The Long and Short (Run) of Trade Elasticities*

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Abstract

We propose a novel approach to estimate the trade elasticity at various horizons. When large countries change MFN tariffs, small trading partners that are not in a preferential trade agreement experience plausibly exogenous tariff changes. The differential growth rates of imports from these countries relative to a control group – countries not subject to the MFN tariff scheme – can be used to identify the trade elasticity. We build a panel dataset combining information on product-level tariffs and trade flows covering 1995-2017, and estimate the trade elasticity at short and long horizons using the local projections method. Our main finding is that the trade elasticity in the year of the exogenous tariff change is about 0.2, and the long-run trade elasticity is around 1. Our long-run estimates are smaller than typical in the literature, and it takes 7-10 years to converge to the long run, implying that (1) the welfare gains from trade are high and (2) there are substantial market penetration costs to accessing new customers.

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1 Introduction

The elasticity of trade flows to trade barriers – the "trade elasticity" – is the central parameter in international economics. Quantifications of the impact of shocks or trade policies on trade flows, GDP, and welfare hinge on its value.

This paper develops and implements a novel approach to estimating trade elasticities. We make two contributions relative to existing methods. First, we tackle the issue of endogeneity of tariffs. Our identification strategy relies on the key institutional feature of the WTO system: the Most Favored Nation principle. Under this principle, a country must apply the same tariffs on all its WTO member trading partners. We make use of the fact that many trade partners are small, and estimate the trade elasticity based on the response of exports from small trading partners following an MFN tariff change in an importing country. The identifying assumption is that when a country changes its MFN tariff, it is unlikely that it did so in response to developments in the small exporters. Our estimation procedure then compares the trade flows from these small exporters to the country changing its MFN tariffs to a control group of exporters to the same country to whom MFN tariffs don't apply and thus for which tariffs did not change. This happens when the control country is in a preferential trade agreement with the importer.

Second, we provide estimates over several time horizons, ranging from 1 to 10 years. Because tariff changes can be autocorrelated, to estimate the impact of a tariff change at longer horizons we use time series methods, namely local projections (Jordà, 2005). This approach takes into account the fact that tariffs themselves may have a dynamic impulse response structure. One useful outcome of this exercise is that we can compare short- and long-run elasticities obtained within the same estimation framework. It is well-known that trade elasticities estimated from cross-sectional variation in tariffs tend to be much higher than the short-run elasticities needed to fit international business cycle moments. Normally, this divergence is attributed to the fact that the elasticities estimated from cross-sectional variation essentially reflect the long run. However, existing estimates either use purely cross-sectional variation (e.g. Caliendo and Parro, 2015), or a time difference over only one horizon (e.g. Head and Ries, 2001; Romalis, 2007). In both cases it is unclear whether what is being estimated is a long-run elasticity, an elasticity over a fixed time horizon, or a mix of short- and long-run elasticities. Our exercise provides mutually consistent estimates of the short- and the long-run elasticities, as well as the full path of the trade responses over time.

Our analysis uses the standard global database of international trade flows from BACI, and tariffs from UN TRAINS. The level of disaggregation is HS 6-digit, and the time period is 1995-2017.

Our main results can be summarized as follows. First, we estimate the long-run trade elasticity to be around 1, much lower than common estimates in the trade literature. This is consistent with a positive reverse causality between tariff and trade changes, whereby existing trade elasticity estimates are large in part because tariffs are reduced in sectors with larger anticipated trade flow increases. Second, short- and long-run trade elasticities differ substantially. The trade elasticity in the year of the initial tariff change is 0.2, and it takes 7 years for the elasticity to converge to its long-run value. The trade elasticity point estimate is stable between years 7 and 10, though the standard errors also widen. Third, there is substantial sectoral heterogeneity in the trade elasticity estimates. Across the 9 broad HS 1-digit sectors, the long-run elasticities range from 0.5 to 3. In addition, there is a fanning-out of elasticities over time, such that the estimated values across sectors differ by more at longer horizons. The year-zero trade elasticities range from 0.1 to 0.5.

Anderson and van Wincoop (2004) and Head and Mayer (2015) provide summaries of existing trade elasticity estimates. The common (but not the only) approach in international trade has been to use tariff variation to estimate this elasticity (Caliendo and Parro, 2015; Head and Ries, 2001; Romalis, 2007). Existing estimates do not attempt to address the reverse causality of tariffs with respect to trade flows, and do not distinguish multiple time horizons. An alternative is to estimate an elasticity of substitution structurally (e.g. Feenstra, 1994; Broda and Weinstein, 2006; Feenstra et al., 2018). In some environments the substitution elasticity governs the trade elasticity, but in others it does not. Our approach is not confined to environments in which the trade elasticity coincides with the elasticity of substitution. Our estimates complement analyses of firm-level responses to tariff changes (e.g. Berman, Martin, and Mayer, 2012; Fitzgerald and Haller, 2018). While these papers document the micro elasticities, our analysis yields the macro elasticities at multiple horizons.

The rest of the paper is organized as follows. Section 2 lays out the econometric framework and the identification strategy. Section 3 describes the data, and Section 4 the main results. Section 5 concludes.

2 Estimation Framework

2.1 Definition

As the objective of this paper is to estimate elasticities of trade volumes to trade cost shocks at different time horizons, we start with a definition of a horizon-specific trade elasticity. Let i and j index countries, p products, and t time. Let $X_{i,j,p,t}$ be the trade volume, and $\phi_{i,j,p,t}$ the "iceberg" trade cost. Denote by Δ_h a time difference in a variable between periods t and $t+h$: $\Delta_h x_t \equiv x_{t+h} - x_t$.

Definition. The *horizon-h trade elasticity* ε^h is defined as

$$\varepsilon^h = \frac{\Delta_h \ln X_{i,j,p,t}}{\Delta_h \ln \phi_{i,j,p,t}}. \tag{2.1}$$

Note that the long-run trade elasticity is obtained as $h \to \infty$. It measures the permanent change in trade flows that accompanies a permanent change in trade costs.

2.2 Estimation

In practice, we will be using tariff variation to estimate ε^h. Let the total trade costs be multiplicative in ad valorem tariffs $\tau_{i,j,p,t}$ and non-tariff costs $\kappa_{i,j,p,t}$:

$$\phi_{i,j,p,t} = \kappa_{i,j,p,t} \cdot (1 + \tau_{i,j,p,t}).$$

Then $\varepsilon^h \approx \Delta_h \ln X_{i,j,p,t} / \Delta_h \tau_{i,j,p,t}$, where we applied the approximation $\ln(1+\tau) \approx \tau$.

Let there be an exogenous change $\Delta_1 \tau_{i,j,p,t-1}$ in tariffs between $t-1$ and t. We estimate the following equation using local projections:

$$\Delta_h \ln X_{i,j,p,t} = -\beta_X^h \Delta_1 \tau_{i,j,p,t-1} + \delta_{i,p,t} + \delta_{j,p,t} + \delta_{i,j,p} + u_{i,j,p,t}^X, \tag{2.2}$$

where the δ's are fixed effects. This equation will give us an estimate β_X^h of the impact of a single-period change in tariffs from $t-1$ to t on change in trade flows between t and $t+h$. If $\Delta_1 \tau_{i,j,p,t-1}$ was a one-time change in tariffs, the coefficient β_X^h is an estimate of ε^h for each h.

