Trade Agreements: What Do Governments Maximize?*

Francesco Amodio† Leonardo Baccini‡ Giorgio Chiovelli§ Michele Di Maio¶

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Abstract

The traditional political economy view of trade is that governments choose tariffs to maximize a weighted sum of producer and consumer surplus, with relative weights capturing the influence of producer lobbies. Such weights determine both the level of tariffs and their relationship with comparative advantage and import penetration. To partially identify these weights, we use data on Preferential Trade Agreements (PTAs) and the associated changes in tariffs on agricultural imports. We exploit plausibly exogenous variation in comparative advantage as induced by rainfalls during the growing season within and across countries in the years prior to the final signature to identify its impact on the extent of tariff reduction across crops. We find that when comparative advantage in producing a given crop increases governments decrease tariffs on imports of that crop to a smaller extent. These results suggest that during trade negotiations governments place a high weight on producers relative to consumers in their objective function. Our estimates imply that the average percent reduction in tariffs mandated by the PTAs in our sample would have been at least two times higher – from 41% to 93% – in the absence of any rainfall-induced increases in comparative advantage during the negotiation period.

Keywords: agricultural tariffs, political economy of trade, trade agreements.

JEL Codes: F11, F13, F14, F15.

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†McGill University and CIREQ.

‡McGill University and CIREQ.

§Universidad de Montevideo.

¶Sapienza University of Rome.

1 Introduction

The political economy view of trade is that governments are concerned with the distributional implications of their tariff choices, and subject to the pressure of special interest groups (Van Long and Vousden 1991; Grossman and Helpman 1994, 1995a,b; Bagwell and Staiger 1999). In its simplest formulation, the government problem is to choose the tariff level that maximizes a weighted sum of producer and consumer surplus. The greater the influence of producer lobbies, the greater the relative weight placed on producers in the government's objective function.

The objective of this paper is to identify such relative weight. From Goldberg and Maggi (1999) to Gawande, Krishna, and Olarreaga (2009), several papers have taken the theory of Grossman and Helpman (1994) to the data using structural estimation methods.[1] Our approach is different. First, we present a simple theoretical framework showing that the relative weight attached to producers in the government's objective function determines not only the level of import tariffs, but also their relationship with comparative advantage and import penetration. Higher comparative advantage makes both the negative effect of foreign competition on producer surplus and its positive effect on consumer surplus larger in magnitude. If the government weigh the former more than the latter, tariffs will increase with comparative advantage. The opposite holds if the government places a high weight on consumers relative to producers.

Second, we take this prediction to the data. We focus on agricultural products and tariffs on agricultural imports. We combine geographical and climate information at very fine spatial resolution to build a plausibly exogenous, time-varying source of variation for comparative advantage in producing a given crop. We then relate this measure to the changes in tariffs on agricultural imports mandated by a large number of Preferential Trade Agreements (PTAs). Specifically, we test whether changes in comparative advantage as induced by climate shocks during the negotiation period affect a country's negotiated change in tariffs. We find that when comparative advantage in producing a given crop increases governments decrease tariffs on imports of that crop to a smaller extent. When interpreted through the lens of the model, this finding suggests that governments place a high weight on producers relative to consumers in their objective function.

Our empirical strategy exploits variation in comparative advantage as induced by rainfalls during the growing season within and across countries in the years prior to the final PTA signature to identify its impact on the magnitude of tariff reduction across crops. To validate our newly constructed source of variation for comparative advantage, we use data on trade flows across countries to show that it correlates strongly with net exports in the direction that theory predicts. We also evaluate the robustness of our findings using rainfalls during the non-growing season as a *placebo*. Evidence robustly shows that positive (negative) changes in comparative advantage that materialize during the PTA negotiation period are associated with a lower (higher) negotiated reduction in import tariffs. Based on our estimates, we calculate that the average percent reduction in tariffs mandated by the PTAs in our sample would have been at least two times higher – from 41% to 93% – in the absence of any rainfall-induced increases in comparative

[1] See Gawande and Krishna (2008) for a review.

advantage during the negotiation period.

The climate shocks that we consider and exploit for identification are transitory. Although they trigger changes in comparative advantage, if government officials had full information over comparative advantage, they would not change their behavior at the PTA negotiation table. This would work against us finding any relationship between the shock measure we build and the negotiated change in tariffs. Therefore, our findings also imply that governments are not fully informed over own comparative advantage, and that the changes in agricultural production associated with climate shocks are regarded as permanent at least to some extent. That is, governments continuously update their beliefs over comparative advantage in producing a given crop, and shocks as we measure them yield changes in such beliefs.

The remainder of the paper is organized as follows. Section 2 presents a simple canonical model that guides the empirical analysis. Section 3 presents the data. Section 4 illustrates the empirical strategy and results. Section 5 concludes.

2 The Model

Consider two countries, home (H) and foreign (F), and two goods, N and M, with good N serving as numeraire. Both goods are produced in both countries by single independent producers using inputs that are specific to each good. The marginal cost of producing good N is equal to one in both countries. The home producer of good M has marginal cost equal to c while the foreign producer has marginal cost equal to one. It follows that c also measures the inverse comparative advantage of country H in producing good M.

The representative consumer in country H has preferences given by $U = C_N + u(C_M)$. We assume $u(C_M) = vC_M - \frac{C_M^2}{2}$, where v is a positive parameter. The analysis that follows focuses on good M, exchanged in country H at price p. The corresponding demand curve is $D(p) = v - p$ and consumer surplus is $S(p) = u(D(p)) - pD(p) = D^2(p)/2$.

The home government chooses a specific tariff t on imports. If tariffs are not prohibitive, it follows that $p = p^* + t$, where p and p^* are the prices charged by the domestic and foreign producer respectively. The quantities produced are given by q and q^* respectively. At equilibrium, the marginal utility of the representative consumer equals the market price, and the total quantity consumed is equal to the total quantity produced so that $v - q - q^* = p = p^* + t$.

The domestic and foreign producers engage in Cournot competition. They take each other's produced quantity as given and choose the level of q and q^* respectively that maximize their profits

$$\begin{aligned} \Pi &= pq - cq = (v - q - q^*)q - cq \\ \Pi^* &= p^*q^* - q^* = (v - t - q - q^*)q^* - q^* \end{aligned} \tag{1}$$

Notice that t enters the profit function of the foreign producer as an increase in its marginal cost, which is equal to $1 + t$. Taking the first order conditions and solving the system of two equations in two unknowns we get

$$q(t,c,v) = \frac{v - 2c + 1 + t}{3} \qquad q^*(t,c,v) = \frac{v - 2(1+t) + c}{3} \tag{2}$$

We can now plug these quantities into the profit functions of the domestic and foreign producer and get

$$\Pi(t,c,v) = \left(\frac{v - 2c + 1 + t}{3}\right)^2 \qquad \Pi^*(t,c,v) = \left(\frac{v - 2(1+t) + c}{3}\right)^2 \tag{3}$$

Notice that, as expected, for positive levels of profits, the marginal cost (comparative advantage) of the domestic producer c is negatively (positively) related to the domestically produced quantity and profits, but positively (negatively) related to the foreign produced quantity and profits. The opposite holds for the level of import tariff t. An increase in v increases quantities produced and profits for both the domestic and foreign producer.

