Detecting Collusion in Swiss Meat Tariff-rate Quota Auctions

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Abstract

Switzerland utilizes Tariff-rate quota (TRQ) systems for most meat imports. One of the methods used to allocate licences, or TRQs, to import goods at a lower "in-quota" tariff, is auctions. Since Switzerland has completely banned domestic production of religiously slaughtered meat, all kosher and halal meat must be imported, and their corresponding TRQs are auctioned off. Despite the goal and design of both auction systems being the same, auctions for kosher TRQs consistently exhibit near-zero prices, while prices in halal auctions do not. I investigate whether this difference in price is due to collusion. I use data on the variance of market shares to detect collusion. Using a Kolmogorov-Smirnov test statistic applied to the kernel density estimations of the changes in market share of firms reveals no statistical evidence of collusion in the kosher TRQ auctions. Instead, low prices can be explained by quota "under-fill", i.e. an oversupply of licenses in the kosher TRQ auctions.

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1 Introduction

Governments use auctions for the allocation of a vast array of assets, such as treasury bonds, seized items from smuggling or crime, and import quotas. This paper looks at auctions of a special case of import quota, namely rights to import religiously regulated meat, i.e. halal and kosher meat, into Switzerland. Switzerland uses a tariff-rate quota (TRQ) system for most meat imports. A certain quantity of a good is allowed to be imported at a lower tariff, and after that quantity has been exceeded, imports are only possible at a much higher, often prohibitively so, tariff. Since ritually slaughtered meat production is banned in Switzerland, all meat must be imported, and all tariff rate quotas are auctioned off.

A common problem for any auctioning authority is potential collusion by bidders. Given the facts that the kosher auctions exhibit near-zero prices, while the halal auctions do not, and both auctions have high barriers to entry and a small number of participants, it is not unreasonable to suspect collusion.

I use statistical screens for collusion to investigate whether the prices in the kosher auctions is a result of collusion. To achieve this, I exploit the similarity of both religious meat TRQ auctions and use the halal auctions as a competitive baseline. I examine the consistency of market shares: If a cartel agrees to split up a market or auction amongst its members, then market shares will be more rigid. I measure the change in market share of firms in every auction, and test whether the changes in market share in kosher and halal TRQ auctions are drawn from the same distribution.

This paper adds to the existing literature on cartel detection by extending the methods used to detect collusion in retail markets and procurement auctions, into multi-unit forward auctions. The literature so far has predominantly focused on procurement auctions, because they are generally more conducive to collusion than most forward auctions. Procurement auctions are a form of reverse auction, which feature one buyer, often the government, and many sellers. Forward auctions, on the other hand, feature many buyers, and just one seller.

2 History of Swiss Agricultural policy and Tariff-Rate Quotas

The history of Swiss agricultural trade policy since the mid-20th century is defined by constant tensions between pressures to liberalize trade, both from outside and within, and long-standing domestic goals of food security.

Before the start of the Second World War, Switzerland was importing around half of the food it consumed. Although the state had already planned a minor expansion of farmland in 1939, the "Anbauschlacht", the fight for self-sufficiency, was launched by Friedrich Wahlen, working as division head in the federal war nutrition bureau [1], in November 1940. Without permission from his superiors, he presented his plan to the public to widespread support. The plan succeeded in doubling the nation's farmland, and the degree of self-sufficiency increased from 52% to 59% in 1945, although this coincided with a roughly one-third reduction in the average caloric intake (Moser, 2021).

The lingering fears after WWII led Switzerland to target self-sufficiency and food security in agricultural policies. This resulted in the passing of the 1951 Agriculture Act. The Landwirtschaftsgesetz (LwG) of October 1951 implemented price and purchase guarantees, fixing prices for agricultural products and promising to buy surplus production that farmers were unable to sell. Additionally, the government reserved the right to restrict imports or add additional tariffs on goods if the foreign price of a good was deemed to be too low. This latter measure closely mirrors the logic of modern tariff-rate quota systems. This led Swiss prices for food to be almost completely cut off from international trade.