One possible problem with this interpretation that in the data, tariffs themselves may change between t and $t+h$ following an initial shock $\Delta_1 \tau_{i,j,p,t-1}$. If we don't take into account that the tariff changes might be staggered over time, we would over-estimate the trade elasticity: attribute a large change in trade flows to a small initial tariff change not taking into account subsequent, dependent, tariff changes.[1] To account for this, we estimate how the initial shock in tariffs translates into the h-period change:

$$\Delta_h \tau_{i,j,p,t} = -\beta_\tau^h \Delta_1 \tau_{i,j,p,t} + \delta_{i,p,t} + \delta_{j,p,t} + \delta_{i,j,p} + u_{i,j,p,t}^\tau. \tag{2.3}$$

The horizon h trade elasticity can then be recovered as $\varepsilon^h = \frac{\beta_X^h}{\beta_\tau^h}$. This estimation can be carried out at different horizons $h = 0, ..., H = 10$, to trace the full profile of ε^h over h.

2.3 Identification

Estimating (2.2) by OLS would be similar to the common approach in the literature that treats all tariff variation as exogenous, with the caveat that we explicitly highlight the different impacts at different horizons. The estimating equations include importer-product-time and exporter-product-time fixed effects to control for changes in multilateral resistance, as well as a time-invariant source-destination-

[1] This is a problem similar to that faced by the fiscal multiplier literature.

product fixed effect to account for changes in product-specific impacts of bilateral resistance forces line distance. The identification problem then arises entirely from time-varying, bilateral, non-tariff barriers or other components of the error term.

In practice tariffs are set by governments which, in turn, are influenced by lobbyists, and subject to the WTO policy framework. There are three concerns with viewing applied tariff changes as exogenous. First, it is possible that a third factor drives both tariff changes and changes in trade flows. A newly elected government, for instance, could change various policies, including tariffs. This could lead to greater import demand due to lower tariffs, as well as the other policy changes. In a similar spirit, business cycle fluctuations could induce governments to change tariffs. Again, imports would change in part because of the tariff change, and in part due to the changes in economic conditions. Second, there could be reverse causality. It could be that governments change tariffs because of observed or anticipated changes in trade patterns. Third, it could be that foreign governments influence the country's government in question to change tariffs, either through the WTO body, or through other channels.

An instrument for tariff changes is difficult to find, as tariff changes (and more broadly, changes in trade policy) are unlikely to ever be unanticipated or orthogonal to economic activity. We turn to specific characteristics of the WTO's Most Favored Nation (MFN) tariff system to construct a plausibly exogenous instrument. All member countries of the WTO bound by treaty to set tariffs, subject to certain importer-specific bounds ("MFN bounds"), that apply uniformly to all other countries in the WTO. Exceptions to this agreement are countries that are in preferential or regional trade agreements (PTA/RTA) such as NAFTA. Tariffs between member countries of such agreements may be lower than the MFN tariff rate. The specific institutional feature of the MFN system we focus on is that a change in the MFN tariff rate applied by any importer (such as the US) against a trading partner (such as China) will also affect other countries subject to MFN rates (such as Hungary). Notice that while the country-specific MFN bounds set the maximum possible tariff rate that can be applied, actual product-level tariffs that are applied to all MFN trading partners can and do vary around the bounds.

As our baseline instrument, we use the insight that when a country changes its MFN rate on a product, it might do so due to lobbying by a partner country or concerns about imports from a partner country. However, as a consequence of this tariff change, third countries that are MFN partners are also affected. From the point of view of these third countries, the tariff change is plausibly exogenous. The response of imports from these third countries can then identify the trade elasticity. Further, to eliminate concerns that trade flows at the country/product level might be trending over time, we construct a control group of countries who – because they are in a PTA/RTA – are unaffected by the MFN tariff change.

This setup allows us to succinctly state the source of our identifying variation: we compare the change in imports from countries hit by a plausibly exogenous tariff change, due to their facing MFN tariffs, to the changes in imports from countries unaffected by the MFN system, whose tariffs did not change at the same time as they are trading on different terms.

Of course, it is not possible to identify the rationale behind every product-level tariff change. We presume that these endogeneity concerns will largely apply to large trading partners (for instance, the US and China). Our instrument therefore assumes that any MFN tariff changes applied to large trading partners are possibly endogenous, and so these trade flows will not be part of the baseline treatment or control group. Our baseline instrument is:

$$\begin{aligned}\Delta_1 \tau^{instr}_{i,j,p,t-1} \quad = \quad & \mathbf{1}\left(\tau_{i,j,p,t} = \tau^{\text{applied MFN}}_{i,j,p,t}\right) \times \mathbf{1}\left(\tau_{i,j,p,t-1} = \tau^{\text{applied MFN}}_{i,j,p,t-1}\right) \\ & \times \mathbf{1}\left(\text{not a major trading partner in } t-1 \text{ in aggregate}\right) \\ & \times \mathbf{1}\left(\text{not a major trading partner in } t-1 \text{ at product level}\right) \\ & \times \mathbf{1}\left(\text{not a major trading partner in } t \text{ in aggregate}\right) \\ & \times \mathbf{1}\left(\text{not a major trading partner in } t \text{ at product level}\right) \\ & \times \left[\tau^{\text{applied MFN}}_{i,j,p,t} - \tau^{\text{applied MFN}}_{i,j,p,t-1}\right].\end{aligned}$$

These terms can be understood as follows. The first two indicators simply say that the applied MFN tariff is binding for the countries and product in question both in the initial $t-1$ and final period t. The next four indicators relate to whether or not the exporter is a major trading partner in $t-1$ or t, either in terms of aggregate trade, or in terms of trade in product p. Finally $\tau^{\text{applied MFN}}_{i,j,p,t} - \tau^{\text{applied MFN}}_{i,j,p,t-1}$ is simply the change in the tariff from $t-1$ to t.

Then, we can estimate instrumented versions of equations (2.2) and (2.3), instrumenting the one year endogenous tariff change $\Delta_1 \tau_{i,j,p,t-1}$ with the instrument $\Delta_1 \tau^{instr}_{i,j,p,t-1}$. Further, we can directly estimate the horizon h trade elasticity, using:

$$\Delta_h \ln X_{i,j,p,t} = -\beta^h \Delta_h \tau_{i,j,p,t} + \delta_{i,p,t} + \delta_{j,p,t} + \delta_{i,j,p} + u_{i,j,p,t} \tag{2.4}$$

where we instrument $\Delta_h \tau_{i,j,p,t}$ with the same instrument $\Delta_1 \tau^{instr}_{i,j,p,t-1}$. Notice this specification simply combines the two instrumented local projections (2.2)-(2.3) and directly identifies the trade elasticity at horizon h: $\widehat{\beta}^h$ is an estimate of ε^h. Estimating (2.4) directly has the advantage that we can obtain standard errors for the elasticity estimates.

While our baseline estimates treat the trade elasticity as invariant across product categories, in practice, we also estimate the specifications for product sub-categories to obtain the distribution of β^h_p's.