We can plug these equilibrium quantities in the consumer surplus to get

$$S(t,c,v) = \frac{(2v - c - 1 - t)^2}{18} \tag{4}$$

Finally, the home government collects revenues from tariffs equal to $R(t,c,v) = tq^*(t,c,v)$.

Before continuing, note that this simple framework delivers a clear prediction regarding the well-established relationship between exports and comparative advantage. If the economy of country F is symmetric to the one of country H, the quantity sold of good M by the domestic producer in the partner country is given by

$$\tilde{q}(t^*,c,v^*) = \frac{v^* - 2(c + t^*) + 1}{3} \tag{5}$$

where v^* is the consumer preference parameter in the foreign economy, and t^* is the import tariff imposed by the foreign country government. Net exports are given by

$$x(t,c,v) = \tilde{q}(t^*,c,v^*) - q^*(t,c,v) = \frac{v^* - v - 2(t^* - t)}{3} - c + 1 \tag{6}$$

It follows that $\partial x(t,c,v)/\partial c < 0$: net exports increase (decrease) with comparative advantage (the marginal cost) of the domestic producer.

Non-cooperative Equilibrium The objective of the home government is to find the value of import tariff t that maximizes its payoff. In the same spirit as Grossman and Helpman (1994, 1995a,b) and up to, most recently, Maggi and Ossa (2020), we assume that lobbies represent the interests of domestic producers. We capture the influence they have on the government with a bias parameter a that is added as an extra weight attached to the domestic producer surplus by the government in its payoff compared to standard welfare. It follows that a can also be interpreted as the weight that the government places on producers relative to consumers in its objective function.

The government objective function is therefore

$$G(t,c,v) = R(t,c,v) + (1+a)\Pi(t,c,v) + S(t,c,v) \tag{7}$$

and the optimal choice of tariff is given by the level of t that maximizes it.

We are interested in the impact of a change in the relative domestic producer marginal cost c on the optimal tariff t. Notice that[2]

$$\text{sign}\left\{\frac{\partial t}{\partial c}\right\} = \text{sign}\left\{\frac{\partial^2 R(t,c,v)}{\partial t \partial c} + (1+a)\frac{\partial^2 \Pi(t,c,v)}{\partial t \partial c} + \frac{\partial^2 S(t,c,v)}{\partial t \partial c}\right\} \tag{10}$$

From the equilibrium expressions above we get

$$\frac{\partial^2 R(t,c,v)}{\partial t \partial c} = \frac{1}{3} \qquad \frac{\partial^2 \Pi(t,c,v)}{\partial t \partial c} = -\frac{4}{9} \qquad \frac{\partial^2 S(t,c,v)}{\partial t \partial c} = \frac{1}{9} \tag{11}$$

Which we can substitute in equation 10. The following proposition follows.

PROPOSITION 1. *In the non-cooperative equilibrium, if $a > 0$ then $\partial t/\partial c < 0$. The opposite holds if $a < 0$.*

Proposition 1 states that, if the bias in the weight attached by the government to producers is positive, optimal import tariffs will decrease when the marginal cost (comparative advantage) of the domestic producer increases (decreases). The opposite holds if the weight bias is negative.

The logic behind this result goes as follows. Import tariffs determine the extent of foreign competition in the domestic market. When t increases, domestic producer surplus increases while consumer surplus decreases. The relative efficiency of the domestic producer c determines not only the *levels* of producer and consumer surplus, but how they *change* with trade openness. When comparative advantage is higher (c is lower), both the negative effect of foreign competition on producer surplus and its negative effect on consumer surplus are larger in magnitude. If the government weighs producers more than consumers, it weighs the higher sensitivity of producer surplus to tariffs more, and the optimal tariff t increases with comparative advantage (decreases with c). If the government weighs consumers more than producers, it weighs the higher sensitivity of consumer surplus to tariffs more, and the optimal tariff t decreases with comparative advantage (increases with c). Proposition 1 illustrates how we can infer the sign

[2]The first order condition that implicitly defines t is given by

$$\frac{\partial G(t,c,v)}{\partial t} = 0 \tag{8}$$

Applying the implicit function theorem we get

$$\frac{\partial t}{\partial c} = -\frac{\frac{\partial^2 G(t,c,v)}{\partial t \partial c}}{\frac{\partial^2 G(t,c,v)}{\partial t^2}} \tag{9}$$

where $\partial^2 G(t,c,v)/\partial t^2 < 0$ from which it follows that $\text{sign}\{\partial t/\partial c\} = \text{sign}\{\partial^2 G(t,c,v)/\partial t \partial c\}$.

of a by looking at how tariffs respond to changes in the comparative advantage of domestic producers.

A clear relationship exists between Proposition 1 above and Proposition 2 in Grossman and Helpman (1994) and equation 5 in Maggi and Ossa (2020). Their models focus on the case of a positive bias in the weight attached to producer surplus by the government in its objective function ($a \geq 0$). Proposition 2 provides the structural equation that relates the equilibrium level of import tariffs to the ratio of domestic output to imports and the elasticity of import demand. A high ratio of domestic output to imports is associated with higher equilibrium import tariffs while a high import demand elasticity is associated with lower equilibrium tariffs. In the words of Grossman and Helpman (1994): "The political power of a particular organized sector is reflected by the ratio of domestic output to imports. In sectors with a large domestic output, the specific factor-owners have much to gain from an increase in the domestic price, while (for a given import demand elasticity) the economy has relatively little to lose from protection when the volume of imports is low." This notion of having *much to gain* from tariffs has to do with the higher sensitivity of producer surplus to tariffs. Accordingly, in our model, higher comparative advantage maps into a higher ratio of domestic output to imports and higher equilibrium import tariffs. When the producer weight bias is negative ($a < 0$), the relationship goes in the opposite direction, and higher comparative advantage and ratio of domestic output to imports are associated with lower import tariffs at equilibrium.

Cooperative Equilibrium In the cooperative equilibrium, home and foreign governments cooperatively choose the pair (t, t^*) of respective import tariffs that maximizes their joint payoff as given by

$$G(t, c, v) + G^*(t^*, c, v^*) \tag{12}$$

Assuming that the foreign country also attaches a positive weight bias a to producers, the cooperative equilibrium choice of t is the one that – omitting the irrelevant joint payoff components – maximizes

$$R(t, c, v) + (1 + a)\Pi(t, c, v) + S(t, c, v) + (1 + a)\Pi^*(t, c, v) \tag{13}$$

The only difference with respect to the non-cooperative case is that the objective function now includes the producer surplus of the foreign producer in the domestic market, which depends on t. It can be easily shown that, consistent with Maggi and Ossa (2020), the equilibrium level of tariffs in the cooperative equilibrium is lower than the non-cooperative equilibrium level, provided that v or c are high enough.

Following the same procedure as above we obtain the following proposition.

PROPOSITION 2. *In the cooperative equilibrium, if $a > -1/2$ then $\partial t/\partial c < 0$. The opposite holds if $a < -1/2$.*

We therefore have a similar result as in the non-cooperative equilibrium, but a moderately negative producer weight bias is already sufficient for tariffs to increase with comparative advantage.

