

2.2 Inventory Trade Model with ($\underline{s}$,$\overline{s}$) Ordering

To illustrate how anticipated tariff reductions might bias estimates of the elasticity of substitution we generalize the model described above, allowing firms to decide the timing of their purchases by including a ($\underline{s}$,$\overline{s}$) ordering policy. In particular we adopt AKM's partial-equilibrium model in which a homogeneous storable good is imported by a continuum of monopolistically competitive retailers that face a CES demand and decide whether to import or not every period. In advance of an upcoming tariff reduction, importers delay their orders, but continue to satisfy their demand by running down their inventories.

Ordering implies a fixed shipment cost, causing firms to order infrequent but large shipments. On top of the fixed cost, retailers face demand uncertainty and a one period delivery lag, leading to precautionary inventory holdings. Under this setup, retailers run down their stocks to $\underline{s}$ and then replenish it up to $\overline{s}$. Retailers are identical except for their history of demand shocks, that determines their current inventory holdings. Let $p_{j,t}$ denote the importer j specific retail prices and $\nu_{j,t}$ the demand shock in period t. Importer j faces the following demand for its variety:

$$c_{j,t} = e^{\nu_{j,t}} p_{j,t}^{-\sigma} \tag{4}$$

The variable cost of importing is $\omega_t = \omega(1 + \tau_t)$, common across all importers. We assume that exporters are perfectly competitive, so that the pass-through (to retailers) of the tariff reduction is complete. At the beginning of each period retailers observe their inventory holdings, $s_{j,t}$ and their demand shock, $\nu_{j,t} \sim^{iid} N(0, \sigma_\nu^2)$, assumed to be i.i.d. across firms and time[9], and then price their good and decide to import or not. To import, retailers need to pay a fixed cost f. We assume that importing is irreversible, $m_{j,t} \geq 0$. Because of demand uncertainty, importers will never run down their inventories to zero, $\underline{s} > 0$, and because of a one period delivery lag, sales can never exceed current inventory holdings:

$$q_{j,t} = \min[e^{\nu_{j,t}} p_{j,t}^{-\sigma}, s_{j,t}] \tag{5}$$

Assuming the goods only depreciate in the warehouse at the rate δ, the law of motion

[9] The iid demand shock is necessary to obtain 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.

for the inventories is:

$$s_{j,t+1} = (1-\delta)[s_{j,t} - q_{j,t}] + m_{j,t} \tag{6}$$

We drop the firm subscript j for simplicity and denote the firm's value of adjusting inventories by $V^a(s,\nu)$ and of not adjusting by $V^n(s,\nu)$. Every period retailers optimize by choosing $V(s,\nu) = \max\{V^a(s,\nu), V^n(s,\nu)\}$, where

$$V^a(s,\nu) = \max_{p,m>0} q(p,s,\nu)p - \omega m - f + \beta EV[s',\nu'] \tag{7}$$
$$V^n(s,\nu) = \max_{p} q(p,s,\nu)p + \beta EV[s',\nu']$$

are subject to (6) and (5). 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 static models, demand for the good, $q_{j,t}$, can be satisfied using inventories. Moreover, because firms optimize the timing of their purchases, $m_{j,t}$, responds to the incentives of future price declines.

When facing an upcoming decline of the variable cost of importing, retailers face the following trade-offs. On the one hand, goods are cheaper in the future and the ordering cost is delayed. On the other hand, because inventories are declining as demand continues to be satisfied, the marginal value of inventories increases. Hence, the price increases and some sales are lost. Additionally, because inventories move away from their stationary level, higher inventory holding costs are incurred over a brief period. In the simulations below we show that the benefits of delaying orders outweigh the costs and that for reasonable inventory holding intensities, anticipated tariff reductions lead to *anticipatory bumps* and *liberalization bumps*.[10]

2.3 Simulations

We simulate the model described above to illustrate that when firms anticipate upcoming tariff reductions by delaying their orders the trade elasticity can deviate significantly

[10]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.

from the elasticity of substitution. When imports are held as inventories, and tariff changes are anticipated, trade flows *slump* before and *bump* after the time of the tariff change. In the meantime the consumption of imports remains relatively constant. Hence, the response of imports crossing the border exceeds the response of their consumption.

2.3.1 Calibration

We perform 53 simulations of the model generating a dataset for each one them. Each simulated dataset consists of monthly imports and their sales (consumption) of 2,000 firms over 48 periods. Every period firms receive an idiosyncratic demand shock. In period 25 the aggregate tariff shock takes place. We model it to be a permanent anticipated decrease in the tariff rate τ of 1 pp.[11] As mentioned before, firms are homogeneous except for their history of idiosyncratic demand shock. Hence, and given the partial equilibrium setting, the simulations shall be viewed as corresponding to the imports of a certain good.

The parameters used in our benchmark calibration are shown in Table 1. The degree of anticipation to the tariff reduction will be determined by the degree to which goods are held as inventories, that is the incentives importers have to order infrequently and use inventories to satisfy their demand. This is summarized by the inventory-sales ratio (I/S), or the amount of average monthly sales held as inventories. The I/S ratio is jointly determined by the fixed cost of ordering, the depreciation rate of the good, the variance of the demand shock and the interest rate. In our benchmark calibration we assign the annual interest rate to be around 4% by setting $\beta = 0.96^{1/12}$. We set $f = 0.05$ so that the annual amount of resources put into paying the fixed costs of orders to be around 2% worth of annual revenues. We set the depreciation rate to be 2.5% per month or around 30% per year. Finally, we set $\sigma_\nu = 0.6^2$, so that the standard deviation of sales is around 36% of the average. This yields an inventory sales ratio of 2.17. This value is within the range targeted by similar quantitative exercises of previous literature and in the lower bound of values reported for inventories of imported goods. Finally, the elasticity of substitution, our object of interest, is set to 4.

Second, we consider a simulation under the benchmark calibration when the tar-

[11] 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.

iff reduction is unanticipated. Third, we simulate the model calibrated to yield a low inventory-sales good by setting $f = 0.001$ and $\delta = 0.1$, so that the average inventory-sales ratio is 1.44 and retailers import in every period. In addition, we perform 50 simulations to assess the sensitivity to each of the parameter values that determine the inventory-sales ratio $(f, \delta, \beta, \sigma_n u)$. In particular, we vary each of the four parameters while holding constant at their benchmark value the other three parameter.[12] Moreover, we assess the sensitivity to the depreciation rate when there is no fixed cost of ordering and inventory holdings are solely due to precautionary motives.

Before reporting the results of estimating the elasticity of substitution with the simulated datasets, we discuss the dynamics around a tariff reduction. Figure 1 shows the aggregate consumption and import response to a 1pp decrease in tariffs. The top left panel shows the benchmark case. Imports (red line) strongly anticipate the upcoming tariff cut, dropping by more than 20% in the month before the tariff reduction.[13] After the change has materialized, imports spike. This is the *bump* and *slump* of trade around the tariff reduction. In contrast, the consumption of imports (blue line) is much smoother, in line with the response of imports under a static import demand equation such as (1). The top right panel shows the response under the low I/S ratio calibration. In this case, the response of imports and consumption of imports is almost identical. The bottom left panel shows the response under the benchmark calibration when the tariff reduction is unanticipated. In this case there is no anticipation, however there is a non negligible spike just after the shock realization due to the magnification of inventories. Panels B and C highlight that for consumption to deviate from imports, both, the good has to be held in inventories and the tariff shock has to be anticipated. Panel D reports the behavior of inventory holdings for the three simulations. The red line indicates that the tamed response of consumption of imports in the benchmark case is possible because importers satisfy their input demand by running down their inventory holdings.

[12] The parameter values and inventory-related moments of all 52 alternative calibrations are reported in Table D.3.

[13] With 5 months until the tariff change, firms start synchronizing their orders with the goal of minimizing per-order fixed cost in the months before the change. These echo effects generate a short-lived spike in imports in months 7 and 8.

2.3.2 Bias in the Elasticity of Substitution

We now estimate the elasticity of substitution for each one of the 53 simulated datasets. In the context of FTAs, tariffs generally change at annual frequency hence standard estimation methods use annual trade flows. We aggregate firm-level monthly flows of imports, m_{jt}, and their consumption, q_{jt}, to the annual frequency and estimate average elasticities from the following equation:

$$\ln(y_{jt}) = \sigma \ln(1 + \tau_t) + u_{jt} \tag{8}$$

where the trade elasticity is estimated when $y_{jt} = m_{jt}$ and the elasticity of substitution is estimated from $y_{jt} = q_{jt}$. Because the anticipatory dynamics induced by the tariff change are relatively short lived, the relative change in consumption (import) flows in year one and four yield elasticity estimates that are unaffected by those. Hence, we set the true elasticity to be the estimate resulting from the consumption flows in year one and four.[14] We then compare the true elasticity with the estimate resulting from import and consumption flows in the two years around the tariff change. This is the empirically relevant comparison since during FTAs tariffs change annually.

We also estimate an anticipatory elasticity by considering the within year growth rate of imports in response to the upcoming tariff reduction. In particular, we compare average monthly imports in the two months before the tariff reduction with the average during five months of the middle of the year, i.e. $\ln(m_{jt,11:12}/m_{jt,4:8})$, and estimate the following equation:.

$$\ln(m_{jt,11:12}/m_{jt,4:8}) = \sigma^S \ln(1 + \tau_{t+1}) + u_{jt} \tag{9}$$

where σ^S is the elasticity to the upcoming tariff reduction that informs of the magnitude of the *anticipatory slump*.

In Table 2 we report the estimates of (8) for the benchmark calibration under an anticipated and unanticipated 1pp tariff reduction and for the low I/S calibration. Columns

[14]Notice that in this model the estimated elasticity of substitution is not necessarily equal to σ. This is because the model includes non unitary pass-through of tariffs to consumption prices or variable mark ups. Under the pricing policy described in section 2, as the variable cost declines mean revenues increase and importers economize more efficiently on the fixed cost of ordering. Therefore, the pass-through of tariff on consumer prices is more than one. We abstract from this and focus on the bias that stems from the anticipatory dynamics.

1 and 3 provide the estimate using $y_{jt} = \{m_{jt}, q_{jt}\}$ in years one and four as dependent variables, respectively. For the three cases, the trade elasticity and the elasticity of substitution are almost identical and the identification of the standard static approach holds.[15] However, when considering the two years around the tariff change, the trade elasticity (column 2) overestimates the true elasticity (column 3) when the tariff reduction is anticipated in the benchmark calibration. The bias is sizeable. If instead consumption of imports are used (column 4), the bias becomes negligible. This is because even though purchases become erratic around the time of the tariff reduction, their consumption remains relatively smooth.

The relationship between the bias in the elasticity of substitution and the anticipatory slump that emerges when considering all 52 calibrations further support the previous results. Figure 2 plots the biases of all 52 simulations against their corresponding anticipatory slump. There are the two main findings. In first place, the bias from using imports in the estimation of the elasticity of substitution (red line) increases in the magnitude of the *anticipatory slump*, measured by the estimate of σ^S from (9).[16] Secondly, using consumption of imports (blue line) almost entirely corrects for the bias unconditionally of the magnitude of the anticipatory slump. These findings indicate that if firms anticipate upcoming tariff reductions then using imports instead of consumption as the dependent variable might lead to an overestimated elasticity of substitution, even when using annual flows. In the next section we study the empirical relevance of this potential bias by considering how US imports from Mexico anticipated NAFTA's scheduled tariff phaseouts.

3 Evidence of Anticipation during NAFTA

In the previous section we illustrated that when tariff reductions are anticipated, standard methods of estimating the elasticity of substitution may be biased because imports and their consumption diverge at the time of the tariff reduction. During the NAFTA the entire path of tariff phaseouts was public knowledge, providing importers with strong incentives to delay their purchases in advance of staged phaseouts. This section provides

[15]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.

[16]Similarly, the bias is increasing in the inventory-sales ratio as can be seen in Figure D.5, indicating that anticipation is closely related to the amount of equilibrium inventory holdings of a good.

evidence that importers indeed responded to these incentives and that at product level anticipation was increasing in the degree of inventory holdings. We first establish that during the NAFTA, phased-out tariffs were the main source of variation in tariff levels. Next, we lay out and implement our empirical approach to estimating anticipation. Finally, we show that anticipation was strongest for goods that are characterized by higher a inventory-sales ratio.

3.1 Background

The NAFTA was signed by the three presidents of the US, Canada and Mexico in December 1992 after a lengthy negotiation. It took another year to be approved by legislators in the three countries. US Congress ratified it on November 20, 1993, and the 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 US 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 the NAFTA was one of the first major preferential FTA and its tariffs reductions undercut the Most-Favored-Nation (MFN) rates, the NAFTA has been widely studied to evaluate the gains from trade and, hence, to estimate the elasticity of substitution[17]. We argue that neglecting the anticipated nature of NAFTA's tariff reductions biases these elasticity estimates upwards.