Discussion This setup, which is an instrumented "diff-in-diffs," sets a high bar for identification in the following sense. First, the instrument and our estimating equation are differenced. We will always control for importer-product-year and exporter-product-year fixed effects, which eliminate concerns about broad tariff changes by a country across a number of products simultaneously, or time-varying importer- or exporter-product-specific supply or demand shocks. Further, we will always control for an importer-exporter-product fixed effect, which eliminates the mean bilateral product-level growth rate, removing concerns about any gravity variables that survive in the differenced specification. Any residual changes in tariffs are then not coming out of broader liberalizations/changes in trade policy or in response to any country-level economic conditions, and so most likely are the result of actions aimed at a specific partner in a specific product. Then, by eliminating the trade partners that are the likely targets of these tariff changes, the variation picked up by the instrument are tariff changes that are highly likely to be exogenous. Finally, by only identifying the elasticity from the differential growth rate of imports from the "treatment" group relative to countries in PTAs/RTAs (the "control" group), we leverage the time-series dimension of our data and allow for the elasticity estimates that might differ over different horizons due to general equilibrium feedback effects from the initial tariff changes.

Additionally, in our baseline estimates, the partner countries we believe suffer from an endogeneity problem are excluded from the treatment and the control group. We also conduct a robustness exercise where we include these countries in the treatment group (here, the instrument is simply the change in the MFN tariff rate for all countries subject to the MFN tariff rate).

Other candidates for instruments One downside of our instrument is that we cannot be certain we know which partner countries are involved in the MFN tariff change. We can conduct robustness exercises, but without inside knowledge of the reasons behind each MFN tariff change, our instrument will always face this issue. There are other candidate instruments that are theoretically feasible given the WTO framework. Here, we discuss these instruments and issues with each of them.

A natural candidate instrument is a WTO accession. When a country such as China joins the WTO, the negotiations are protracted, and there are substantial anticipation effects (see for instance Pierce and Schott, 2016). However, once China joins the WTO and sets its MFN tariffs, small third countries in the WTO are also affected by these MFN tariffs. These countries are plausibly facing an exogenous change, conditional on the anticipation effects, as they were likely not key players in the negotiations. While there are a few WTO accessions in our data, a key problem with implementing this instrument is that product-level tariff data are typically not available for countries *before* they join the WTO. It is therefore not possible to construct the exogenous tariff change (the change from the pre-WTO rate to the MFN rate).[2]

[2] We have contacted the national statistical agencies of countries that joined the WTO in our sample. Most agencies

A second instrument would be a change in the MFN bound, which is the maximum tariff a country in the WTO can apply against other countries. While these are likely less discretionary, the MFN bounds are set in the WTO accession treaty and very hard to change ex-post. The lack of instances of changes in the bounds implies there is insufficient variation in this instrument to estimate the elasticity.

Anticipation Effects One concern we face is the presence of anticipation effects. The third countries in the treatment group might adjust their exports in advance if they anticipate the tariff change as a result of negotiations between the importer and the large partner country. This would violate our identification assumption that the tariff change is exogenous for this group. This issue is further complicated by the fact that tariff decreases often follow a tariff increase (tariffs are autocorrelated), as we will demonstrate below. Separating anticipation effects from the effects of autocorrelated changes in tariffs is very challenging. While in general one can check for the presence of such anticipation effects by examining pretrends, in our context such pretrends might be expected, not because of anticipation effects but because trade flows are responding to the previous tariff increase that preceeded the exogenous decrease.

We note that such anticipation effects will (a) certainly be present in the standard OLS approach to estimating the elasticity where all tariff changes are treated as exogenous; and (b) only bias our estimates if they differentially affect the treatment and control groups. It is unclear in our context that the control group is unaffected. The PTA/RTA trading partner might also adjust their exports in anticipation of an MFN tariff increase against the large MFN partner, for instance. Further, both groups might respond to the autocorrelation of tariff changes, though the autocorrelation and the prevalance of tariff changes might differ between the groups. To the extent that there are differential pretrends, we can control for them using a standard pretrend control of lagged tariff changes.

2.4 Mapping Back to Theory: An Example

We stress that equations (2.2), (2.3), and (2.4) are "model free," and under our identification assumptions will produce estimates of ε^h by definition. The mapping between these estimates and parameters in theoretical models then depends on model structure. This section sketches one example of a mapping from the estimated parameters ε^h to a partially specified theory. We suppress the product dimension in the exposition to economize on notation.

Let the trade flows follow the gravity relationship:

$$X_{i,j,t} \propto \prod_{k=0}^{\infty} \phi_{i,j,t-k}^{-\theta_k} \cdot S_{i,t} \cdot D_{j,t} \tag{2.5}$$

do not have this data.

where $S_{i,t}$ and $D_{j,t}$ are the multilateral resistance terms, that vary by importer and exporter respectively, but not country pair. The non-standard feature of (2.5) is that time t trade flows are allowed to depend on past values of iceberg trade costs $\phi_{i,j,t-k}$ with a horizon-dependent elasticity θ_k. This would be the case if, for example, adjustment of trade is sluggish, and conditions in the past affect the trading relationships that exist in the present. Of course, this specification nests the traditional contemporaneous gravity equation, which obtains when $\theta_k = 0 \ \forall k > 0$. The assumption of dependence of current trade on past trade costs is falsifiable, and our empirical work can be viewed as an econometric test of this assumption. We assume that the structure of θ_k's is such that the long-run trade elasticity $\varepsilon \equiv \sum_{k=0}^{\infty} \theta_k$ is finite. This would be the case, for instance, if $\theta_k = 0 \ \forall k > K < \infty$.

Plugging in the form of iceberg trade costs and taking logs:

$$\ln X_{i,j,t} \propto \sum_{k=0}^{\infty} (-\theta_k \ln \kappa_{i,j,t-k} - \theta_k \tau_{i,j,t-k}) + \ln S_{i,t} + \ln D_{j,t}.$$

The impact of a single-period change in tariffs at t on trade at $t+k$ is:

$$\frac{\partial \ln X_{i,j,t+k}}{\partial \tau_{i,j,t}} \approx -\theta_k.$$

However, in the data tariff changes are persistent. The impact of a one-time permanent change in tariffs that occurs between $t-1$ and t on trade at $t+h$ is

$$\frac{\partial \ln X_{i,j,t+h}}{\partial \tau_{i,j,t}} = -\sum_{k=0}^{h} \theta_k \equiv -\theta^h. \tag{2.6}$$

Note the switch from a subscript on θ_k to a superscript on θ^h, to denote the cumulative nature of the latter. As $h \to \infty$, $\theta^h \to \varepsilon$, the long-run trade elasticity.

The h-year difference in trade flows is:

$$\begin{aligned} \Delta_h \ln X_{i,j,t} &\approx -\sum_{k=0}^{\infty} \theta_k \Delta_h \tau_{i,j,t} + \Delta_h \ln S_{i,t} + \Delta_h \ln D_{j,t} + u_{i,j,t} \\ &= -\sum_{l=0}^{h} \theta^l \Delta_1 \tau_{i,j,t+h-1-l} + \Delta_h \ln S_{i,t} + \Delta_h \ln D_{j,t} + u_{i,j,t} \end{aligned}$$

where the error term corresponds to the change in non-tariff bilateral trade costs, $u_{i,j,t} = -\sum_{k=0}^{\infty} \Delta_h \theta_k \ln \kappa_{i,j,t}$.