This is because in choosing t the government internalizes the negative impact of import tariffs on profits made by the foreign producer in the domestic market, which is smaller in magnitude when home comparative advantage is higher (c is lower). When the weight attached to (both home and foreign) producers relative to consumers increases, the government values more the higher sensitivity of home producers' profits and lower sensitivity of foreign producers' profits to tariffs. A moderately negative producer weight bias is enough for both effects to dominate the higher sensitivity of consumer surplus to tariffs, so that the optimal tariff t increases with comparative advantage (decreases with c).

Generalization Going back to equation 10, we can derive the following, more general propositions.

PROPOSITION 3. *In the non-cooperative equilibrium, if*

$$a > a_{NC} = -\frac{\frac{\partial^2 S(t,c,v)}{\partial t \partial c} + \frac{\partial^2 \Pi(t,c,v)}{\partial t \partial c} + \frac{\partial^2 R(t,c,v)}{\partial t \partial c}}{\frac{\partial^2 \Pi(t,c,v)}{\partial t \partial c}} \tag{14}$$

then $\partial t/\partial c < 0$. *The opposite holds if* $a < a_{NC}$.

PROPOSITION 4. *In the cooperative equilibrium, if*

$$a > a_C = -\frac{\frac{\partial^2 S(t,c,v)}{\partial t \partial c} + \frac{\partial^2 \Pi(t,c,v)}{\partial t \partial c} + \frac{\partial^2 R(t,c,v)}{\partial t \partial c} + \frac{\partial^2 \Pi^*(t,c,v)}{\partial t \partial c}}{\frac{\partial^2 \Pi(t,c,v)}{\partial t \partial c} + \frac{\partial^2 \Pi^*(t,c,v)}{\partial t \partial c}} \tag{15}$$

then $\partial t/\partial c < 0$. *The opposite holds if* $a < a_C$.

Combining the two expressions above and rearranging we get

$$a_C = \left(a_{NC} - \frac{\frac{\partial^2 \Pi^*(t,c,v)}{\partial t \partial c}}{\frac{\partial^2 \Pi(t,c,v)}{\partial t \partial c}} \right) \frac{\frac{\partial^2 \Pi(t,c,v)}{\partial t \partial c}}{\frac{\partial^2 \Pi(t,c,v)}{\partial t \partial c} + \frac{\partial^2 \Pi^*(t,c,v)}{\partial t \partial c}} \tag{16}$$

from which it follows that $a_C < a_{NC}$ with the difference being decreasing (increasing) in the extent to which the sensitivity of home (foreign) producer surplus to tariffs changes with comparative advantage.

Focusing on Cournot competition may seem restricting at first, but the model predictions are generalizable to all settings where the choices of home and foreign producers are strategic substitutes. Moreover, Kreps and Scheinkman (1983) show that the Cournot equilibrium quantity is also the equilibrium production decision of oligopolistic firms in a setting where, in the first stage, they decide independently and simultaneously how much they will produce, and subsequently bring these quantities to market, each learns how much the other produced, and engage in Bertrand-like price competition. This is the reason why agricultural markets are often presented as a textbook example of a Cournot market setting (Osborne 2009). Indeed, agricultural producers make production plans infrequently, and once productions decisions are made it is difficult to adjust their output levels because of fixed costs or investment in specialized capacity. The empirical analysis that follows matches the theoretical model by focusing on agricultural products and tariffs on agricultural imports.

3 Data and Measurement

3.1 Sources

We build the sample for our empirical analysis starting from the list of PTAs reported in Table A.1 of Appendix A. The list considers all PTAs signed between 1995 and 2014 that involve at least one of following major economies as partner: Australia, Canada, China, Japan, United States, and for which data on the negotiated tariff changes are available at the product level.

Tariff Changes We derive information on the tariff reductions mandated by these PTAs from Design of Trade Agreements (DESTA) database (Dür, Baccini, and Elsig 2014). This provides detailed information on various types of PTAs implemented between 1947 and 2014. For each agreement, the data records the identity of partners, the year of signature and implementation, sector coverage, depth of commitments, trade integration and compliance tools. Crucially for our purpose, the DESTA dataset also provides information on baseline tariffs and reductions through the implementation period for each product at the level of 6-digit Foreign Trade Harmonized (HS) code.[3] Tariff schedules are extracted from the officially negotiated ones listed in the appendices of the PTAs. Thus, the tariff cuts we consider are *de jure* and not *de facto* since countries can still set applied tariffs that are different from the negotiated ones. We focus specifically on agricultural products, mapping each corresponding 6-digit HS product code to the set of crops for which we can obtain data on potential yields at the sub-national level. The top panel of Figure 1 shows the average recorded percentage change in tariff by crop for the entire sample of PTAs that we consider in our analysis. The bottom panel of the same Figure shows instead the average tariff change by partner country.

Crop Suitability and Potential Yields We retrieve information on soil suitability and potential yields for different crops within and across countries from the Global Agroecological Zones (GAEZ) project database (IIASA/FAO 2012). Pursued jointly by the Food and Agriculture Organization of the United Nations (FAO) and the International Institute for Applied System Analysis (IIASA), the project uses detailed agronomic-based knowledge to assess land suitability and potential yields attainable for a large set of crops. The corresponding data are freely available online, and have already been used in economic and, specifically, trade studies (Costinot and Donaldson 2012; Costinot, Donaldson, Vogel, and Werning 2015; Costinot, Donaldson, and Smith 2016). The planet is divided into grid cells of 9km x 9km and, for each of the main crops, the data provide information on suitability and potential yield at that level. In particular, we use the information on total production capacity per hectare under rain-fed agriculture and low levels of inputs. These estimates of production capacity are solely based on agro-climatic conditions, and are therefore exogenous to any change in the technology of agricultural production that might have occurred with the implementation of PTAs.

[3] For further information on the specifics of tariff data, see Baccini, Dür, and Elsig 2018.

Rainfalls We complement the variation within and across countries in soil suitability and potential yields across crops with variation in rainfall as measured by monthly rainfall statistics in 1989 through 2015. We use the information belonging to the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) dataset. CHIRPS incorporates satellite imagery with in-situ station data to create rainfall time series at the 0.05 degree resolution grid level (Funk et al. 2015). This methodology and dataset has been shown to outperform other land surface and rainfall model products, such as GLDAS and GPCC, in characterizing rainfall shocks and drought events in areas with complex topography (Awange et al. 2015; Agutu et al. 2017). In order to merge rainfall with suitability and potential yields data we aggregate CHIRPS monthly rainfall statistics at the GAEZ-FAO cell level.

Growing Seasons The same monthly rainfall shock does or does not have an impact on agricultural output of a specific crop depending on whether it happens during the growing season or not. We explicitly take this into account using the information provided by the global data set of Monthly Irrigated and Rainfed Crop Areas (MIRCA2000). This is a dataset of monthly growing areas of 26 irrigated and rain-fed crops with related crop calendars for 402 spatial units around the world (Portmann, Siebert, and Döll 2010). We match these crops to those classified in the GAEZ-FAO database.

Trade Flows For each country in our sample, we gather information on exports to any other country in the sample and for each one of the crops that are part of the analysis. We retrieve information on the value of exports at the corresponding 6-digit HS codes from the UN-Comtrade database (United Nations Statistics Division 2020). In order to be consistent with the analysis of tariff changes, we consider the same time frame of the PTAs in our sample and focus on the period from 1995 to 2014.

