Rain, Agriculture, and Tariffs

Paulo Bastos
Odd Rune Straume
Jaime A. Urrego

The World Bank
Development Research Group
Trade and Integration Team
March 2013

Abstract

This paper examines whether and how rainfall shocks affect tariff setting in the agricultural sector. In a model of strategic trade policy, the authors show that the impact of a negative rainfall shock on optimal import tariffs is generally ambiguous, depending on the weight placed by the domestic policy maker on tariff revenue, profits and the consumer surplus. The more weight placed on domestic profits, the more likely it is that the policy

maker will respond to a rainfall shortage by reducing import tariffs. These findings are robust to alternative assumptions about market structure and the timing of the game. Using detailed panel data on applied tariffs and rainfall for 70 nations, the authors find robust evidence that rainfall shortages generally induce policy makers to set lower tariffs on agricultural imports.

This paper is a product of the Trade and Integration Team, Development Research Group. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at <http://econ.worldbank.org>. The author may be contacted at pbastos@worldbank.org.

The Policy Research Working Paper Series disseminates the findings of work in progress to encourage the exchange of ideas about development issues. An objective of the series is to get the findings out quickly, even if the presentations are less than fully polished. The papers carry the names of the authors and should be cited accordingly. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the International Bank for Reconstruction and Development/World Bank and its affiliated organizations, or those of the Executive Directors of the World Bank or the governments they represent.

Rain, agriculture, and tariffs*

Paulo Bastos[†]

Odd Rune Straume[‡]

Jaime A. Urrego[§]

Keywords: Rainfall shocks; optimal tariffs; strategic trade policy; agriculture.

JEL: F1; L1; O1

*We would like to thank the Editor, two anonymous referees, and Will Martin for very helpful comments. The views expressed herein are those of the authors and not of the institutions they are affiliated with.

[†]Corresponding author. Development Research Group–Trade, The World Bank, 1818 H Street NW, Washington DC, United States. E-mail: pbastos@worldbank.org. Tel. +1 202 473 4332.

[‡]Department of Economics/NIPE, University of Minho, Portugal; and Department of Economics, University of Bergen. E-mail: o.r.straume@eeg.uminho.pt

[§]Research Department, Inter-American Development Bank, United States. E-mail: jaimeu@iadb.org

"...drought [in "rice countries"] is, perhaps, scarce ever so universal as necessarily to occasion a famine, if the government would allow a free trade."—Adam Smith (1776, IV.5.45)

1 Introduction

Random fluctuations in weather may have severe adverse effects on agricultural producers and consumers. How can policy makers mitigate these impacts? Recent empirical research suggests that greater openness to trade alleviates the adverse effects of weather shocks on domestic consumers. Using district-level panel data for colonial India in 1875-1919, and exploiting the construction of the railroad network to identify the effects of increased openness, Burgess and Donaldson (2011) document that the arrival of railroads dramatically constrained the ability of rainfall shortages to cause famine.¹ But while this evidence points to the existence of a causal link between openness and weather-related famine, import tariffs on agricultural goods remain high in many nations, and relatively little is known about the extent to which countries use trade policy *strategically* to mitigate the impacts of weather shocks on domestic welfare.²

In this paper, we examine whether and how rainfall shocks affect tariff setting in the agricultural sector. To identify key mechanisms at play, we first set up a model of international oligopoly in which domestic and foreign agricultural producers compete in the home market. International trade is potentially costly due to import tariffs optimally set by the domestic policy maker. A rainfall shortage increases the marginal costs of domestic producers, thus generating a shortfall in agricultural output that foreign producers have an incentive to meet. Consequently, the shock affects the marginal effects of import tariffs on tariff revenue, domestic profits and the consumer surplus, and thereby the optimal policy response.

We find that the impact of a rainfall shock on optimal import tariffs is not clear-cut. A rainfall shortage leads to a higher volume of agricultural imports and therefore higher marginal tariff revenues. All else equal, this increases the optimal tariff. On the other hand, by making home production more costly, the shock reduces incentives for using tariffs as an instrument to shift rents from foreign to domestic producers. This leads, *ceteris paribus*, to a lower optimal tariff. Finally, a rainfall shortage also reduces domestic consumers' surplus due to a lower total supply of the agricultural good. This increases (reduces) the negative effect of import tariffs on domestic consumers if food demand is

¹This evidence is consistent with Donaldson (2013), who shows that railroads contributed to reduce the exposure of agricultural prices and real incomes to rainfall shocks.

²Gibson et al. (2001) emphasize that high protection for agricultural commodities in the form of tariffs continues to be the major factor restricting world trade.

sufficiently (not too) convex, leading, all else equal, to lower (higher) tariffs. The overall impact of the rainfall shock on optimal import tariffs is, therefore, generally ambiguous, depending on the weight placed by the domestic policy maker on each of these policy objectives, and on the shape of the food demand function. A larger weight placed on domestic profits will enlarge the scope for a rainfall shortage to cause tariff reductions. A stronger concern for domestic consumers may have a similar effect, but only if demand is sufficiently convex, i.e., if the demand for the agricultural good becomes sufficiently inelastic at lower consumption levels.

We proceed by verifying the extent to which the main predictions of our theory are sensitive to assumptions about the timing of the game and the mode of competition. In the basic model, we assume that a rainfall shortage increases the marginal costs of agricultural production, as the affected producers must spend more resources on irrigation in order to achieve a given level of output. However, in some agricultural markets producers may have limited access to irrigation technology, and hence have limited ability to adjust output following the shock. We therefore modify the timing of the game, letting the policy maker, and subsequently the foreign producers, make their optimal decisions in response to an exogenous drop in domestic output. Reassuringly, we find that the results of the basic model remain qualitatively unchanged under this alternative setting, while also showing that a rainfall shortage is more likely to induce tariff cuts when producers have greater access to irrigation technology. In another extension to the basic model, we examine if and how our main results depend on the assumption of oligopolistic competition. Applying the theoretical framework of Bagwell and Staiger (2001), who analyze strategic trade policy under perfect competition, we re-examine the effect of a rainfall shortage on optimal import tariffs when firms are competitive rather than oligopolistic. We find, once again, that the key predictions of our basic model remain qualitatively similar.

We then examine empirically the impact of rainfall shocks on effectively applied tariffs. Using detailed panel data on applied tariffs and rainfall for 70 nations over 1988-2006, we find that rainfall shortages generally lead to lower applied tariffs on agricultural imports. The positive relationship between rainfall and import tariffs is robust to several alternative empirical specifications, tends to be stronger in countries with greater access to irrigation, and applies fairly widely across the set of agricultural products and regions considered. The main exception refers to nations in Africa, for which we find no evidence of significant tariff adjustment in response to rainfall shocks. This lack of response may plausibly reflect the fact that governments of African nations tend to depend more heavily on import tariffs for revenue (Devarajan et al., 1999). In this case, tariff revenue is likely to carry a larger weight on the governments' objective function, and thereby offset opposite incentives via profits and/or the consumer surplus. Overall, however, our empirical findings suggest

that policy makers around the world often adjust agricultural import tariffs strategically in response to rainfall shocks.

In addition to the work cited above, our paper is related to the theoretical and empirical literature on optimal tariffs and strategic trade policy, including Bickerdike (1907), Graaf (1949–1950), Spencer and Brander (1983), Dixit (1984), Brander and Spencer (1985), Eaton and Grossman (1986), Grossman and Helpman (1994, 1995), Brander (1995), Gawande et al. (2000), Broda et al. (2008) and Bagwell and Staiger (2001, 2012a, b). We are not aware of previous research, either theoretical or empirical, focusing on the effects of rainfall shocks on optimal tariffs in the agricultural sector. Our work is also broadly related to the emerging literature on how weather shocks shape economic, social and political outcomes (Deschênes and Greenstone, 2007; Maccini and Yang, 2009; Burgess et al., 2009; Brückner et al., 2011; Jones and Olken, 2010; Dell et al., 2012).

The remainder of the paper is organized as follows. Section 2 develops a theoretical model in which rainfall shocks impact on the optimal agricultural tariffs set by the domestic policy maker. Section 3 describes the empirical strategy, while section 4 presents the data employed in the empirical analysis. Section 5 presents the main results, before section 6 examines their robustness. Section 7 examines heterogeneity of effects across products and countries. Section 8 concludes.

2 A model of weather shocks and optimal agricultural tariffs

Consider an oligopolistic domestic market for a homogeneous agricultural good that is supplied by n domestic and m foreign producers.³ Domestic demand for the agricultural good is given by the inverse demand function

$$p = 1 - Q, \quad (1)$$

where

$$Q = \sum_{i=1}^n q_i + \sum_{j=1}^m \hat{q}_j \quad (2)$$

is total supply of the good, with q_i and $\hat{q}_j$ being quantities supplied by the domestic producer i and the foreign producer j , respectively.⁴ There is a constant marginal cost of

³It is common to adopt oligopoly models to investigate international trade in agricultural markets. Early theoretical and empirical research in this literature includes Sarris and Freebairn (1983), Karp and McCalla (1983), Kolstad and Burris (1986), Paarlberg and Abbott (1986) and Pick and Park (1991). Krishna and Thursby (1992) note that agricultural trade is often conducted through marketing boards for the product in question, both in developed and developing countries. Building on this observation, they examine optimal tax/subsidy policies with export marketing boards that compete as oligopolists in world markets.