If there was a one-time exogenous shock to tariffs at a specific calendar t, $\Delta_1 \tau_{i,j,t-1}$, is easy to verify from the definition (2.1) that $\varepsilon^h = \theta^h$, and it could just be estimated by regressing $\Delta_h \ln X_{i,j,t}$ on that tariff change for each h, which corresponds exactly to equation (2.2).

However, tariff changes may be autocorrelated, and so a time-t innovation $\Delta_1 \tau_{i,j,t-1}$ may be followed by further changes later. To be concrete, suppose that tariff changes are AR(1) with coefficient ρ:

$$\Delta_1 \tau_{i,j,t} = \rho \Delta_1 \tau_{i,j,t-1} + \eta_{i,j,t},$$

where $\eta_{i,j,t}$ is an orthogonal innovation. Then, the impact of a time-t change in tariff on h-period ahead trade flows is given by:

$$\Delta_h \ln X_{i,j,t} = -\left(\theta^0 \rho^h + \theta^1 \rho^{h-1} + \theta^2 \rho^{h-2} + ... + \theta^h\right) \Delta_1 \tau_{i,j,t-1} + \Delta_h \ln S_{i,t} + \Delta_h \ln D_{j,t} + u_{i,j,t}.$$

Similarly, the expected impact of a time-t change in tariff on h-period ahead tariff itself is:

$$\Delta_h \tau_{i,j,t} = \left(1 + \rho + \rho^2 + ... + \rho^h\right) \Delta_1 \tau_{i,j,t} + \widetilde{\eta}_{i,j,t},$$

where $\widetilde{\eta}_{i,j,t}$ is a linear combination of different lags of $\eta_{i,j,t}$. This is none other than the local projection tariff change equation (2.3).

Then the h-period ahead trade elasticity is:

$$\varepsilon^h \equiv \frac{\theta^0 \rho^h + \theta^1 \rho^{h-1} + \theta^2 \rho^{h-2} + ... + \theta^h}{1 + \rho + \rho^2 + ... + \rho^h}.$$

This expression clarifies the nature of the empirical elasticity estimates. They answer the question: how does a shock to tariffs at time t change trade flows at time $t+h$, taking into account of the fact that tariff changes themselves can be serially correlated? It is a generalization of (2.6), which obtains when tariff changes are uncorrelated – $\rho = 0$ – and thus innovations to tariff levels are permanent. Note also that $\lim_{h \to \infty} \varepsilon^h = \varepsilon$ under the maintained assumption that the long-run elasticity is finite.

3 Data and Basic Patterns

Our trade data is the BACI version of the UN-Comtrade dataset, covering years 1995-2017. The data contain information on the trade partners, years, product codes at the HS6-level of disaggregation as well as the value and quantity traded. We link these data to two sources of information on tariffs. Our primary source of tariff data is the TRAINS dataset, also covering 1995-2017. This dataset includes information on the applied tariff and the MFN tariff for each year. We supplement these data with information from the WITS dataset on tariffs, covering 1996-2017. Unfortunately, for many countries comprehensive information on tariff rates is not available before they join the WTO. For robustness exercises, we also use data containing information on standard gravity variables such as distance, common border, common language etc from CEPII.

The most detailed product classification available in the trade data is at the HS6 level. However, we face the constraint that the data are provided in several different revisions of HS codes. Further, even within a year, countries report trade flows in different vintages of HS codes.[3] While some concordances of HS6 codes over time are available, we do not implement these fully here as they necessitate splitting values of trade across product codes in different revisions or aggregating product codes. As we do not observe transaction-level trade, any such split will introduce composition effects into our tariff measures. In particular, we could have spurious tariff changes coming from averaging tariffs when product codes are combined over time. Instead, our definition of a product is an HS6 code of a specific revision, tracked over time. We link product codes across revisions *only* when there is a one-to-one mapping between the codes across revisions. This approach is conservative, but it does instead introduce noise in any very long run elasticity estimates, as over a 20-25 year horizon there will be fewer product codes that map uniquely across revisions. Hence, our baseline horizon over which we estimate the trade elasticity is ten years, which corresponds typically to only two HS revisions. Across two revisions, typically 89% of product codes have a unique mapping, minimizing the noise. Appendix Table A1 provides the fraction of codes that map uniquely across revisions.[4]

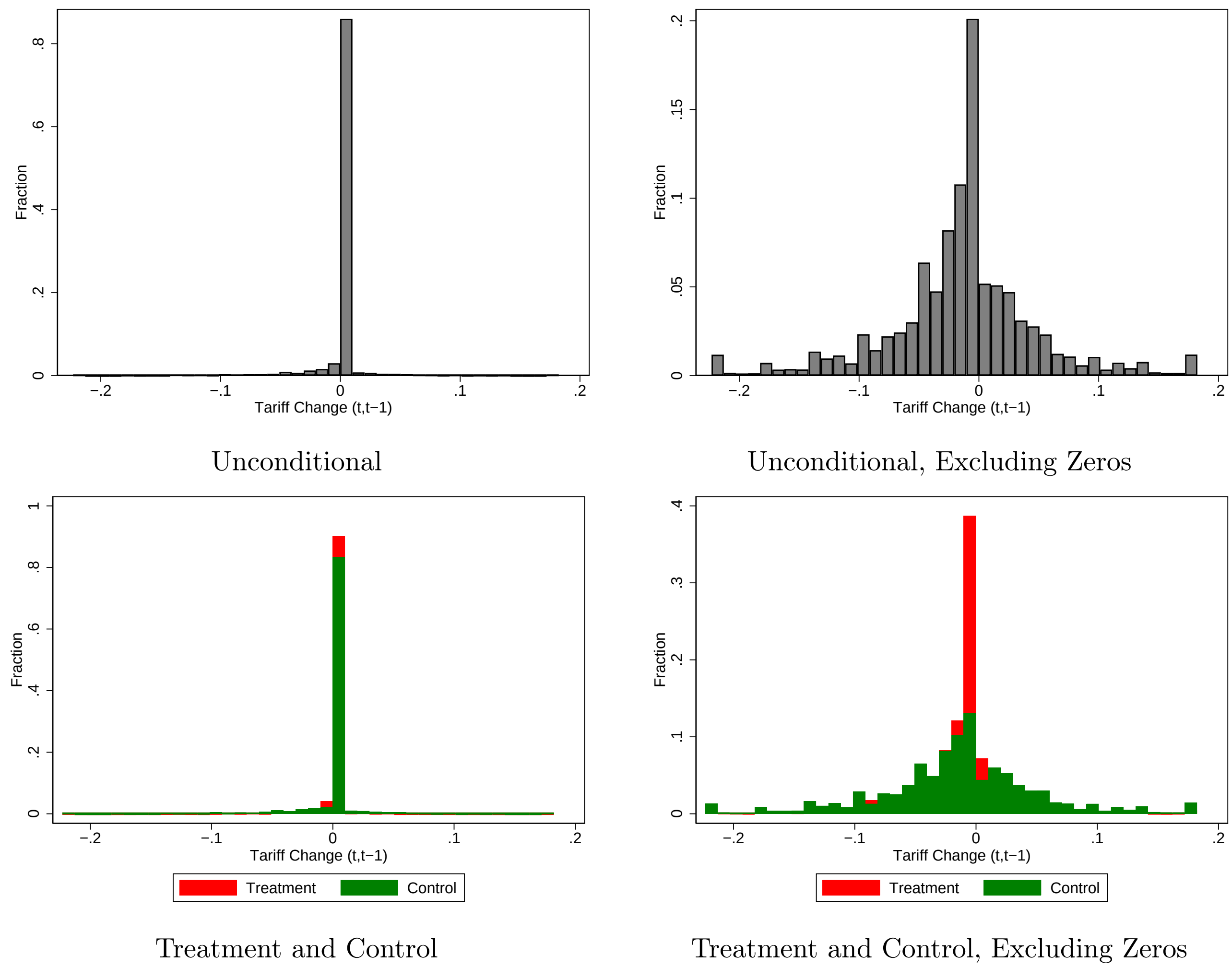
Patterns in tariff changes Figure 1 plots the histograms of tariff changes. The left panels plot all data, while the right panels plot the data conditioning on observing a tariff change. Note that while more than half the mass is below zero, there is also a substantial share of observations in which tariffs increase, conditional on a change. The bottom two panels separate treatment (red) and control (green) groups. Both experience a range of tariff changes. Figure 2 plots the autocorrelation functions for tariffs. The impact change is normalized to 1. The 1-period negative autocorrelation is evident for both treatment and control groups. This pattern motivates the use of time-series methods that explicitly account for the fact that impact tariff changes are not fully permanent.