Some of the tariff cuts took place immediately on January 1st of 1994 and the rest were scheduled to be phased out gradually over various stages of tariff reductions. Step reductions took place on January 1st for up to 15 years. In fact, 96% of NAFTA's tariff reductions were known at least one year in advance since NAFTA's original text specified the phaseout schedules of all goods at HS-8 level. 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[18]. As you can see in Table 3, most of the HS-8 goods were already zeroed by 1993,

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

[18] 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

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 about if NAFTA would become effective[19] it is unclear that the latter reductions could have been anticipated. But once signed, scheduled reductions of class B, C and C+ goods were certainly anticipated to become effective.[20] 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.

3.2 Data

Our estimation of anticipation to tariff reductions focuses on US imports from Mexico between 1990 and 1999. To study the response of trade flows to scheduled tariff phaseouts we use trade flows at the monthly frequency and expand the estimation strategy described in the section 2.1. In particular, we take changes over the sub-periods in a year of the (double-differenced) trade flows. If upcoming tariff reductions were anticipated as predicted by the import demand of the subsection 2.2, then imports in the months before the reduction should drop in comparison to the earlier months of the same year. We would also expect to see a sharp increase in the imports subsequent to the tariff reduction, in line with the stocking-up effect.

After taking the double-difference of the standard import demand equation in section 2.1, we were left with the following expression:

$$\underbrace{\ln\left(\frac{v_{iczt}}{v_{ic'zt}}\Big/\frac{v_{i'czt}}{v_{i'c'zt}}\right)}_{m_{zt}^{DD}} = -\,\sigma\underbrace{\ln\left(\frac{1+\tau_{iczt}}{1+\tau_{ic'zt}}\Big/\frac{1+\tau_{i'czt}}{1+\tau_{i'c'zt}}\right)}_{\tau_{z,t}^{DD}} \tag{2}$$

In the implementation of the double-difference approach we follow Romalis (2007). This allows us to map the anticipation demonstrated later in this section to the biased elasticity of substitution that we document in the next section. The reference importer

as you can see in Figure D.1 of the Appendix.

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

[20]We cannot ascertain at which degree agents internalized these scheduled reduction. 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.

i' is chosen such that exporters c and c' face the same tariffs in destination i' at any period t, i.e. $\tau_{i'czt} = \tau_{i'c'zt}\ \forall z, t$. Given the four directions of trade flows and the choice of reference importers, the only relevant tariff changes are the ones pertaining to importer i. In line with this, the reference importer is an aggregate of 12 countries of the European Union (EU12).[21] These countries did not have a FTA with Mexico, nor with any of the reference exporters during our sample period. The choice of EU12 restricts our sample period up until 1999, since in 2000 the European Union and Mexico signed a FTA.

In addition to this, the choice of reference groups is also dictated by the need of large country groups. This helps in countering the issue of trade lumpiness that becomes pervasive at high frequency and disaggregate HS-6 product categories.[22] For this reason, the reference exporter is an aggregate of 137 countries - rest of the world (RoW) - with which neither the US nor the EU12 established a preferential FTA during 1990-1999.[23]

We obtain imports at HS-6 level and monthly frequency. We consider CIF (Customs, Insurance and Freight) imports for consumption which disregards imports for re-export purpose and includes insurance and freight charges that controls for the changes in shipping costs. The tariff considered are the applied rates, that is, the ratio of duties over Freight-On-Board (FOB) value of imports.[24] US import data and applied tariffs are obtained from the USITC's database. European trade flows are obtained from Eurostat. Finally, because the phaseout classification is at HS-8 level and there is variation within HS-6 levels, we trade-weight each HS-8 good classification using average trade flows over our full sample period. The characteristics of the resulting sample by phaseout classification are very similar to the original at HS-8 level.[25]

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

[22] Because our identification of the anticipatory effects rely on the variation in monthly trade flows, the relevant observations are those HS-6 with non-zero consecutive trade flows between monthly 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 3.5 we dig deeper into this sample selection. We find that anticipatory effects are even stronger for less frequently traded goods.

[23] See the list of 137 countries in the Table D.2.

[24] 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.

[25] We report Table 3 at HS-6 level in Table D.1 of the Appendix

3.3 Methodology

We estimate the anticipatory effects by taking sub-period differences of (2). In what follows, $\overline{n}$ and $\underline{n}$ will denote sub-periods of the year t.

$$\underbrace{m^{DD}_{z,t,\overline{n}} - m^{DD}_{z,t,\underline{n}}}_{\Delta_{\overline{n}-\underline{n}} m^{DD}_{z,t}} = -\sigma \left[\Delta_{\overline{n}-\underline{n}} \ln\left(\frac{1+\tau_{iczt}}{1+\tau_{ic'zt}}\right)\right] + \Delta_{\overline{n}-\underline{n}} u_{z,t} \tag{10}$$

The right hand side of (10), under the standard assumption of no anticipation, is null. This is due to the fact that scheduled tariffs only change on an annual basis, i.e. $\Delta_{\overline{n}-\underline{n}}\tau_{iczt} = 0 \; \forall c, z$. This illustrates that according to static models of trade, $\Delta_{\overline{n}-\underline{n}} m^{DD}_{z,t}$ does not respond to upcoming tariff changes. To study the relevance of potential anticipatory behavior, we estimate (1) the within year response of trade to the upcoming tariff change; and (2) the response of trade immediately after the bygone tariff reduction. Precisely, our baseline anticipatory effects are estimated using the following specifications:

$$\Delta_{\overline{n}:\underline{n}} m^{DD}_{z,t-1} = \sigma^S \left[\ln\left(\frac{1+\tau_{i,c,z,t}}{1+\tau_{i,c',z,t}}\right) - \ln\left(\frac{1+\tau_{i,c,z,t-1}}{1+\tau_{i,c',z,t-1}}\right)\right] + \delta_z + u_{z,t} \tag{11}$$

$$\Delta_{\overline{n}:\underline{n}} m^{DD}_{z,t} = \sigma^B \underbrace{\left[\ln\left(\frac{1+\tau_{i,c,z,t}}{1+\tau_{i,c',z,t}}\right) - \ln\left(\frac{1+\tau_{i,c,z,t-1}}{1+\tau_{i,c',z,t-1}}\right)\right]}_{\equiv \Delta\tau^{DD}_{z,t}} + \delta_z + \delta_t + u_{z,t} \tag{12}$$

The estimation equation (11) quantifies the within-year anticipatory decline i.e. $\overline{n}, \underline{n} \in t$. The estimate of σ^S is the anticipatory elasticity and is identified through the time variation in tariff reductions over the years. A positive value of σ^S would imply that the imports fall in the months before the tariff reduction.

On the other hand, the estimation equation (12) captures the rebound in imports in the period immediately after the tariff reduction. In this equation, we compare the import flows in the first few months relative to the sub-period in the previous year (before the tariff fall) i.e. $\overline{n} \in t$ and $\underline{n} \in t-1$.[26] Since we are taking changes over the year, year fixed effects are included. The estimate of σ^B signifies the post anticipation spike in imports as firms replenish their stocks.

[26] Only for this specification we have used $\ln(1+v_{icz\overline{n}})$, so that we do not lose observations that appear before the tariff change but not right afterwards. This mutes the estimated trade bump since we are assigning a very low growth in products which would not be considered in the regression otherwise.

In the equations above, δ_z and δ_t are the product and year fixed effects that account for seasonal or growth trend effects of z between period $\overline{n}$ and $\underline{n}$ and that are not eliminated by the double-differences.[27] Monthly averages over periods $\overline{n}$ and $\underline{n}$ are taken to construct the growth rate $\Delta_{\overline{n}-\underline{n}} m^{DD}_{z,t}$. For example $\Delta_{10:12-4:9}\, m^{DD}_{zt}$ takes the log difference between the monthly average of m^{DD}_{zt} from October to December ($\overline{n}$) and the monthly average of m^{DD}_{zt} from April to September ($\underline{n}$). In years in which exporters from c to i were facing expected tariff reductions on January 1st of the next year, we expect trade to plunge before the reduction ($\sigma^S > 0$) and rise sharply after it ($\sigma^B < 0$), while in years without any significant tariff reduction we expect no movements in trade flows around the same period.

3.4 Baseline Results

In this section we show that imports responded strongly to the incentives of de-stocking and stocking-up around the tariff reductions as predicted by the dynamic trade model of section 2.2. For goods that were phased out, trade flows a few months before the tariff reduction plunged with respect to a reference period of the same year at rates that are comparable to the trade elasticity estimates in the literature. In the aftermath of the tariff changes, imports rebound.

Results are presented in Table 4. Panel A reports the elasticity estimates by phaseout categories. To obtain this, we interact the tariff variable with an indicator variable that is one if the initial tariff on the HS-6 good was phased out (that is if it belongs to class B, C or C+). The first three columns report the estimates of σ^S from (11) with different base periods ($\underline{n}$). 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 σ^B from (12) with different rebound periods ($\overline{n}$). In the period right after the tariff reduction, 1 percentage tariff reduction is associated with a 12% increase in imports in the months right after the reduction relative to the months right before it. Importantly, we find no significant effect on the goods which were not scheduled to be phased-out as suggested by the second row of panel A.

[27] In the baseline estimation equation z will be a HS-6 good. Results are robust to using fixed effects at HS-4, HS-2 or HS-section level.

Table 4 also shows that the estimated anticipatory effects are robust to considering different time windows. As it was the case in the model of section 2.2, the response increases as we consider the sub-period closer to the tariff reduction (from column 3 to 1 and columns 6 to 4). In Table 5 we report that these results are unchanged when we consider different choices of product/industry fixed effects that control for seasonality.

These results indicate that during 1990 and 1999 US imports from Mexico plunged and then rebounded in the around the tariff reductions. To put the magnitude of the anticipatory effects in perspective, column 1 of Table 10 reports the estimate of the annual trade elasticity. For phased-out goods, the immediate rebound effect from the anticipated tariff changes ($\hat{\sigma}^B = 12$) is double as large as the annual trade elasticity (7) and almost as large as the long run elasticity (14). This illustrates that even though trade responds gradually to tariff changes[28], around the time of the tariff reductions, when reductions are anticipated trade responds strongly. Next we show that these effects are more important for goods that are presumably more storable.

3.5 Anticipation and Storability

In this subsection we investigate how the anticipatory effects vary with the degree of product storability. In the model of section 2, the degree of anticipation strongly relies on firms' ability to delay their shipments without disrupting demand for their goods. Hence we expect to find a positive relationship between anticipatory effects and storability.

Measuring storability has proven to be difficult.[29] We proxy it by considering the lumpiness of its imports. In the model of section 2.2, more storable goods (lower depreciation rates) are characterized higher inventory-sales ratios and more infrequent orders. We build on this insight and relate lumpier trade with the good being held more intensively as inventories.[30] We measure trade lumpiness using the Herfindahl–Hirschman index of monthly concentration of the annual US imports, calculated as follows:

$$HH_g = \sum_{m=1}^{12} \left(\frac{v(g,m)}{\sum_m^{12} v(g,m)} \right)^2 \tag{13}$$

[28]See for example Baier and Bergstrand (2007), Gallaway et al. (2003), and Yilmazkuday (2019).

[29]Some papers such as Alessandria et al. (2010) or Chang et al. (2009) propose continuous measures of storability but only for a limited number of goods and at more aggregate levels than HS-6.

[30]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 $v(g,m)$ are value of imports of good g in month m.[31] 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 a very disaggregate level (HS 10-digit, district of entry and source country) and consider HH_g in the second year g enters our sample.[32] Then we take the median HH_g at HS 6-digit level to obtain HH_z.

Table 6 contains results of estimating (11) and (12) with an interaction of the indicator variable that assumes value 1 for phased-out goods with above median HH_z. Comparison of results in Table 4 and 6 strongly suggest that the anticipatory slump and liberalization *bump* are driven by the goods which are more storable. Similar to the results presented earlier, anticipatory effects are not significantly present for other good categories.

We also interact the response to the tariff change with the continuous measure of the HH index and estimate the following equation:

$$\Delta_{\overline{n}-\underline{n}} m^{DD}_{z,t-1} = \sigma^S_0\ \Delta\tau^{DD}_{z,t} + \sigma^S_1\ \Delta\tau^{DD}_{z,t} \times HH_z + \sigma^S_2\ \Delta\tau^{DD}_{z,t} \times HH^2_z + \delta_z + u_{z,t,n-n'} \quad (14)$$

We limit this exercise to the goods that were phased-out, for which we found significant and economically sizeable anticipatory elasticities. This is the same estimation equation as (11), incorporating the interaction of $\Delta\tau^{DD}_{z,t}$ with HH_z and HH^2_z. Including the squared term of the HH index is important in capturing the interaction as results reported in Table D.4 of the Appendix show. The anticipatory elasticity now is the combination of the coefficients $\sigma^A_{i\,\in\,\{0,1,2\}}$.

In Figure 3 we report the response of $\Delta_{11:12-3:10} m^{DD}_{z,t}$ to a one percentage point drop in tariffs in the upcoming year for different percentiles of the HH Index. 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. The results are similar when we consider $\Delta_{11:12-5:10} m^{DD}_{z,t}$ or $\Delta_{10:12-4:9} m^{DD}_{z,t}$ and are reported in Figure D.3 of the Appendix.

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

[32] 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 Canada and Mexico to control for the average distance of sourcing countries. The distribution of the HH index is reported in Figure D.2 in the Appendix. Results are robust to including averages over more than the second year and including Canada and Mexico.