⁴We adopt the simplifying assumption of linear demand in order to identify key mechanisms whereby a rainfall shortage shapes tariff setting incentives. Below we examine the implications of considering

production equal to c ($\hat{c}$) for domestic (foreign) producers. In addition, foreign producers must pay a per-unit tariff t for supplying the domestic market. This tariff is set by a domestic policy maker with the following objective function:

$$\Omega = T + \alpha \sum_{i=1}^n \pi_i + \beta S, \quad (3)$$

where

$$T = t \sum_{j=1}^m \hat{q}_j \quad (4)$$

is total tariff revenue,

$$\pi_i = (p - c) q_i \quad (5)$$

is the profit of the domestic producer i , and

$$S = \frac{1}{2} Q^2 \quad (6)$$

is domestic consumers' surplus. The specification of Ω is sufficiently general to encompass a variety of different policy objectives, where we allow the policy maker to place different weights on domestic profits and consumers' surplus: $\alpha \geq 0$ and $\beta \geq 0$, respectively.⁵

The profit of a foreign producer j is given by

$$\hat{\pi}_j = (p - \hat{c} - t) \hat{q}_j. \quad (7)$$

We consider the following two-stage game:

Stage 1: The domestic policy maker sets the import tariff t .

Stage 2: The domestic and foreign producers choose quantities simultaneously and non-cooperatively.

We look for a subgame-perfect Nash equilibrium, solving the model by backwards induction.

2.1 Equilibrium supply of the agricultural good

Each producer chooses its supply of the agricultural good to maximize its profits. The first-order conditions for a domestic and foreign producer, respectively, are given by

$$\frac{\partial \pi_i}{\partial q_i} = 1 - 2q_i - \sum_{k \neq i} q_k - \sum_{j=1}^m \hat{q}_j - c = 0 \quad (8)$$

alternative specifications for food demand, and discuss their empirical relevance.

⁵Notice that these weights are relative to the weight on tariff revenues. For example, if $\alpha < (>) 1$, the policy maker places a smaller (larger) weight on domestic profits than on tariff revenues. The case of $\alpha > 1$ is referred to by Bagwell and Staiger (2001) as a case where the government is influenced by 'political-economy considerations' (e.g., due to industry lobbying).

and

$$\frac{\partial \hat{\pi}_j}{\partial \hat{q}_j} = 1 - 2\hat{q}_j - \sum_{s \neq j} \hat{q}_s - \sum_{i=1}^n q_i - \hat{c} - t = 0. \quad (9)$$

Applying symmetry, $q_i = q_k = q$ and $\hat{q}_j = \hat{q}_s = \hat{q}$, the Nash equilibrium output of domestic and foreign producers, respectively, are given by

$$q = \frac{1 - (m+1)c + m(\hat{c} + t)}{m + n + 1} \quad (10)$$

and

$$\hat{q} = \frac{1 - (n+1)(\hat{c} + t) + nc}{m + n + 1}. \quad (11)$$

Total output is therefore

$$Q = \frac{n(1-c) + m(1 - \hat{c} - t)}{m + n + 1}, \quad (12)$$

which gives a domestic market price

$$p = \frac{1 + nc + m(\hat{c} + t)}{m + n + 1}. \quad (13)$$

Profits of domestic and foreign producers are given by $\pi = q^2$ and $\hat{\pi} = \hat{q}^2$, respectively.

2.2 Optimal import tariff

At the first stage of the game, the domestic policy maker chooses the import tariff, t , to maximize its objective function, given by (3). The optimal tariff is implicitly given by

$$\frac{\partial \Omega}{\partial t} = \frac{\partial T}{\partial t} + \alpha n \frac{\partial \pi}{\partial t} + \beta \frac{\partial S}{\partial t} = 0. \quad (14)$$

The second-order condition,

$$\frac{\partial^2 \Omega}{\partial t^2} = -m \left(\frac{2(n+1)(m+n+1) - (2\alpha n + \beta)m}{(m+n+1)^2} \right) < 0, \quad (15)$$

is satisfied if

$$\alpha < \tilde{\alpha} := \frac{2(n+1)(m+n+1) - m\beta}{2nm}. \quad (16)$$

To ensure equilibrium existence with an interior solution in the production subgame, we assume that the sextuple $(c, \hat{c}, n, m, \alpha, \beta)$ belongs to a set Θ , defined by

$$\Theta := \{(c, \hat{c}, n, m, \alpha, \beta) \mid q(t^*) > 0, \quad \hat{q}(t^*) > 0, \quad \alpha < \tilde{\alpha}\}. \quad (17)$$

Solving (14) with respect to t , the explicit expression for the optimal import tariff is given by⁶

$$t^* = \frac{\left[(1 - \hat{c} + n(c - \hat{c}))(m + n + 1) + 2\alpha n(1 - c - m(c - \hat{c})) - \beta(m(1 - \hat{c}) + n(1 - c)) \right]}{2(n+1)(m+n+1) - (2\alpha n + \beta)m}. \quad (18)$$

⁶The condition $\alpha < \tilde{\alpha}$ ensures that the denominator in (18) is positive.

The optimal tariff balances three different policy concerns: (i) raising tariff revenues, (ii) shifting oligopoly rents from foreign to domestic producers, and (iii) increasing consumers' surplus. Notice that more rent shifting and an increase in consumers' surplus are conflicting policy targets. Thus, a larger weight on domestic profits leads to a higher optimal tariff,

$$\frac{\partial t^*}{\partial \alpha} = \left(\frac{2n(m+n+1)}{2(n+1)(m+n+1) - (2\alpha n + \beta)m} \right) q(t^*) > 0, \quad (19)$$

while a larger weight on consumers' surplus leads to a lower optimal tariff,

$$\frac{\partial t^*}{\partial \beta} = - \left(\frac{(m+n+1)}{2(n+1)(m+n+1) - (2\alpha n + \beta)m} \right) Q(t^*) < 0. \quad (20)$$

2.3 Rainfall shortage

A negative rainfall shock implies that the affected producers must spend more resources on irrigation in order to achieve a given level of output, making agricultural production more expensive. We therefore model a domestic rainfall shortage as an increase in the marginal cost of domestic production, c . For simplicity, we assume that domestic and foreign producers have the same marginal production cost initially; i.e., we evaluate the domestic cost increase at $c = \hat{c}$. The effect on the optimal tariff can then be summarized as follows:⁷

Proposition 1 *Suppose that markets are oligopolistic and that domestic and foreign firms have initially the same production costs. In this case,*

- (i) *a domestic rainfall shortage always leads to a higher import tariff if α is sufficiently low,*
- (ii) *a domestic rainfall shortage leads to a lower import tariff if α is sufficiently high and if m is sufficiently large relative to n ,*
- (iii) *the higher is β , the larger is the scope for a higher import tariff in response to a domestic rainfall shortage.*

Proof. (i) From (18) we have

$$\frac{\partial t^*}{\partial c} = n \left(\frac{m+n+1+\beta-2\alpha(m+1)}{2(n+1)(m+n+1) - (2\alpha n + \beta)m} \right) > 0 \text{ if } \alpha < \bar{\alpha} := \frac{m+n+\beta+1}{2(m+1)}. \quad (21)$$

(ii) From (21) we see that $\partial t^*/\partial c < 0$ if $\alpha > \bar{\alpha}$. However, it remains to show whether this case is relevant, i.e., whether $\bar{\alpha} \in \Theta$ for some parameter configurations. Setting $c = \hat{c}$ and

⁷We evaluate the effect of a domestic rainfall shortage by considering a marginal increase in the domestic cost of agricultural production. However, it can easily be shown that the effect on the optimal tariff is qualitatively identical if we instead consider a discrete increase in marginal production costs.

inserting the optimal import tariff into (10)-(11), an interior solution exists if $\alpha < \frac{n(1+\beta)+1}{2n}$ and $\beta < \frac{m+2(n+1)}{m}$. It is straightforward to verify that, if these two inequalities hold, then the second-order condition $\alpha < \tilde{\alpha}$ is satisfied. Furthermore, $\frac{n(1+\beta)+1}{2n} > \bar{\alpha}$, implying $\bar{\alpha} \in \Theta$, if $m > \frac{n^2-1}{n\beta+1}$. Part (iii) of the proposition follows directly from the definition of $\bar{\alpha}$. ■

For a given level of the import tariff, a domestic rainfall shortage, by increasing the domestic cost of agricultural production, leads to lower market shares for domestic producers. Although some of the fall in domestic production is replaced by increased imports, there will also be a reduction in the total supply of the agricultural good to the domestic market. Thus, domestic producers as well as consumers are hurt by a negative rainfall shock. Since domestic producers (consumers) would suffer (benefit) from a lower import tariff, it might seem somewhat counterintuitive that a lower import tariff can be an optimal policy response to a rainfall shortage only if the policy maker places a sufficiently large weight on domestic profits, and that the scope for such a policy response is larger the less weight the policy maker places on consumers' surplus. The intuition for this result, though, can be found by considering how a domestic cost increase affects the policy maker's trade-off among its three different policy targets. These are given by the three terms in (14), and we will consider each of the three different policy targets in turn.

(i) The effect of using import tariffs to raise tax revenues is given by

$$\frac{\partial T}{\partial t} = m \left(\hat{q} + t \frac{\partial \hat{q}}{\partial t} \right) = m \left(\hat{q} - t \left(\frac{n+1}{m+n+1} \right) \right). \quad (22)$$

An increase in domestic production costs leads to a higher import volume (since $\hat{q}$ is increasing in c) and therefore higher marginal tariff revenues. All else equal, this increases the optimal tariff.