Examples of the Instrument Appendix Table A2 provides an illustration of how the instrument is implemented. For three large importing countries (the USA, Japan and Germany) in 2005, we list partner countries that are either in the treatment, control or excluded group. As our instrument is defined at the product-level, countries that are in the treatment group for one product might be in the control group or excluded group for another (either because they trade at a non MFN rate on some products due to a PTA that differentiates by product, or because they are a major trading partner at the product-level). Similarly, countries that are in the control group for some products might also be in the excluded group for others. This applies in particular to countries that are large overall trading partners and are in RTAs (such as Canada for the US), but also have some trade with the US where products enter at MFN rates (often these MFN rates are the same as the PTA rates

[3] As far as we are aware, there is no double counting of trade flows in different vintages.

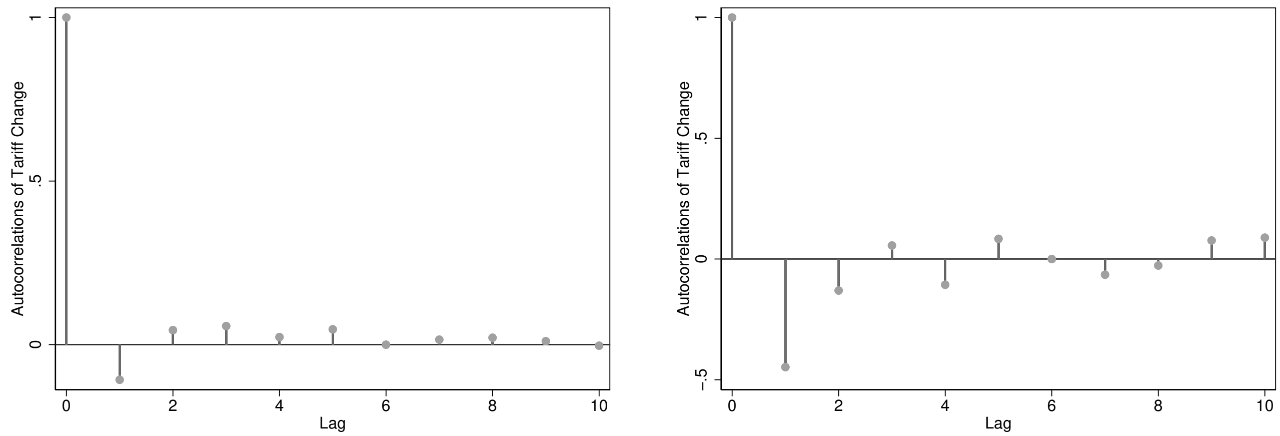
[4] Naturally, alternative specifications where we include several lags of tariff changes will require longer horizons than ten years, and increase the standard errors of the estimates.

Figure 1: Patterns in Tariffs: Frequency of changes



Notes: These figures display the frequency of tariff changes in our data. The top two panels display the unconditional frequency of all tariff changes (top left) and frequency excluding zeros (top right). The bottom panel displays the overlap in the frequency of changes in the treatment and control groups, including zero changes (left panel) and removing zero changes (right panel).

Figure 2: Patterns in Tariffs: Autocorrelation



Treatment Control

Notes: These figures display the autocorrelation of tariff changes for the treatment (left panel) and control (right panel) groups.

and are zero). In this instance, the products from Canada entering the US not under NAFTA, or under rates where NAFTA and MFN rates are the same, would be excluded from the analysis, and not used in the treatment or control groups.

As the table highlights, for the US, countries in NAFTA such as Canada and Mexico are important in the control group. The excluded group includes large trading partners like Germany, China, Japan and the UK. Countries that are in the treatment group include smaller trading partners who trade many products at MFN rates like the Netherlands, Switzerland and Ireland. While we do not incorporate explicit data on regional trade agreements, the instrument design appropriately assigns countries in customs unions or RTA/PTAs to control or excluded groups.[5] For Germany, for instance, EU member countries do not appear in the treatment groups, and are only part of the control or excluded groups.[6]

[5]The instrument might be improved if we could additionally incorporate information on RTAs/PTAs. This would help in particular in assigning observations to the control group instead of the excluded group in some instances where the RTA/PTA rate is the same as the MFN rate and the country is a large trading partner. Currently, these observations have to be excluded. Unfortunately, while aggregate data on RTAs is available, this data is typically not product-level. Many free trade agreements exclude certain products, and applying them to all products is problematic for our estimation. Assigning observations to the excluded group increases our standard errors but is the conservative solution.

[6]Notice again while tariffs between France and Germany are zero, and while France is clearly in a customs union with Germany, France can appear in the excluded group for Germany if the EU's MFN tariffs on a product moving from France to Germany are zero in two consecutive periods.

Summary statistics: Treatment vs Control Table 1 compares the treatment, control and excluded groups in the period before the tariff change. In terms of the dollar value of trade flows, countries in the control and excluded groups are larger than the treatment group, on average. This is consistent with the instrument excluding major trading partners, and larger trading partners being more likely to be in preferential trade agreements. Countries in the control group have systematically lower tariffs in place as well, again consistent with this group largely including countries in PTAs or RTAs. Tariff growth is more negative for the control group, and similar for the treatment and excluded group.

Notice that these systematic differences between the treatment and control group countries are soaked up in our estimation by partner country-product-time fixed effects. As our specifications are in differences, these fixed effects capture the time-varying differences in these partner characteristics.