To summarize, the results in Tables 4, Table 6 and Figure 3 document that imports of the goods that experienced phaseouts fell significantly in advance of tariff reductions and rebounded sharply afterwards. More importantly, this effect was strongest for goods that are more intensively held as inventories. We take these results as evidence for the fact that during the window around tariff reductions imports and their consumption diverged significantly. Unfortunately, we can't 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 solution to overcome this lack of data and estimate the elasticity of substitution by introducing a measure of consumed imports.

4 Biases in the Elasticity of Substitution

In the previous section we showed that in advance of upcoming tariff reductions, US imports from Mexico experienced sizeable *anticipatory slumps* and *liberalization bumps* thereafter. As indicated by the model in section 2.2, these dynamics indicate that the assumption that imports equal their consumption might be violated in the context of the gradual tariff liberalization of the NAFTA. To overcome the lack of consumption of imports data we propose a process for the consumption of imports. Using our consumption measure of imports indicates that the elasticity of substitution is largely overestimated at annual frequency and that some of the bias remains in the average elasticity. These results demonstrate a larger role of the dynamic response to trade liberalizations. We first describe the consumption measure. Next, we validate it through model simulations and empirically. We then apply it to estimate the elasticity of substitution. Finally, we consider several alternative assumptions on the consumption process.

4.1 Measuring Consumption of Imports

The difference between imports and their consumption can arise due to the presence of inventories. At high frequencies, the two variables can diverge significantly as the literature has demonstrated extensively (Alessandria et al. (2010a, 2011a, 2011b)). To measure consumption of imports we begin with the monthly law of motion of inventory holdings specified in (6) of the model. The end of the month inventory holdings are,

$$\tilde{s}_{icz,n} = \tilde{s}_{icz,n-1} + m_{icz,n} - \tilde{q}_{icz,n} \tag{15}$$

where i indexes the destination and c the source country. We denote the month by n and z is a product at HS6 level. The tilde on top of inventory holdings, $\tilde{s}$, and consumption of imports, $\tilde{q}$, indicate that they are not available at this level of disaggregation.[33] Monthly imports, m, are obtained from the data. We begin by making an innocuous assumption of initial inventory holdings and then roll it forward using (15).[34] Hence, the critical variable to be estimated is the process of consumption of imports, $\tilde{q}$. We define our baseline process for consumption in country i of imports from country c of product z as,

$$\tilde{q}_{icz,n} = \frac{\tilde{s}_{icz,n-1} + m_{icz,n}}{k_{icz}} \tag{16}$$

The right hand side of (16), establishes that a constant fraction $1/k$ of current inventory holdings, $\tilde{s} + m$, is used for consumption. The key ingredients of the consumption process are; the monthly import data, and the constant rate of usage, namely the inverse of the inventory-sales ratio, denoted by k.[35] In the model of section 2, the stationary inventory-sales ratio essentially depends on product-specific factors such as the depreciation rate and the fixed cost of ordering. Additionally, from an empirical perspective the frequency of trade has been shown to depend on the delivery lags and the time to trade (Hummels and Schaur (2013), Bekes et al. (2017)). Therefore we allow for different inventory-sales ratio across products and directions of trade.

We obtain the inventory-sales ratio, k_{icz}, by exploiting its relationship with the lumpiness of trade. In particular, we use the fact that a high inventory-sales ratio will be associated with less frequent shipments. therefore, we multiply the Herfindahl-Hirschman (HH) index of monthly concentration of annual imports by 12 to obtain the number of months worth of sales purchased in the average import order. As in section 3.5, we calculate the HH index at HS-6 level by taking the median over HH indexes calculated at HS10 and

[33] In the model consumption of imports are sales. This is a simplification. We interpret consumption of imports as the fraction of the imported good $m_{icz,t}$ used as sales or in production by the importer.

[34] In particular we assume that in the first month inventory holdings are the monthly average of imports in the first year multiplied by the inventory-sales ratio. Our results do not rely on this assumption.

[35] A convenient feature of the assumed process of consumption of imports is that it generates non-zero values at any time frequency even when actual imports are zero, thereby overcoming issues associated with missing values (See Silva and Tenreyro (2006)).

entry-district level in the second year the good appears in our sample[36]. In section 4.4 we demonstrate that our results are robust to different calculations of k. Finally note that we are assuming no time to market, that is, no lag between the reception of goods and its availability for consumption, since imports received at n are readily available for their consumption. We will relax this assumption in the robustness checks of this measure.

Figure 4 illustrates the behavior of our baseline measure in the case of a specific HS-6 good, namely vehicles used for transport of goods exported from Mexico to the US. We highlight two facts. First, the consumption of imports closely tracts the pattern of actual imports. In fact, at annual frequency correlation between US imports from Mexico and our baseline measure of its consumption is 98% in the full sample. Second, the time series of consumption of imports is much smoother than actual imports. This can be observed in the abrupt halt in importing in the middle of 1994. During this gap in imports, our measure infers a gradual running down of inventories. As imports resume, both consumption of imports and inventories grow. These two ingredients are crucial to our purpose, since they balance high frequency drops and rises with the overall level of trend in trade volumes. For example, in the three months before January of 1997 imports fell and then spiked after January. However, our measure of consumption of imports does not reflect this reversal since in the previous part of the year imports had been on the rise.

4.2 Validation of the Imputed Consumption of Imports

We validate our baseline measure of consumption by following two strategies. First, we examine how it performs relative to actual consumption in the model simulations of section 2.3. Second, we examine whether it behaves smoother than the *bumps* and *slumps* in the response of imports to the tariff reductions of the NAFTA documented in section 3.

The implementation of our measure of the consumption in the model is straightforward. In each of the 52 simulations we set k to be the average inventory sales ratio of the first year.[37] The main difference with respect to (16) is that in the model, contemporane-

[36]Because we don't observe this level of disaggregation of the European trade data, we assume that $k_{US,c,z} = k_{EU,c,z}$.

[37]Additionally we also considered the case when the cost of ordering is a revenue tax and when purchases depreciate in transit and results are unchanged.

ous orders cross border in the next period and are not available for consumption. Hence, in the model simulations, m_t drops out of (16). In Figure 5 we plot the bias from using $m_{j,t}, q_{j,t}$ and our imputed measure of consumption, $\tilde{q}_{jt}$ against the anticipatory elasticity for the 52 simulations as in Figure 2. The dashed blue line fits the linear relationship between the bias when using the imputed measure of consumption and the anticipatory slump. It closely tracts that of the blue line, the actual consumption of imports dictated by the model. In our benchmark calibration the bias is eliminated entirely. Moreover, the correlation between actual and imputed consumption is similarly strong when comparing years that forego the anticipatory dynamics in the two years around the tariff reduction (years one and four of the simulations) as can be seen from column 3 of Table 7.

The empirically relevant validation is to examine whether the *anticipatory slump* is muted when the imputed process of consumption is used as the left hand side variable in (11). In Table 8 we show that the anticipatory elasticity is economically negligible and statistically insignificant for phased-out goods, as well as for others, when considering the imputed consumption of imports. This indicates that our imputed consumption flow is relatively smooth in advance of the tariff reduction, foregoing the anticipatory effects that caused biases to elasticity estimates in the model simulations from 2.3.2. Given these results, we conclude that our imputed consumption of imports (1) corrects for any deviations between imports and their consumption in the presence of anticipatory dynamics, and (2) is as valid as imports when these dynamics are absent. In the next subsection we apply our measure of consumption to estimate the elasticity of substitution using the consumption of US imports from Mexico during the early years of NAFTA.

4.3 Elasticity Estimates with Consumption of Imports

We now examine whether the anticipation we documented in section 3.4 affects the estimated elasticity of substitution. To do so, we follow the double-difference approach described in 2.1, but use import flows to estimate the trade elasticities, and our measure of consumed imports to estimate the elasticity of substitution. Precisely, We set $y_{zt}^{DD} = \tilde{q}_{zt}^{DD} \equiv \ln\left(\frac{\tilde{q}_{US,MEX,z,t}}{\tilde{q}_{US,RoW,z,t}} / \frac{\tilde{q}_{EU,MEX,z,t}}{\tilde{q}_{EU,RoW,z,t}}\right)$ to estimate the elasticity of substitution. Where $\tilde{q}_{i,j,z,t}$ is the aggregation of monthly flows from (16) to the annual frequency. We first provide estimates of the average, or cross-sectional, elasticity and then consider the distinction between short-run and long-run elasticities.

4.3.1 Average Elasticity Estimates

Estimates of the cross-sectional elasticity of substitution capture the average elasticity by pooling together all the year and products alike. This estimate is most relevant for static models of trade and crucial in its welfare implications (Arkolakis et al. (2012)). Following Romalis (2007), and Head and Ries (2001); we use the following estimation equation derived in (2) to estimate the elasticity of substitution:

$$y_{zt}^{DD} = \sigma \tau_{z,t}^{DD} + \delta_z + \delta_t + u_{zt} \tag{17}$$

Product and time fixed effects, δ_z and δ_t, are added to capture product-level export price differences and time trends in shipping costs that have differential effect on US imports from Mexico. We report the results in Table 9.[38] In Panel A we report the elasticity estimate for all goods. When using consumption of imports (column 2) instead of trade flows (column one) the elasticity drops from 8.9 to 7.7.[39] This implies a considerable upward bias of 16% in the estimates that are based on import flows. In Panel B we consider how the elasticity of substitution of phased-out goods is affected. We expect these goods to be the main drivers of the bias, since the anticipatory dynamics were stronger for them. We find that the bias is indeed larger for the at around 21%. While the trade elasticity of phased-out goods is 13.2 its elasticity of substitution is 10.9. For non-phased-out goods the bias is negligible as their elasticity falls from 6.6 to 6. In the robustness section we show that this pattern persists and is sometimes amplified under alternative measures of the import consumption process.

4.3.2 Dynamic Elasticity Estimates

We now make the distinction between the short-run and long-run response of the consumption of imports. We generalize (17) by applying an unrestricted Error-Correction

[38] 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.

[39] 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 those early years with less trade loom large in obtaining large trade elasticities.

Mechanism (ECM) model and estimate the following equation:

$$\Delta y_{zt}^{DD} = \sigma^{SR}\ \Delta\tau_{z,t}^{DD} + \sigma^{LR}\ \tau_{z,t-1}^{DD} + \alpha\ y_{z,t-1}^{DD} + \delta_t + \delta_z + u_{zt} \tag{18}$$

where $\Delta y_{z,t}^{DD} = y_{z,t}^{DD} - y_{z,t-1}^{DD}$.[40] Short-run or one-year elasticity is denoted by σ^{SR} and $-\sigma^{LR}/\alpha$ denotes the long-run elasticity.[41] This formulation generalizes (17) 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 elasticity and the elasticity of substitution.[42]

In Table 10 we report the short-run and long-run elasticities from (18). 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. 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 3.4. In contrast, non-phased-out goods yield similar estimates when using imports flows or consumption of imports. It is also noticeable that the estimated 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. As shown in the model simulations of section 2.3.2, the bias emanating from anticipatory effects become negligible in the long run. In the model, anticipation 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 habit formation that are absent in the model. In effect, Table 10 shows that our measure of consumption of imports yields an almost identical long run elasticity of substitution and trade elasticity

[40] This assumes that imports and tariffs have order of integration 1 and are cointegrated.

[41] In a restricted version, one would add a lag of the dependent term to (17). That would impose the restriction $\sigma^{SR} = \sigma^{LR}$.

[42] Our exercise is aimed towards highlighting differential anticipatory dynamics at different horizons. For that purpose, we focus on comparing the response of trade and consumption. To address the time-series concerns, we have also estimated the specification in (17) in annual differences which does not contain lagged dependent variable as a regressor. Results of this confirm the findings in this section.

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 and duration of the long-run adjustment. The ratio of long- to short-run elasticity is an important feature of dynamic models of trade.[43] Table 10 shows that long-run trade elasticity is around twice as big as 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 of around 3.7.

Moreover, the full adjustment to the long run response takes longer using the consumption response. In Figure 6 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.7. In Figure 7 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%.

4.4 Robustness

The results described in the previous section are robust to several alternative assumptions and empirical implementations on the processes of the consumption of imports. Results of estimating (17) and (18) under these alternative processes described below are presented in Table 11.

One Period Time to Market Lag. - Under the baseline measure, once imports are received at the destination, they are immediately available for consumption. However, there can be lags in domestic deliveries or lead times to market the imports. This would

[43] See for example Arkolakis (2010), Engel and Wang (2011), Crucini and Davis (2016), Alessandria et al. (2018).

make current imports unavailable for sale. Hence, the process that assumes a one period lag in the lead time between reception and consumption of imports would have the following representation:

$$\tilde{q}_{icz,t} = \frac{\tilde{s}_{icz,t-1}}{k_{icz}} \tag{19}$$

The results with this version are contained in the third column of Table 11. The dynamic elasticity estimates in Panel A are unchanged from the baseline results. In Panel B we observe that the use of this measure also causes reduction in the estimate. The estimate elasticity falls from 8.9 with import flows to 7.3 with consumption measure, which implies a bias of 22%.

