JAE Journal of Agricultural Economics

Journal of Agricultural Economics, Vol. 70, No. 3, 2019, 859–873
doi: 10.1111/1477-9552.12355

AES Prize Essay

Market Integration and Market Efficiency under Seasonal Tariff Rate Quotas

Judith Hillen[1]

Abstract

Switzerland applies seasonal tariff rate quotas (TRQs) for the import of many fruits and vegetables during the domestic harvest season. We examine how this system affects the relationship between Italian and Swiss tomato prices and test for physical market integration and spatial equilibrium conditions over time. We use detailed, transaction-based data on trade flows and trade costs and estimate an extended parity bounds model, following Barrett and Li (2002). We confirm that in the summer season, when TRQs are in place, markets are inefficient. While quota holders receive positive rents, the marginal rents for importers without quota shares are negative. This inhibits trade flows above the in-quota import quantity allowed by TRQs. Hence, despite leading to inefficiencies and creating rents for importers, seasonal TRQs are effective in protecting domestic production against competing imports.

Keywords: *parity bounds model*; *Switzerland*; *tariff rate quotas*; *tomato trade*.

JEL classifications: *D40, F14, Q17.*

1. Introduction

Tariff rate quotas (TRQs) are two-level tariffs with a low 'in-quota' tariff for imports up to a defined quota volume and a higher 'out-of-quota' tariff charged for all subsequent imports. As a result of the tariffication efforts in the Uruguay Round of the General Agreement on Trade and Tariffs, TRQs were adopted for products previously subject to non-tariff measures, such as pure import quotas. Since then, they have

---

[1] Judith Hillen is in the Research Division Competitiveness and System Evaluation, Agroscope Tänikon, Switzerland. E-mail: judith.hillen@agroscope.admin.ch for correspondence. She is a PhD Candidate at the Department of Agricultural Economics at Göttingen University, Germany. I acknowledge the support of the Swiss Federal Office for Agriculture for providing access to the data. The views expressed in this article are the sole responsibility of the author and do not reflect, in any way, the position of the Swiss Federal Office for Agriculture.

been a widely used instrument to control market access and are still applied in more than 40 countries, particularly for politically sensitive agricultural products (Beckman *et al.*, 2017; WTO, 2018). Non-seasonal TRQs have received considerable research attention, and their mechanisms and economic effects have been studied extensively (e.g. Boughner *et al.*, 2000; Skully, 2001; de Gorter and Kliauga, 2006).

Ever since TRQs were first introduced, economists have heavily criticized the instrument (e.g. Abbott and Paarlberg, 1998; Gibson *et al.*, 2001; Abbott, 2002). This criticism has addressed the non-tariff barrier effects that TRQs cause, their complex effects on price stability, the quota rents that they generate, and the fact that quota allocation is often non-transparent. Abbott and Paarlberg (1998) find that TRQs either mimic pure quotas or function like pure tariffs, depending on import quantities and how the tariffs and quota volume are set. Switches between these two states can occur, so that the mechanism is not always predictable and the effect on price stability is uncertain. Moreover, Gibson *et al.* (2001) state that often 'mega-tariffs' (>100%) and highly complex tariff line regulations apply, which is contrary to the original TRQ principles of market access and clear tariffication. Finally, it has been shown conceptually and empirically that quota-holding importers can capture rents (Skully, 2001; Abbott, 2002). Therefore, quota allocation mechanisms are critical, especially if they are non-transparent or discriminatory, as is the case with 'first-come, first served' or historical allocation (Skully, 2001; de Gorter and Kliauga, 2006).

Less research attention has been dedicated to seasonal TRQs, which are only effective during domestic supply seasons. Such TRQs are mostly applied for fruit and vegetables, with the aim of protecting domestic production from competing imports in season, while allowing a cheap import supply out of season (de Gorter and Kliauga, 2006). Currently, the European Union, Iceland, Norway, South Korea and Switzerland apply seasonal TRQs for several perishable fresh fruit and vegetable products (WTO, 2018). The analysis of seasonal TRQs is made more complicated by the fact that they often do not have fixed yearly quota volumes; instead, the yearly quota volume is adjusted depending on market conditions (e.g. the size of the domestic harvest).

Given their wide application and the lack of previous empirical studies, we analyse how this policy instrument affects market integration and market efficiency using the example of Swiss tomato imports. Using an extended parity bounds model (PBM) and detailed customs data on trade flows, tariff costs and prices, we study how seasonal TRQs applied by Switzerland affect Italian–Swiss tomato trade, market integration and rents throughout the year. Section 2 outlines the setting and the framework of our analysis. Section 3 explains our data and methods, while section 4 presents our results. Section 5 concludes.

2. Setting

Switzerland has a long history of strong border protection for agricultural products. Following the Uruguay Round, TRQs replaced the previous instrument of import quotas (Swiss Federal Council, 1994). The TRQ system for tomatoes is seasonal, as it is for many domestically grown fruits and vegetables. Figure 1 schematically illustrates how this TRQ functions.[2] During the Swiss tomato season, when domestically

---

[2] For a detailed explanation of the Swiss TRQ system and references to the specific legal texts, see Loi *et al.* (2016).