Increasing domestic prices, production surpluses, and mounting international pressure during the GATT Uruguay Round finally prompted the Swiss government to reform its agricultural policy. The Uruguay Round, held between 1986 and 1993, was the eighth round of trade negotiations on the General Agreement on Tariffs and Trade. The round ended in 1994 with the creation of the World Trade Organization (WTO), and produced the first binding multilateral Agreement on Agriculture. Most importantly, one of the main goals of the agreement was the process of tariffication.

[1] Chef der Abteilung für landwirtschaftliche Produktion und Hauswirtschaft im Eidgenössischen Kriegsernährungsamt.

The tariffication proposal aimed to replace all non-tariff barriers with tariff-rate quotas (TRQs) and to reduce these tariffs over time. Tariff-rate quotas are a two-tiered tariff system. Unlike a traditional import quota, which prohibits all imports of a certain good after the quota has been filled, a TRQ system still allows for imports, just at a higher, "out-of-quota" tariff rate. Under this system, a preferential lower tariff rate is charged to a limited quota volume of imports. Once this quota has been exhausted, subsequent imports must pay the higher "out-of-quota" tariff.

The Swiss response to the Uruguay Round was "Agrarpolitik 2002". Price and purchase guarantees were completely abolished, and support for farmers instead took the form of direct payments. These payments were no longer dependent on the amount of production of the farmer. Instead, they were contingent on the "ökologischer Leistungsnachweis (ÖLN)", an environmental mandate. This capped the amount of fertilizer farmers could use and forced part of their land to be used for the purposes of biodiversity, among other things. Import quotas were transformed into TRQs. In 2002, TRQs were mostly allocated via the "prise en charge" system, where TRQs were distributed based on the purchase of domestic products. While heavily criticized by foreign trading partners, it did not violate WTO rules (World Trade Organization, 1996).

3 Theory of Tariff-Rate Quotas

In the standard small country trade model, a simple specific tariff acts as a linear tax t, lifting the horizontal world supply curve uniformly to $P_w + t$, where P_w refers to the world price. Under perfect competition, this tariff leads to the domestic price $P_d = P_w + t$. A tariff-rate quota, by comparison, yields a non-linear, step function tariff structure dependent on quota volume Q_q. For the first Q_q units of the imported good a tariff t is applied, and a tariff $T > t$ is applied to all subsequent imports.

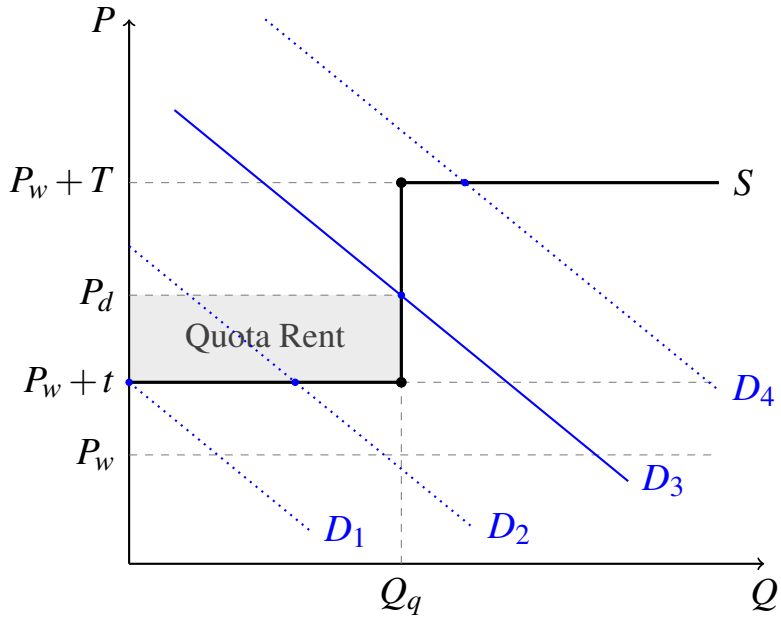

Figure 1: TRQ market framework highlighting the generation of quota rent under demand D_3.