Different Inventory-Sales Ratios. - In our baseline measure we use a different inventory-sales ratio, k_{icz}, only for different exporter countries i, since we don't consider more disaggregated EU-12 trade flows to calculate HH indexes. 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. This does not affect our results presented in the fourth column of Table 11. The estimates of the dynamic elasticities are very close to the ones using our baseline consumption measure. The bias in the average elasticity is only slightly smaller than our baseline bias in the aggregate.

Demand Shock. - We extend our baseline version of the process of $\tilde{q}$ by including a demand shock, ν_t. This demand shock is equivalent to an aggregate demand shock in the model presented earlier since it is a HS6-specific shock for all firms. The process for predicted consumption of imports then takes the following form:

$$\hat{q}_{icz,t} = \underbrace{\frac{\tilde{s}_{icz,t} + m_{z,t}}{k_{icz}}}_{\text{expected}} + \underbrace{\frac{m_{icz,t+1}}{k_{icz}} - \mathbb{E}_t(m_{icz,t+1})}_{\text{shock } (\nu_t)} \tag{20}$$

$$\tilde{q}_{icz,t} = \min\left[\hat{q}_{icz,t},\ \tilde{s}_{icz,t-1} + m_{icz,t}\right] \tag{21}$$

The first term on the right hand side of (20) 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 favourable contemporaneous demand shock if we observe orders higher than the good's average imports in the following period. This assumes the existence of a delivery lag between purchase orders and reception of imports of one month, as it was the case in the model. 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. We calculate $\mathbb{E}_t m_{t+1}$ by taking the average of imports of the contemporaneous and the previous five months, i.e. $1/6 \sum_{i=-5}^{0} m_{t+i}$. Finally, (21) imposes that consumption of imports can't exceed contemporaneous inventory holdings, as we assumed in the model by requiring (5).

As explained above, in the model contemporaneous imports are orders, so that in the model analogous process of our measure with demand shocks, the expected term is $\frac{\tilde{s}_{j,t}}{k}$ and the shock is $\frac{m_{j,t}}{k} - \mathbb{E}_{t-1}(m_{j,t})$. In Table D.6 of the Appendix we report that in the model simulations this measure is similarly effective in reducing the bias from anticipation[44]. In Figure D.4 of the Appendix, we show how the measure with demand shocks behaves under the same import pattern as illustrated in Figure 4. Now imports precede consumption of imports, since demand shocks are obtained from deviations between next period's imports and lagged imports.

In column five of the Table 11 we report the results of estimating (17) using actual imports and the measure with demand shocks as the dependent variable. In Panel A we report the results of estimating (18) with the consumption measure with demand shocks. The aggregate short-run elasticity is substantially lower than our baseline estimate. However, as anticipated, the effect on the long-run elasticity is not substantial. This is consistent with anticipation largely affecting the short-run elasticity. Moreover, due to a larger reduction in the short-run estimate, the ratio of long- to short-run elasticity comes out to be much bigger with the consumption as dependent variable. In the average estimate in panel B, the bias of cross-sectional elasticity increases to 22%, falling from 8.9 to 7.3.

In the last column, we also consider the case in which the expected imports per months of sales, $\mathbb{E}_{t-1}(m_{j,t})$ is calculated using a symmetric 6 months lags and leads window. In this case we obtain a bigger bias yielding a 39% difference in the estimate using the import flows (m^{DD}) and the consumption measure ($\tilde{q}^{DD}$).

[44] However, its effectiveness in the model is sensitive to varying the number of leads and lags included in the calculation of the expected imports per months of sales, $\mathbb{E}_{t-1}(m_{j,t})$. Therefore, we consider the measure without demand shock as our baseline.

This section documented that the biases we found in the average and short run elasticity of substitution using our baseline measure of the consumption of imports instead of imports are robust to various alternative assumptions on the consumption process and alternative implementations of it. Although quantitatively these alternative measures yield slightly different reductions in the estimate, the main findings are unchanged, underscoring the importance to smooth out the response of trade flows around the time of anticipated tariff reductions.

5 Conclusions

We make three points in the paper. First, we show that there are *slumps* and *bumps* in trade flows around the tariff phaseouts from the NAFTA. Second, one can estimate the underlying consumption response using our novel measure of consumption of imports. This measure is validated through Monte Carlo simulations of a standard model of trade extended with $(\underline{s},\overline{s})$ inventory management. Unlike trade flows, in the data, our consumption measure does not exhibit anticipatory effects. Third, application of the measure to the US imports from Mexico during NAFTA's staged tariff reductions shows that anticipatory effects bias the short-run and average elasticity estimate whereas the long-run response is unaffected. This differential bias at different horizons implies an underestimation of the gradualness in the trade response, as the ratio of long-run to short-run elasticities rises after our correction.

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 the high frequency trade data and the 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. (2011b) 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 disaggaregate inventory data becomes available.

An additional advantage of our consumption of imports measure is that it overcomes some of the issues related to missing values in trade flows (Silva and Tenreyro (2006)).

The presence of zero trade flows is problematic especially due to the widely used log-linear and difference-in-difference estimation methods. Generally, the zero values end up being ignored. Our measure addresses this, in an intuitive rather than a technical way, by bringing the data closer to the structural variables. This creates an opportunity to revisit and further explore the implications of trade policy changes.

Finally, in the episode studied in this paper the implementation of the tariff reductions were certain to take place. Nonetheless, the anticipatory effects we document here are potentially sizeable 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 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, Horag Choi, and Kim J. Ruhl, "Trade Adjustment Dynamics and the Welfare Gains from Trade," 2018.

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

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

_ , _ , and _ , "Trade and Inventory Dynamics," *European Central Bank E-Book*, 2011.

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

_ , 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 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.

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," 2018.

Bekes, Gabor, Lionel Fontagne, Balazs Murakozy, and Vincent Vicard, "Shipment Frequency of exporters and demand uncertainty: An inventory management approach," *Review of World Economics*, 2017, *153*, 779–807.

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.

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.

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," *NBER WP w25638*, 2019.

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

_ , Phillip Luck, Maurice Obstfeld, and Katheryn N. Russ, "In Search of the Armington Elasticity," *Review of Economics and Statistics*, 2018, *100(1)*, 135–150.

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.

Head, Kieth 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.

Hillbery, 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.

Hummels, David and Georg Schaur, "Time as a Trade Barrier," *American Economic Review*, 2013, *103(7)*, 2935–2959.

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.

Kropf, Andreas and Philip Saure, "Fixed Cost per Shipment," *Journal of International Economics*, 2014, *92*, 166–184.

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

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

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.

Staiger, Robert, "A Theory of Gradual Trade Liberalization," *Deardorff, A., Levinsohn, J., and Stern, R. (eds.) New Directions in Trade Theory, University of Michigan Press*, 1995.

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

Table 1: Parameters and Moments of the Benchmark Calibration

Parameter		Benchmark	Low I/S
f	Fixed Cost Ordering	0.05	0.001
σ_ν	Variance of Taste Shocks	0.6^2	0.6^2
δ	Monthly Depreciation Rate	2.50%	10%
σ	Elasticity of Substitution	4	4
β	Monthly Interest Rate	$0.96^{(1/12)}$	$0.96^{(1/12)}$
Moments			
	Equilibrium monthly I/S Ratio	2.54	1.44
	HH Index	0.21	0.09
	Annual Fixed Cost over Mean Revenues	3.6%	0.1%

Table 2: Model Simulation Average Elasticities

Sample Period:	Years 1 & 4	Years 2 & 3	Years 1 & 4	Years 2 & 3
Dep. Var. :	m_t	m_t	q_t	q_t
$1\{\text{Benchmark}\} \times \log(1+\tau_t)$	-4.4	-9.2	-4.1	-4.3
	(0.71)	(0.73)	(0.69)	(0.68)
$1\{\text{Low I/S}\} \times \log(1+\tau_t)$	-4.0	-4.5	-4.0	-3.9
	(0.27)	(0.28)	(0.31)	(0.32)
$1\{\text{Unanticipated}\} \times \log(1+\tau_t)$	-4.3	-4.7	-4.1	-4.2
	(0.71)	(0.73)	(0.69)	(0.68)
N	12000	12000	12000	12000
Adjusted R^2	0.087	0.100	0.110	0.110

Note: Estimates are obtained from estimation equation (8) varying the dependent variable and the sample period included. Columns one and two use annual imports as the dependent variable. Columns three and four use annual consumption of imports or sales. Tariff changes take place in the first month of the third year in the simulations. Hence column one and three using sample years 1 and 4 are not subject to the bias from anticipation. Standard errors, in parentheses, are clustered at firm level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Phaseout Categories of HS-8 Goods Imported to US from Mexico

Classes	1993 Number Goods	1993 Scheduled Tariff	1993 Import Share	1999 Number Goods	1999 Median Tariff	1999 Import Share
A - 1 stage	438	5.51%	15.36%	367	0%	13.93%
B - 5 stages	760	8.95%	9.08%	695	0%	9.76%
C - 10 stages	641	6.49%	3.31%	498	2.64%	3.26%
C+ - 15 stages	68	19.00%	0.54%	66	10.39%	0.71%
D - Zeroed by 1993	4,814	0.01%	62.02%	4,249	0%	36.77%
Unclassified	264	0.89%	9.67%	1,920	0.02%	35.58%
TOTAL	6,985	2.17%	100%	7,772	0.26%	100%

Table 4: Anticipatory Slumps & Bumps

US Imports from Mexico	Dep. Var.:	$\Delta_{\underline{n}:\overline{n}} m^{DD}_{z,t-1}$ Fall	Fall	Fall	$\Delta_{\underline{n}:\overline{n}} m^{DD}_{z,t}$ Rise	Rise	Rise
	$\overline{n}$	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
Panel A: Phaseout Categories							
$\mathbf{1}\{Phased\}\Delta\tau^{DD}_{z,t}$		6.1***	4.6***	4.1***	-11.7**	-8.6**	-7.6**
		(2.10)	(1.34)	(1.46)	(4.67)	(4.07)	(3.21)
$\mathbf{1}\{Other\}\Delta\tau^{DD}_{z,t}$		-1.6	-1.0	-0.2	-2.7	-1.5	-3.6
		(2.76)	(2.25)	(2.38)	(2.77)	(2.70)	(2.46)
Panel B: All Goods							
$\Delta\tau^{DD}_{z,t}$		0.7	0.7	1.1	-5.5**	-3.7	-4.7***
		(1.48)	(1.40)	(1.73)	(2.58)	(2.48)	(2.15)
HS6 FE		✓	✓	✓	✓	✓	✓
Year FE					✓	✓	✓
N		6023	6285	7076	7014	7014	8323
Adj R2		0.075	0.103	0.087	0.266	0.244	0.263

Note: Estimates are obtained from (11) and (12) using different within-year periods growth rates. Standard errors, in parentheses, are clustered at HS-2 product level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Anticipatory Slumps & Bumps - Fixed Effects Robustness

Dep. Var.:	$\Delta_{\underline{n}:\overline{n}} m^{DD}_{z,t-1}$			$\Delta_{\underline{n}:\overline{n}} m^{DD}_{z,t}$		
US Imports from Mexico	Fall	Fall	Fall	Rise	Rise	Rise
$\overline{n}$	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
$\mathbf{1}\{Phased\}\Delta\tau^{DD}_{z,t}$	6.1***	4.0**	4.9***	-11.7**	-8.9**	-13.1***
	(2.10)	(1.93)	(1.77)	(4.67)	(3.43)	(4.58)
$\mathbf{1}\{Others\}\Delta\tau^{DD}_{z,t}$	-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 (11) and (12) using different fixed effects. Standard errors, in parentheses, are clustered at HS-2 product level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Anticipatory Slumps & Bumps - Storability

Dep. Var.:	$\Delta_{\underline{n}:\overline{n}} m^{DD}_{z,t-1}$			$\Delta_{\underline{n}:\overline{n}} m^{DD}_{z,t}$		
US Imports from Mexico	Fall	Fall	Fall	Rise	Rise	Rise
$\overline{n}$	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
$\mathbf{1}\{HH_z > \text{Med}(HH_z)\}\mathbf{1}\{Phased\}\Delta\tau^{DD}_{z,t}$	7.1**	5.8***	4.9***	-17.0**	-12.7*	-11.5**
	(2.75)	(1.99)	(1.63)	(7.45)	(6.64)	(5.79)
$\mathbf{1}\{Other\}\Delta\tau^{DD}_{z,t}$	-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 (11) and (12) with interaction with storability. Storability is proxied by the lumpiness of imports given by the HH index of concentration of imports over the year. 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 7: Model Based Validation of the Imputed Consumption of Imports

	Observed	Observed	Imputed	Imputed
Sample Period:	Years 1 & 4	Years 2 & 3	Years 1 & 4	Years 2 & 3
Dep. Var. :	q_t	q_t	$\tilde{q}_t$	$\tilde{q}_t$
1 { Benchmark } $\times \log(1+\tau_t)$	-4.1	-4.3	-3.9	-4.5
	(0.69)	(0.68)	(0.62)	(0.58)
1 { Low I/S } $\times \log(1+\tau_t)$	-4.0	-3.9	-4.0	-3.9
	(0.31)	(0.32)	(0.27)	(0.27)
1 { Unanticipated } $\times \log(1+\tau_t)$	-4.1	-4.2	-3.9	-4.0
	(0.69)	(0.68)	(0.62)	(0.59)
N	12000	12000	12000	12000
Adjusted R^2	0.110	0.110	0.118	0.113