(ii) The effect of using import tariffs to shift oligopoly rents from foreign to domestic producers is given by

$$\frac{\partial \pi}{\partial t} = \frac{\partial p}{\partial t} q + (p - c) \frac{\partial q}{\partial t} = \left(\frac{2m}{m+n+1} \right) q. \quad (23)$$

Foreign producers will respond to a higher import tariff by reducing their supplies to the domestic market. This leads to a shift in oligopoly rents from foreign to domestic producers through two different channels, represented by the two terms in (23). The price increase that results from less imports makes domestic production more profitable (term 1) and domestic producers will respond by expanding their output, which increases profits in proportion to the price-cost margin (term 2). A domestic rainfall shortage reduces both of these effects, since higher domestic production costs reduce both the output and the price-cost margin of domestic producers (notice that $p - c = q$ in equilibrium), which in turn reduces the marginal rent-shifting effect of import tariffs. In other words, import tariffs become less effective as a rent-shifting instrument if domestic producers become

more cost-disadvantaged. All else equal, this reduces the optimal tariff and, naturally, the effect is stronger the larger weight the policy maker places on domestic profits.

(iii) The effect of using import tariffs to increase domestic consumers' surplus is given by

$$\frac{\partial S}{\partial t} = Q \left(n \frac{\partial q}{\partial t} + m \frac{\partial \hat{q}}{\partial t} \right) = - \left(\frac{m}{m+n+1} \right) Q. \quad (24)$$

An increase in domestic production costs reduces total supply of food in the domestic market. If consumers' surplus is convex in output, which is true for linear demand functions, this means that the reduction in consumers' surplus due to a marginal tariff increase is lower. All else equal, this increases the optimal tariff and, naturally, the effect is stronger the larger weight the policy maker places on consumers' surplus.

Thus, we can conclude that the policy maker will optimally respond to a domestic rainfall shortage by lowering import tariffs if the second of the three above described effects – the reduced effectiveness of import tariffs as a rent-shifting instrument – is sufficiently strong to outweigh the other two effects. Otherwise, the import tariff will increase.

The above analysis is based on the simplifying assumption of linear demand. Although the main mechanisms of the model, as given by the three different effects described above, generalize well beyond the assumption of linear demand, it is worth considering the extent to which our results are robust to alternative demand assumptions. In particular, the result that a tariff increase has a larger negative impact on consumers at higher consumption levels relies on the assumption that consumers' surplus is convex in output. For a general inverse demand function $p(Q)$, this requires that

$$p'(Q) + Qp''(Q) < 0.$$

In other words, consumers' surplus is convex in output for concave, linear and 'not-too-convex' demand functions. However, since demand for food is likely to become quite inelastic for low consumption levels, consumers' surplus might be concave in output for the range of output levels that are relevant for rainfall shortages that cause a serious cut-back in domestic production.⁸ If this is the case, a rainfall shortage will increase the negative effect of import tariffs on consumers' surplus, thereby increasing the scope for tariff reductions as an optimal response to a negative rainfall shock.

⁸In empirical studies, demand for food is generally found to be inelastic (Andreyeva et. al. 2010). O'Hare and Kammen (2008) argue that it seems reasonable to assume that demand for food becomes less and less elastic as agricultural output declines. As food consumption falls, consequences like malnutrition and starvation begin to appear, impacts much more compelling than the hedonic costs of consuming a less-preferred diet or wasting less food. Consistent with this hypothesis, Andreyeva et. al. (2010) survey a large body of evidence on the price elasticity of demand for food and conclude that demand is relatively more elastic for categories like "food away from home", "soft drinks" and "juice".

2.4 Extensions

In this subsection we consider two different extensions to the model. First, we modify the timing of the game by considering the case where domestic producers are not able to adjust their output decisions in response to a rainfall shortage. Second, we abandon the oligopoly assumption and consider the case of perfectly competitive markets.

2.4.1 No domestic output adjustment

In some agricultural markets, due to a lack of access to sufficient amounts of irrigated water, it might not be feasible to use irrigation in order to compensate for a rainfall shortage. If this is the case, domestic producers will have limited ability to adjust output in response to rainfall-induced tariff changes. We explore this scenario by modifying the timing of the game, letting the policy maker, and subsequently the foreign producers, make their optimal decisions in response to an exogenous drop in domestic production.

Let total domestic output be denoted by $\bar{q} := \sum_{i=1}^n q_i$. For a given tariff level, the best-response from foreign suppliers are given by (9). In the symmetric equilibrium, with $\hat{q}_j = \hat{q}$ for all $j = 1, \dots, m$, the output chosen by each foreign producer is given by

$$\hat{q} = \frac{1 - \bar{q} - t - \hat{c}}{m + 1}. \quad (25)$$

Substituting $\hat{q}$ from (25) into (3), where $\sum_{i=1}^n \pi_i = (p - c) \bar{q}$ and $S = \frac{1}{2} (\bar{q} + m\hat{q})^2$, and maximizing with respect to t , the optimal import tariff, as a function of an exogenous domestic output level, is given by

$$t^* = \frac{(m + 1) (1 - \hat{c} + (\alpha - 1) \bar{q}) - \beta (\bar{q} + m (1 - \hat{c}))}{2 (m + 1) - m\beta}. \quad (26)$$

The second-order condition of the maximization problem holds if $\beta < \frac{2(m+1)}{m}$.⁹ We also assume that $\bar{q}$ is sufficiently low to ensure an interior solution with strictly positive import volumes.

We analyze the import tariff response to a domestic rainfall shortage by considering a marginal reduction in domestic production, $\bar{q}$.¹⁰

Proposition 2 *Suppose that markets are oligopolistic but domestic firms are not able to adjust output in response to a rainfall shock. In this case,*

⁹The second-order condition is explicitly given by

$$\frac{\partial^2 W}{\partial t^2} = -m \frac{(2(m+1) - m\beta)}{(m+1)^2} < 0.$$

¹⁰Due to the linearity assumptions of the model, the tariff response is qualitatively identical if we instead consider a discrete fall in domestic production.

(i) a domestic rainfall shortage leads to a higher (lower) import tariff if α is sufficiently low (high),

(ii) the higher is β , the larger is the scope for a higher import tariff in response to a domestic rainfall shortage.

Proof. (i) From (26) we have

$$\frac{\partial t^*}{\partial \bar{q}} = \frac{(\alpha - 1)(m + 1) - \beta}{2(m + 1) - m\beta} < (>) 0 \text{ if } \alpha < (>) 1 + \frac{\beta}{m + 1}. \quad (27)$$

An interior solution always exists for $\alpha > 1 + \frac{\beta}{m+1}$ if $\bar{q}$ is sufficiently low, which we assume to be the case. Part (ii) of the proposition follows directly from (27). ■

Comparing Propositions 1 and 2, it is clear that the effect of a domestic rainfall shortage on import tariffs, in qualitative terms, does not depend on whether domestic producers are able to adjust their output in response to the rainfall shock or not. Notice also that the results in Proposition 2 hold for any initial level of $\bar{q}$ (that yields positive import volumes).

The intuition behind these results follows closely the intuition given for Proposition 1. The effects that go through the policy maker's incentive for raising tariff revenues and increasing consumers' surplus are almost identical under the two different scenarios, as the equilibrium effect of higher marginal production costs is similar to an exogenous cut-back in production. The incentives for using import tariffs to shift oligopoly rents from foreign to domestic producers are also qualitatively similar, although the quantitative effect is somewhat different when domestic producers cannot respond strategically to a change in import tariffs. Formally, the effect of a tariff increase on domestic profits in the case of no domestic output adjustment, is given by

$$\frac{\partial (\sum_{i=1}^n \pi_i)}{\partial t} = \bar{q} \frac{\partial p}{\partial t} = \frac{m\bar{q}}{m + 1}. \quad (28)$$

A higher import tariff increases the domestic market price, which increases domestic profits. However, if domestic producers are not able to adjust their output in response to the tariff change, the positive profit effect is smaller than it would have been if the domestic producers could meet the price increase by increasing their output. Thus, the incentive to use import tariffs to increase domestic profits is smaller in the absence of domestic output adjustment. Nevertheless, a drop in domestic production due to rainfall shortage will reduce this policy incentive even further, contributing, all else equal, to a lower import tariff. As before, this effect establishes a negative relationship between rainfall shortage and import tariffs if the policy maker places a sufficiently large weight on domestic profits in his objectives.