Following Skully (2001), I categorize market coutcomes of a TRQ regime into four distinct cases, demonstrated in Figure1 depending on the domestic demand function. In the first case, D_1, the demand function intersects the supply function at $Q = 0$, and no imports occur.[2] In the second case, D_2, the quota is not binding. In this scenario, there is essentially no difference between the TRQ and a simple tariff. Both D_1 and D_2 lead to $Q_d < Q_q$, or *underfill*.

In the third case, D_3, the quantity demanded at price $P_w + t$ is larger than Q_q, and the quantity demanded at price $P_w + T$ is smaller than Q_q. The demand curve intersects the supply curve where the supply curve is perfectly vertical. If demand increases, the demand curve shifts right, but quantity remains the same. Instead, the quota rent

[2]The quantity demanded for imports at price P_w is the "excess demand".

$(Pd - (P_w + t)) \cdot Q_q$ increases as the price does. The quota rent is the economic rent collected by those who own quota rights. Total welfare stays the same, but there is a direct transfer to producers from consumers. This is different from a linear tariff where a positive demand shock increases total welfare[3]. The government is able to increase t without any additional deadweight loss. This simply lets the government regain the quota rent as tax receipts. Additionally, the government can also replace the TRQ system with a simple tariff, and pay importers a subsidy the size of the quota rent, which is a pareto improvement over the TRQ system.

In the fourth case, demand is large enough that some goods are imported with the out-of-quota tariff. Here, the government again faces a "free lunch" scenario — raising t to equal T lets the state capture all the quota rent from the producers. Quota rents are $(T - t) \cdot Q_q$, the highest possible. Although TRQs were originally introduced to allow countries with import quotas to be able to "keep" the spirit of the quota in place, its effects are actually more interesting. One insight from this model of perfect competition is that the state can always replace the TRQ system with a combination of tariffs and subsidies that results in equal or higher overall welfare. In fact, unless the quota is binding, the government can simplify the system with no risk. In underfill, the TRQ system is simply a tariff. In the over-quota, the state may retake all the quota rent by introducing a simple tariff T.

Case 3 is the most interesting. In case 2 and 4, any change to the world price is reflected one to one in the domestic price. In 3 however, domestic prices are completely insulated from world price shocks, as long as the shock is not so big as to cause underfill. On the other hand, positive domestic demand shocks decrease only result in higher prices, and such, higher rents.

A binding quota can be thought of as a tax charged by the producer to the consumer directly. It allows the state to subsidise the producer without officially having to do it. A TRQ system is a simple tariff when it is not binding. When it is binding, the domestic price is largely isolated from the world price, and domestic production only happens if the quota binds.

[3]For goods that are not perfectly inelastic.

4 Political Economy

4.1 The Fight Against Non-Tariff Barriers

When TRQs were introduced in the 1994 Uruguay round, the newly formed WTO aimed to have countries move away from non-tariff barriers, like import bans, and move towards transparent, fairer tariffs. A process called *tariffication*. TRQs were supposed to act as a compromise, allowing hesitant countries to maintain some control over the total volume of imports. Despite the WTOs goal of fairness and transparency, they did not specify or regulate how TRQs could be allocated. Instead, the WTO defaulted to the GATT Article XIII, which governed the "Administration of Quantitative Restrictions".

4.2 GATT Article XIII

GATT Article XIII outlines three core principles for how an importing Nation must distribute import rights:

- **The Principle of Non-discrimination** states that a country may not restrict imports from one country without also restricting imports from all other countries.
- **The Principle of Trade Distribution** states that the distribution of trade shares of countries under quotas must follow the distribution that trade would've followed in the absence of restrictions.
- **Transparency and Predictability** state that allocation method, quota volume, dates, and restrictions must be clearly defined, transparent, and predictable.