Note: Estimates are obtained from estimation equation (8) varying the dependent variable and the sample period included. Columns one and two are the same as columns three and four in Table 2. Columns three and four use our baseline predicted measure of consumption of imports, described in (16). Standard errors, in parentheses, are clustered at firm level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Empirical Validation of the Imputed Consumption of Imports

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

Note: Estimates are obtained from (11) 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 4, here we use our baseline measure of consumption of imports from (16) 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 9: Static Elasticities - Baseline

US Imports Mexico	(1)	(2)	
Dep. Var. :	$m_{z,t}^{DD}$	$\tilde{q}_{z,t}^{DD}$	Bias
Panel A: All Goods			
$\tau_{z,t}^{DD}$	-8.9***	-7.7***	16%
	(1.10)	(1.05)	
Panel B: Phaseout Categories			
$1\{$ *Phased* $\} \times \tau_{z,t}^{DD}$	-13.2***	-10.9***	21%
	(1.61)	(1.57)	
$1\{$ *Others* $\} \times \tau_{z,t}^{DD}$	-6.6***	-6.0***	10%
	(1.35)	(1.33)	
Year FE	✓	✓	
HS6 FE	✓	✓	
Observations	15153	15153	

Note: All estimates are obtained form equation 17 and by varying the dependent variable. Columns one and three use imports, while columns two and four use our baseline predicted measure of consumption of imports, described in (16). Standard errors, in parentheses, are clustered at HS-6 level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 10: Dynamic Elasticities - Baseline Measure

Dep. Var. :	$m_{z,t}^{DD}$	$\tilde{q}_{z,t}^{DD}$	Bias
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)	
Year FE	✓	✓	
HS6 FE	✓	✓	
N	11290	11290	
adj. R^2	0.345	0.314	

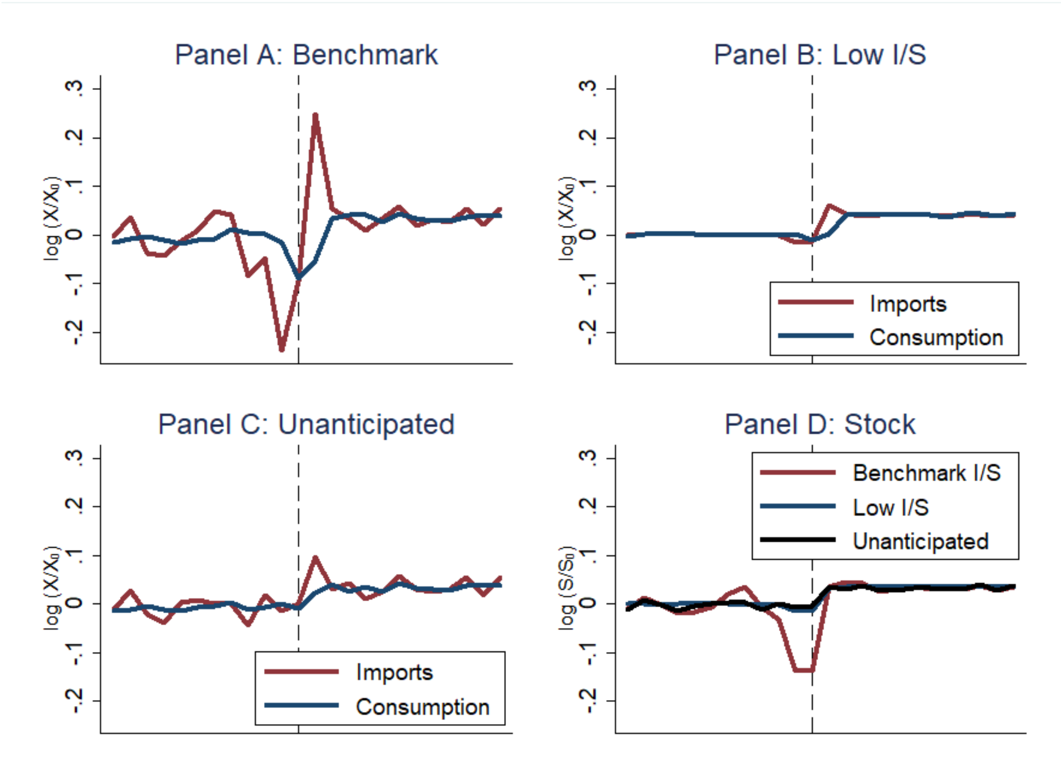
Note: All estimates are obtained form (18) and by varying the dependent variable. Columns one uses actual imports, while column two uses our baseline measure of consumption of imports, described in (16). Standard errors, in parentheses, are clustered at HS-6 level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 11: Elasticities - Robustness

Dep. Var. :	$\Delta m_{z,t}^{DD}$	$\Delta \tilde{q}_{z,t}^{DD}$				
		Baseline	Time to Market	Common k_z	Demand Shock with 6 Lags	Demand Shock with 6 Lags & Leads
Panel A: Dynamic Response						
Short-run (σ^{SR})	-4.2***	-2.6***	-2.6***	-2.8***	-1.3*	-1.5*
Long-run ($-\sigma^{LR}/\alpha$)	-9.6***	-9.2***	-9.3***	-9.5***	-9.0***	-9.1***
Year FE	✓	✓	✓	✓	✓	✓
HS6 FE	✓	✓	✓	✓	✓	✓
N	11019	11019	11019	11019	11019	11019
Panel B: Average Response						
$\tau_{z,t}^{DD}$ (σ)	-8.9***	-7.7***	-7.3***	-7.9***	-7.3***	-6.4***
Bias		16%	22%	13%	22%	39%
Year FE	✓	✓	✓	✓	✓	✓
HS6 FE	✓	✓	✓	✓	✓	✓
N	14646	14646	14646	14646	14646	14646

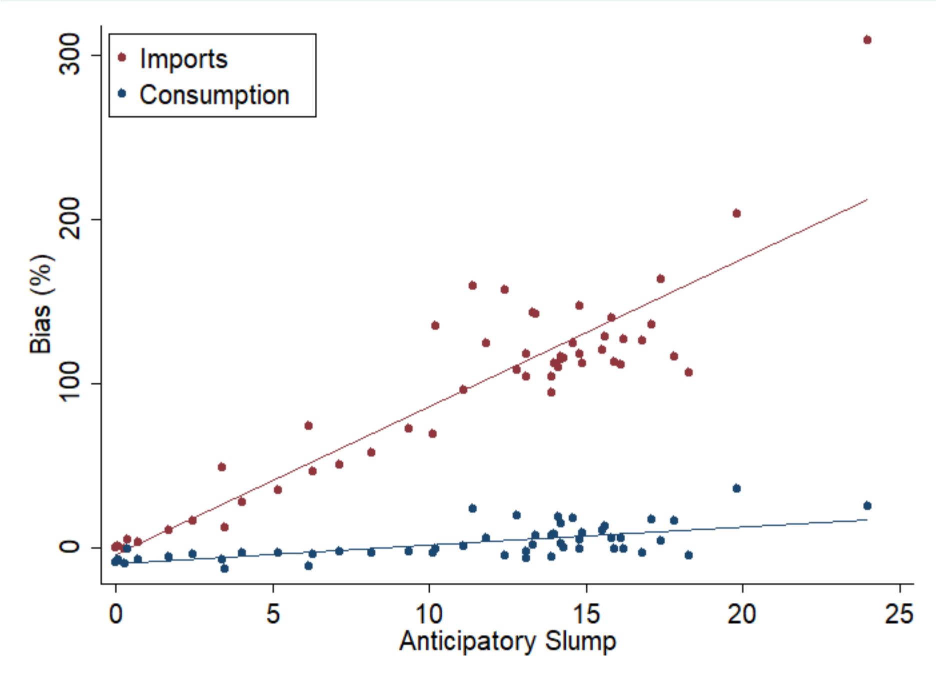
Note: The estimates in panel A are obtained by estimating (18) and by varying the dependent variable. Panel B reports the results of estimating (17). Column one uses actual imports, while all other columns use different measures of consumption of imports, described in section 4.4. Robust standard errors are in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 1: Impulse Response Function of Aggregate Variables in the 3 Simulations



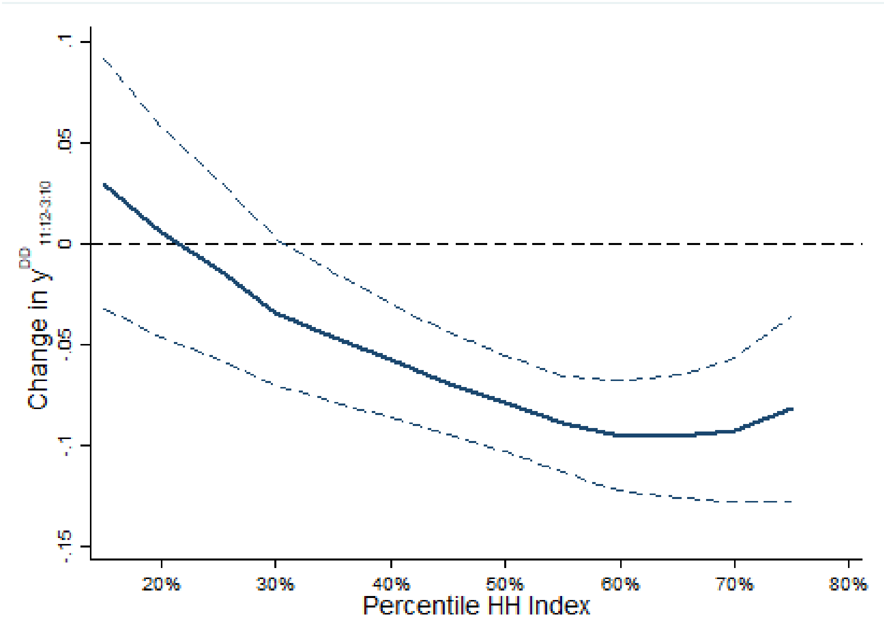
Note: In all four panels the yaxis is log changes with respect to the average level of the corresponding variable in the first 12 months of the simulation. Panel A are aggregate consumption and imports from the simulations under the benchmark calibration reported in Table 1. Panel B is the result of the simulation from calibration X from the alternative calibrations reported in Table D.3. Panel C is the result of the simulation from the benchmark calibration with an unanticipated tariff reduction. Panel D reports the behavior of end of period stock holdings for all three simulations.

Figure 2: Anticipatory Slump and the Bias in the Elasticity of Substitution



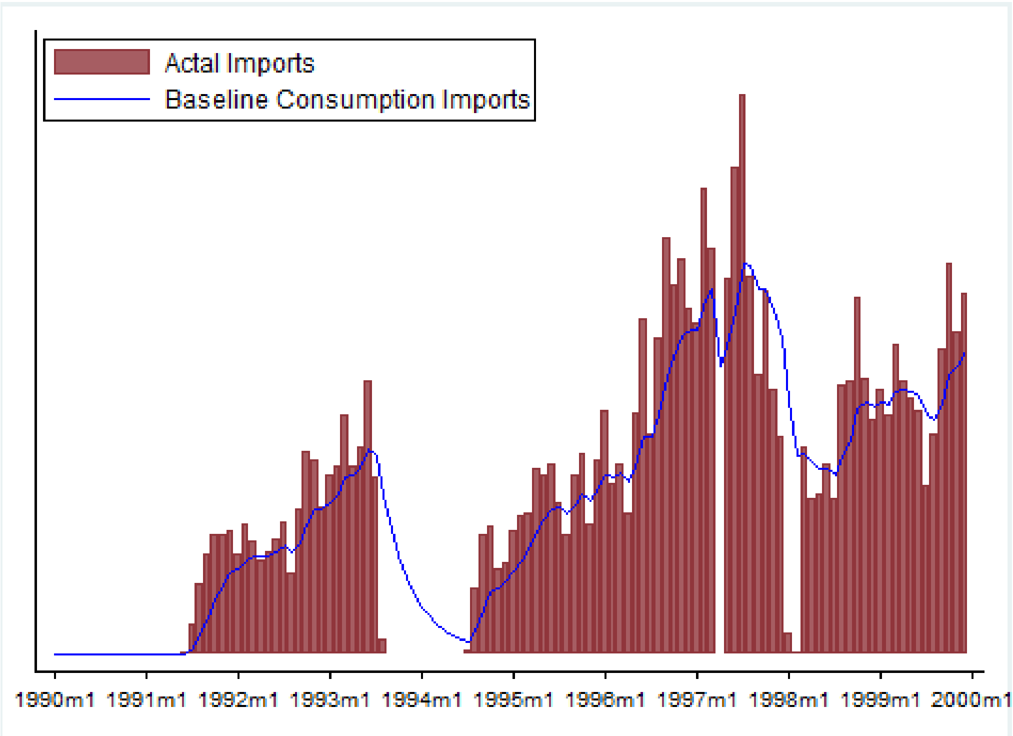
Note: Dots are the results from the simulations under the 51 calibrations reported in Tables 1 and D.3. The bias in the elasticity of substitution on the yaxis is measured as the difference in the estimate of σ from (2) in the years around the tariff change and q_{jt} in years one and four. Red uses $y_{jt} = m_{jt}$ and blue uses $y_{jt} = q_{jt}$. The anticipatory slump is the estimate of σ^S from (9).