3.2 Climate shocks to Comparative Advantage

Our empirical strategy relies on a plausibly exogenous source of variation in the comparative advantage of each country in producing a given crop. We do so by leveraging variation in rainfalls during the growing season within and across countries over time.

We start by measuring rainfall shocks as follows. For each country in our dataset, we identify all GAEZ-FAO grid cells located in the country. For each one of them, we derive the long-term monthly precipitation average and standard deviation over the entire period for which rainfall data are available, i.e. 1981 to 2017. We then obtain the following standardized rainfall measure

$$\frac{R_{cimt} - \mu_{cim}}{\sigma_{cim}} \tag{17}$$

where R_{cimt} is the amount of rainfall in cell c located in country i as recorded in month m of year t, and μ_{cim} and σ_{cim} are the monthly long-term average and standard deviation respectively in the same cell. We define a *positive* rainfall shock dummy P_{cimt} that is equal to one if standardized rainfalls are higher than 0.5, and a *negative* rainfall shock dummy N_{cimt} that is equal to one if standardized rainfalls are lower than -0.5. As such, these dummies are equal to one if the amount of rainfall in the cell is a half standard deviation higher or lower than its monthly long-term average, thus capturing unusually high or low precipitation levels in each cell and month.

We then interact these rainfall shock indicators with suitability within and across countries and growing calendar information across crops. Let S_{cik} be the potential production capacity or suitability of cell c in country i to produce crop k, which does not change over time. Let instead G_{cikm} be a dummy equal to one if month m belongs to the growing season of that same crop k in the same cell.[4] We calculate

$$\begin{aligned} \textit{Positive Shock}_{ikt} &= \sum_{c\,\in\,i}\sum_{m=1}^{12} P_{cimt} \times G_{cikm} \times S_{cik} \\ \textit{Negative Shock}_{ikt} &= \sum_{c\,\in\,i}\sum_{m=1}^{12} N_{cimt} \times G_{cikm} \times S_{cik} \end{aligned} \tag{18}$$

These measures are specific to each country, crop, and year. They encapsulate in a single measure the incidence of unusual rainfalls during the growing season of a given crop in those areas within the country that are suitable to produce that crop. Both measures are zero if no extreme rainfalls are recorded in any cell in any month during the year, i.e. $P_{cimt} = N_{cimt} = 0$. They are also equal to zero if extreme rainfalls happen in areas that are unsuitable to produce the crop, i.e. $S_{cik} = 0$, or they occur outside the growing season, i.e. $G_{cikm} = 0$. In our empirical analysis, we will modify these measures to consider shocks that occur outside the growing season and conveniently use them as *placebo* shocks.

Before continuing, Table 1 provides summary statistics for all the variables we use in the empirical analysis. The top panel shows the summary statistics for the sample used to test for the relationship between comparative advantage and trade flows. The bottom panel reports the summary statistics for the PTA tariff data sample, where we look at the relationship between comparative advantage and negotiated tariff change. On average, agricultural tariffs fall by 41% as a result of the PTAs in our sample, with substantial variation across crops, PTAs and countries involved. In operationalizing the rainfall shock and aggregate suitability measures, we augment them of one and take the logarithm. Prior to implementing the regression analysis, we also rescale and divide them by their sample standard deviation in order to make reported coefficient estimates interpretable as changes in the dependent variable that follow a one standard deviation increase in the independent variable of interest.

[4] Notice that the growing season of the same crop can vary across and even within countries depending on the crop calendar. For instance, maize is cultivated in July in the northern hemisphere in Asia (e.g. Northern and North-eastern China, India, Pakistan), Southern Europe, Africa (mostly Egypt) and North America (USA, Mexico). In January, only in South-eastern China and Vietnam (Portmann et al. 2008).

4 Empirical Strategy and Results

4.1 Comparative Advantage and Net Exports

Our simple theoretical framework delivers a clear prediction on the relationship between comparative advantage and exports: net exports of a given crop increase with a country's comparative advantage in producing that crop. We start our empirical analysis by taking this prediction to the data. This also serves the purpose of validating rainfall and suitability-based shocks as defined above as sources of variation in comparative advantage to produce agricultural products.

We implement the following regression specification

$$\textit{Net Exports}_{ijkt} = \alpha_k + \delta_t + \lambda_i + \theta_j + \beta\,\textit{Shock}_{ikt} + \gamma\,\textit{Shock}_{jkt} + u_{ijkt} \tag{19}$$

where $\textit{Net Exports}_{ijkt}$ is the net value of exports of crop k from country i to country j in year t. $\textit{Shock}_{ikt}$ and $\textit{Shock}_{jkt}$ are the previously defined shock measures for country i and j respectively. The set of crop fixed effects α_k captures and nets out average differences across crops, while the set of year fixed effects δ_t captures year-specific trends. λ_i and θ_j capture country i and country j fixed effects respectively. We also include aggregate suitability $\sum_{c\,\in\,i} S_{cik}$ of both country i and country j as controls in all specifications. Notice that these are time invariant but specific to each country and crop. u_{ijkt} captures any residual determinant of net exports, which we allow to be correlated between observations belonging to the same country pair and year by clustering standard errors at that level.

If the shock measures we build represent a credible time-varying source of variation for comparative advantage, we should expect $\beta > 0$ and $\gamma < 0$ when considering positive shocks, and the opposite when considering negative shocks. Table 2 shows the estimation results. We begin considering each country shock and type separately, starting with positive shocks to country i in column 1. A one standard deviation increase in *positive* rainfall shocks to a given crop – which raise country i's comparative advantage in producing that crop – increases net exports of the crop by 10% of a standard deviation. The corresponding coefficient estimate is significant at the 1% level. Conversely, the results in column 2 show that a one standard deviation increase in *negative* rainfall shocks – which decrease country i's comparative advantage – decreases net exports by 18% of a standard deviation, with the effect being significant at the 1% level. When considering shocks to the partner country, the point estimates – reported in column 3 and 4 – are similar in magnitude, but opposite in sign. In column 5, we include all shock measures together. The sign and significance of all point estimates is unchanged, and their magnitude changes only to a small extent. Notice also that, across all specifications, own (partner's) permanent suitability to produce a given crop is associated with an increase (decrease) in net exports. These results altogether show that the rainfall and suitability-based shocks that we build are a credible source of variation in comparative advantage, and – consistent with the first theoretical prediction – systematically affect net exports.

4.2 Comparative Advantage and Negotiated Tariff Change

We now move to explore the empirical relationship between comparative advantage and tariffs. According to the theoretical framework, if the government attaches a high weight to producers relative to consumers in its objective function, import tariffs will increase with comparative advantage. The opposite holds if the producer weight bias is low enough. We take these model implications to the data and, specifically, to the tariff changes mandated by the PTAs in our sample.

We test whether changes in comparative advantage as induced by rainfall and suitability-based shocks during the negotiation period affect a country's negotiated change in tariffs. If the government attaches a high weight to producers relative to consumers, a *positive* rainfall shock to a given crop that affects a given country during the negotiation period – which raises its comparative advantage in producing that crop – should lead its government to not decrease import tariffs on that crop, or to decrease them to a smaller extent. The opposite holds if the producer weight bias is low enough. Similarly, if the weight bias attached by the government to producers is high enough, a *negative* rainfall shock to a given crop should lead the government to decrease import tariffs on that crop to a larger extent.