2.4.2 Perfect competition

The oligopoly assumption used in the main version of the model may be less suitable for some agricultural markets, particularly in developing countries. We will therefore analyze if and how our main results might be affected by the assumption of imperfect competition. Suppose instead that the domestic market is supplied by competitive (domestic and foreign) firms. As in Bagwell and Staiger (2001), we assume that the domestic and foreign industries are characterized by positively sloped supply functions and associated profit (producer surplus) functions. The domestic and foreign supply functions are given by, respectively,

$$q(p) = \frac{p - c}{2} \quad (29)$$

and

$$\hat{q}(\hat{p}) = \frac{\hat{p}}{2}, \quad (30)$$

where p is the domestic price, given by (1), and $\hat{p}$ is the export price for foreign suppliers. The parameter c is a shift parameter that shifts down the domestic supply function in case of a rainfall shortage.¹¹ The prices p and $\hat{p}$ satisfy the arbitrage condition

$$p = \hat{p} + t \quad (31)$$

and the competitive equilibrium is characterized by the market-clearing condition

$$Q = q(p) + \hat{q}(\hat{p}). \quad (32)$$

From (1) and (29)-(32), the domestic price in the competitive equilibrium is given by

$$p = \frac{1}{2} \left(1 + \frac{1}{2} (c + t) \right). \quad (33)$$

The domestic policy maker optimally sets the import tariff to maximize an objective function similar to (3), now given by

$$\Omega = T + \alpha\pi + \beta S, \quad (34)$$

where $T = t\hat{q}(\hat{p})$ is tariff revenue, π is domestic producer surplus, and S is consumers' surplus, given by (6). Since $\partial\pi/\partial p = q(p)$, domestic producer surplus is given by

$$\pi(p) = \int_0^p q(s) ds = \frac{p}{2} \left(\frac{p}{2} - c \right). \quad (35)$$

¹¹In contrast to the cost assumption in the oligopoly model, these supply functions imply decreasing returns to scale. This difference is consistent with the often held notion that market structure (oligopoly versus perfect competition) is endogenously determined by technology. However, it is straightforward to show that the results from the oligopoly model would be qualitatively similar if we changed the cost functions to a linear-quadratic form $C(q) = cq + q^2$, with c being the cost-shifting parameter, which would correspond to a supply function given by (29). Details of these calculations are available upon request.

Solving the policy maker's maximization problem, it is straightforward to derive an explicit expression for the optimal import tariff:

$$t^* = \frac{8 + 4c - 4\beta + 2c\beta + 2\alpha - 3c\alpha}{24 - 2\beta - \alpha}. \quad (36)$$

The second-order condition is

$$\frac{\partial^2 W}{\partial t^2} = -\frac{1}{32} (24 - 2\beta - \alpha) < 0, \quad (37)$$

which is satisfied if $\alpha < 24 - 2\beta$.¹² As in the oligopoly model, optimal import tariff setting balances three different considerations: (i) raising tariff revenues, (ii) increasing domestic producer surplus, and (iii) increasing consumer surplus. Once more, (ii) and (iii) are conflicting policy targets, as domestic producers benefit from a higher import tariff while consumers benefit from lower tariff level. Thus,

$$\frac{\partial t^*}{\partial \alpha} = \frac{8q(t^*)}{24 - 2\beta - \alpha} > 0; \quad \frac{\partial t^*}{\partial \beta} = -\frac{8Q(t^*)}{24 - 2\beta - \alpha} < 0. \quad (38)$$

A negative rainfall shock leads to a downward shift in the domestic supply curve. As before, due to the linearity of the model, the effects on optimal tariff setting of a marginal increase in c and a discrete increase in c are identical. In line with our previous analysis, we also assume that domestic and foreign production costs are ex ante identical; i.e., we evaluate the effect of the rainfall shock at $c = 0$.

Proposition 3 *Suppose that markets are perfectly competitive and that domestic and foreign firms have initially the same production costs. In this case,*

- (i) *a domestic rainfall shortage leads to a higher (lower) import tariff if α is sufficiently low (high),*
- (ii) *the higher is β , the larger is the scope for a higher import tariff in response to a domestic rainfall shortage.*

Proof. (i) From (36) we have

$$\frac{\partial t^*}{\partial c} = \frac{4 + 2\beta - 3\alpha}{24 - 2\beta - \alpha} > (<) 0 \text{ if } \alpha < (>) \frac{1}{3} (4 + 2\beta). \quad (39)$$

We also need to show that an interior solution always exists for $\alpha > \frac{1}{3} (4 + 2\beta)$. For $c = 0$, an interior solution requires $\beta < 7$ and $\alpha < 3 + \beta$. The latter inequality also ensures that the second-order condition $\alpha < 24 - 2\beta$ is satisfied. Equilibrium existence for $\alpha > \frac{1}{3} (4 + 2\beta)$ is confirmed by noticing that $3 + \beta > \frac{1}{3} (4 + 2\beta)$ for all $\beta \geq 0$. Part (ii) of the proposition follows directly from (39). ■

¹²In addition, an interior solution with positive domestic and foreign supply requires that $\beta < \frac{14-17c}{2(1-c)}$ and $\alpha < \frac{2\beta+3c-2c\beta+6}{2(1-c)}$.

A comparison of Propositions 1 and 3 reveals that the effect of domestic rainfall shortage on import tariffs does not depend crucially on whether agricultural markets are oligopolistic or competitive. In either case, a sufficiently large weight on domestic producer surplus in the policy maker’s objective function is necessary for import tariffs to fall in response to a negative rainfall shock.

The decomposition of effects shown in Section 2.2 also applies in the case of perfect competition. A downward shift in the domestic supply curve implies that some domestic production is replaced by imports but total supply to the market goes down. The increased import volume increases marginal tariff revenues, while the lower total supply implies that the reduction in consumer surplus due to a tariff increase is lower (since consumers’ surplus is convex in output). Both of these effects contribute to a higher import tariff in response to a domestic rainfall shortage.

As before, the counteracting effect is the concern for domestic producer surplus. A higher import tariff increases the domestic producer price, and the corresponding increase in domestic producer surplus is positively correlated with total domestic output. Technically, this effect is given by

$$\frac{\partial \pi}{\partial t} = \frac{\partial \pi}{\partial p} \frac{\partial p}{\partial t} = q \frac{\partial p}{\partial t} = \frac{q}{4} = \frac{2 + t - 3c}{32}. \quad (40)$$

A negative rainfall shock (i.e., an increase in c) reduces domestic output and therefore reduces the marginal profit gain of increasing the domestic price through higher import tariffs. All else equal, this reduces the optimal tariff, and, if this effect is sufficiently strong (which requires a sufficiently high value of α), it will outweigh the two other effects and enforce a negative equilibrium relationship between rainfall shortage and import tariffs.

3 Empirical strategy

To estimate the impact of rainfall shocks on applied import tariffs we adopt the following econometric specification:

$$\ln \text{tariff}_{ict} = \alpha + \beta \ln \text{rain}_{ct} + \gamma \ln \text{rain}_{ct} * \text{agric}_i + \lambda_i + \tau_c + \tau_t + \mu_{ict}, \quad (41)$$

where tariff_{ict} is the mean of import tariffs applied on product i by country c in year t ; rain_{ct} is the amount of rainfall recorded in country c in year t ; agric_i is a dummy variable that takes the value of one for agricultural products; λ_i is an industry fixed-effect, τ_c is a country fixed-effect and τ_t is a year fixed-effect. μ_{ict} is an idiosyncratic error term.

Our main interest lies on γ , which reveals whether and how countries use trade policy strategically to mitigate the adverse effects of rainfall shortages on the agricultural sector. Conditional on industry and year fixed-effects, identification of the causal effect of interest

relies on the plausible assumption that within-country variation in rainfall over time is orthogonal to other determinants of import tariffs.

4 Data

Our empirical analysis makes use of the following sets of data:

1. *Import tariffs* We use annual data on bilateral applied tariffs by country and product (SITC 2-dig., Rev. 4) from the TRAINS database of the United Nations Conference on Trade and Development. These data are generally available from 1988 onwards, but the extent of time coverage differs considerably across countries. We construct both simple and import-weighted averages of bilateral applied tariffs by country-product-year. For a given country-product pair, the former measures are defined as the simple average of applied tariffs on imports from the various source countries in year t . The latter measures are defined as the weighted average of such bilateral import tariffs, where the weights are the share of each source country in total country-product imports in a base period.¹³ Data on bilateral imports used to construct these weights come from the United Nations Commodity Trade Statistics Database (COMTRADE). To account for tariff binding, we will further make use of analogous information on bound tariff rates.¹⁴ These data also come from TRAINS, but are only available from 1995.
2. *Rainfall and irrigation* We use the data set on population-weighted rainfall levels by country-year constructed and made available online by Dell et al. (2012). The original source of the historical rainfall data is the Terrestrial Air Temperature and Precipitation: 1900-2006 Gridded Monthly Time Series (Version 1.01), compiled by Kenji Matsuura and Cort Willmott (2007) in conjunction with NASA. This database provides worldwide (terrestrial) monthly precipitation information at 0.5×0.5 degree resolution. Dell et al. (2012) use geospatial software to aggregate these rainfall data to the country-year level, weighting by the population distribution within the country.¹⁵ We further use country-level data on the proportion of agricultural land that is irrigated. These data come from the World Development Indicators of the World Bank, and are generally available for the period 2001-2009.

We combine these sets of data to construct an unbalanced panel at the product-country-year level, covering 70 nations over the period 1988-2006. Table A.1 in the appendix

¹³The base period is the first year for which tariff data are available for the tariff-setting country.

¹⁴The most-favored-nation tariff rate resulting from negotiations associated with GATT/WTO membership.

¹⁵These data are also used by Jones and Olken (2010).

summarizes the data sources and variable definitions. To ensure adequate coverage for each country, we excluded information for nations that do not have at least three consecutive years of tariff and rainfall data. Table A.2 lists the countries and corresponding time periods covered in our sample, while Table A.3 details the product classification we employ. To identify agricultural products we use the UN statistics division of the SITC classification. For robustness, we also consider a broader definition that includes as well other agricultural products.¹⁶ Irrigation data are available for 32 of the 70 countries initially considered. These data generally refer to the 2001-2009 period, but the extent of time coverage differs across countries. We therefore use the average value of this variable among non-missing observations for each of the 32 countries as a (time-invariant) proxy for access to irrigation at the country-level.