Figure 3: Anticipatory Elasticity and Storability



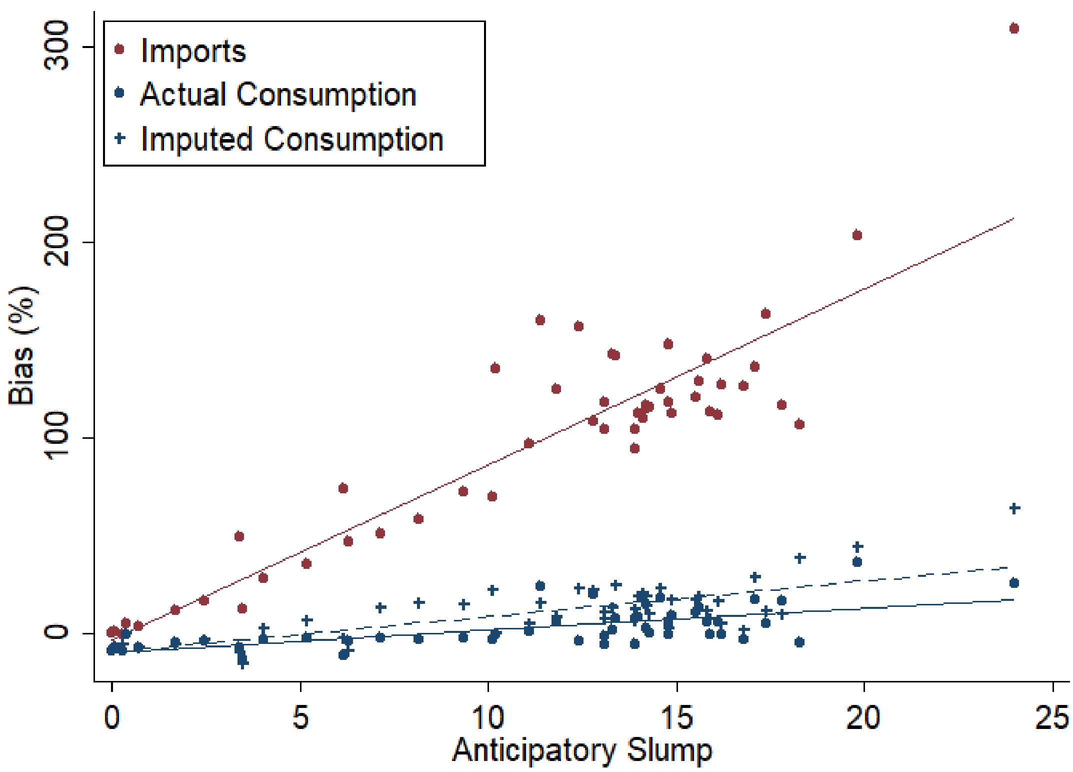
Note: The yaxis corresponds to the predicted $\Delta_{11/12:3/10} y^{DD}_{z,t-1}$ from estimating equation (14) given $\Delta\tau^{DD}_t = -0.01$ at different percentiles of the HH Index. The sample includes only HS-6 goods that were phased out. It is calculated as $\hat{\sigma}^A = \hat{\sigma}^A_0 \times \Delta\tau^{DD}_t + \hat{\sigma}^A_1 \times \Delta\tau^{DD}_t \times P(HH) + \hat{\sigma}^A_2 \times \Delta\tau^{DD}_t \times P(HH)^2$. The estimation results with coefficients for $\sigma^A_{i=\{0,1,2\}}$, are reported in Table D.4 of the Appendix. The distribution of the HH index can be seen in Figure D.2. Its calculation is described in 3.5. Points with the dashed lines are within the 90% confidence interval, calculated using the delta method.

Figure 4: Example of our Baseline Measure



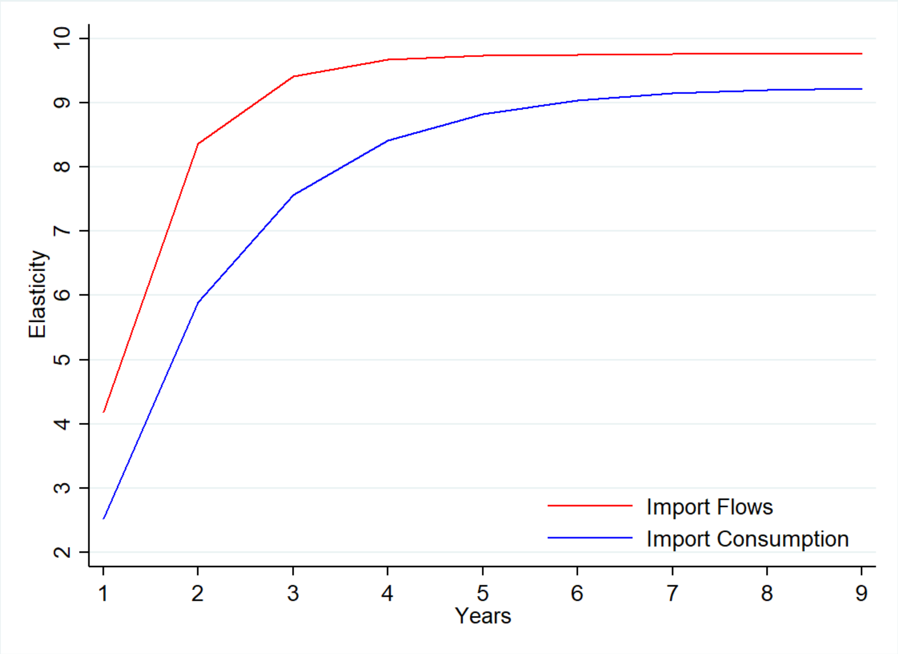
Note: The yaxis is in levels. The example here shown corresponds to HS6 code 870421, described as "Vehicles; compression-ignition internal combustion piston engine (diesel or semi-diesel), for transport of goods, (of a gvw not exceeding 5 tonnes)". Consumption of imports are calculated as in (16).

Figure 5: Model-Based Validation of Imputed Consumption of Imports



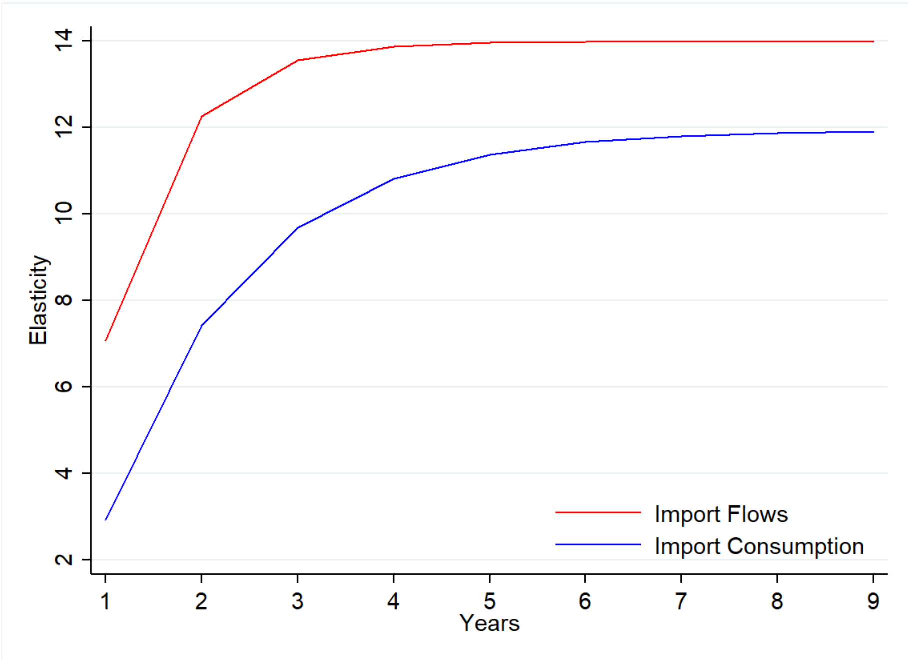
Note: Dots are the results from the simulations under the 51 calibrations reported in Tables 1 and D.3. The bias in the elasticity of substitution on the yaxis is measured as the difference in the estimate of σ from (2) in the years around the tariff change and q_{jt} in years one and four. Red uses $y_{jt} = m_{jt}$ and blue uses $y_{jt} = \{q_{jt}, \tilde{q}_{jt}\}$. The anticipatory slump is the estimate of σ^S from (9).

Figure 6: Dynamic Elasticity - All HS6 Goods



Note: On the y-axis are the trade elasticity estimated obtained from (18) for $N = [1, 5]$. The sample only 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 (16). The dashed lines are the 68% confidence interval. Standard errors are robust.

Figure 7: Dynamic Elasticity - Phased-Out Goods



Note: On the y-axis are the trade elasticity estimated obtained from (18) for $N = [1, 5]$. 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 (16). The dashed lines are the 68% confidence interval. Standard errors are robust

Appendix

A Difference-in-Difference Approach

In the background of the demand equation (1) is a representative consumer whose period-t utility is given by a Cobb-Douglas aggregator over products:

$$C_{it} = \prod_{z} C_{izt}^{\alpha_{iz}}$$

where α_{iz} is the expenditure share of product z in country i and C_{izt} denotes the total consumption of good z in country i in period t. Differentiated varieties of product z can be sourced from different countries. These varieties are combined in a Dixit-Stiglitz form,

$$C_{izt} = \left(\sum_{c} m_{iczt}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

where m_{icz} is the quantity of product z consumed in country i sourced from exporter c in period t. This leads to an import demand equation given by,

$$m_{iczt} = \left(\frac{p_{czt}(1+\tau_{iczt})}{P_{izt}} \right)^{-\sigma} C_{izt}$$

where P_{izt} is the importer-specific price index given by $P_{izt} = \left(\sum_{c} \left(p_{czt}(1+\tau_{iczt}) \right)^{1-\sigma} \right)^{1/(1-\sigma)}$. We transform import demand equation into Free-On-Board (FOB) value to overcome measurement problems in quantities.[45] We multiplying both sides of the import demand equation by the unit price i.e. $v_{iczt} = m_{iczt} p_{czt}$. In what comes next, we aim to remove the exporter-specific unit-price term and the importer-specific price indices and aggregate demand term.

Next we take the ratio of country i's import demand from country c and c', thereby eliminating importer i-specific effects:

$$\frac{v_{iczt}}{v_{ic'zt}} = \left(\frac{(1+\tau_{iczt})}{(1+\tau_{ic'zt})} \right)^{-\sigma} \left(\frac{p_{czt}}{p_{c'zt}} \right)^{1-\sigma}$$

Secondly, considering a reference exporter i' and taking logs on both sides elimiates

[45] See Hillbery and Hummels (2012).

the exporter-specific price terms:

$$\ln\left(\frac{v_{iczt}}{v_{ic'zt}}\Big/\frac{v_{i'czt}}{v_{i'c'zt}}\right) = -\sigma\ln\left(\frac{1+\tau_{iczt}}{1+\tau_{ic'zt}}\Big/\frac{1+\tau_{i'czt}}{1+\tau_{i'c'zt}}\right) \tag{22}$$

B General Equilibrium Considerations

In this section we study (1) how prices of Mexican exports to the US responded to upcoming tariff reductions; and (2) how Canada's exports to the US responded to US-Mexico tariff reductions.

B.1 Anticipatory Effects in Exporter Prices

In the model of section 2 we assume that exporters are perfectly competitive and that the purchase price, ω is exogenous and constant[46]. In reality, however, it could be the case that when suppliers observe a temporary drop in their sales they offered 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 3. 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:

$$\Delta_{\overline{n}:\underline{n}}UV^{D}_{z,t-1} \equiv \log\left(\frac{UV^{Mex,US}_{z,t,\overline{n}}}{UV^{Mex,EU12}_{z,t,\overline{n}}}\Big/\frac{UV^{Mex,US}_{z,t,\underline{n}}}{UV^{Mex,EU12}_{z,t,\underline{n}}}\right) = \sigma^{A,UV}\Delta\tau^{D}_{z,t} + \delta_z + u_{z,t} \tag{23}$$

$\sigma^{A,UV}$ 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 11,

[46] In the model, introducing an ad-hoc supply elasticity dampens the *anticipatory slump* only slightly and the results of section 2.3 are unchanged

except that we take only a reference importing country. We restrict the sample to the sample considered in Table 4, 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.8. Neither in the aggregate, nor for phased-out goods, we observe any significant movement in unit values before an upcoming tariff change.