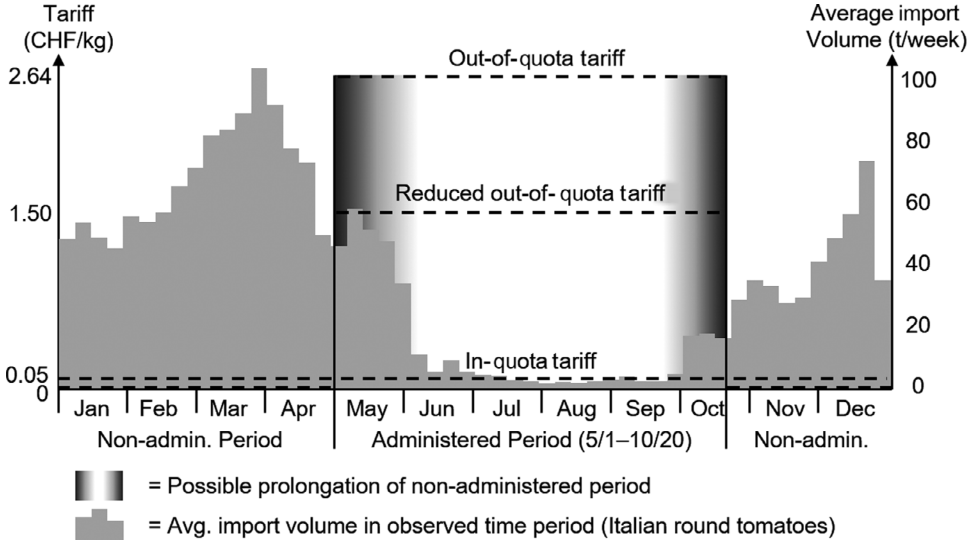

Figure 1. Applicable tariff rates and import volumes of tomato imports from the EU

produced tomatoes are available, the system aims to protect domestic production from cheaper import competition. The official policy goals are to (i) support farm income by keeping domestic producer prices high, and (ii) to ensure domestic food supply, as the degree of self-sufficiency is of great concern to Swiss agricultural policy (Loi *et al.*, 2016; Ferjani *et al.*, 2018). Outside the Swiss tomato season, the system is designed to ensure sufficient supply through imports. The average weekly import volumes for Italian round tomatoes in Figure 1 show that indeed, only low quantities are imported during the summer month, and larger volumes of up to 100 tons per week out of season, during winter and spring.

More specifically, from 21 October until 30 April, unlimited tomato imports are allowed at a low in-quota tariff of 0.05 CHF/kg or even 0.00 CHF/kg.[3] During this time, there is no competition with domestic products, and the quota is not effective ('non-administered period'). If the Swiss tomato harvest starts later than 1 May or ends before 20 October, the Swiss Federal Office for Agriculture (FOAG) can prolong the non-administered period. This usually happens in May and early October and can vary from year to year.

In the administered period, there are in-quota and out-of-quota tariffs. There are limited quotas for imports at the low in-quota tariff of 0.05 CHF/kg, which is equivalent to 1.4% of the average Swiss retail price. Requests for such quotas are discussed and agreed upon on a weekly basis by the umbrella organization Swisslegumes, taking into account current domestic production and demand estimates. Producers, importers, traders and retailers are represented in this inter-branch organization. They jointly decide whether and what volume of imports is needed and request that FOAG

---

[3] For imports from EU and European Free Trade Association (EFTA) trade partners there is an additional agreement about duty-free imports. This is limited to 10,000 tons net for all types of tomatoes (TRQ number 106) and is only applicable in the non-managed period (Swiss Federal Council, 2008). Above this quantity, the in-quota tariff of 0.05 CHF/kg applies.

opens a corresponding quota. FOAG then officially releases the quota and allocates quota shares to individual importers. Due to these flexible weekly quota openings, also the annual quota volume can vary from year to year.

Quota allocation is calculated based on an importer's share of the previous year's domestic purchases and imports. Hence, historically large importers get access to large quota shares. Historically smaller importers receive proportionally smaller quota shares, and new entrants into the market receive no access to quota shares in their first year. Generally, importers fully exploit the released quota quantities. Quantities exceeding these quotas can only be imported at a high out-of-quota tariff (2.64 CHF/kg, equivalent to 73.9% of the average retail price). If there is full supply through domestic production, or even oversupply, no quotas are released in the respective week, and a reduced out-of-quota tariff (1.50 CHF/kg, equivalent to 42.0% of the average retail price) applies to all imports. This reduced rate is a historical compromise without economic justification.

Even though only relatively low volumes are imported at these high tariff rates in the administered period (see Figure 1), they lead to high additional costs for the importers, which are ultimately passed on to Swiss consumers. For tomato imports, these extra tariffs, paid on top of the in-quota tariff of 0.05 CHF per kg add up to 259,414 CHF per year on average (for 2011–2015).

As the yearly quota volume in this Swiss system is flexible and negotiated on a weekly basis, the standard textbook analysis of a TRQ (with a fixed quota volume and four possible excess demand conditions – no trade, quota not binding, quota binding and quota no longer binding – see e.g. Skully, 2001) does not apply. The specific Swiss TRQ system has been previously analysed by Loi *et al*. (2016) and Gray *et al*. (2017). Both studies suspect the system to generate rents that are then captured by the downstream sector, particularly the large retailers. Yet, they do not prove the existence or quantify these rents empirically, which is one of the aims of this study.

3. Data and Methods

3.1. Data

We combine data on prices, trade costs and trade flows, analysing weekly data from March 2011 until May 2015, as this is the longest timeframe available. We chose the case of Italian tomato imports because in Switzerland tomatoes are the product with the largest volume of trade that is subject to seasonal TRQs, and Italy is a major trade partner for which reliable price data are available.[4] Table 1 gives an overview of our data.

3.1.1. Price data

The Swiss domestic tomato season is quite short (from roughly May to September), and domestic producer and wholesale prices are only reported during these months. To construct a continuous domestic Swiss retail price series we use retail prices for ordinary, round, red tomatoes (not cocktail tomatoes, not on the vine, non-organic).