TABLE 1: Comparing Treatment, Control and Excluded Groups

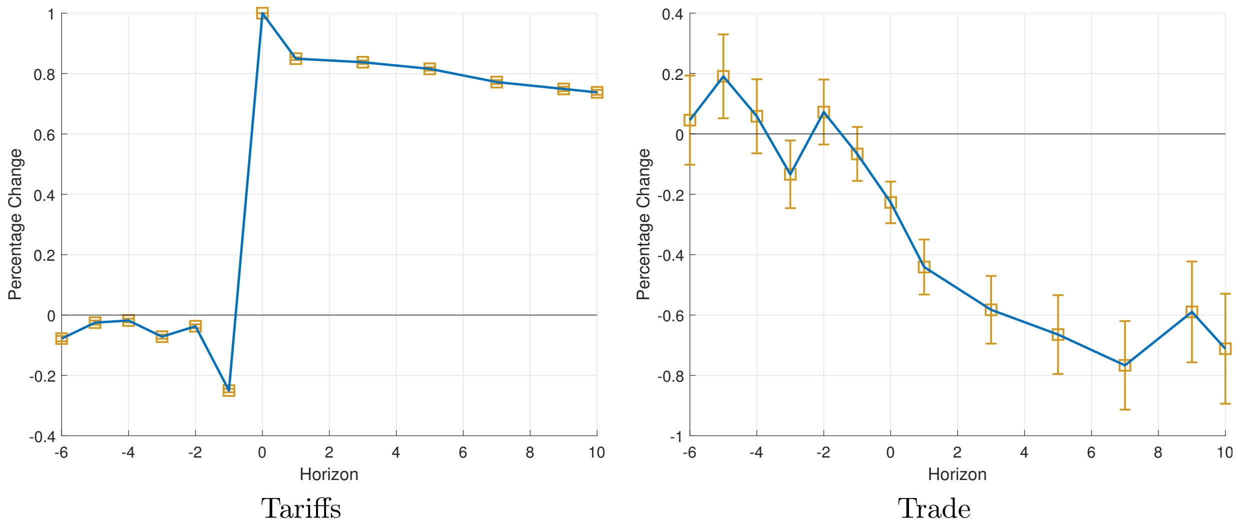
	Treatment		Control		Excluded	
	Mean	Median	Mean	Median	Mean	Median
Panel A: Trade Flows						
Trade Value, $t-1$	586.21	31.42	2321.43	78.22	3677.83	81.29
Change in Trade, $(t-2, t-1)$	-8.27	0.86	99.31	1.34	219.82	2.00
Change in Trade %, $(t-2, t-1)$	278.16	5.68	219.82	4.51	305.68	6.22
Panel B: Tariffs, Including Zero Changes						
Tariff Rate, $t-1$	5.46	2.20	1.42	0.00	6.94	4.30
Change in tariff, $(t-2, t-1)$	-0.09	0.00	-0.40	0.00	-0.12	0.00
Panel C: Tariffs, Excluding Zero Changes						
Tariff Rate, $t-1$	9.96	7.50	7.74	6.00	11.79	10.00
Change in tariff, $(t-2, t-1)$	-0.78	-0.55	-2.78	-1.83	-0.94	-0.90

Notes: Trade values are in thousands of USD. Tariffs are in percentages. Panel A compares trade flows between the treatment, control and excluded groups. Panels B and C compare tariffs between the three groups. The statistics in Panel B include zero tariffs, and in Panel C exclude zero tariffs.

4 Results

We begin by estimating the impact effects of a one-time tariff change on h-periods ahead trade flows and tariffs, as in (2.3) and (2.2), using our instrumental variables approach. The left panel of Figure 3 reports the time path of tariff changes h periods after the initial 1-unit change. Thus, by construction the $h = 0$ value is 1. The mean reversion in tariff levels is evident: following an initial impulse of 1, only 0.8 of the change remains after about 5 years. At the same time, there appears to

Figure 3: Local Projections: Tariffs and Trade



Notes: This figure displays the results from estimating equations (2.2) and (2.3)– the local projection of tariff growth (left panel) and imports (right panel) on one period tariff growth instrumented at various horizons. The equation is estimated with no pretrend controls. Standard error bars indicate 95% confidence intervals. Standard errors are clustered at the bilateral country-pair-product level.

be a pre-trend, with the $h = -1$ value of -0.2. We will control for this pre-trend by including lags of tariff changes in our robustness checks.

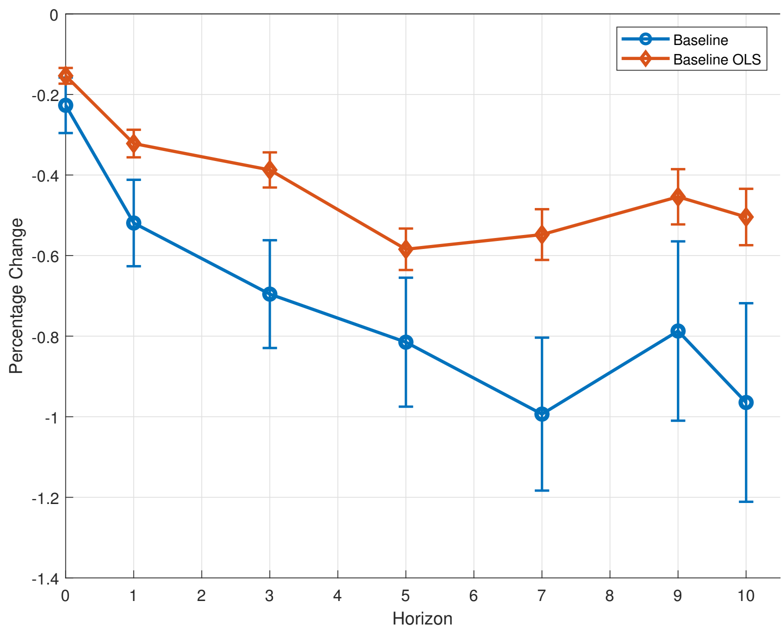
The right panel of 3 estimates the impact of an initial tariff change on trade flows. Here, the pre-trend is not evident. Trade flows have an elasticity to tariff changes of -0.2 on impact, converging a range of -0.75 to -0.8 in the long run.

Figure (2.4) reports our baseline estimates of the trade elasticity ε^h across horizons. The point estimate is -0.2 on impact, and -1 in the long run. Over the first 7 years, the elasticity converges smoothly to the long-run value. The red line reports the OLS estimates. Actually, OLS produces a smaller trade elasticity than IV. The time pattern is roughly similar for OLS and IV.