B.2 Trade Diversion: Effects on Canadian Exports to the US

An interesting question that is clouded by the difference-in-difference approach employed in section 3 is how third parties' trade with the US responds to US reduction on Mexican import tariffs and, in particular, to the observed anticipatory slumps and bumps. This question is particularly interesting in the case of Canada, the other member of the NAFTA. If Mexican and Canadian goods are complementary, e.g. they are intermediates combined in the importers' production process, then imports Canadian might experience similar slumps and bumps. Alternatively, if the goods are substitutes, purchases of Canadian goods might increase if Mexican goods become unavailable before the tariff drop. To gain some insights on trade diversion effects of the documented anticipation, we estimate the following regression:

$$\Delta_{\overline{n}:\underline{n}} y_{z,t-1}^{DD,CAN} = \sigma^{A} \; \Delta x_{z,t}^{DD,CAN} + \sigma^{A,Diversion} \; \Delta x_{z,t}^{DD,MEX} \delta_z + u_{z,t} \tag{24}$$

This is very similar to the baseline estimation of the anticipatory slump (11), except that we now include the change in τ^{DD} for another trading partner and we are interested not in σ^{A}, but in $\sigma^{A,Diversion}$. Results in Table D.9 show that imports for those goods on which Mexican imports declined, Canadian exports increased, that is, we find evidence of trade diversion. The anticipatory elasticity is around half of the slump in exports from Mexico to the US. Moreover, we observe that for the goods for which Mexico's tariffs were phased-out, there is a similar anticipatory slump in line with the results of section 3.[47]

[47]Unfortunately the classification of products into phase-out categories from the CUSFTA are not available to us. However, presumably the classification is correlated with the NAFTA's and results from D.9 are indicative of similar dynamics in US imports from Canada.

C Model: Closed Form of Anticipation

C.1 Stockout Avoidance Model

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,

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

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,

$$i(s,\eta) = \begin{cases} i_0 + \eta \left(\frac{\sigma}{\sigma-1}\omega\right)^{-\sigma} - s & \text{if } \eta < \bar{\eta}(s) \\ i_0 & \text{if } \eta \geq \bar{\eta}(s) \end{cases} \tag{25}$$

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

$$\begin{aligned} EV(s) = &\int_{\eta<\bar{\eta}(s)} \left[\eta\left(\frac{\sigma}{\sigma-1}\omega\right)^{1-\sigma} - \omega i_0 \eta \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} \omega^{1-\sigma} + \omega s\right] dF(\eta) \qquad (26) \\ &+ \int_{\eta\geq\bar{\eta}(s)} \left[\eta^{1/\sigma} s^{(\sigma-1)/\sigma} - \omega i_0\right] dF(\eta) + \beta EV[(1-\delta)i_0] \\ = &\left(\frac{\sigma\omega}{\sigma-1}\right)^{1-\sigma} \frac{1}{\sigma}\Psi_1(s) + s^{(\sigma-1)/\sigma}\Psi_2(s) - \omega i_0 + F(\bar{\eta}(s))\omega s + \beta EV[(1-\delta)i_0] \end{aligned}$$

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

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 (26),

$$s_0 = \left(\frac{\sigma}{\sigma-1}\omega\right)^{-\sigma} (\alpha\sigma - 1)^{-1/\alpha} \left[\frac{1-\beta(1-\delta)}{\beta(1-\delta)}\right]^{-1/\alpha} \tag{27}$$

The optimal purchases are given by substituting $s_0 = i_0(1-\delta)$ and (27) in (25).

C.2 Anticipatory Effects

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 (26) 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',

$$s' = \left(\frac{\sigma\omega'}{\sigma-1}\right)^{-\sigma}(\alpha\sigma-1)^{-1/\alpha}\left(\frac{(\omega/\omega')-\beta(1-\delta)}{\beta(1-\delta)}\right)^{-1/\alpha} \tag{28}$$

This expression is similar to the one in (27). 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: Sample Characteristics

Categories	HS6-Goods	HS6-Year Pair	%	Mexico's Import Share 1990-1993	Median Duty 1993
Phased-out	451	5,283	16.51%	12.33%	7,71 %
Class A	129	1,541	4.81%	14.04%	6.50%
Non NAFTA	2,274	15,182	78.68%	73.63%	0.15 %
TOTAL	2,854	32,006	100%	0.81%	

Table D.2: Reference Exporter Countries

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

Table D.3: Parameters and Moments of the Robustness Calibrations

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%
$\delta,\ f=0$	20	0.05	0.6ˆ2	0.3	0.96ˆ(1/12)	1.24	0.09	5.07%
$\delta,\ f=0$	21	0	0.6ˆ2	0.01	0.96ˆ(1/12)	1.95	0.09	0.00%
$\delta,\ f=0$	22	0	0.6ˆ2	0.02	0.96ˆ(1/12)	1.78	0.09	0.00%
$\delta,\ f=0$	23	0	0.6ˆ2	0.03	0.96ˆ(1/12)	1.69	0.09	0.00%
$\delta,\ f=0$	24	0	0.6ˆ2	0.04	0.96ˆ(1/12)	1.63	0.09	0.00%
$\delta,\ f=0$	25	0	0.6ˆ2	0.05	0.96ˆ(1/12)	1.58	0.09	0.00%
$\delta,\ f=0$	26	0	0.6ˆ2	0.075	0.96ˆ(1/12)	1.5	0.09	0.00%
$\delta,\ f=0$	27	0	0.6ˆ2	0.1	0.96ˆ(1/12)	1.44	0.09	0.00%
$\delta,\ f=0$	28	0	0.6ˆ2	0.15	0.96ˆ(1/12)	1.35	0.09	0.00%
$\delta,\ f=0$	29	0	0.6ˆ2	0.25	0.96ˆ(1/12)	1.25	0.08	0.00%
$\delta,\ f=0$	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.4: Anticipatory Slumps & Bumps - Storability Interaction

US Imports from Mexico	Dep. Var.:		$\Delta_{\overline{n}:\underline{n}} m^{DD}_{z,t-1}$	
		Fall	Fall	Fall
	$\overline{n}$	11:12	11:12	10:12
	$\underline{n}$	4:8	4:10	4:9
Panel A: All Goods				
$\Delta\tau^{DD}_{z,t}$		-42.4***	-22.8	-25.7*
		(14.05)	(13.70)	(13.64)
$\Delta\tau^{DD}_{z,t} \times HH_z$		280.0***	157.5*	174.1**
		(92.18)	(84.61)	(85.67)
$\Delta\tau^{DD}_{z,t} \times HH^2_z$		-415.6***	-244.1*	-266.7**
		(156.46)	(129.00)	(133.89)
Panel B: Phaseout Goods				
$\Delta\tau^{DD}_{z,t}$		-53.4***	-71.0***	-78.0***
		(18.27)	(22.33)	(25.74)
$\Delta\tau^{DD}_{z,t} \times HH_z$		372.6***	478.6***	518.5***
		(99.47)	(138.39)	(173.83)
$\Delta\tau^{DD}_{z,t} \times HH^2_z$		-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 (14) using different time horizons in the within year growth rate. Estimates from this Table are used in the construction of Figure 3 for which a tariff reduction of 1% generates stronger anticipatory slumps 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: Elasticities Consumer vs. Non-Consumer Goods

US Imports Mexico Dep. Var. :	(1) $m_{z,t}^{DD}$	(2) $\tilde{q}_{z,t}^{DD}$	(3) $\Delta m_{z,t}^{DD}$	(4) $\Delta \tilde{q}_{z,t}^{DD}$	Bias
1 { Non-Consumer Goods } $\times\ \tau_{z,t}^{DD}$	-10.4***	-8.15***			28%
	(1.60)	(1.59)			
1 { Consumer Goods } $\times\ \tau_{z,t}^{DD}$	-7.90***	-7.43***			6%
	(1.41)	(1.36)			
1 { Non-Consumer Goods } $\times\ \Delta\tau_{z,t}^{DD}$			-6.82***	-4.31***	58%
			(1.70)	(1.17)	
1 { Consumer Goods } $\times\ \Delta\tau_{z,t}^{DD}$			-2.28*	-1.68*	36%
			(1.33)	(0.96)	
Year FE	✓	✓	✓	✓	
HS6 FE	✓	✓	No	No	
N	15800	15800	11693	11693	
Adjusted R^2	0.02	0.02	0.003	0.006	

Note: Estimates in column 1 and 2 are obtained form equation 17. Estimates in column 1 and 2 are obtained form equation 18. Columns two and four use our baseline predicted measure of consumption of imports, described in (16). HS-6 goods are classified into consumer goods according to the BEC industry classification. Standard errors in columns one and two, in parentheses, are clustered at HS-6 level, and in columns three and four are robust. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.6: Model Simulation - Measure with Demand Shock in Long Run Elasticity

	Simulated	Simulated	Proxy	Proxy
Sample Period:	Years 1 & 4	Years 2 & 3	Years 1 & 4	Years 2 & 3
Dep. Var. :	q_t	q_t	$\tilde{q}_t$	$\tilde{q}_t$
1 { Benchmark } $\times \log(1+\tau_t)$	-4.18***	-4.34***	-4.10***	-4.43***
	(0.04)	(0.04)	(0.03)	(0.03)
1 { Low I/S } $\times \log(1+\tau_t)$	-4.05***	-3.97***	-4.00***	-3.99***
	(0.01)	(0.01)	(0.01)	(0.01)
1 { Unanticipated } $\times \log(1+\tau_t)$	-4.18***	-4.04***	-4.10***	-3.76***
	(0.04)	(0.04)	(0.03)	(0.03)
N	60000	60000	60000	60000
Adjusted R^2	0.48	0.48	0.58	0.58

Note: All estimates are obtained form equation 8 and by varying the dependent variable and the sample period included. Columns one and three are the same as columns three and four in Table 2. Columns three and four use as the measure of consumption of imports that includes a demand shock with 6 lags in the expected value of imports, described in (20) and (21). Standard errors, in parentheses, are clustered at firm level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.7: Dynamic Elasticity Estimates

Dep. Var. :	(1) $\Delta m_{z,t}^{DD}$	(2) $\Delta \tilde{q}_{z,t}^{DD}$	(3) $\Delta m_{z,t}^{DD}$	(4) $\Delta \tilde{q}_{z,t}^{DD}$
$\Delta\tau_{US,z,t}^{Mex,RoW}$	-4.19***	-2.53***		
	(1.25)	(0.89)		
$\tau_{US,z,t-1}^{Mex,RoW}$	-7.31***	-4.62***		
	(1.15)	(0.81)		
$1\{Phased\} \times \Delta\tau_{US,z,t}^{Mex,RoW}$			-7.07***	-2.92**
			(1.98)	(1.37)
$1\{Phased\} \times \tau_{US,z,t-1}^{Mex,RoW}$			-10.5***	-5.97***
			(1.64)	(1.14)
$1\{Others\} \times \Delta\tau_{US,z,t}^{Mex,RoW}$			-2.70*	-2.18*
			(1.48)	(1.11)
$1\{Others\} \times \tau_{US,z,t-1}^{Mex,RoW}$			-5.57***	-3.89***
			(1.43)	(1.04)
$y_{z,t-1}^{DD}$	-0.75***	-0.50***	-0.75***	-0.50***
	(0.01)	(0.01)	(0.01)	(0.01)
Year FE	✓	✓	✓	✓
HS6 FE	✓	✓	✓	✓
N	11290	11290	11290	11290
adj. R^2	0.344	0.314	0.345	0.314

Note: All estimates are obtained from (18). Columns one and three use the actual import flows as dependent variable. Columns two and four use the consumption of imports as the dependent variable. The last row shows the speed of adjustment towards the long-run value. Standard errors, in parentheses, are clustered at HS6 level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.8: 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				
$\Delta\tau^D_{z,t}$		0.18	0.20	0.61
		(1.04)	(0.81)	(0.76)
Panel B: Phaseout Categories				
$1 \{$ *Phased* $\} \times \Delta\tau^D_{z,t}$		-0.02	-0.31	0.54
		(1.22)	(0.94)	(0.86)
$1 \{$ *Others* $\} \times \Delta\tau^D_{z,t}$		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 (23) 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.9: Response of Canadian Exports to the US to Mexican Tariff Phaseouts

US Imports from Canada	Dep. Var.:	$\Delta_{\overline{n}:\underline{n}} m^{DD}_{z,t-1}$	
		Fall	Fall
	$\overline{n}$	11:12	11:12
	$\underline{n}$	3:10	5:10
Panel A: All Goods			
$\Delta\tau^{DD,MEX}_{z,t}$		-3.19**	-2.53*
		(1.28)	(1.27)
$\Delta\tau^{DD,CAN}_{z,t}$		3.43	2.13
		(2.98)	(2.81)
Panel B: Phaseout Categories			
$1\ \{\ \mathit{Phased}\ \} \times \Delta\tau^{DD,MEX}_{z,t}$		-4.35***	-3.64*
		(1.57)	(2.04)
$1\ \{\ \mathit{Phased}\ \} \times \Delta\tau^{DD,CAN}_{z,t}$		10.8**	9.90**
		(5.36)	(4.67)
$1\ \{\ \mathit{Others}\ \} \times \Delta\tau^{DD,MEX}_{z,t}$		-1.56	-0.78
		(1.92)	(1.93)
$1\ \{\ \mathit{Others}\ \} \times \Delta\tau^{DD,CAN}_{z,t}$		-1.10	-2.72
		(3.00)	(3.26)
HS6 FE		✓	✓
Observations		4946	4743
Adjusted R^2		0.14	0.14