---

[4] The top three countries of origin for Swiss round red tomato imports (not cocktail, on the vine or organic) are Morocco, Spain and Italy. However, only for Italy sufficiently detailed weekly price data are available to conduct this analysis.

Table 1

Description of price and trade data for Swiss–Italian tomato trade

Variable	Unit	Description	Source	Mean	SD
P^{CH}	CHF/kg	Swiss retail price	FOAG	3.57	0.41
P^{IT}	CHF/kg	Italian wholesale price	ISMEA	1.80	0.44
$Tariff^{avg}$	CHF/kg	Average tariff cost for Italian tomato imports, weighted by weekly import volume	KIC	0.38	0.59
$Tariff^{marg}$	CHF/kg	Marginal tariff cost for Italian tomato imports: highest tariff rate paid in observed week	KIC	0.80	1.06
Trade	dummy (0/1)	Dummy variable for observed trade flows of >5 tons per week	KIC	0.74	n/a

Notes: Continuous weekly data from March 2011 until May 2015 is used for all variables (220 observations). Mean and standard deviation refer to the whole sample data, including administered and non-administered period.

FOAG, Swiss Federal Office for Agriculture, ISMEA, Italian Service Institute for Agricultural and Food Markets, KIC, Kontingente Import Controlling (by FOAG), SD, standard deviation.

For Italy, we use wholesale price data, which is the relevant level for international trade. The comparison of Swiss retail and Italian wholesale prices leads to a permanent measurement difference in price levels. This wholesale-retail marketing margin is considered in the later empirical model.

3.1.2. Trade volume data

We use data on Swiss imports of Italian tomatoes derived from a transaction-based import controlling tool administered by the Swiss customs authorities. We only consider non-organic round tomatoes with a diameter of <80 mm (tariff line 0702.009), excluding tomatoes on the vine and cocktail tomatoes. As the database reports country of origin, import volume, import value, applied tariff rate and total tariffs paid per individual import transaction *i*, we are able to calculate the total import volume from Italy and the associated tariff costs in any given week *t*. In the ensuing empirical analysis, we distinguish between 'trade' and 'no-trade' periods.

3.1.3. Trade cost data

To correctly represent the complex Swiss TRQ system with its four different tariff rates (0.00 or 0.05 CHF/kg in-quota, and 1.50 or 2.64 CHF/kg out-of-quota), we distinguish between average and marginal tariffs. The average tariff is the volume-weighted effectively paid tariff rate, which we calculate by weighting the tariff rate applied to an individual import transaction *i* by this transaction's share in the overall volume of imports in week *t*, and summing over all transactions:

$$Tariff_t^{avg} = \frac{\sum_i (Vol_i \times Tariff_i)}{\sum_i Vol_i} \text{ for all transactions } i \text{ in week } t. \quad (1)$$

In contrast, the marginal tariff is defined as the highest observed tariff rate that applied to an import transaction in week *t*. This is the tariff rate that any additional importer would pay. As quotas are always filled, in the administered period the marginal tariff rate is de facto the out-of-quota tariff (2.56 CHF/kg) or (in weeks without quota openings) the reduced out-of-quota tariff (1.50 CHF/kg):

$$Tariff_t^{marg} = \max_i(Tariff_i) \text{ for all transactions } i \text{ in week } t. \tag{2}$$

Overall trade costs (*TC*) consist of the variable tariff costs, as calculated above, plus other unknown trade costs, such as transport and marketing costs. We assume that these other costs were constant over time over the duration of our sample (*Fixcost*):

$$TC_t^{avg} = Tariff_t^{avg} + Fixcost \tag{3}$$

$$TC_t^{marg} = Tariff_t^{marg} + Fixcost \tag{4}$$

We do not estimate or approximate these fixed costs but include them as a constant measurement error in the model, as explained in the following section.

3.2. Parity bounds model

Our study combines trade and price analysis. Following Barrett (2001) we distinguish between market integration (i.e. physical trade behaviour) and market efficiency between the trade partners (i.e. the relationship between prices, costs and resulting rents). To do so, we apply a parity bounds model (PBM), which was first suggested by Spiller and Huang (1986) and further developed by Baulch (1997) and Park *et al.* (2002). We use an extended model specification by Barrett and Li (2002), which enables us to combine trade and price data.

The standard PBM defines three different cases or 'regimes', and estimates the probability of observing each of these regimes at a given point in time. In the first case, the spatial price differential between two markets, here Switzerland (*CH*) and Italy (*IT*), is equal to trade cost (*TC*), implying market efficiency with no rents.

$$P_t^{CH} - P_t^{IT} = TC_t \tag{5}$$

Alternatively, the price differential can be smaller than the trade cost. In this case, there are no profitable spatial arbitrage opportunities.

$$P_t^{CH} - P_t^{IT} < TC_t \tag{6}$$

In the third case, the price differential exceeds trade costs. This implies that spatial arbitrage opportunities are not fully exploited, positive rents exist, and markets are not efficient.

$$P_t^{CH} - P_t^{IT} > TC_t \tag{7}$$

The inefficiency depicted in equation (7) can occur for numerous reasons such as trade restrictions, public price support and non-competitive pricing practices (Baulch, 1997; Hranaiova and de Gorter, 2005). These equations can also be re-written in terms of rents R_t, which are equal to, less than or greater than zero for the above three cases, respectively.

$$R_t = P_t^{CH} - P_t^{IT} - TC_t \tag{8}$$

Such rents only explain the spatial efficiency or inefficiency between two markets and do not account for trade flows. Following Barrett and Li (2002) we therefore divide each of the three cases above into two subcategories depending on whether (i) trade does or (ii) does not flow. The result is a total of $j = 6$ regimes, which occur with probability λ_j (see Table 2).