4.3 TRQ Administration Methods

The WTO provide seven main methods to distribute TRQs, listed in Table 1. The first is the "Applied Tariff", where the quota is so large as to never bind, making the TRQ act exactly like a tariff. The next 2 most common methods are the license on demand (LD) and first-come, first served (FCFS). The latter behaves exactly as one would expect. License on demand has firms submitting "bids" for TRQs. This works identically to first-come, first served until the quota is filled, which results in every firm receiving a proportional share of the quota. If demand is twice as large as the total volume of TRQs, every firm/bidder receives 50 % of the what they requested.

Table 1: Methods of TRQ administration

Method of TRQ administration	**Explanation**	**Percent of all TRQs (2023)**
Applied tariff	Unlimited imports are allowed at or below the in-quota tariff rate: that is, the quota is not enforced.	29.7
License on demand	Licenses are required to import at the in-quota tariff. If the demand for licenses is less than the quota, Q, the system operates like a first-come, first-served system. Usually, if demand exceeds Q, the import volume requested is reduced proportionally among all applicants.	16.3
First-come, first-served	The first Q units of imports to clear customs are charged the in-quota tariff, all subsequent imports are charged the over-quota tariff.	12.7
Historical	The right to import in-quota tariff is allocated in proportion to import market shares in a base period.	2.4
Auction	The right to import at the in-quota tariff is auctioned.	5.3
State trader	The right to import in-quota is granted wholly or primarily to a state trading organization or an organization representing domestic producers of the controlled product.	1.3
Mixed	A combination of two or more of the seven methods above.	0.4
Other or not specified	Methods that do not correspond to the seven methods above or are not specified in WTO notifications.	5.6

Source: Adapted from Skully (2001); updated using data from World Trade Organization (2024). Percentages don't add up to 100 because of inactive TRQs, where $t = T$, which are included in the total number of TRQs, but not considered a category.

Because these two methods share similarities with auctions, and depending on the exact setup, even feature prices like auctions, they are considered "Quasi-market" allocations. TRQs are also allocated by the discretion of States or producer groups. Historical allocations distribute TRQ based on imports in previous periods, or domestic production in previous periods. The "state-trader" allocation method reserves all right to import in-quota to the state, where the "producer group" method gives that right to a domestic producer group.These methods of administration are called discretionary methods. Finally, TRQs may be sold at auctions or distributed using multiple of the previously mentioned methods.

Given that producer group, state trader, and the historical administration method often coincide with a monopoly or market power of the importers, who were able to lobby for the methods over "fairer" alternatives, it may be surprising that quota fill is often higher in these methods, than in auctions. A firm given a monopoly over TRQs will, ceteris paribus, import less than a market where TRQs are distributed competitively, since the fact the profit maximizing quantity is smaller than the quantity under competition.

4.4 The Endogeneity of Administration Method

This is caused by the fact that how total volume of the quota is endogenous. Total volume and allocation method are dependent. A non-binding quota means owning the rights to import is worth very little, the Quota rent is 0. Thus, if a country needs to convince a special interest group, like a cartel, to agree to tariffication, the prospect of worthless TRQs is rather unconvincing. But if the quota is binding, the TRQs act as a bribe to those domestic groups, without the state having to report an expenditure, or an increase in tax.

These discretionary methods bring additional benefits to a cartel. Cartels are inherently unstable, due to the incentive to defect. Under a binding quota, where each member of the cartel is allocated a fixed number of quotas, defection becomes impossible. A member of the cartel cannot decrease their prices, as the number of goods it can import and sell is fixed. It allows an oligopoly to enjoy a stable equilibrium at the monopoly price, instead of a cournot equilibrium, where firms compete by simultaneously choosing their output quantities, and market prices adjust based on total aggregate supply.

4.5 The Relative Importance of Administration Methods

In 2000, six years after the the 1994 Uruguay round, 47% of TRQs acted as applied tariffs, with license on demand and an FCFS making up the rest of the bulk with 25% and 11% of all TRQs (Skully, 2001).

Auctions only make up 4% of total TRQs. Despite Auctions outperforming all methods in theory, they require the market to be liquid, which contributes to their unpopularity. Additionally, auctions may also be hard to implement considering political considerations, as described in the previous chapter.