We implement the following regression specification

$$\textit{Tariff Change}_{ijkt} = \alpha_k + \delta_t + \lambda_i + \theta_j + \beta\ \textit{Shock}_{ikt-l} + \gamma\ \textit{Initial Tariff}_{ijkt} + u_{ijkt} \tag{20}$$

where $\textit{Tariff Change}_{ijkt}$ is the change in tariffs on crop k imposed by country i on imports from country j as mandated by the PTA signed in year t. As before, we let the set of crop, year, and countries fixed effects – α_k, δ_t, λ_i and θ_j – capture and net out average differences across crops, years, and partner countries. $\textit{Shock}_{ikt-l}$ is the shock measure for country i in some period $t - l$ prior to the signature year. We also use the initial level of tariffs $\textit{Initial Tariff}_{ijkt}$ and aggregate suitability of both country i and country j as additional controls. u_{ijkt} captures any residual determinant of the negotiated tariff change. Consistent with the previous analysis of trade flows, we allow such residuals to be correlated between crop-level observations that belong to the same PTA by clustering standard errors at that level.

A possible concern with this empirical strategy is that the rainfall and suitability-based shocks that we consider are transitory. Indeed, the corresponding measures are defined by looking at monthly deviations of rainfalls from their long-term average at the cell level in each country. If government officials had full information, they would acknowledge their transitory nature, recognize them as such, and not change their behavior at the tariff negotiation table. For these shocks to have any impact, it must be the case that governments are not fully informed over comparative advantage, and/or that the resulting changes in agricultural production are regarded as permanent at least to some extent. That is, governments continuously update their beliefs over comparative advantage in producing a given crop, and shocks as we measure them yield changes in such beliefs.

A second issue with this approach pertains to the choice of the appropriate time frame. While it is clear that we should consider shocks that occur prior to the PTA signature, it is not clear what is the appropriate time window to consider. We address this issue by taking a data-driven approach. Table A.2 in Appendix A shows the coefficient estimates from equation 20 that we obtain when considering positive and negative shocks occurring at different points in time prior to the PTA signature. In column 1, we consider shocks that occur in the year prior to the signature. In column 2, we consider the sum of shocks that occur in then previous two years. In column 3, 4, and 5, we consider all shocks that occur in the previous 3, 5, and 7 years respectively. Above and beyond the sign and magnitude of coefficients, which we will discuss later on, results shows that shocks that occur up to 3 years prior to the signature have a systematic relationship with the negotiated change in tariffs.

Column 1 of Table 3 reports the same estimates of column 3 of Table A.2. Crop-specific positive rainfall shocks prior to the final signature – which raise a country's comparative advantage in producing a given crop – cause a smaller reduction of import tariffs on that crop. The opposite holds for negative rainfall shocks – which decrease comparative advantage. Point estimates as such that a one standard deviation increase in cumulated positive (negative) rainfalls over the 3 years prior to the signature reduces (increase) the magnitude of the negotiated tariff reduction by 11 (9) percentage points. These effects are significant at the 1% and 5% level respectively. In column 2, we include as additional controls both country's overall time-invariant aggregate suitability to produce the crop, with little consequences for the magnitude and significant of the shocks' coefficient estimates. When interpreted through the lens of the theoretical framework, these results show that governments place a high weight on producers relative to consumers in their objective function.

In column 3, we implement a *placebo* test. We construct rainfall shock measures as before, but considering now rainfalls during non-growing season months. These shocks should not have any impact on a country's comparative advantage and thus the negotiated tariff change. This is what the corresponding coefficient estimates show. When included together with the original measures, shocks during the non-growing season exhibit no systematic relationship with the negotiated change in tariffs. In columns 4 and 5, we evaluate further the robustness of results by looking at shocks that occur in the year of the signature, once again thinking about those as *placebos*. The corresponding coefficient estimates are very small in magnitude and insignificant, while those of the original shock measures remain unchanged in magnitude and highly significant.

Positive (negative) rainfall shocks to partner countries decrease (increase) own comparative advantage. We can thus flip equation 20 on its own and investigate the relationship between own shocks and the negotiated change in partner's import tariff. If governments attach a high weight to producers relative to consumers in their objective function, we should expect partner import tariff changes to move in the opposite direction with respect to own tariff changes. The coefficient estimates reported in Table 4 show that this is the case. Estimates are ordered as in Table 3, with *placebo* estimates being insignificant as the previous ones.[5]

[5]Table A.3 in Appendix A show that also in this case it is meaningful to consider shocks that occur up to 3 years prior to the signature.

To conclude, Table A.4 in Appendix A investigates the extent to which the shocks we consider and their impact on tariffs are indeed crop-specific. For comparison, column 1 and 4 report the estimates shown in column 2 of Table 3 and Table 4 respectively. In columns 2, 3, 5, and 6 we include separately as additional regressors the average positive and negative shocks among all other crops that are part of the PTA. The estimated coefficients of the main, crop-specific shock measures remain relatively stable. This indicates that, while rainfall shocks appear to be weakly correlated across crops, it is the shock to a specific crop that affects the corresponding negotiated tariff change.

Evidence altogether shows that positive (negative) changes in comparative advantage that materialize during the negotiation period cause a lower (higher) negotiated reduction in import tariffs. This suggests that governments place a high weight on producers relative to consumers in their objective function.

Using our estimates, we can predict the percent reduction in tariffs that we would have observed in the absence of any rainfall-induced changes in comparative advantage over the sample period. Specifically, we take the estimates in column 2 of Table 3 as benchmark, set the value of positive rainfall shocks equal to zero for all observations, and predict the associated counterfactual percent reduction in own tariffs. We calculate that, in the absence of any positive rainfall shocks, the average percent reduction in tariffs mandated by the PTAs in our sample would have been at least two times higher – from 41% to 93%. Negative rainfall shocks are associated with higher tariff reductions. Yet, setting these equal to zero as well, we calculate that the average percent reduction in tariffs would have still been higher – from 41% to 61% – in the absence of any climate-induced shocks to comparative advantage during the negotiation period.

5 Conclusion

This paper partially but causally identifies the relative weight that governments place on producers vs. consumers in deciding trade policies. Such weight captures the strength and influence of producer lobbies and is key in traditional political economy of trade models. Our strategy for identification combines both theory and empirics. On the theory side, we show that when home and foreign producers engage in Cournot competition the weight that governments attach to producers relative to consumers determines both the level of tariffs and their relationship with comparative advantage: if the government weighs producers more than consumers, tariffs increase with comparative advantage. On the empirical side, we focus on agricultural products and exploit granular information on crop soil suitability and rainfalls during the growing season to build a plausibly exogenous source of variation in a country's comparative advantage in producing a given crop. We find that changes in comparative advantage as induced by rainfall and suitability-based shocks during PTA negotiations affect a country's negotiated change in tariffs. In particular, when comparative advantage in producing a given crop increases governments decrease tariffs on imports of that crop to a smaller extent. When interpreted through the lens of the model, these results suggest that during trade negotiations governments attach a high weight on producers relative to consumers in their objective function. Our estimates and calculations indicate that the average percent reduction in tariffs mandated by the PTAs in our sample would have been at least two times higher in the absence of any rainfall-induced increase in comparative advantage during the negotiation period. Our findings also indirectly suggest that governments are not fully informed over countries' comparative advantage in producing a given crop, and continuously update their beliefs. Future research will have to dig deeper into such learning process and its theoretical and empirical implications for trade policy.