Whenever trade occurs, markets are physically integrated. If there are no observable trade flows, markets are not integrated but segmented, irrespective of their efficiency. In regime 1, there is *perfect integration*, as markets are physically integrated and in an efficient spatial equilibrium (zero rents). Regimes 3 and 5 describe physically integrated markets but in a state of market disequilibrium with positive or negative rents (*imperfect integration*). Regimes 2 and 6 represent *segmented equilibrium* because there is no trade, but this is in line with spatial equilibrium conditions, as rents for trade would be zero (regime 2) or even negative (regime 6). Finally, in regime 4, markets are in *segmented disequilibrium* because the lack of trade means that they are not integrated even though positive rents remain unexploited.

For rent estimation, we allow for a sampling and measurement error v_t, with mean α and variance σ_v^2. The potentially non-zero mean α accounts for permanent, time-invariant factors such as the unobservable trade cost components in *Fixcost* and the difference between retail (*CH*) and wholesale (*IT*) price level. The variance parameters account for all other transitory measurement differences or errors. For example, we convert all prices into one currency, even though not all exchange rate changes are passed on immediately (Liefert and Persaud, 2009), leading to temporary errors in our estimates of the difference between Swiss and Italian tomato prices.

To estimate the probabilities of the regimes, we need to assume some distribution of the data generating process, even though this is naturally unknown and not observable. Following the PBM literature (Baulch, 1997; Barrett and Li, 2002) we assume that the rents R_t are described by a half-normal distribution.[5]

$$R_t = \begin{array}{ll} v_t + u_t & (\text{for } R_t > 0) \\ v_t & (\text{for } R_t = 0) \\ v_t - u_t & (\text{for } R_t < 0) \end{array} \tag{9}$$

For $R_t \neq 0$, we add a positive half-normal error term u_t with variance σ_u^2. This error term is independent of the general sampling and measurement error v_t and reflects the additional variation of positive and negative rents. The result is the following specification of the distribution functions for each regime:

$$f_t^1 = f_t^2 = \frac{1}{\sigma_v}\varphi\left[\frac{R_t - \alpha}{\sigma_v}\right](\text{regime}1 + 2, R_t = 0) \tag{10}$$

$$f_t^3 = f_t^4 = \left[\frac{2}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right]\varphi\left[\frac{R_t - \alpha}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right] \times \left[1 - \Phi\left[\frac{-(R_t - \alpha)\sigma_u/\sigma_v}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right]\right] \tag{11}$$
$$(\text{regime } 3 + 4, R_t > 0)$$

---

[5] Fackler and Goodwin (2001) point out that this is arbitrary, and the results of PBM estimation are known to be sensitive to this assumption. However, Figure A1 in the on-line appendix shows that the observed rents' distribution indeed follows an approximately half-normal pattern if correcting for the constant measurement error. Further, we apply a distribution-independent block bootstrapping procedure to our model results (section 4).

Table 2

Description of the six possible regimes

	$P_t^{CH} - P_t^{IT} = TC_t\ (R_t = 0)$	$P_t^{CH} - P_t^{IT} > TC_t\ (R_t > 0)$	$P_t^{CH} - P_t^{IT} < TC_t\ (R_t < 0)$
Trade	λ_1 (perfect integration)	λ_3 (imperfect integration)	λ_5 (imperfect integration)
No Trade	λ_2 (segmented equilibrium)	λ_4 (segmented disequilibrium)	λ_6 (segmented equilibrium)

Note: P^{CH} = Swiss price, P^{IT} = Italian price, R = Rent, TC = Trade Cost, λ_k = Probability of regime k.

Source: own representation, based on Barrett and Li (2002)

$$f_t^5 = f_t^6 = \left[\frac{2}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right]\varphi\left[\frac{R_t - \alpha}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right] \times \left[1 - \Phi\left[\frac{(R_t - \alpha)\sigma_u/\sigma_v}{(\sigma_u^2 + \sigma_v^2)^{1/2}}\right]\right] (\text{regime } 5 + 6, R_t < 0) \tag{12}$$

where φ is the standard normal density function and Φ is the standard normal cumulative distribution function. Using these distribution functions, we can define the likelihood of observing the sample data $\{R_t, Trade_t\}$ as

$$L = \prod_{t=1}^{T}\left(A_t \times \left[\lambda_1 f_t^1 + \lambda_3 f_t^3 + \lambda_5 f_t^5\right] + (1 - A_t) \times \left[\lambda_2 f_t^2 + \lambda_4 f_t^4 + \lambda_6 f_t^6\right]\right). \tag{13}$$

The variable A_t takes the value one when trade takes place in week t, and zero otherwise. λ_k states the probabilities of the six regimes. Maximizing the log-likelihood function in equation (13) generates estimates for the error parameters α, σ_u and σ_v. To do so we use the '*L-BFGS-B*' method proposed by Byrd *et al.* (1995) subject to the constraints $0 \leq \lambda_k \leq 1$ and $\sum_k \lambda_k = 1$. As a result of the distributional assumptions and the included error terms, the regimes are separated by parity bounds that allow for some variation, so that even in the zero rents regimes, rents do not need to be precisely zero (see Baulch, 1997).

The key variable in this model is the series of weekly rents (R_t). Due to the non-linearity of the Swiss TRQ system, we distinguish between average and marginal rents. For average rents, we consider volume-weighted weekly average tariff costs ($Tariff^{avg}$, equation 1). This reflects the average rents realised by the actors who imported tomatoes in that week, either at in-quota or out-of-quota tariffs. In contrast, the marginal rents represent the rents realised by the importer who paid the highest tariff rate in a given week ($Tariff^{marg}$, equation 2). We analyse both types of rents because average rents tell us about the observed market outcome and marginal rents about the outcome for potential market entrants.