In 2022, the breakdown of TRQ administrations has shifted minorly. Applied Tariffs make up 40%, License on demand makes up 22%, FCFS makes up 17% and auctions make up 7% (World Trade Organization, 2024).[4]

However, this data is somewhat misleading. Looking at fill rates tells a different story; FCFS and Licence on demand have by far the lowest fill rates, hovering around 43% from 2015 to 2023. This implies a large number of these TRQ administrations consistently provide more import licences than the market demands. The TRQs act like a simple Tariff.

Another issue with looking at the percentage of total TRQs of administrative methods is that of scale. Not all TRQs are of equal size, or equal scope. Almost one-fifth of all scheduled Tariff Quotas are from Norway. Of those, 211 are considered as having "no tariff advantage", which means the in-quota and out-of-quota tariff are equal, or the quota volume is unrestricted. While the WTO can control for TRQs with no tariff advantage, it is much more difficult to control for volume. Of the 22 remaining actual TRQ administrations in Norway, two are for red cabbage and white cabbage. China, on the other hand, is much less granular, and has 6 TRQs which encompass staples like corn, wheat, and rice. Since cabbage TRQs are auctioned in Norway, and rice is administrated by License on demand, auctions will seem much more popular than they actually are. This example is somewhat non-representative, since FCFS and LD are actually overstated by this method. Auctions have an average fill rate of 54%, while the highest fill rates are found in historical allocation, and with producer groups, which have a fill rate of 61% and 69% respectively.

[4]The numbers are higher here than in Table 1 because I have recalculated them after removing inactive TRQs.

A further issue with the WTO classifications is how to classify certain methods. For many administations, TRQ allocation does not fit neatly in one bucket. FCFS, and LD are the biggest culprits here. States regularly set up bureaucratic hurdles leading to outsider firms having difficulties getting licences, resulting in an allocation similar to the ones resulting from discretionary methods.

5 Literature Review

5.1 Detecting Collusion

When it comes to detecting collusion, Harrington (2008) splits detection methods into two camps, the structural, and the behavioral.

The structural approach examines the market for markers of collusion. It asks whether the industry is susceptible to collusion, using factors like the stability of the market, the homogeneity of the goods, barriers to entry to name a few. The second is the behavioral approach, which seeks to determine how parties collude, and what the result of that collusion is. The simplest and strongest behavioral evidence are documents of collusive communication, or firms or workers coming out as whistleblowers. Harrington focuses on behavioral methods, and so do I. The cause is the inherent weakness of structural analysis. Structural analysis can only point you towards industries that have higher likelihood to be cartelized, but not which industries actually are.

Behavioral approaches can be split into two methods again. Direct evidence include testimony, e-mails, notes or other transcripts of communication. While this is the most definitive type of evidence, acquiring it is not something economists can do, and even investigatory bodies struggle. The second method is behavioral screens / forensic econ. While this is only indirect evidence, it allows for easier detection of cartels, and with enough data, can provide a powerful case for collusion. Harrington describes three steps in the behavioral method: Screening identifies suspicious behavior and where collusion is suspected. Verification controls for possible explanatory variables, such as demand and cost factors to eliminate explanations other than collusion. Prosecution involves making the evidence strong enough for it to be used in actually investigating and prosecuting a cartel.

As previously described in the theory of cartels, collusion may be explicit or tacit. It is important to keep in mind how both methods deal with this distinction. Naturally, direct

evidence can only be used to identify explicit collusion. By definition, tacit collusion does not leave a paper trail. Screens, on the other hand, can provide evidence for both, with the caveat that it is completely unable to distinguish between them.

Screening for collusion does not happen randomly. Economic analysis most often follows complaints from buyers or competitors. There is no one size fits all method to detect collusion. Every market or auction suspected of collusion works in slightly different ways, and needs different screens. An unconventional use of empirical screens is by Duggan and Levitt (2002), who compare expected winrates to actual winrates of sumo wrestlers "on the bubble", meaning being close to a winning record in a tournament. While the methodology is innovative, its utility is confined strictly to the context of sumo wrestling. Most cases aren't this extreme however and can share similarities.