4.1 Sectoral Heterogeneity

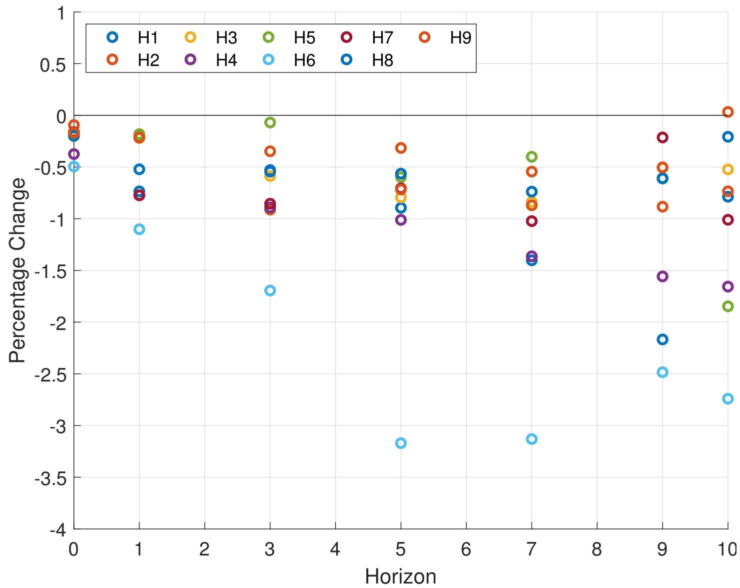
We next estimate the trade elasticities by broad sector. Figure 5 plots the point estimates of the trade elasticities over h for the 9 1-digit HS broad sectors. The long-run elasticities range from less than 1 to 3 even in this coarse sectoral breakdown. In addition, the elasticities fan out over time. The range of elasticities at $h = 0$ is from about 0.1 to 0.5, much narrower in absolute terms than the long-run range. Table 2 presents the summary statistics for the trade elasticities at the 1-digit level,

FIGURE 4: Trade Elasticity: OLS vs IV



Notes: This figure displays the trade elasticity estimated using the baseline instrumented specification in (2.4), compared to the OLS estimates. The equations are estimated with no pretrend controls. Standard error bars indicate 95% confidence intervals. Standard errors are clustered at the bilateral country-pair-product level.

FIGURE 5: Trade Elasticity: Sectoral Heterogeneity



Notes: This figure displays the trade elasticity estimated for individual HS1 sectors using the baseline instrumented specification in (2.4). The equation is estimated with no pretrend controls. Standard error bars indicate 95% confidence intervals. Standard errors are clustered at the bilateral country-pair-product level.

by horizon. The mean and median elasticities at the sector level are quite close to the aggregate numbers reported above.

4.2 Robustness

Figure 3 reveals some evidence of a pre-trend in tariffs. The pre-trend can be controlled for by adding lags of import growth and tariff changes. Columns 2 and 3 of Table 3 add 2 and 5 lags, respectively, to compare the results to the baseline in column 1. The point estimates change very little due to adding lags, although at times the standard errors rise substantially. Table 4 reports the results of local projections of tariffs and trade flows directly on the initial tariff change, as in (2.2)-(2.3), while allowing for 2 and 5 lags. Once again, the point estimates change little when adding lags.

The baseline instrument excludes large trading partners from the control group. Column 4 of Table 3 reports the results of admitting large trading partners into the control group. The point estimates change very little. Column 5 uses quantities instead of values. It turns out that the impact in the long run is mostly on quantities.

Table 2: Trade Elasticity: Sectoral Heterogeneity

	Mean (1)	Median (2)	25 percentile (3)	75 percentile (4)
t	-0.239	-0.189	-0.348	-0.168
$t+1$	-0.497	-0.383	-0.772	-0.215
$t+5$	-0.858	-0.712	-0.894	-0.564
$t+10$	-0.975	-0.761	-1.656	-0.273

Notes: This table presents results from estimating equation (2.4) at the HS1-level. All specifications include importer-HS3-year, exporter-HS3-year and importer-exporter-HS3 fixed effects. Standard errors are clustered at the importer-exporter-HS3 level.

Table 3: Trade Elasticity: Robustness

	Baseline (1)	Two Lags (2)	Five Lags (3)	All Partners (4)	Quantities (5)
t	-0.227***	-0.273***	-0.177***	-0.292***	-0.142***
	(0.035)	(0.047)	(0.091)	(0.018)	(0.043)
$t+1$	-0.519***	-0.594***	-0.439***	-0.536***	-0.372***
	(0.055)	(0.070)	(0.131)	(0.027)	(0.066)
$t+5$	-0.815***	-0.865***	-1.068***	-0.752***	-0.619***
	(0.082)	(0.119)	(0.255)	(0.038)	(0.098)
$t+10$	-0.965***	-0.519***	-1.102***	-0.784***	-0.881***
	(0.082)	(0.055)	(0.540)	(0.056)	(0.150)

Notes: This table presents robustness exercises for the results from estimating equation 2.4. Columns (2) and (3) vary the pretrend controls (including alternatively two lags or five lags of import growth and tariff changes). Column (4) uses an alternative definition of the instrument where all trade partners subject to the MFN regime are included. All specifications include importer-HS3-year, exporter-HS3-year and importer-exporter-HS3 fixed effects. Standard errors are clustered at the importer-exporter-HS3 level. ***, ** and * indicate significance at the 99,95 and 90 percent level respectively.

Table 4: Local Projections: Alternative Controls

	Baseline (1)	Two Lags (2)	Five Lags (3)
Panel A: Tariffs			
$t-5$	-0.025***	-0.017***	
	(0.004)	(0.004)	
$t-2$	-0.037***		
	(0.003)		
$t+1$	0.849***	0.887***	0.881***
	(0.002)	(0.004)	(0.005)
$t+5$	0.816***	0.809***	0.805***
	(0.003)	(0.005)	(0.008)
$t+10$	0.738***	0.694***	0.692***
	(0.004)	(0.008)	(0.013)
Panel B: Trade			
$t-5$	0.191***	0.073	0.000
	(0.071)	(0.087)	(0.000)
$t-2$	0.073	0.000	0.000
	(0.055)	(0.000)	(0.000)
t	-0.227***	-0.321***	-0.177**
	(0.035)	(0.058)	(0.091)
$t+1$	-0.441***	-0.583***	-0.386***
	(0.047)	(0.075)	(0.115)
$t+5$	-0.665***	-0.732***	-0.859***
	(0.067)	(0.122)	(0.205)
$t+10$	-0.712***	-0.697***	-0.763**
	(0.093)	(0.197)	(0.375)

Notes: This table presents the results from estimating equations (2.3) (Panel A) and (2.2) (Panel B) with alternative pretrend controls. All specifications include importer-HS3-year, exporter-HS3-year and importer-exporter-HS3 fixed effects. Standard errors are clustered at the importer-exporter-HS3 level. ***, ** and * indicate significance at the 99,95 and 90 percent level respectively.

4.3 Relationship to Other Estimates

Our preferred IV estimates of the trade elasticity are very close to zero in the short run, rising to about 1 in the long run. These are substantially smaller than the literature, where the estimates range between 5-10 (see for instance the review in Anderson and van Wincoop, 2004). Interestingly, even our OLS estimates, which take all tariff variation as exogenous as typical in the literature, are much smaller than those commonly estimated in other studies. Table 5 investigates the source of these differences.

Panel A of the table estimates the elasticity using a log-levels OLS specification, assuming all tariff variation is exogenous. In this specification, both without fixed effects and with the most commonly used fixed effects to account for multilateral resistance (importer-product-time and exporter-product-time), we find estimates of around 3, which are similar to previous estimates. We then implement a version of the levels specification where we include additional fixed effects, in particular, country-pair-product fixed effects. The elasticity estimates fall sharply to about 0.8, consistent with our baseline OLS estimates. These fixed effects soak up any confounders in the gravity equation that are country-pair-product specific (for instance, different, but constant, shipping costs between a pair of countries for steel and agricultural products). Clearly, including them is important for the estimation.