4. Results

4.1. Descriptive analysis

We see clear seasonal patterns in the Swiss-Italian price difference, tariff costs and trade flows. Table 3 and Figure 2 visualize these differences for all analysed variables. In the non-administered period when quotas are not effective and borders

Table 3

Summary statistics of observed variables (mean and standard deviation)

	$P^{CH} - P^{IT}$ (CHF/kg)	$Tariff^{avg}$ (CHF/kg)	$Tariff^{marg}$ (CHF/kg)	Trade volume (tons/week)
All observations	1.77	0.38	0.80	42.30
	(0.67)	(0.59)	(1.06)	(35.51)
Administered period	2.39	1.03	2.16	7.96
	(0.55)	(0.59)	(0.56)	(11.41)
Non-administered period	1.43	0.03	0.05	63.10
	(0.45)	(0.02)	(0.00)	(28.22)

Note: Standard deviations are reported in parentheses.
Source: own calculation. The non-administered period includes prolongations.

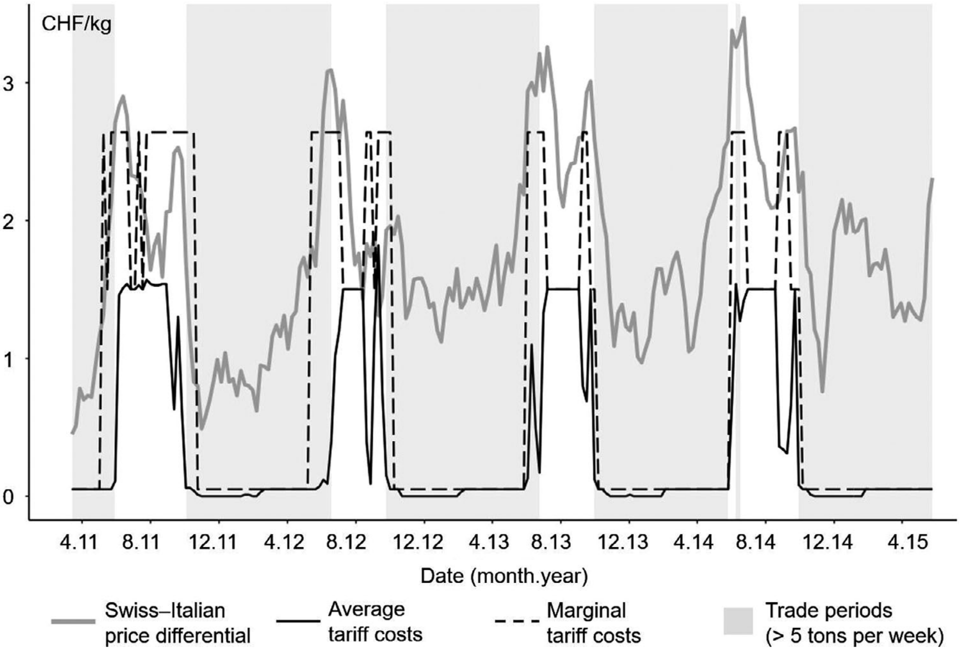

Figure 2. Relationships between price differentials, trade flows and tariff costs

are open for unlimited tomato imports, the average price difference is relatively low at 1.43 CHF/kg and the average applied tariff is only 0.03 CHF/kg. During the administered summer period (ca. June–September) when only limited amounts of imports enter at the low in-quota tariff, both values increase; the average applied tariff is 1.03 CHF/kg, and the price gap between Switzerland and Italy rises to 2.39 CHF/kg.

Figure 2 illustrates the pattern of trade flows. We consider any week in which Switzerland imports at least 5 tons of tomatoes from Italy to be a ‘trade week’, and these weeks are shaded in Figure 2. We consider weekly imports of fewer than 5 tons to be negligible and the corresponding weeks to be 'no-trade weeks'.[6] From roughly October to June of most years there are constant trade flows from Italy to Switzerland, indicating physical market integration. From July to September, however, there are (almost) no Italian tomato imports. Hence, during the domestic tomato season when TRQs are administered, the Italian and Swiss markets are segmented.

To determine whether Swiss and Italian tomato markets are efficient, we estimate the rents over time. We define rents as the difference between the Swiss and the Italian prices minus the trade costs. Trade costs are made up of variable tariff costs plus other fixed transport and marketing costs (compare section 3). We observe the tariff costs, but data on the fixed, non-tariff trade costs are missing. Furthermore, since we compare Swiss retail prices with Italian wholesale prices, the price difference also includes an unobserved positive wholesale-retail marketing margin. Due to these unobserved cost components we cannot directly estimate rent levels. However, if we assume that the non-tariff trade and marketing costs are constant over time (and captured in the constant α, which is jointly estimated with all other parameters in the PBM) then we can estimate changes in rents from week to week during our sample period.

4.2. Parity bounds model estimation results

Table 4 summarizes the PBM estimation results. As expected, the constant measurement error is positive ($\alpha = 1.826$), as an estimate of the non-tariff costs and the retail/wholesale markup, assumed constant over the period. Looking at the regime probabilities for average rents, there are three striking results. First, regimes with positive rents account for more than 60% of the total sample period ($\lambda_3 + \lambda_4$). Second, efficient market equilibrium with zero rents is only reached in 22.9% of all weeks (λ_1). Finally, when there are negative rents, no or only negligible (fewer than 5 tons) trade takes place, implying that importers react rationally to arbitrage opportunities ($\lambda_6 = 15.7\%$, while $\lambda_5 = 0\%$). Overall, these results, which are based on weighted average tariffs suggest the existence of inefficiencies and large opportunities for positive importer rents over much of the sample period.