Harrington divides methods into four categories:

a) "Is Firm Behavior Inconsistent with Competition?"

b) "Has There Been a Structural Break in Firm Behavior?"

c) "Does the Behavior of Suspected Colluding Firms Differ from that of Competitive Firms?"

d) "Is Firm Behavior More Consistent with Collusion than with Competition?"

I will use the same categories to structure the literature review.

5.1.1 Is Firm Behavior Inconsistent with Competition?

Bajari and Ye (2003) look at procurement auction with homogeneous goods. Cost are independent after controlling for publicly observable variables, like distance to job site. Importantly, Since the value of the contracts is just the price minus the cost, bidding functions should be identical under competition. They then test for both exchangeability (bidding functions being identical) and independence of bids. Independence says that unexplained costs are uncorrelated and exchangeability says variables affect bids the same for all firms. It is not important that a variable, say *distance*, has the same exact coefficient in each firms cost function, but that the direction is identical for all firms.

Kawai and Nakabayashi (2022) look at collusion in government procurement auctions in Japan. Instead of estimating cost functions, the use the fact that there is rebidding after an unsuccessful auction to check if bidding behavior is consistent. Japan uses first-price sealed bid auctions with a reserve price that is secret to bidders.[5] The reserve price is calculated by taking each item and procedure needed for a project and estimating an itemized price. The formula as well as the unit prices are known to bidders, so estimating the reserve price is not difficult, but since prices of items is rounded, the reserve price is somewhat random. Because the second auction is identical to the first, costs stay identical. The second auction bids should represent the bidders costs in a competitive equilibrium. The second lowest bidder should not gain from further underbidding. They find that in auctions where the lowest and second lowest bids were close together in the initial auction, it is almost always the case that in the subsequent auction, the lowest bidder is the same, and the margin is tiny. This suggest that the second-lowest bidders are not bidding optimally. The authors find that of the largest 1000 firms in their dataset, 613 show evidence of collusive behavior, and 37% of auctions were won by these firms.

The difference between Bajari and Ye (2003), Porter and Zona (1993, 1999) and Kawai and Nakabayashi (2022) nicely shows how different auction designs allow for different collusion screens.

5.1.2 Has There Been a Structural Break in Firm Behavior?

The second method Harrington describes is examining structural breaks in behavior. This means examining how prices, quantity, as well as their variances and their covariances between firms changed after a cartel was created or ended. This requires data either from before or after the suspected cartels formed. If an auction is suspected to have been colluded from the first time it ran, this method is wholly useless. Igami and Sugaya (2022) show how increased competition collapsed the vitamin c cartel. Dietl et al. (2010) finds that collusive behavior in sumo tournaments reduced after (Duggan and Levitt, 2002) was published as public scrutiny increased, but reappeared again three years later.

5.1.3 Does the Behavior of Suspected Colluding Firms Differ from that of Competitive Firms?

The third method examines behavior of firms suspected of colluding, and those not suspected. Porter and Zona (1999) looks at three bidders who were found to be colluding

[5] Since this is a procurement auctions, bids need to be below the reserve price, not above

and compares their bidding behavior to the other bidders. They found that for all other bidders, bids decreased in distance, but increased in distance for the three colluding firms.

5.1.4 Is Firm Behavior More Consistent with Collusion than with Competition?

Finally, the fourth method tries to test whether behavior is actually consistent with collusion, compared to the other three, which simply ask whether it is consistent with competition.

Under imperfect monitoring, cartels will have to reduce prices to punish noncompliance occasionally (Green and Porter, 1984). Evidence of this means make alternative explanations, for seemingly uncompetitive markets, like uncertainty, oligopolistic illiquidity, less attractive.

Banerji and Meenakshi (2004) look at wheat auctions in India. The auctions are open oral ascending bid. Only a subset of bidders, the three largest ones, exhibit collusive markers. They find that the case for collusion is stronger than the case for competition.