Figure 1 provides illustrative evidence on the rainfall variable we employ for a subset of countries. The dashed lines in these diagrams refer to major, widely-documented droughts observed in each nation. Many of these extreme weather events were associated with the *El Niño* or *La Niña* phenomena, including Argentina (1999), Bolivia (1998), Brazil (1998, 2003), Colombia (1992, 1997), Chile (1998), Costa Rica (2001), Guatemala (1997, 2001) and Peru (2000).

[Figure 1 about here]

Our theory applies to countries that have discretion to set import tariffs on agricultural goods. A potential concern is that, in reality, tariff setting might be constrained by limits associated with GATT/WTO membership. As shown in Figure 2, however, countries typically set their tariffs on agricultural goods well below the bound tariffs imposed by such multilateral tariff agreements; see Gibson et. al (2001, pp. 20-21) for further data and discussion. This implies that policy makers have ample policy space to adjust tariffs strategically in response to rainfall shortages. We will nevertheless address this concern directly in the econometric analysis below.

[Figure 2 about here]

Table 1 reports summary statistics on the final panel data set employed in the regression analysis. As can be seen, most observations refer to developing countries in Latin America and Caribbean, Asia-Pacific and Africa.¹⁷

[Table 1 about here]

¹⁶ As shown in Table A.3, this latter definition includes as well SITC product categories "08", "09", "11", "12" and "29".

¹⁷ We adopt a broad definition of the term "Asia-Pacific", comprising all nations in Asia and Oceania.

5 Main results

Table 2 reports our baseline results. Columns (1) and (2) report the estimates obtained using a simple average of import tariffs as the dependent variable, while columns (3) and (4) report results from using import-weighted tariffs. By definition, the former measures give equal weights to all bilateral applied tariffs within each country-product-year. They are therefore less sensitive to potential bias arising from the fact that a higher tariff imposed on a given source country may lead to zero or little equilibrium imports from that nation. The latter measures have the advantage of placing a larger weight on tariffs imposed on countries for which import volumes of that product are larger to begin with. If such differential import shares reflect heterogeneity in fundamentals across source countries (e.g., due to stronger comparative advantage in agriculture), the policy maker may optimally favor larger adjustments to import tariffs imposed on major food exporters, so as to obtain larger impacts from the policy response. It is therefore important to use both measures.

[Table 2 about here]

The estimates reported in columns (1) and (3) of Table 2 show no significant effects of rainfall shocks on overall import tariffs. This result is not surprising, considering that rainfall shortages would not be expected to affect tariff setting in the non-agricultural sector, and that agricultural goods represent a relatively small proportion of the full spectrum of products. Columns (2) and (4) point, however, to significant impacts of rainfall shocks on import tariffs of agricultural products: the coefficient of interest is positive and statistically significant at the 1% level, suggesting that a rainfall shortage induces policy makers to set lower tariffs on agricultural imports. When seen in conjunction with our theoretical model, this result suggests that policy makers place a considerable weight on domestic producer surplus when setting import tariffs.

6 Robustness

We conduct a number of checks to verify the robustness of our empirical findings. First, we examine the extent to which the results are sensitive to composition of our sample. To do this, we restrict the sample to include only countries that report at least four consecutive years of tariff and rainfall data. This restriction reduces the number of countries in the estimation sample to 51, down from the 70 initially considered. Reassuringly, the estimates yielded by this restricted sample remain very similar, both qualitatively and quantitatively (Table 3).

[Table 3 about here]

We proceed by verifying the extent to which the results are sensitive to the definition of agricultural products we employ. In our baseline analysis, we rely on the UN statistics division of the SITC classification. For robustness, in Table 4 we consider a broader definition that includes as well other agriculture-related products (Table A.3). The results reported in this table show that our findings remain very similar when this alternative definition is used.

[Table 4 about here]

Table 5 reports the estimates obtained when considering this broader definition of agricultural products and the restricted sample of countries that report at least four consecutive years of tariff and rainfall data. Once again, the results remain very similar.

[Table 5 about here]

As mentioned above, a potential concern for our empirical analysis is that tariff setting might be constrained by limits associated with GATT/WTO membership. We adopt two alternative strategies to verify the extent to which our results are sensitive to tariff binding. First, we restrict the sample to include only country-product-year observations in which applied tariffs are considerably smaller than the corresponding bound tariffs. Second, we account for censoring by adopting a Tobit random effects model on the full estimation sample.

Table 6 reports the results yielded by the first of these strategies. While the analysis in the previous section spanned the 1988-2006 period, information on bound tariffs is only available from 1995. Hence we begin by showing in column (1) that our baseline results remain qualitatively similar when we restrict the sample to include this sub-period only. In columns (2)-(4) we report results from analogous regressions, but now imposing progressively more stringent restrictions on the distance between applied and bound tariffs. Reassuringly, we find that the coefficient of interest remains remarkably stable across all the subsamples considered.

[Table 6 about here]

A potential concern with the results reported in Table 6 is that this approach introduces sample selection, which may affect the estimated coefficients directly. We therefore turn to the Tobit random effects estimator. This method makes it possible to account for censoring due to tariff binding without introducing sample selection. A downside of the Tobit model, however, is that it is not possible to correct the standard errors for potential idiosyncratic correlation across products and over time within each country, implying that the standard errors are likely to be biased downwards. Table 7 reports the estimated marginal effects. Columns (1) and (3) refer to models with country random-effects (including

also product and year dummies), while columns (2) and (4) refer to models with product fixed-effects (including also country and year dummies). We find that the marginal effects of interest are always remarkably similar to the OLS point estimates reported in column (1) of Table 6. Taken together, the results from these two strategies provide evidence that the potential bias imposed by tariff binding does not appear to be an important concern in our application.

In the analysis thus far, we have adopted a linear function of rainfall. To account for potential nonlinearity in the policy response to extreme events such as drought, we modify our basic specification by considering instead a set of dummy variables that are intended to capture extreme realizations of rainfall. In columns (1) and (4) of Table 8, we consider a dummy variable that takes the value of one when a realization of rainfall for a given country-year is below the 15th percentile of the rainfall distribution in the period 1988-2006.¹⁸ Consistent with the results reported earlier, the estimates indicate that severe rainfall shortages induce policy makers to set lower tariffs on agricultural imports. In columns (2) and (5), we introduce a dummy variable that equals one when the level of rainfall for a given country-year is above the 85th percentile of this distribution. The results indicate that larger volumes of rainfall are associated with higher agricultural tariffs, what is again consistent with the linear specification.¹⁹ The results in columns (3) and (6) reveal that these conclusions remain unchanged when including both these dummy-variables and interaction terms together in the same regression.

7 Heterogeneity of effects across products and countries

We now examine the extent to which the impacts of rainfall shocks on agricultural tariffs are heterogeneous across products and countries. Table 9 presents the results from regressions in which the rainfall variable is interacted with dummy variables for each of the agricultural products included in the UN statistics division of the SITC classification (see Table A.3). The results in columns (1) and (3) suggest that a rainfall shortage leads to tariff reductions in most of the products considered. When considering both simple and weighted import tariffs, we find positive and significant effects for all product categories,

¹⁸We define this variable based on the full country-level data on the log of rainfall for this period. We have considered alternative thresholds to define the dummy variable and have obtained qualitatively similar results.

¹⁹Extremely high realizations of rainfall in a short period of time can cause floods. Floods may (or may not) reduce agricultural output in a given year. While a flood typically reduces agricultural output in the months it occurs, it also tends to increase agricultural productivity in the following growing season, what has the opposite effect (Banerjee, 2007). Based on annual data on country-level rainfall, it is however difficult to separate floods from consistently higher volumes of rainfall spread over the year.

with the exception of the categories "live animals" and "oilseeds and oleaginous fruits". In columns (2) and (4), we conduct a similar analysis, but including now interactions terms between log rainfall and individual dummy variables for each agricultural product considered in the broader definition defined earlier.

[Table 9 about here]

Table 10 reports separate estimates by region. Since our sample comprises a very small number of jurisdictions in North America and Europe, we report results for countries in Africa, Latin America and Caribbean and Asia-Pacific. The estimates for the latter two regions are very similar to those obtained for the full sample. For Africa, however, we obtain insignificant coefficients on the interaction term of interest.²⁰ In the context of our model, how can we rationalize these insignificant results? One potential explanation is that agricultural producers in Africa tend to have less access to irrigation technologies. As discussed in section 2.4, for a given weight placed by domestic policy maker on domestic profits, the inability to adjust output in response to a rainfall shortage will reduce the likelihood that such shock leads to a tariff reduction. Alternatively, policy makers in Africa may generally place a smaller weight on domestic profits, perhaps because agricultural producers there tend to be relatively smaller and less organized collectively. On the other hand, as also discussed above, a negative rainfall shortage is more likely to induce tariff reductions when demand for food is more inelastic for low consumption levels. This would appear to be more likely the case in African countries, where food consumption tends to be closer to subsistence levels, making tariff reductions in response to a rainfall shortage more likely there. The lack of response revealed by the data may however reflect the fact that governments of African nations tend to depend more heavily on import tariffs for revenue (Devarajan et al., 1999). In such a case, tariff revenue is likely to carry a larger weight on the governments' objective function, and thereby offset opposite incentives via profits and/or the consumer surplus.