Analysing rents based on marginal tariffs gives a different picture. The perfect market equilibrium with zero marginal rents and trade (λ_1) accounts for 64.2% of all weeks, and positive marginal rents are not observed in any weeks ($\lambda_3 = \lambda_4 = 0$). In weeks with no trade, marginal rents are usually negative ($\lambda_6 = 24.8\%$) and at most zero ($\lambda_2 = 1.1\%$). Hence, for non-quota holders, the applied tariffs are prohibitive. There is no opportunity at all for positive rents, and with almost 35%, rents are even negative ($\lambda_5 + \lambda_6$), providing no incentive to enter the market.

The above estimates resulting from A_t the maximum likelihood estimation are all time-invariant over the whole sample period. To better understand the seasonal patterns of the regime prevalence, we construct a time-varying variable $\tilde{\lambda}_t^k$. This binary indicator variable defines which regime k has the highest probability of occurring at each point in time t. In times of no or negligible trade ($A_t = 0$), we compare the conditional probabilities of regimes 1, 3 and 5. In times of trade ($A_t = 1$), we compare the

---

[6] This threshold is chosen rather arbitrarily, assuming that large commercial imports start at approximately one ton per weekday. In shifting this threshold between 3 and 8 tons per week, the results remain qualitatively the same.

Table 4

Maximum likelihood estimates of regime frequencies for Italian tomato imports

	No rents		Positive rents		Negative rents		Error term estimates		
	λ_1 (trade)	λ_2 (no trade)	λ_3 (trade)	λ_4 (no trade)	λ_5 (trade)	λ_6 (no trade)	α	σ_u	σ_v
Average rent	0.229 (0.086)	0.000 (0.032)	0.512 (0.184)	0.102 (0.050)	0.000 (0.024)	0.157 (0.044)	1.826 (0.222)	0.561 (0.127)	0.381 (0.105)
Marginal rent	0.642 (0.191)	0.011 (0.002)	0.000 (0.019)	0.000 (0.008)	0.099 (0.036)	0.248 (0.032)	1.826* (n/a)	1.187 (0.235)	0.522 (0.100)

Notes: *α is fixed to the level of the estimation with average rents, as marginal rents do not reflect the actual market outcome. 'No trade' refers to trade volumes of fewer than 5 tons per week. Robust standard errors reported in parentheses. Standard errors are calculated with block bootstrapping (4 blocks of 55 weeks each to cover all seasons, 10,000 bootstrap samples). These are robust standard errors for the actual sample distribution, independent of distributional assumptions (Künsch, 1989). For average rents, 53 out of the 10,000 simulated samples did not converge in the maximum likelihood estimation and were replaced by the original sample.

conditional probabilities of regimes 2, 4 and 6.[7] We aggregate the variable $\tilde{\lambda}_t^k$ over the observed years and calculate seasonal averages for each calendar week. Figure 3 displays the regime probabilities throughout the year, based on average rents.

Periods of market integration with trade prevail in the non-administered period and its prolongations (October–early June). These periods are most often characterised by positive rents (λ_3) but sometimes also by zero rents (λ_1). The probability of negative rents is consistently zero.

In periods of no trade (i.e. in the administered period in summer), regime 2, in which markets are efficient and rents equal zero is never observed ($\lambda_2 = 0$). Instead, when quotas are released and in-quota imports prevail, average rents are most likely

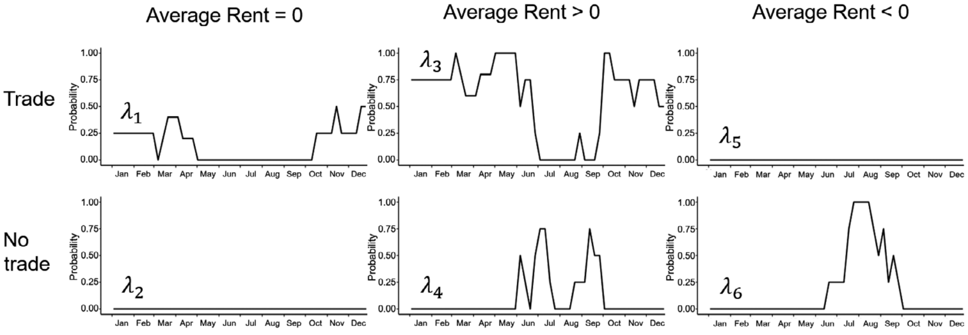

Figure 3. Seasonal regime probabilities for Italian–Swiss tomato trade (average rents)
Source: Own calculations of time-varying conditional regime probabilities, aggregated per ISO calendar week.

---

[7] The exact construction of the variable is derived in Barrett and Li (2002), p. 289.

to be positive (λ_4). Later on in the administered period, when there is full domestic supply and no quotas are opened, particularly mid-July until early September, average rents become negative (λ_6) because the high out-of-quota tariffs apply to all imports.

Looking at marginal rents, however, the situation is different (Figure 4). During the winter months, there is a 100% probability that marginal rents are zero ($\lambda_1 = 1$), indicating that markets are in equilibrium and additional importers are free to enter the market. During the potential prolongation periods (May, October), rents are more often zero ($\lambda_1 > 0.5$) than negative ($\lambda_5 < 0.5$). Finally, in times of no trade in the summer months, marginal rents are always negative (λ_6). This suggests that quotas are binding and any additional imports would yield negative rents, providing no incentive for traders who do not hold quota shares to be active on the market.