5.2 Simple Screens

As pointed out by Huber and Imhof (2019), econometric behavioral screens can be further classified into complex methods that estimate cost or demand functions, or in the case of Kawai and Nakabayashi (2022), clever use of a specific quirk of an auction. However this may not always be feasible, which is why simple screens for collusion are needed too. All methods so far have been complex methods. [6]

Athey et al. (2004) show how cartels must sacrifice efficiency and have rigid prices if member firms have private costs, to prevent members of misreporting their private costs, which would allow them to lower prices and cheat the cartel. Harrington and Chen (2006) predict higher price rigidity under collusion to prevent detection from external antitrust authorities.

Abrantes-Metz et al. (2006) uses this to propose a variance screen for collusion. A variance screen has the advantages that it is cheap, easy to estimate, has empirical and theoretical support, and is hard to avoid. That is to say, it is costly for a cartel to prevent

[6] Complex methods do not actually have to be "complex", but they do involve estimating some cost or utility function.

price rigidity. The authors show how after the cartel collapsed, frozen fish sold to the Defense Personnel Support Center in Philadelphia, prices decreased by 16% and the standard deviation of price increased by 263%.

During the lysine and citric acid cartels, prices for both goods increased by 30% and 13% respectively. For the lysine cartel price variance decreased, but for the citric acid cartel, it increased. This can be attributed to the fact that the citric acid cartel existed for a long time, and variance in price was caused by periodic punishment (Bolotova et al., 2008).

The variance screen for collusion is most commonly done using the coefficient of variation (CV). The coefficient of variation is the standard deviation σ_t divided by the arithmetic mean bid μ_t (Imhof et al., 2018): [7]

$$CV_t = \frac{\sigma_t}{\mu_t} \tag{1}$$

The coefficient of variation allows comparisons between the variance of different datasets having different means. For forward auctions, the coefficient of variation is not as useful, as firms collude to bring prices down, not up. The result is that the effect of collusion on the CV is ambiguous: If a cartel fixes bids to be very low, the CV will increase, even if the variance of bids decreases in parallel.

6 Institutional Framework and Data

6.1 Institutional Framework

Swiss meat TRQ auctions are pay-as-bid, multi-unit auctions. Each bidder may bid 5 different price-quantity bundles. The best bids are accepted in order until all licenses are awarded. If the final bid that is accepted has a quantity larger than the remaining quantity to be sold, the bidder may choose to accept it with a proportionally cut quantity, or reject it. Although the auction technically has no reserve price, the in-quota tariff still needs to be paid, and so the in-quota tariff can also be considered the reserve price.

Import licenses are valid for a given period, most often a few months to a year. Licenses may be sold to third parties for most categories. Each auction encompasses multiple specific tariff codes. The largest of these auctions is the one for high-quality

[7] t denotes tender here, not time

Beef (HQB), which includes most expensive cuts of Beef. The government publishes the exact quantity won by each bidder as well as the number of participants, the number of bids, as well as the lowest price and average price. The lowest price paid by a bidder who didn't receive their whole bid quantity is published as well.

For HQB, 40% of TRQs are allocated based on domestic production, and 10% are allocated based on domestic market purchases, the *prise en charge* system. The other 50% are sold via auction.

Since both these allocation methods aren't possible for ritually slaughtered meat, all TRQs are sold via auction. Because any kosher/halal beef TRQ works for any cut of kosher or halal beef[8], fears existed[9] that these cheaper licenses would be used to import regular Beef, meaning unlike regular meat TRQs, these licenses are not allowed to be resold.

6.2 Data

The auction result data spans the import periods from January 1, 2023 to December 31, 2025. Halal and kosher auction results have only been published online since April 2023. Halal and kosher auctions are held quarterly and the data includes 12 auctions each. High-quality beef auctions are held every four weeks, and so the data includes 37 individual auctions. Average prices and total quantity allocated in 2025 are shown in Table 2, and Figure 2 shows the average quarterly price per kg of each auction.