[Table 10 about here]

We proceed by examining more directly the predictions of our theory about the role of access to irrigation in shaping the effects of a rainfall shock on agricultural import tariffs. As noted above, our theory predicts that a greater ability to adjust output in response to a rainfall shortage increases the incentives to shift oligopoly rents from foreign to domestic

²⁰Nevertheless, there are reasons to remain cautious in interpreting these insignificant results as evidence that African nations do not lower import tariffs strategically in response to rainfall shortages. First, although still sizable, sample size is considerably smaller for Africa than for the other two regions. Second, when using the main sample and weighted import tariffs as the dependent variable, the magnitude of the coefficient of interest is fairly similar across regions.

producers. All else being equal, greater access to irrigation would therefore be expected to magnify the positive relationship between rainfall and agricultural import tariffs. To examine this prediction, we use country-level data on the proportion of total agricultural land that is irrigated. As mentioned above, these data are available for 32 of the 70 countries initially considered. Hence our estimation sample is reduced accordingly. Table 11 reports the corresponding results. In line with the predictions of our theoretical model, the estimates in columns (2) and (4) suggest that greater access to irrigation contributes to magnify the positive relationship between rainfall and agricultural import tariffs.

[Table 11 about here]

8 Concluding remarks

We have examined theoretically and empirically the effects of rainfall shocks on tariff setting in the agricultural sector. In a model of strategic trade policy, we have shown that the impact of a negative rainfall shock on optimal tariffs is generally not clear-cut, depending crucially on the weight placed by the domestic policy maker on each of the various policy objectives, and on the shape of the food demand function. We have then estimated the impact of rainfall shocks on applied tariffs. Using detailed panel data on applied tariffs and rainfall for 70 nations, we have found robust evidence that rainfall shortages generally lead to lower tariffs on agricultural imports. When interpreted in conjunction with our theory, this result suggests that policy makers place a considerable weight on domestic producer surplus when setting import tariffs.

Appendix

[Tables A.1-A.3 about here]

References

- [1] Andreyeva, T., Long, M.W. and Brownell, K.D. (2010). "The Impact of Food Prices on Consumption: A Systematic Review of Research on the Price Elasticity of Demand for Food." *American Journal of Public Health*, 100: 216-222.
- [2] Banerjee, L. (2007). "Effects of flood on agricultural wage formation in Bangladesh: An Empirical Analysis." *World Development*, 35: 1989-2009.
- [3] Bagwell, K. and Staiger, R. (2001). "Strategic trade, competitive industries and agricultural trade disputes." *Economics and Politics*, 13: 113-128.

- [4] Bagwell, K. and Staiger, R. (2012a). "The Economics of Trade Agreements in the Linear Cournot Delocation Model." *Journal of International Economics*, 88(1): 32-46.
- [5] Bagwell, K. and Staiger, R. (2012b). "Profit Shifting and Trade Agreements in Imperfectly Competitive Markets." *International Economic Review*, 53(4): 1067-1104.
- [6] Bickerdike, C. (1907). "Review of A. C. Pigou's Protective and Preferential Import Duties." *Economic Journal*, 17: 98-108.
- [7] Brander, J. (1995), "Strategic Trade Policy." in G. Grossman and K. Rogoff (eds.): *Handbook of International Economics*, Amsterdam: North-Holland, 3: 1395-1455.
- [8] Brander, J. and Spencer, B. (1985). "Export subsidies and international market share rivalry." *Journal of International Economics*, 18: 83-100.
- [9] Brückner, M. and Ciccone, A. (2011). "Rain and the Democratic Window of Opportunity." *Econometrica*, 79: 923-947.
- [10] Broda, C., Limão, N., and Weinstein, D. (2008). "Optimal Tariffs and Market Power: The Evidence." *American Economic Review*, 98: 2032-2065.
- [11] Burgess, R. and Donaldson, D. (2011). "Can Openness Mitigate the Effects of Weather Fluctuations? Evidence from India's Famine Era" *American Economic Review*, 100: 449-453.
- [12] Burgess, R., Dêschenes, O., Donaldson, D. and Greenstone, M. (2009). "Weather Related Death in India", MIT.
- [13] Deschênes, O. and Greenstone, M. (2007). "The Economic Impacts of Climate Change: Evidence from Agricultural Output and Random Fluctuations in Weather." *American Economic Review*, 97: 354-385.
- [14] Devarajan, S., Go, D.S., Li, G. (1999). "Quantifying the fiscal effects of trade reform: A general equilibrium model estimated for 60 countries." The World Bank, Policy Research Working Paper 2162.
- [15] Dixit, A. (1984). "International Trade Policy for Oligopolistic Industries." *Economic Journal*, 94: 1-16
- [16] Dell, M., Jones, B., Olken, B. (2012). "Temperature Shocks and Economic Growth: Evidence from the Last Half Century." *American Economic Journal: Macroeconomics*, 4(3), 66-95.

- [17] Donaldson, D. (2013). "Railroads of the Raj: Estimating the Impact of Transportation Infrastructure." *American Economic Review*, forthcoming.
- [18] Eaton, J., Grossman, G. (1986). "Optimal Trade and Industrial Policy under Oligopoly." *Quarterly Journal of Economics*, 101: 383–406.
- [19] Gibson, P., Wainio, J., Whitley, D. and Bohman, M. (2001). "Profiles of Tariffs in Global Agricultural Markets". Agricultural Economic Report No. 796, Market and Trade Economics Division, Economic Research Service, U.S. Department of Agriculture.
- [20] Karp, L. S. and McCalla, A.F. (1983). "Dynamic Games and International Trade: An Application to the World Corn Market." *American Journal of Agricultural Economics*, 65: 641–56.
- [21] Krishna, K. and Thursby, M. (1992). "Optimal policies and marketing board objectives." *Journal of Development Economics*, 38, 1–15.
- [22] Kolstad, C. D. and Burris, A.E. (1986). "Imperfectly Competitive Equilibria in International Commodity Markets." *American Journal of Agricultural Economics*, 68: 25–36.
- [23] Maccini, S. and Yang, D. (2009). "Under the Weather: Health, Schooling, and Economic Consequences of Early-Life Rainfall." *American Economic Review*, 99(3): 1006–1026.
- [24] Matsuura, K. and Willmott, C.J. (2007). Terrestrial Air Temperature and Precipitation: 1900–2006 Gridded Monthly Time Series, Version 1.01. <http://climate.geog.udel.edu/~climate/>.
- [25] Gawande, K. and Bandyopadhyay, U. (2000). "Is Protection for Sale? Evidence on the Grossman-Helpman Theory of Endogenous Protection." *Review of Economics and Statistics*, 82(1): 139–52.
- [26] Graaf, J. (1949–1950). "On Optimum Tariff Structures." *Review of Economic Studies*, 17(1): 47–59.
- [27] Grossman, G. and Helpman, E. (1994). "Protection for Sale." *American Economic Review*, 84: 833–50.
- [28] Grossman, G. and Helpman, E. (1995). "Trade Wars and Trade Talks." *Journal of Political Economy*, 103: 675–708.

- [29] Jones, B. and Olken, B. (2010). "Climate shocks and exports." *American Economic Review*, 99: 454-459.
- [30] O'Hare, M. and Kammen, D. (2008). "Memorandum on Land Use Change and the Global Food System.", UC Berkeley.
- [31] Paarlberg, P. L. and Abbott, P.C. (1986). "Oligopolistic Behavior by Public Agencies in International Trade: The World Wheat Market." *American Journal of Agricultural Economics*, 68: 528-42.
- [32] Pick, D.H. and Park, T.H. (1991). "The Competitive Structure of U.S. Agricultural Exports." *American Journal of Agricultural Economics*, 73: 133-141.
- [33] Sarris, A. H. and Freebairn, J. (1983). "Endogenous Price Policies and International Wheat Prices." *American Journal of Agricultural Economics*, 65: 214-24.
- [34] Smith, A. (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations*. Methuen & Co., Ltd.
- [35] Spencer, B. and Brander, J. (1983). "International R&D rivalry and industrial strategy." *Review of Economic Studies*, 50: 707-22.

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.
ln simple tariffs	41,043	2.034	1.221
ln weighted tariffs	40,606	1.582	1.680
ln rain	41,043	2.469	0.757
agric	41,043	0.129	0.335
agric2	41,043	0.209	0.406
irrig	18,812	13.626	17.476
North America	41,043	0.046	0.211
Latin America and Caribbean	41,043	0.369	0.482
Europe	41,043	0.053	0.225
Africa	41,043	0.200	0.400
Asia-Pacific	41,043	0.329	0.469
Number of countries	70		
Number of products	65		

Country-level data on the proportion of agricultural land that is irrigated are available for 32 countries.