4.3. Limitations

All the above estimates should be interpreted with care and seen as approximations rather than precise numerical results. Tests with simulated data and block bootstrapping procedures show that for relatively small sample sizes (in our case 220 observations), our model does converge to the true parameters without systematic bias but with some imprecision. The bootstrapped robust standard errors (Table 4) demonstrate that the estimates are significant, but display large variances. In particular, an imprecise estimate of the constant measurement error ($\alpha = 1.826$, with robust standard error = 0.222) could bias our results. α captures the constant measurement gap between wholesale and retail prices, as well as constant, non-tariff trade costs, and it is estimated based on distributional assumptions (see section 3). If α is overestimated, all rents are underestimated. The above described rent distribution would shift upαward, with less negative and more positive rents. Analogously, underestimating α would mean that true rents are constantly lower than our results. In either case, this would affect only the overall level of rents and not their seasonal distribution. Hence, our conclusions regarding the administered and non-administered periods would still hold. For marginal rents, we do not re-calculate α but take the value

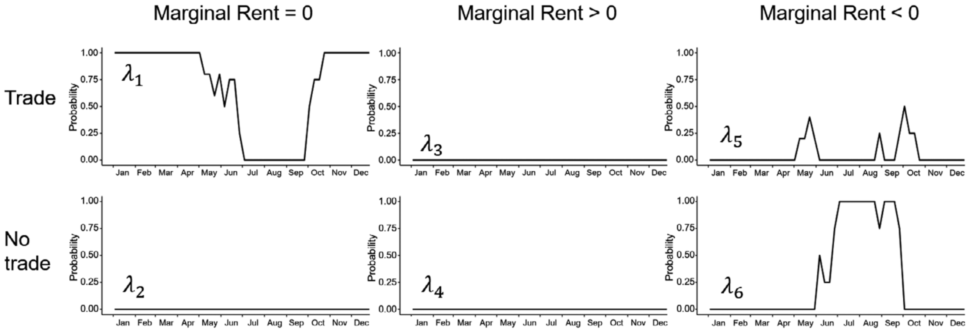

Figure 4. Seasonal regime probabilities for Italian–Swiss tomato trade (marginal rents)
Source: Own calculations of time-varying conditional regime probabilities, aggregated per ISO calendar week.

estimated from the average rents because our distributional assumptions are valid for actually observed rents and not for their marginal behaviour.

A further limitation of our study concerns the question of who actually captures the rents. The rent is generated at the stage of the importers. Previous studies have looked at TRQ systems with respect to industry competition and market power (e.g. Scoppola, 2010; Pouliot and Larue, 2012). In Switzerland, the large retailers import directly and hold import quotas themselves. Additionally, they are supplied by different importing companies. Because of this vertical integration and multiple supply relationships, we suspect but cannot prove that at least part of the importer rents are captured by downstream retailers.

5. Discussion and Conclusion

We analysed tomato trade from Italy to Switzerland under a seasonal TRQ system. Incorporating detailed price, trade flow and cost data, we examine market integration (i.e. physical trade) and market efficiency (i.e. rent generation). We conclude that seasonal TRQs for tomato imports succeed in protecting high-cost domestic production in Switzerland, but at the cost of large inefficiencies.

Our analysis shows that both market integration and market efficiency differ between the administered summer period and the non-administered winter period. In the non-administered period, only the low in-quota tariff applies and causes little market distortion, so that markets are mostly in equilibrium with zero rents for importers. During this time, there are unrestricted large import flows and importers are free to enter the market. This is politically desired, as there is no domestic tomato production to be protected, and consumers benefit from a large variety of low-cost imports.

During the administered period, however, the TRQ system functions like a flexible quota. Cheap in-quota imports are only allowed when there is a domestic supply shortage, and these quotas are completely filled. The quota holders benefit from large rents, while marginal rents are negative, so above-quota imports are unattractive and the quota is binding. As quota shares are allocated based on historical purchase volumes, only the large established players profit, while new market entrants are kept out of the market. This mechanism is reinforced by the fact that private market players, via their participation in the umbrella organization Swisslegumes, themselves determine when and how many quotas will be opened. Therefore, the system contributes to maintaining the status quo of high market concentration among importers and retailers.

Eventually, Swiss consumers pay the price for this seasonal protection through high retail prices during the administered period. Indeed, for Swiss consumers domestic tomatoes are more expensive in season than imported tomatoes out of season. Swiss tomato producers clearly benefit, as the price gap to foreign markets (here Italy) increases substantially during the administered domestic season, and the Swiss price becomes completely detached from foreign market developments. The seasonal administration maintains high and stable domestic prices as long as there are Swiss tomatoes on the market. Furthermore, maintaining high prices and limiting imports ensures that there is domestic production in the first place and thus contributes to the goal of higher self-sufficiency. However, TRQs specifically and border protection in general are certainly not the most targeted and efficient means of supporting farm incomes, as stressed by Gray *et al.* (2017). And it can be questioned whether increasing self-sufficiency for a non-staple food product such as tomatoes justifies the many market distortions and inefficiencies associated with the TRQ system, especially because Switzerland remains fully import dependent out of season.

Comparing our findings for seasonal TRQs with previous studies on non-seasonal TRQs, we conclude the following. The criticism of non-seasonal TRQs also applies to seasonal TRQs during the administered periods. The goal of tariffication is not reached, as the seasonal TRQ mimics a pure quota and thus represents a non-tariff barrier. In addition, quota-holders capture large rents, and the historical allocation mechanism is discriminatory against new market entrants. In contrast with non-seasonal TRQs, however, the seasonal administration limits these distortions and inefficiencies to the few months each year in which there is domestic production. Moreover, the consensual weekly quota openings coordinated by Swisslegumes in the administered period allow the system to flexibly react to domestic supply conditions by adjusting imports quantities. This makes the instrument attractive for fresh produce with limited storability. The distinction between administered and non-administered periods also makes price stability effects more predictable than under normal TRQs. During the administered period, domestic prices are high, stable and insulated from foreign developments. For the rest of the year, international price signals can be passed on through almost unrestricted trade.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table A1: Swiss tariff rates for tomato imports from the EU
Figure A1: Density function of the observed average rents

References

Abbott, P. C. ‘Tariff-rate quotas: Failed market access instruments?’, *European Review of Agricultural Economics*, Vol. 29, (2002) pp. 109–130.