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Tables and Figures

Table 1: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	Obs.
		Panel A. Trade Flows Sample			
Year	2004.5	5.766	1995	2014	18840
Net Exports (Million USD)	0.544	48.498	-1084.542	1517.419	18840
Log of Own Positive Rainfall Shock	14.436	3.198	0	19.878	18840
Log of Own Negative Rainfall Shock	14.712	3.186	0	20.159	18840
Log of Partner Positive Rainfall Shock	14.74	3.14	0	19.878	18840
Log of Partner Negative Rainfall Shock	15.039	3.119	0	20.159	18840
Log of Own Crop Suitability	16.3	3.068	3.892	21.452	18840
Log of Partner Crop Suitability	16.621	3.027	3.892	21.452	18840
		Panel B. PTA Sample			
Signature Year	2006.471	3.059	1996	2013	4035
Own Initial Tariff	9.34	18.642	0	391.2	4035
Partner Initial Tariff	8.242	20.992	0	391.2	4035
Negotiated Own Tariff	3.674	10.47	0	107.25	4035
Negotiated Partner Tariff	2.073	7.375	0	108.165	4035
% Change in Own Tariff	0.406	0.389	0	0.997	4035
% Change in Partner Tariff	0.414	0.397	0	0.997	4035
Log of Own Positive Rainfall Shock at $t-1$	14.53	3.231	0	19.551	4035
Log of Own Negative Rainfall Shock at $t-1$	14.753	3.331	0	20.156	4035
Log of Own Positive Rainfall Shock $(t-2, t-1)$	15.269	3.19	0	20.361	4035
Log of Own Negative Rainfall Shock $(t-2, t-1)$	15.476	3.299	0	20.703	4035
Log of Own Positive Rainfall Shock $(t-3, t-1)$	15.651	3.164	1.609	20.759	4035
Log of Own Negative Rainfall Shock $(t-3, t-1)$	15.939	3.258	0	21.096	4035
Log of Own Positive Rainfall Shock $(t-5, t-1)$	15.922	3.155	1.609	21.08	4035
Log of Own Negative Rainfall Shock $(t-5, t-1)$	16.229	3.284	0	21.418	4035
Log of Own Positive Rainfall Shock $(t-7, t-1)$	16.319	3.156	1.946	21.487	4035
Log of Own Negative Rainfall Shock $(t-7, t-1)$	16.656	3.27	0	21.771	4035
Log of Own Crop Suitability	14.481	2.702	1.609	19.02	4035
Log of Partner Crop Suitability	10.998	5.741	0	19.02	4035

Notes. The table reports summary statistics for all the variables we use in the empirical analysis. The top panel shows the summary statistics for the sample used to explore the relationship between comparative advantage and trade flows. The bottom panel reports the summary statistics for the PTA sample, where we look at the relationship between comparative advantage and negotiated tariff change (Sources: CHIRPS, COMTRADE, DESTA, GAEZ-FAO, MIRCA).

Table 2: Rainfall Shocks and Net Exports

	Net Exports				
	(1)	(2)	(3)	(4)	(5)
Own Positive Shock	0.105***				0.071***
	(0.029)				(0.025)
Own Negative Shock		-0.181***			-0.145***
		(0.032)			(0.027)
Partner Positive Shock			-0.107***		-0.080***
			(0.028)		(0.024)
Partner Negative Shock				0.168***	0.124***
				(0.033)	(0.027)
Own Suitability	0.083**	0.362***	0.185***	0.182***	0.257***
	(0.033)	(0.044)	(0.021)	(0.021)	(0.042)
Partner Suitability	-0.117***	-0.115***	-0.012	-0.284***	-0.161***
	(0.021)	(0.021)	(0.030)	(0.046)	(0.041)
Own Country FE	Yes	Yes	Yes	Yes	Yes
Partner Country FE	Yes	Yes	Yes	Yes	Yes
Crop FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	18840	18840	18840	18840	18840
R^2	0.068	0.069	0.068	0.069	0.070

Notes. (* p-value$<$ 0.1; ** p-value$<$0.05; *** p-value$<$0.01) The unit of observation is a crop by country pair and year. The dependent variable is the net value of exports of own country when trading when partner country in the year. Shocks are calculated by summing up positive or negative monthly rainfall shocks (0/1) during the growing season of the crop at the cell level across the country weighted by the potential productivity (suitability) of each cell to produce the crop. Clustered standard errors at the country pair-year level.

Table 3: Rainfall Shocks and Negotiated Change in Own Import Tariffs

	Tariff Change (%)				
	(1)	(2)	(3)	(4)	(5)
Positive Shock	-0.111***	-0.139***	-0.141***	-0.114**	-0.106**
Growing Season $(t-3, t-1)$	(0.038)	(0.042)	(0.043)	(0.049)	(0.049)
Negative Shock	0.087**	0.098**	0.090**	0.104**	0.104**
Growing Season $(t-3, t-1)$	(0.039)	(0.039)	(0.040)	(0.045)	(0.044)
Positive Shock			-0.051		-0.047
Non-growing Season $(t-3, t-1)$			(0.094)		(0.095)
Negative Shock			0.077		0.076
Non-growing Season $(t-3, t-1)$			(0.092)		(0.093)
Positive Shock				-0.010	-0.013
Growing Season t				(0.008)	(0.008)
Negative Shock				0.001	-0.002
Growing Season t				(0.010)	(0.011)
Own Initial Tariff	0.194***	0.194***	0.194***	0.194***	0.194***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Own Crop Suitability		0.028***	0.029***	0.028***	0.029***
		(0.010)	(0.011)	(0.010)	(0.010)
Partner Crop Suitability		0.003	0.003	0.003	0.003
		(0.007)	(0.007)	(0.007)	(0.007)
Own Country FE	Yes	Yes	Yes	Yes	Yes
Partner Country FE	Yes	Yes	Yes	Yes	Yes
Crop FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	4035	4035	4035	4035	4035
R^2	0.641	0.642	0.643	0.642	0.643