Table 2: Baseline estimates

Dep. variable	ln simple tariffs		ln weighted tariffs	
	(1)	(2)	(3)	(4)
ln rain _{jt}	0.064 [0.076]	0.035 [0.076]	0.125 [0.094]	0.082 [0.093]
ln rain _{jt} * agric _i		0.230*** [0.047]		0.338*** [0.064]
Observations	41,043	41,043	40,606	40,606
Number of countries	70	70	70	70
Number of products	65	65	65	65
R-squared	0.572	0.574	0.401	0.403

The estimation method is OLS. Each model includes product, country and year fixed effects. Robust standard errors clustered by country in brackets. *** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

Table 3: Robustness, restricted sample

Dep. variable	ln simple tariffs		ln weighted tariffs	
	(1)	(2)	(3)	(4)
ln rain _{jt}	0.039 [0.092]	0.006 [0.091]	0.106 [0.113]	0.061 [0.111]
ln rain _{jt} * agric _i		0.263*** [0.049]		0.354*** [0.068]
Observations	32,436	32,436	32,117	32,117
Number of countries	51	51	51	51
Number of products	65	65	65	65
R-squared	0.579	0.582	0.415	0.418

The estimation method is OLS. Each model includes product, country and year fixed effects. Robust standard errors clustered by country in brackets. *** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

Table 4: Robustness, alternative definition of agricultural goods

Dep. variable	ln simple tariffs		ln weighted tariffs	
	(1)	(2)	(3)	(4)
ln rain _{jt}	0.064 [0.076]	0.015 [0.074]	0.125 [0.094]	0.062 [0.092]
ln rain _{jt} * agric _i		0.235*** [0.051]		0.304*** [0.059]
Observations	41,043	41,043	40,606	40,606
Number of countries	70	70	70	70
Number of products	65	65	65	65
R-squared	0.572	0.574	0.401	0.403

The estimation method is OLS. Each model includes product, country and year fixed effects. Robust standard errors clustered by country in brackets. *** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

Table 5: Robustness, alternative definition of agricultural goods and restricted sample

Dep. variable	ln simple tariffs		ln weighted tariffs	
	(1)	(2)	(3)	(4)
ln rain _{jt}	0.039 [0.092]	-0.015 [0.089]	0.106 [0.113]	0.040 [0.110]
ln rain _{jt} * agric _i		0.261*** [0.056]		0.317*** [0.063]
Observations	32,436	32,436	32,117	32,117
Number of countries	51	51	51	51
Number of products	65	65	65	65
R-squared	0.579	0.583	0.415	0.418

The estimation method is OLS. Each model includes product, country and year fixed effects. Robust standard errors clustered by country in brackets. *** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

Table 6: Accounting for tariff binding

<i>Panel A</i>	Dep. variable: ln simple tariffs			
	Full sample (1)	Applied < 0.9 Bound (2)	Applied < 0.8 Bound (3)	Applied < 0.7 Bound (4)
ln rain _{jt}	0.022 [0.070]	0.004 [0.071]	0.007 [0.071]	0.011 [0.071]
ln rain _{jt} * agric _i	0.218*** [0.053]	0.228*** [0.050]	0.225*** [0.049]	0.223*** [0.048]
Observations	33,454	31,128	30,538	29,798
Number of countries	69	69	69	69
Number of products	65	65	65	65
R-squared	0.580	0.582	0.582	0.583
<i>Panel B</i>	Dep. variable: ln weighted tariffs			
	Full sample (1)	Applied < 0.9 Bound (2)	Applied < 0.8 Bound (3)	Applied < 0.7 Bound (4)
ln rain _{jt}	0.071 [0.087]	0.069 [0.094]	0.072 [0.095]	0.065 [0.098]
ln rain _{jt} * agric _i	0.271*** [0.068]	0.277*** [0.066]	0.272*** [0.065]	0.265*** [0.064]
Observations	33,114	29,980	29,403	28,726
Number of countries	69	69	69	69
Number of products	65	65	65	65
R-squared	0.416	0.415	0.414	0.411

The estimation method is OLS. Due to availability of data for bound tariffs, the period of analysis is restricted to 1995-2006. Each model includes product, country and year fixed effects. Robust standard errors clustered by country in brackets. *** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

Table 7: Accounting for tariff binding, tobit random effects

Dep. variable	ln simple tariffs		ln weighted tariffs	
	(1)	(2)	(3)	(4)
$\ln \text{rain}_{jt}$	0.030 [0.026]	0.034 [0.026]	0.091** [0.043]	0.105** [0.043]
$\ln \text{rain}_{jt} * \text{agric}_i$	0.220*** [0.018]	0.220*** [0.017]	0.273*** [0.029]	0.267*** [0.028]
Observations	33,454	33,454	33,114	33,114
Number of countries	69	69	69	69
Number of products	65	65	65	65
Country effects	Random	Fixed	Random	Fixed
Product effects	Fixed	Random	Fixed	Random
Log likelihood	-38777.222	-38718.094	-52882.104	-52832.222

The estimation method is Tobit random effects. Due to availability of data for bound tariffs, the period of analysis is restricted to 1995-2006. Each model includes year fixed-effects. Marginal effects reported. Standard errors in brackets. *** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

Table 8: Non-linear specification of rainfall

Dep. variable	ln simple tariffs			ln weighted tariffs		
	(1)	(2)	(3)	(4)	(5)	(6)
low rain_{jt}	0.137 [0.086]		0.131 [0.086]	0.081 [0.098]		0.073 [0.098]
$\text{low rain}_{jt} * \text{agric}_i$	-0.340** [0.143]		-0.296** [0.143]	-0.407** [0.182]		-0.343* [0.186]
high rain_{jt}		-0.062 [0.068]	-0.060 [0.068]		-0.044 [0.094]	-0.042 [0.094]
$\text{high rain}_{jt} * \text{agric}_i$		0.265* [0.143]	0.253* [0.144]		0.379** [0.181]	0.366** [0.183]
Observations	41,043	41,043	41,043	40,606	40,606	40,606
Number of countries	70	70	70	70	70	70
Number of products	65	65	65	65	65	65
R-squared	0.572	0.572	0.572	0.401	0.401	0.402

The estimation method is OLS. Each model includes product, country and year fixed effects. Robust standard errors clustered by country in brackets. *** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

Table 9: Estimates by individual agricultural product

Dep. variable	ln simple tariffs		ln weighted tariffs	
	(1)	(2)	(3)	(4)
ln rain _{jt}	0.034 [0.076]	0.015 [0.074]	0.082 [0.093]	0.062 [0.092]
ln rain _{jt} * live animals	0.118 [0.114]	0.137 [0.115]	0.306 [0.184]	0.326* [0.182]
ln rain _{jt} * meat products	0.286*** [0.074]	0.305*** [0.075]	0.507** [0.195]	0.526*** [0.194]
ln rain _{jt} * dairy products and birds eggs	0.262** [0.114]	0.281** [0.118]	0.536*** [0.159]	0.555*** [0.161]
ln rain _{jt} * cereals	0.320*** [0.062]	0.339*** [0.066]	0.348*** [0.088]	0.368*** [0.092]
ln rain _{jt} * vegetables and fruit	0.296*** [0.059]	0.315*** [0.062]	0.336*** [0.090]	0.355*** [0.094]
ln rain _{jt} * sugar and honey	0.301*** [0.072]	0.320*** [0.077]	0.354** [0.148]	0.374** [0.151]
ln rain _{jt} * cofee, tea, cocoa and spices	0.245*** [0.062]	0.264*** [0.063]	0.266*** [0.092]	0.286*** [0.094]
ln rain _{jt} * oilseeds and oleaginous fruits	-0.015 [0.085]	0.004 [0.084]	0.045 [0.108]	0.064 [0.110]
ln rain _{jt} * feeding stuff for animals		0.001 [0.125]		0.205 [0.151]
ln rain _{jt} * miscellaneous edible products		0.252*** [0.065]		0.256*** [0.078]
ln rain _{jt} * beverages		0.335*** [0.075]		0.126 [0.150]
ln rain _{jt} * tobacco		0.292* [0.159]		0.379** [0.151]
ln rain _{jt} * crude animal and vegetable materials		0.180* [0.102]		0.127 [0.118]
Observations	41,043	41,043	40,606	40,606
Number of countries	70	70	70	70
Number of products	65	65	65	65
R-squared	0.574	0.576	0.404	0.405

The estimation method is OLS. Each model includes product, country and year fixed-effects. Robust standard errors clustered by country in brackets. *** $p \leq 0.01$, ** ≤ 0.05 , * $p \leq 0.1$

Table 10: Estimates by region

<i>Panel A</i>	ln simple tariffs		
	LAC	Africa	Asia-Pacific
ln rain _{jt}	0.142 [0.095]	-0.058 [0.127]	-0.075 [0.142]
ln rain _{jt} * agric _i	0.345*** [0.076]	-0.030 [0.81]	0.303** [0.115]
Observations	15,151	8,248	13,512
Number of countries	22	18	23
Number of products	65	65	65
R-squared	0.528	0.611	0.589
<i>Panel B</i>	ln weighted tariffs		
	LAC	Africa	Asia-Pacific
ln rain _{jt}	0.256* [0.134]	-0.125 [0.217]	-0.113 [0.183]
ln rain _{jt} * agric _i	0.398*** [0.128]	0.274 [0.316]	0.388** [0.155]
Observations	14,969	8,069	13,458
Number of countries	22	18	23
Number of products	65	65	65
R-squared	0.331	0.398	0.448

The estimation method is OLS. Each model includes product, country and year fixed effects. Robust standard errors clustered by country in brackets.
 *** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

Table 11: The role of irrigation

Dep. variable	ln simple tariffs		ln weighted tariffs	
	(1)	(2)	(3)	(4)
ln rain _{jt}	0.048 [0.074]	0.056 [0.074]	0.013 [0.096]	0.024 [0.096]
ln rain _{jt} * agric _i	0.243*** [0.048]	0.132** [0.051]	0.447*** [0.074]	0.291*** [0.069]
ln rain _{jt} * agric _i * irrig _j		0.004*** [0.001]		0.006*** [0.001]
Observations	18,812	18,812	18,683	18,683
Number of countries	32	32	32	32
Number of products	65	65	65	65
R-squared	0.586	0.588	0.422	0.423