Panel B of the table then presents the results of a 5 year differenced OLS specification. The estimates fall sharply across all combinations of fixed effects, and are much closer to 1 in absolute terms. Differencing removes additional confounders, as discussed in section 2.

Panel C then implements a specification in which the five year differenced tariff change on the right-hand-side is instrumented by the actual one year tariff change at the start of the 5-year period. This is an intermediate step between running simple differenced OLS and our full instrumentation strategy. Here, the estimation is by 2SLS, but we do not claim it is an IV since we are using all initial-year tariff changes, rather than the exogenous subset.

The rationale of using only the initial 1-year tariff change is that relying on high-frequency variation minimizes the impact of other confounding factors. In addition, using just the initial year tariff change to identify the coefficient implies that we are closer to picking up a 5-year impact of a tariff change, rather than the impact of tariff changes that occurred late in the 5-year period. This is an object closer to the 5-year elasticity. Again, across all versions of the fixed effects estimates are smaller and even closer to 1. In our preferred specification in Column 5, which is the same as our baseline OLS estimation of equation (2.4), the estimate is -0.584, so quite far below 1.

Panels D and E implement two versions of our IV specification. Panel D has the conservative baseline instrument, excluding major trading partners, and Panel E has the IV including all trading partners with pure diff-in-diff identification. Relative to the OLS estimates in Panel C, both instruments push estimates away from 0. The conservative instrument increases estimates the most relative to OLS, as expected, but has larger standard errors. This instrument brings the estimates closer to 1 in the specifications with the country-pair-product fixed effects.

5 Conclusion

We develop a novel method to estimate the trade elasticity, a key structural parameter in a large class of trade models. To tackle the endogeneity problem that tariffs might be lower in products where countries expect the largest trade flows, we develop an instrument that relies on the MFN principle between WTO members. We estimate trade elasticities at different horizons, and find impact estimates that are close to zero, and long-run estimates close to 1. Our estimates are robust to alternative specifications of the instrument and controls, and uniformly larger than OLS. Our estimates are also not specific to a particular model framework, and apply to all models that have a gravity specification for trade flows in the long run.

Our finding that the trade elasticity differs by horizon and only converges to the "long-run" parameter used in trade models after about 7-10 years implies that the adjustment to trade cost shocks takes about a decade to play out. Our estimates are significantly smaller than those previously estimated in the literature, suggesting the welfare gains from trade are large.

Table 5: Elasticity Estimates: Alternative Approaches

	(1)	(2)	(3)	(4)	(5)
Panel A: Log-levels, OLS					
Trade Value	-3.108***	-3.244***	-3.424***	-1.847***	-0.760***
SE	(0.003)	(0.004)	(0.005)	(0.004)	(0.005)
R2	0.009	0.240	0.262	0.362	0.385
Obs	104428371	104426722	104335941	104098266	104006770
Panel B: 5-year log-differences, OLS					
Trade Value	-1.857***	-1.393***	-0.691***	-1.463***	-0.641***
SE	(0.007)	(0.008)	(0.011)	(0.008)	(0.011)
R2	0.002	0.044	0.100	0.080	0.136
Obs	37125831	37123808	37077344	37044422	36995902
Panel C: 5-year log-differences, 2SLS, tariffs instrumented by actual 1-year tariff change					
Trade Value	-1.217***	-0.794***	-0.554***	-0.838***	-0.584***
SE	(0.015)	(0.017)	(0.024)	(0.017)	(0.025)
R2	0.002	0.001	0.000	0.001	0.000
Obs	37125831	37123808	37077344	37044422	36995902
Panel D: 5-year log-differences, 2SLS, baseline instrument					
Trade Value	-2.669***	-1.733***	-0.796***	-1.691***	-0.815***
SE	0.036	0.045	0.071	0.049	0.076
R2	0.001	0.001	0.000	0.001	0.000
Obs	21460925	21458477	21404389	21386525	21329471
Panel E: 5-year log-differences, 2SLS, all partners instrument					
Trade Value	-1.869***	-1.241***	-0.696***	-1.346***	-0.752***
SE	0.018	0.022	0.035	0.023	0.036
R2	0.002	0.001	0.000	0.001	0.000
Obs	37125831	37123808	37077344	37044422	36995902
Fixed effects					
importer x hs3	no	yes	no	yes	no
exporter x hs3	no	yes	no	yes	no
importer x hs3 x year	no	no	yes	no	yes
exporter x hs3 x year	no	no	yes	no	yes
importer x exporter x hs3	no	no	no	yes	yes

Notes: This table presents the results from estimating the trade elasticity at a single horizon of 10 years using alternatively, a log-levels specification (Panel A), a differenced specification (Panel B) and an instrumented and differenced specification (Panel C). Column (1) reports the results with no fixed effects. Column (2) adds importer-product and exporter-product fixed effects, Column (3) interacts these fixed effects with years, Column (4) includes importer-product, exporter-product and country-pair-product fixed effects and Column (5) includes our baseline fixed effects. Robust standard errors are in paranthesis. ***, ** and * denote significance at the 99,95 and 90% confidence interval.

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Appendix A Data

Table A1: HS Codes Mapping Across Revisions

		Mapped to:				
		HS-92	HS-96	HS-02	HS-07	H12
Mapped from:	HS-96	89.38				
	HS-02	81.55	90.81			
	HS-07	73.34	80.74	88.48		
	HS-12	68.17	74.91	81.81	91.93	
	HS-17	61.85	67.92	73.62	81.99	88.05

Notes: This table presents the fraction of HS codes that can be mapped uniquely from as HS revision in the "Mapped From" row to an HS revision in a "Mapped To" column. All numbers are in percentages.

Table A2: Instrument- Illustration

Importer	Ranking: Trade Value			Ranking: Num. Products		
	Treatment	Control	Excluded	Treatment	Control	Excluded
	(1)	(21)	(3)	(4)	(5)	(6)
USA	NLD	CAN	CAN	NLD	CAN	CAN
	CHE	ESP	CHN	CHE	ESP	CHN
	IRL	IND	MEX	IRL	IND	DEU
	ESP	MEX	JPN	ESP	MEX	GBR
	AUT	BEL	DEU	AUT	BEL	MEX
JPN	GBR	CHN	CHN	GBR	CHN	CHN
	BEL	NLD	USA	BEL	NLD	USA
	CHE	IND	AUS	CHE	IND	DEU
	ESP	BEL	IDN	ESP	BEL	KOR
	NLD	CAN	DEU	NLD	CAN	THA
DEU	IND	FRA	FRA	IND	FRA	FRA
	CAN	NLD	ITA	CAN	NLD	NLD
	KOR	ESP	NLD	KOR	ESP	BEL
	AUS	ITA	GBR	AUS	ITA	ITA
	HKG	BEL	CHN	HKG	BEL	GBR

Notes: This table presents examples of how countries are assigned to treatment, control and excluded groups for some of the largest importers in the data. We use the year 2005 for the illustration. Treatment and Control groups are assigned at the product-level in the baseline, so countries can appear in both treatment and control groups or control and excluded groups for different products as explained in the text. We use the products coded in the HS92 revision. Columns (1)-(3) rank countries in descending order by value of exports and (4)-(6) rank countries by number of products exported.