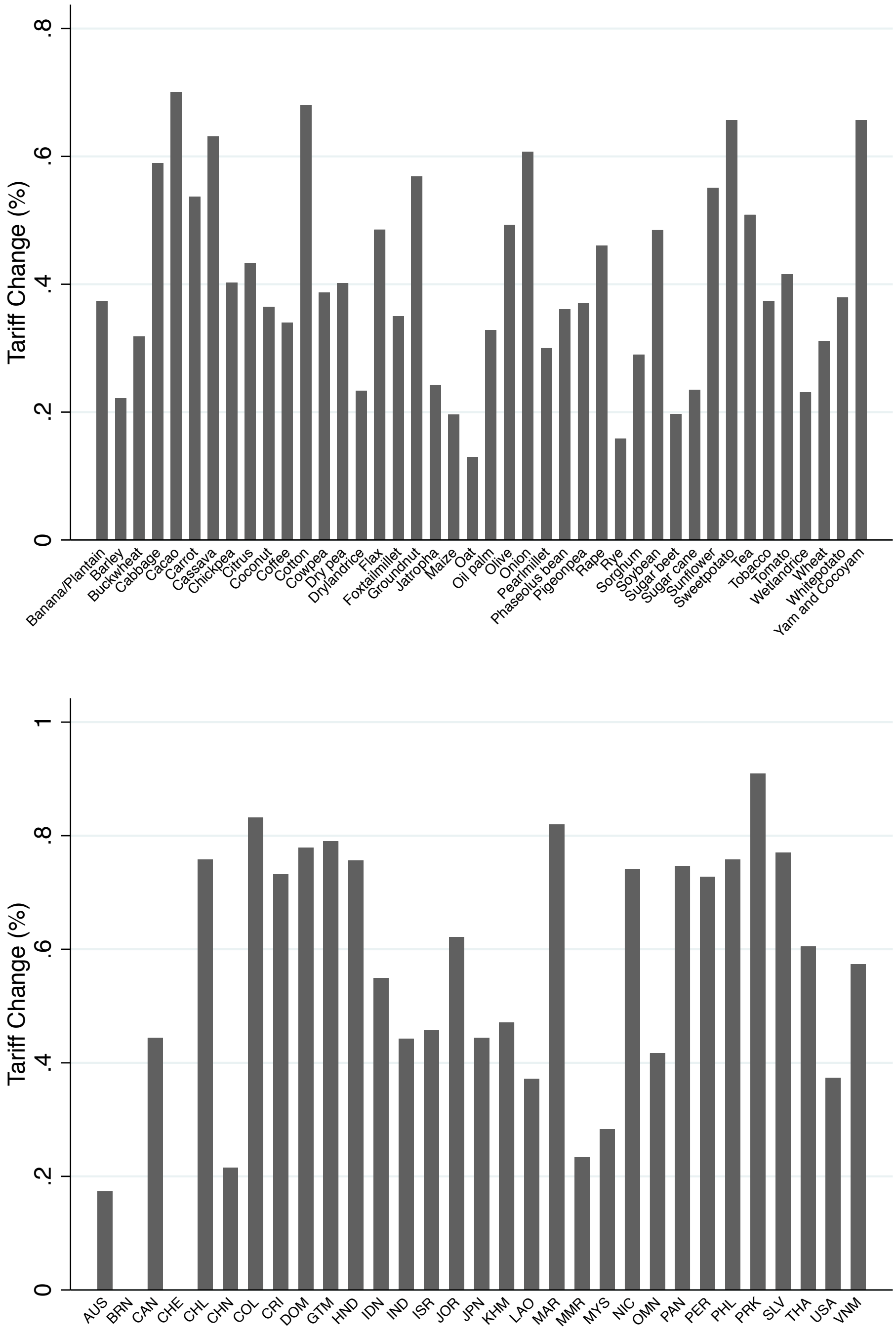
Notes. (* p-value$<$ 0.1; ** p-value$<$0.05; *** p-value$<$0.01) The unit of observation is crop by PTA. The dependent variable is the percentage difference in negotiated own import tariffs between baseline and 12 years after the implementation of the PTA. Shocks are calculated by summing up positive or negative monthly rainfall shocks (0/1) at the cell level across the country weighted by the potential productivity (suitability) of each cell to produce the crop. Shocks during the growing season are calculated by only considering months during the growing season of the crop. Non-growing season shocks are calculated by only considering months during the non-growing season. Suitability and shock variables are in log. Clustered standard errors at the country pair-year level.

Table 4: Rainfall Shocks and Negotiated Change in Partner Import Tariffs

	Tariff Change (%)				
	(1)	(2)	(3)	(4)	(5)
Positive Shock Growing Season $(t-3, t-1)$	0.086** (0.033)	0.084** (0.036)	0.085** (0.037)	0.123** (0.051)	0.125** (0.052)
Negative Shock Growing Season $(t-3, t-1)$	-0.083** (0.034)	-0.082** (0.034)	-0.081** (0.035)	-0.041 (0.031)	-0.040 (0.031)
Positive Shock Non-growing Season $(t-3, t-1)$			-0.014 (0.055)		-0.040 (0.060)
Negative Shock Non-growing Season $(t-3, t-1)$			0.005 (0.053)		0.032 (0.058)
Positive Shock Growing Season t				-0.006 (0.006)	-0.006 (0.006)
Negative Shock Growing Season t				-0.017* (0.010)	-0.018* (0.011)
Partner Initial Tariff	0.209*** (0.013)	0.209*** (0.013)	0.209*** (0.013)	0.209*** (0.013)	0.209*** (0.013)
Own Crop Suitability		0.002 (0.011)	0.002 (0.011)	-0.002 (0.011)	-0.000 (0.011)
Partner Crop Suitability		0.001 (0.006)	0.001 (0.006)	0.001 (0.006)	0.001 (0.006)
Own Country FE	Yes	Yes	Yes	Yes	Yes
Partner Country FE	Yes	Yes	Yes	Yes	Yes
Crop FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	4035	4035	4035	4035	4035
R^2	0.656	0.656	0.656	0.656	0.656

Notes. (* p-value$<$ 0.1; ** p-value$<$0.05; *** p-value$<$0.01) The unit of observation is crop by PTA. The dependent variable is the percentage difference in negotiated partner import tariffs between baseline and 12 years after the implementation of the PTA. Shocks are calculated by summing up positive or negative monthly rainfall shocks (0/1) at the cell level across the country weighted by the potential productivity (suitability) of each cell to produce the crop. Shocks during the growing season are calculated by only considering months during the growing season of the crop. Non-growing season shocks are calculated by only considering months during the non-growing season. Suitability and shock variables are in log. Clustered standard errors at the country pair-year level.

Figure 1: Average Change in Tariff by Crop and Countries



Notes. (Sources: DESTA).

A Appendix

Table A.1: List of Preferential Trade Agreements

Signature Year	Partner A	Partner B	Signature Year	Partner A	Partner B
1996	Canada	Israel	2007	Japan	Indonesia
1996	Canada	Chile	2007	USA	South Korea
2000	USA	Jordan	2008	Australia	Chile
2000	USA	Vietnam	2008	Japan	Brunei (ASEAN)
2001	Canada	Costa Rica	2008	Japan	Cambodia (ASEAN)
2002	Japan	Singapore	2008	Japan	Indonesia (ASEAN)
2003	Australia	Singapore	2008	Japan	Laos (ASEAN)
2003	USA	Chile	2008	Japan	Malaysia (ASEAN)
2004	Australia	Thailand	2008	Japan	Myanmar (ASEAN)
2004	China	Brunei (ASEAN)	2008	Japan	Philippines (ASEAN)
2004	China	Cambodia (ASEAN)	2008	Japan	Singapore (ASEAN)
2004	China	Indonesia (ASEAN)	2008	Japan	Thailand (ASEAN)
2004	China	Malaysia (ASEAN)	2008	Japan	Vietnam (ASEAN)
2004	China	Myanmar (ASEAN)	2008	China	New Zealand
2004	China	Philippines (ASEAN)	2008	Canada	Peru
2004	China	Singapore (ASEAN)	2008	China	Singapore
2004	China	Thailand (ASEAN)	2008	Canada	Colombia
2004	China	Vietnam (ASEAN)	2009	Australia	Brunei (ASEAN)
2004	USA	Australia	2009	Australia	Cambodia (ASEAN)
2004	USA	Costa Rica (CAFTA)	2009	Australia	Indonesia (ASEAN)
2004	USA	Dominican Republic (CAFTA)	2009	Australia	Laos (ASEAN)
2004	USA	El Salvador (CAFTA)	2009	Australia	Malaysia (ASEAN)
2004	USA	Guatemala (CAFTA)	2009	Australia	Myanmar (ASEAN)
2004	USA	Honduras (CAFTA)	2009	Australia	Philippines (ASEAN)
2004	USA	Nicaragua (CAFTA)	2009	Australia	Singapore (ASEAN)
2004	USA	Morocco	2009	Australia	Thailand (ASEAN)
2004	USA	Bahrain	2009	Australia	Vietnam (ASEAN)
2005	Japan	Malaysia	2009	Japan	Switzerland
2005	China	Chile	2009	China	Peru
2006	China	Pakistan	2009	Canada	Jordan
2006	Japan	Philippines	2010	Canada	Panama
2006	USA	Oman	2010	China	Costa Rica
2006	USA	Peru	2011	Japan	India
2006	USA	Colombia	2011	Japan	Peru
2007	Japan	Brunei	2012	Australia	Malaysia
2007	Japan	Chile	2013	Canada	Honduras

Notes. (Sources: DESTA).