The estimation method is OLS. Each model includes product, country and year fixed effects. Robust standard errors clustered by country in brackets. *** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

Table A.1 : Variables and data sources

Variable	Definition	Source
Rainfall	Population-weighted average rainfall by country-year in 100s mm.	Kenji Matsuura and Cort Willmott (2007) and Dell et al. (2012)
Irrigation	Proportion of agricultural land that is irrigated by country (average of non-missing country-year observations for the period 2001-2009).	World Bank WDI
Simple Tariffs	Simple average of bilateral applied import tariffs by country-product-year, SITC classification.	UNCTAD TRAINS
Weighted Tariffs	Weighted average of bilateral applied import tariffs by country-product-year, based on the share of each source country in total country-product imports in the base year, SITC classification.	UNCTAD TRAINS and UN COM-TRADE
Imports	Bilateral imports value by country-product in the base year, SITC classification.	UN COMTRADE

Table A.2 : Sample period by country

Country	Period	Country	Period
Algeria	1993, 1997-1998, 2001-2003, 2005-2006	Lesotho	2001, 2004-2006
Argentina	1992-1993, 1995-2006	Macedonia	2001, 2004-2006
Australia	1991, 1993, 1996-2006	Malawi	1994, 1996-1998, 2001, 2006
Bangladesh	1989, 1994, 1999-2000, 2002-2006	Malaysia	1988, 1991-1993, 1996-1997, 2001-2003, 2005-2006
Belize	1996, 1999, 2001-2003, 2006	Mali	1995, 2001-2006
Benin	2001-2006	Mexico	1991, 1995, 1997-2006
Bolivia	1993-2002, 2004-2006	Morocco	1993, 1997, 2000-2003, 2005-2006
Botswana	2001, 2004-2006	Mozambique	1994, 1997, 2001-2003, 2005-2006
Brazil	1989-2006	Myanmar	2001-2006
Brunei	1992, 2001-2006	Nepal	1993, 1998-2000, 2002-2006
Burkina Faso	1993, 2001-2006	New Zealand	1992-1993, 1996-2000, 2002-2006
Cambodia	2001-2003, 2005	Nicaragua	1995, 1998-2002, 2004-2005
Canada	1989, 1993, 1995-2006	Niger	2001-2006
Chile	1992-1995, 1997-2002, 2004-2006	Nigeria	1988-1990, 1992, 1995-2002, 2005-2006
China	1992-1994, 1996-2001, 2003-2006	Norway	1988, 1993, 1995-1996, 1998, 2000-2003, 2006
Colombia	1991-1992, 1994-1997, 1999-2002, 2004-2006	Pakistan	1995, 1998, 2001-2006
Costa Rica	1995, 1999-2005	Papua New Guinea	1997, 2002-2006
Croatia	2001, 2004-2006	Paraguay	1991, 1994-2006
Cuba	1993, 1997, 2002-2006	Peru	1993, 1995, 1997-2000, 2004-2006
Dominican Republic	1997, 2000-2006	Philippines	1988-1990, 1992-1995, 1998-2006
Ecuador	1993-1999, 2002, 2004-2006	Saudi Arabia	1994, 1999-2000, 2003-2006
El Salvador	1995, 1997-1998, 2000-2002, 2004-2006	Senegal	2001-2006
European Union	1988-2006	South Africa	1990-1991, 1993, 1996-1997, 1999, 2001, 2004-2006
Guatemala	1995, 1997-1998, 2000-2002, 2004-2005	Sri Lanka	1990, 1993-1994, 1997, 2000-2001, 2004-2006
Guyana	1996, 1999-2003, 2006	Switzerland	1990, 1993, 1995-2006
Honduras	1995, 1999-2002, 2004-2005	Taiwan, China	1989, 1992, 1996, 1999-2003, 2005-2006
Indonesia	1989-1990, 1993, 1995-1996, 1999-2006	Togo	2001-2006
Israel	1993, 2004-2006	Trinidad & Tobago	1991-1992, 1996, 1999, 2001-2003, 2006
Jamaica	1996, 2000-2003, 2006	Tunisia	1990, 1992, 1995, 1998, 2002-2006
Japan	1988-2006	Uganda	1994, 2000-2006
Jordan	2000-2003, 2005-2006	United States	1989-2006
Kenya	1994, 2000-2001, 2004-2006	Uruguay	1992, 1995-2002, 2004-2006
Korea, Republic of	1988-1990, 1992, 1995-1996, 1999, 2002, 2004, 2006	Venezuela	1992, 1995, 1997-2000, 2002, 2004-2006
Laos	2000-2001, 2004-2006	Vietnam	1994, 1999, 2001-2006
Lebanon	1999-2002, 2004-2006	Zimbabwe	1996-1999, 2001-2003

Table A.3 : SITC Classification

SITC	Agric	Agric2	Description
00	1	1	Live animals other than animals of division 03
01	1	1	Meat and meat preparations
02	1	1	Dairy products and birds eggs
04	1	1	Cereals and cereal preparations
05	1	1	Vegetables and fruit
06	1	1	Sugars, sugar preparations and honey
07	1	1	Coffee, tea, cocoa, spices, and manufactures thereof
22	1	1	Oil-seeds and oleaginous fruits
08	0	1	Feeding stuff for animals
09	0	1	Miscellaneous edible products and preparations
11	0	1	Beverages
12	0	1	Tobacco and tobacco manufactures
29	0	1	Crude animal and vegetable materials, n.e.s.
03	0	0	Fish, crustaceans, molluscs and aquatic invertebrates, and preparations thereof
21	0	0	Hides, skins and furskins, raw
23	0	0	Crude rubber (including synthetic and reclaimed)
24	0	0	Cork and wood
25	0	0	Pulp and waste paper
26	0	0	Textile fibres (other than wool tops and other combed wool) and their wastes
27	0	0	Crude fertilizers, other than those of Division 56, and crude minerals
28	0	0	Metalliferous ores and metal scrap
32	0	0	Coal, coke and briquettes
33	0	0	Petroleum, petroleum products and related materials
34	0	0	Gas, natural and manufactured
35	0	0	Electric current
41	0	0	Animal oils and fats
42	0	0	Fixed vegetable fats and oils, crude, refined or fractionated
43	0	0	Animal or vegetable fats and oils, processed; waxes and mixtures
51	0	0	Organic chemicals
52	0	0	Inorganic chemicals
53	0	0	Dyeing, tanning and colouring materials
54	0	0	Medicinal and pharmaceutical products
55	0	0	Essential oils and resinoids and perfume materials; toilet, polishing and cleansing preparations
56	0	0	Fertilizers (other than those of group 272)
57	0	0	Plastics in primary forms
58	0	0	Plastics in non-primary forms
59	0	0	Chemical materials and products, n.e.s.
61	0	0	Leather, leather manufactures, n.e.s., and dressed furskins
62	0	0	Rubber manufactures, n.e.s.
63	0	0	Cork and wood manufactures (excluding furniture)
64	0	0	Paper, paperboard and articles of paper pulp, of paper or of paperboard
65	0	0	Textile yarn, fabrics, made-up articles, n.e.s., and related products
66	0	0	Non-metallic mineral manufactures, n.e.s.
67	0	0	Iron and steel
68	0	0	Non-ferrous metals
69	0	0	Manufactures of metals, n.e.s.
71	0	0	Power-generating machinery and equipment
72	0	0	Machinery specialized for particular industries
73	0	0	Metalworking machinery
74	0	0	General industrial machinery and equipment, n.e.s., and machine parts, n.e.s.
75	0	0	Office machines and automatic data-processing machines
76	0	0	Telecommunications and sound-recording and reproducing apparatus and equipment
77	0	0	Electrical machinery, apparatus and appliances, n.e.s., and electrical parts thereof
78	0	0	Road vehicles (including air-cushion vehicles)
79	0	0	Other transport equipment
81	0	0	Prefabricated buildings; sanitary, plumbing, heating and lighting fixtures and fittings, n.e.s.
82	0	0	Furniture and parts thereof; bedding, mattresses, mattress supports, cushions and similar stuff
83	0	0	Travel goods, handbags and similar containers
84	0	0	Articles of apparel and clothing accessories
85	0	0	Footwear
87	0	0	Professional, scientific and controlling instruments and apparatus, n.e.s.
88	0	0	Photographic apparatus, equipment and supplies and optical goods, n.e.s.; watches and clocks
89	0	0	Miscellaneous manufactured articles, n.e.s.
96	0	0	Coin (other than gold coin), not being legal tender
97	0	0	Gold, non-monetary (excluding gold ores and concentrates)

Note: Agricultural products are defined based on Standard International Trade Classification, Revision 4; United Nations Statistics Division

Figure 1: Rainfall and droughts

Figure 2: Average bound and applied import tariffs on agricultural goods

Note: Bound tariffs are MFN rates based on final URAA implementation. Applied tariffs represent annual average. Data on average applied import tariffs refer to 1998, with the exception of Costa Rica (1995), Republic of Korea (1996), Indonesia (1996), India (1997) and Morocco (1997). Source: Economic Research Service, USDA.