Note: Estimates are from (24). In panel B goods are classified into phaseout categories according to staged US tariff reductions on Mexican imports. $\Delta\tau^{DD,c}_{z,t} = \Delta\frac{\ln(1+\tau^{US,c,z,t})}{ln(1+\tau^{US,Row,z,t})}$ for $c = \{Mexico, Canada\}$. Standard errors, in parentheses, are clustered at HS-2 level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure D.1: Median HS-8 Scheduled US Tariff Rates on Mexican by Phaseout Category

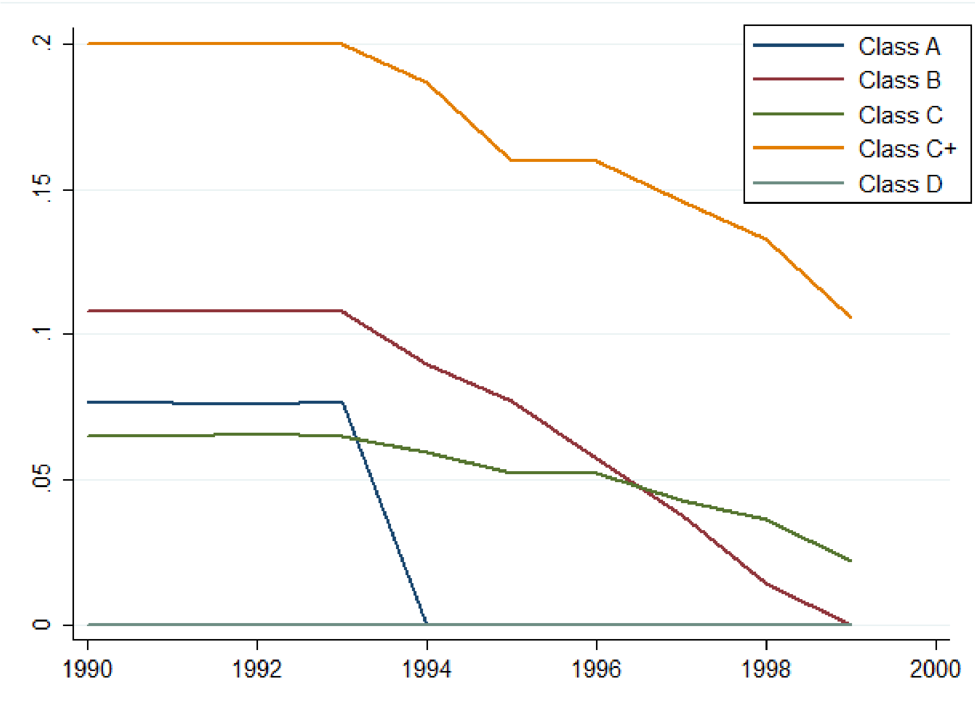
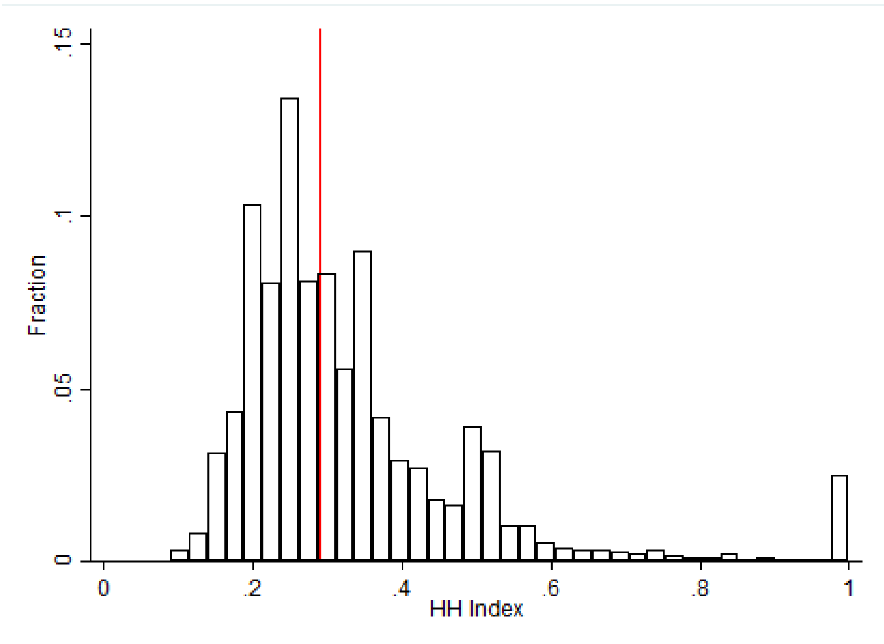
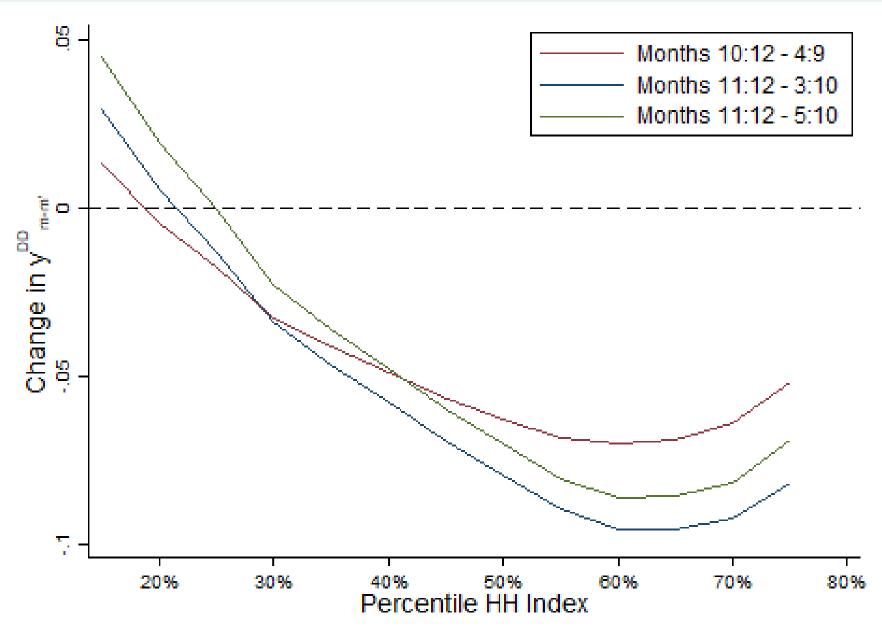


Figure D.2: Distribution of the HH Index



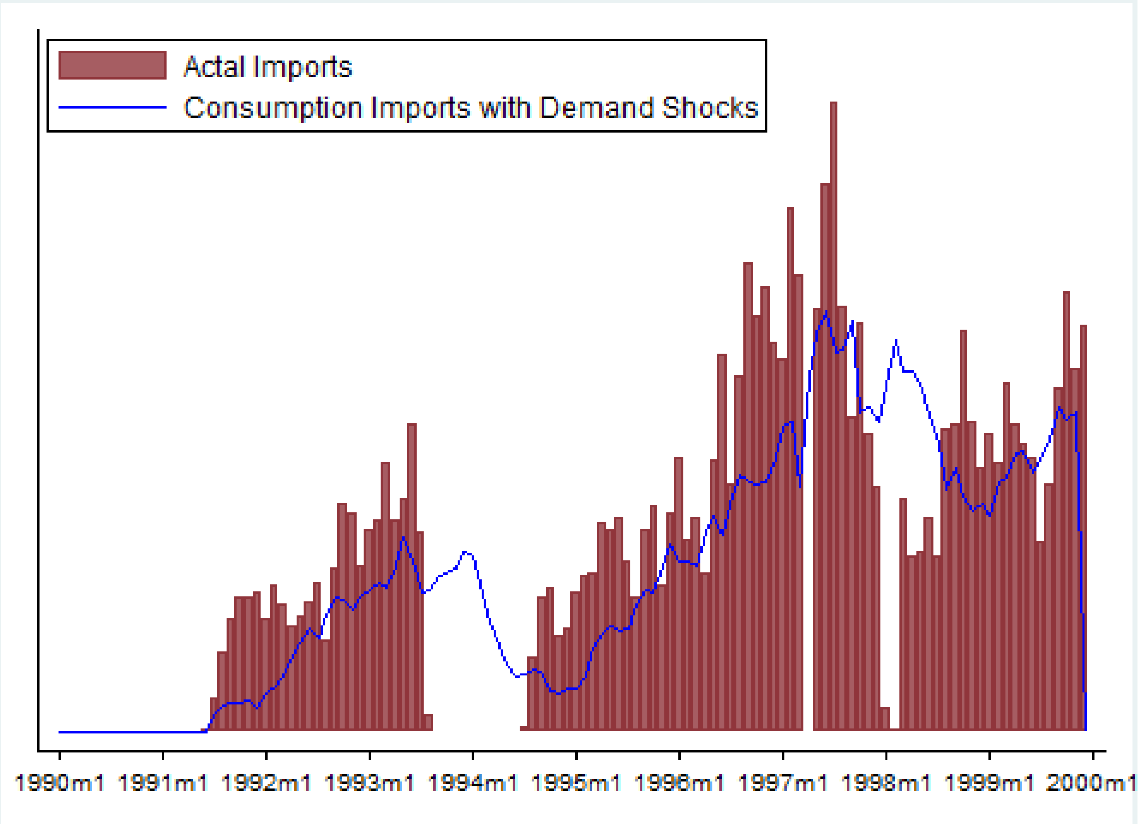
Note: This is the distribution over HH indexes calculated for each HS-6 good uses in section 3.5. For each HS6 product the HH index is calculated taking the median HH index of annual imports of goods at HS-10, district of entry and source country level in the second year the good appears in the sample, excluding Canada and Mexico.

Figure D.3: Anticipatory Elasticity and Storability for different $\Delta y^{DD}_{t,m-m'}$



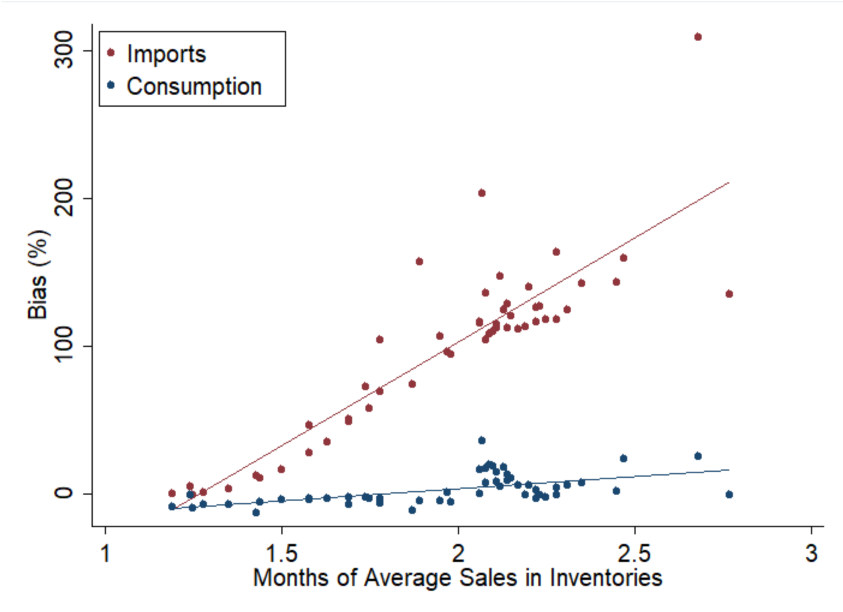
Note: The three plots correspond to the predicted $\Delta y^{DD}_{z,t,m-m'}$ from estimating equation (14) given $\Delta\tau^{DD}_{t+1} = -0.01$ at different percentiles of the HH Index for different values of m and m', that is for different time horizons of the within year growth rate. The sample includes only HS-6 goods that were phased out. It is calculated as $\hat{\sigma}^A = \hat{\sigma}^A_0 \times \Delta\tau^{DD}_{t+1} + \hat{\sigma}^A_1 \times \Delta\tau^{DD}_{t+1} \times P(HH) + \hat{\sigma}^A_2 \times \Delta\tau^{DD}_{t+1} \times P(HH)^2$. The estimation results with coefficients for $\sigma^A_{i=\{0,1,2\}}$, are reported in Table D.4 of the Appendix. The distribution of the HH index can be seen in Figure D.2. Its calculation is described in 3.5. Points with the dashed lines are withn the 90% confidence interval, calculated using the delta method.

Figure D.4: Example of our Measure with Demand Shocks



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 (20).

Figure D.5: The Inventory-Sales Ratio and the Bias in the Elasticity of Substitution



Note: Dots are the results from the simulations under the 51 calibrations reported in Tables 1 and D.3. The bias in the elasticity of substitution on the yaxis is measured as the difference in the estimate of σ from (2) in the years around the tariff change and q_{jt} in years one and four. Red uses $y_{jt} = m_{jt}$ and blue uses $y_{jt} = q_{jt}$. The inventory-sales ratio is measured as the average inventory holdings over sales in the first year of the simulation.