Table A.2: Rainfall Shocks and Negotiated Change in Own Import Tariffs

	Tariff Change (%)				
	(1)	(2)	(3)	(4)	(5)
Positive Shock Growing Season $t-1$	-0.066*** (0.018)				
Negative Shock Growing Season $t-1$	0.043** (0.018)				
Positive Shock Growing Season $(t-2, t-1)$		-0.101*** (0.022)			
Negative Shock Growing Season $(t-2, t-1)$		0.078*** (0.022)			
Positive Shock Growing Season $(t-3, t-1)$			-0.111*** (0.029)		
Negative Shock Growing Season $(t-3, t-1)$			0.087*** (0.030)		
Positive Shock Growing Season $(t-5, t-1)$				-0.054** (0.027)	
Negative Shock Growing Season $(t-5, t-1)$				0.029 (0.027)	
Positive Shock Growing Season $(t-7, t-1)$					-0.039 (0.028)
Negative Shock Growing Season $(t-7, t-1)$					0.014 (0.028)
Own Initial Tariff	0.194*** (0.006)	0.194*** (0.006)	0.194*** (0.006)	0.194*** (0.006)	0.194*** (0.006)
Own Country FE	Yes	Yes	Yes	Yes	Yes
Partner Country FE	Yes	Yes	Yes	Yes	Yes
Crop FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	4035	4035	4035	4035	4035
R^2	0.641	0.642	0.641	0.641	0.641

Notes. (* p-value$<$ 0.1; ** p-value$<$0.05; *** p-value$<$0.01) The unit of observation is crop by PTA. The dependent variable is the percentage difference in negotiated own import tariffs between baseline and 12 years after the implementation of the PTA. Shocks are calculated by summing up positive or negative monthly rainfall shocks (0/1) at the cell level across the country weighted by the potential productivity (suitability) of each cell to produce the crop. Shocks during the growing season are calculated by only considering months during the growing season of the crop. Non-growing season shocks are calculated by only considering months during the non-growing season. Suitability and shock variables are in log. Clustered standard errors at the country pair-year level.

Table A.3: Rainfall Shocks and Negotiated Change in Partner Import Tariffs

	Tariff Change (%)				
	(1)	(2)	(3)	(4)	(5)
Positive Shock Growing Season $t-1$	0.043*** (0.016)				
Negative Shock Growing Season $t-1$	-0.040** (0.016)				
Positive Shock Growing Season $(t-2, t-1)$		0.051*** (0.019)			
Negative Shock Growing Season $(t-2, t-1)$		-0.048** (0.019)			
Positive Shock Growing Season $(t-3, t-1)$			0.086*** (0.029)		
Negative Shock Growing Season $(t-3, t-1)$			-0.083*** (0.029)		
Positive Shock Growing Season $(t-5, t-1)$				-0.011 (0.028)	
Negative Shock Growing Season $(t-5, t-1)$				0.015 (0.028)	
Positive Shock Growing Season $(t-7, t-1)$					0.007 (0.029)
Negative Shock Growing Season $(t-7, t-1)$					-0.003 (0.029)
Partner Initial Tariff	0.209*** (0.006)	0.209*** (0.006)	0.209*** (0.006)	0.209*** (0.006)	0.209*** (0.006)
Own Country FE	Yes	Yes	Yes	Yes	Yes
Partner Country FE	Yes	Yes	Yes	Yes	Yes
Crop FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	4035	4035	4035	4035	4035
R^2	0.656	0.656	0.656	0.655	0.655

Notes. (* p-value<0.1; ** p-value$<$0.05; *** p-value$<$0.01) The unit of observation is crop by PTA. The dependent variable is the percentage difference in negotiated partner import tariffs between baseline and 12 years after the implementation of the PTA. Shocks are calculated by summing up positive or negative monthly rainfall shocks (0/1) at the cell level across the country weighted by the potential productivity (suitability) of each cell to produce the crop. Shocks during the growing season are calculated by only considering months during the growing season of the crop. Non-growing season shocks are calculated by only considering months during the non-growing season. Suitability and shock variables are in log. Clustered standard errors at the country pair-year level.

Table A.4: Rainfall Shocks and Negotiated Change Tariffs Across Crops

	Own Tariff Change (%)			Partner Tariff Change (%)		
	(1)	(2)	(3)	(4)	(5)	(6)
Positive Shock	-0.139***	-0.074*	-0.103**	0.084**	0.067*	0.071*
Growing Season $(t-3, t-1)$	(0.042)	(0.043)	(0.041)	(0.036)	(0.034)	(0.041)
Negative Shock	0.098**	-0.009	0.073*	-0.082**	-0.055	-0.074*
Growing Season $(t-3, t-1)$	(0.039)	(0.041)	(0.037)	(0.034)	(0.034)	(0.038)
Avg. Pos. Shock Other Crops		-1.214***			0.312	
Growing Season $(t-3, t-1)$		(0.231)			(0.219)	
Avg. Neg. Shock Other Crops			0.314			-0.109
Growing Season $(t-3, t-1)$			(0.216)			(0.136)
Own Initial Tariff	0.194***	0.194***	0.194***			
	(0.011)	(0.011)	(0.011)			
Partner Initial Tariff				0.209***	0.209***	0.209***
				(0.013)	(0.013)	(0.013)
Own Crop Suitability	0.028***	0.024**	0.025**	0.002	0.003	0.003
	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)	(0.011)
Partner Crop Suitability	0.003	-0.001	0.003	0.001	0.002	0.001
	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
Own Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Partner Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Crop FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4035	4035	4035	4035	4035	4035
R^2	0.642	0.648	0.643	0.656	0.656	0.656

Notes. (* p-value$<$ 0.1; ** p-value$<$0.05; *** p-value$<$0.01) The unit of observation is crop by PTA. The dependent variable is the percentage difference in negotiated own import tariffs between baseline and 12 years after the implementation of the PTA. Shocks are calculated by summing up positive or negative monthly rainfall shocks (0/1) at the cell level across the country weighted by the potential productivity (suitability) of each cell to produce the crop. Shocks during the growing season are calculated by only considering months during the growing season of the crop. Non-growing season shocks are calculated by only considering months during the non-growing season. Suitability and shock variables are in log. Clustered standard errors at the country pair-year level.