Abbott, P. C. and Paarlberg, P. L. ‘Tariff rate quotas: Structural and stability impacts in growing markets’, *Agricultural Economics*, Vol. 19, (1998) pp. 257–267.

Barrett, C. B. ‘Measuring integration and efficiency in international agricultural markets’, *Review of Agricultural Economics*, Vol. 23, (2001) pp. 19–32.

Barrett, C. B. and Li, J. R. ‘Distinguishing between equilibrium and integration in spatial price analysis’, *American Journal of Agricultural Economics*, Vol. 84, (2002) pp. 292–307.

Baulch, B. ‘Transfer costs, spatial arbitrage, and testing for food market integration’, *American Journal of Agricultural Economics*, Vol. 79, (1997) pp. 477–487.

Beckman, J., Dyck, J. H. and Heerman, K. E. *The Global Landscape of Agricultural Trade, 1995–2014*, US Department of Agriculture, Economic Research Service (2017).

Boughner, D. S., de Gorter, H. and Sheldon, I. M. ‘The economics of two-tier tariff-rate import quotas in agriculture’, *Agricultural and Resource Economics Review*, Vol. 29, (2000) pp. 58–69.

Byrd, R. H., Lu, P., Nocedal, J. and Zhu, C. ‘A limited memory algorithm for bound constrained optimization’, *SIAM Journal on Scientific Computing*, Vol. 16, (1995) pp. 1190–1208.

Fackler, P. L. and Goodwin, B. K. ‘Spatial price analysis’, *Handbook of Agricultural Economics*, Vol. 1, (2001) pp. 971–1024.

Ferjani, A., Mann, S. and Zimmermann, A. ‘An evaluation of Swiss agriculture’s contribution to food security with decision support system for food security strategy’, *British Food Journal*, Vol. 120, (2018) pp. 2116–2128.

Gibson, P. R., Wainio, J., Whitley, D. B. and Bohman, M. *Profiles of Tariffs in Global Agricultural Markets*, US Department of Agriculture, Economic Research Service Report No. 34055, 2001.

de Gorter, H. and Kliauga, E. 'Reducing tariffs versus expanding tariff rate quotas', in K. Anderson and W. Martin (eds.), *Agricultural Trade Reform and the Doha Development Agenda* (New York, NY: Palgrave-Macmillan; Washington, DC: World Bank, (2006) pp. 117–160.

Gray, E., Adenäuer, L., Flaig, D. and van Tongeren, F. *Evaluation of the Relevance of Border Protection for Agriculture in Switzerland*, OECD Food, Agriculture and Fisheries Papers, No. 109 (OECD Publishing, Paris, 2017).

Hranaiova, J. and de Gorter, H. 'Rent seeking with politically contestable rights to tariff-rate Import quotas', *Review of International Economics*, Vol. 13, (2005) pp. 805–821.

Künsch, H. R. 'The jackknife and the bootstrap for general stationary observations', *The Annals of Statistics*, Vol. 17, (1989) pp. 1217–1241.

Liefert, W. and Persaud, S. *The Transmission of Exchange Rate Changes to Agricultural Prices*, Economic Research Report No. 76 (US Department of Agriculture, 2009).

Loi, A., Esposti, R., Gentile, M., Aragrande, M., Bruni, M., Berisio, S. and Saguatti, A. *Policy Evaluation of Tariff Rate Quotas*, Report mandated by the Swiss Federal Office for Agriculture (Areté srl, Bologna, 2016).

Park, A., Jin, H., Rozelle, S. and Huang, J. 'Market emergence and transition: Arbitrage, transaction costs, and autarky in China's grain markets', *American Journal of Agricultural Economics*, Vol. 84, (2002) pp. 67–82.

Pouliot, S. and Larue, B. 'Import sensitive products and perverse tariff-rate quota liberalization', *Canadian Journal of Economics/Revue canadienne d'économique*, Vol. 45, (2012) pp. 903–924.

Scoppola, M. 'The liberalisation of tariff rate quotas under oligopolistic competition', *Journal of Agricultural Economics*, Vol. 61, (2010) pp. 584–604.

Skully, D. W. *Economics of Tariff-Rate Quota Administration*, US Department of Agriculture, Economic Research Service (2001).

Spiller, P. T. and Huang, C. J. 'On the extent of the market: Wholesale gasoline in the northeastern United States', *The Journal of Industrial Economics*, Vol. 35, (1986) pp. 131–145.

Swiss Federal Council. Message on the approval of the GATT/WTO Agreements*(Uruguay Round)* (SR 94.079, 19 September 1994). Available at: https://www.amtsdruckschriften.bar.admin.ch/viewOrigDoc/10107964.pdf?id = 10107964&action = open (last accessed 13 November 2018).

Swiss Federal Council. *Ordinance on Rates of Duty for Goods in trade with member states of EFTA and the EU*(Free Trade Ordinance 1, SR 632.421.0, 18 June 2008). Available at: https://www.admin.ch/opc/de/official-compilation/2008/3519.pdf (last accessed 13 November 2018).

WTO (World Trade Organization). *Tariff Download Facility* (2018). Available at: http://tariffdata.wto.org/ (last accessed 13 November 2018).