Table 2: Swiss Beef TRQ Auctions: Overall Average Quota Prices (2023–2025) and Total Allocated Volumes (2025)

Category	**Overall Average Price (CHF/kg)**	**2025 Total Quantity (kg)**
Standard High-Quality Beef	12.42	6'975'293
Halal Beef	2.98	410'003
Kosher Beef	0.04	295'006

[8]As opposed to regular beef auctions, where cuts are bundled in individual auctions based on type and price.

[9]Parliamentary Initiative 15.499

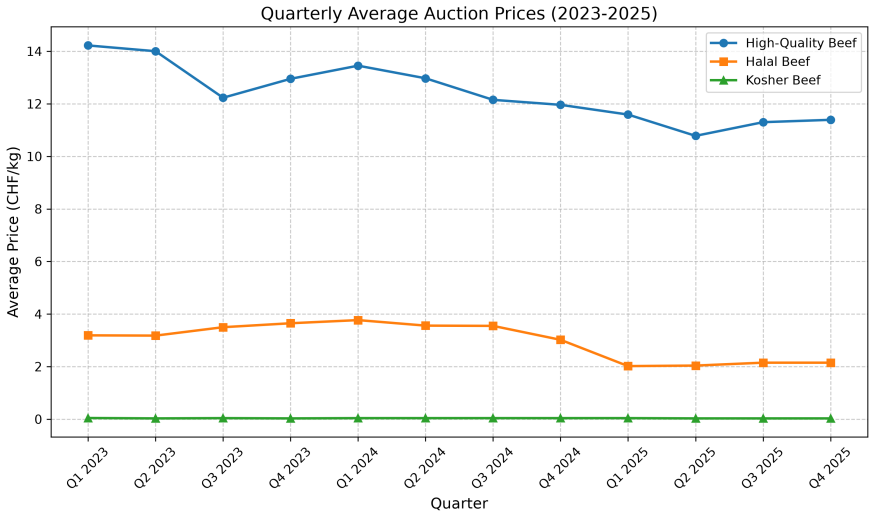

Figure 2: Prices of HQB, halal, and kosher auctions

7 Empirical Strategy

7.1 Why Collusion is Possible

Near zero prices, as exhibited in Table 2, in the kosher auction are not the only reason to suspect collusion. There are large barriers to entry — only firms or persons that are part of the religious communities may participate in their respective auctions. The kosher auction has 8 to 10 bidders on average, where as the halal auctions have slightly more, with 12 to 15 on average.

Furthermore, Swiss meat TRQ auction are more susceptible to collusion than other similar auctions: For auctions where bidders compete for the right to import and sell a certain good, or for that good itself, it is almost always easier to collude in the retail markets.

Imagine a cartel of gas stations in a city. Oil is sold at auction by the state oil firm. The cartel can collude to fix retail prices, but the cartel has no market power in the oil auctions, which leaves price-fixing in the retail market as the only way to earn rents.

In the halal and kosher auctions, any possible cartel has good reason to prefer colluding in the auctions compared to in the retail market: The respective religious communities, meaning those who follow the dietary rules strictly, are close knit, and often have friends and family outside the country. Collusion in the retail market is unlikely first because humans are less likely to collude against friends and community members, and second,

because consumers can compare cross border prices. For meat that can only be imported, it would be difficult to explain why domestic prices are much higher than the foreign price plus the tariff.

7.2 Limitations of Screens in the Present Context

For the reasons mentioned above, a majority of the literature on detecting collusion and behavioral screens focus on retail markets or procurement auctions. Procurement auctions have only one winner, small groups of bidders, oftentimes represent large sums of government expenditure, and feature transparency of bids. Although bid transparency is often implemented with the goal of limiting collusion, it may make monitoring easier for a cartel (Stigler, 1964).

Much of the literature on collusion in multi-unit forward auctions, on the other hand, is theoretical. Discussion is focused on uniform pay versus pay-as-bid, where it is agreed that collusion is more easily facilitated in uniform price auction (Pycia and Woodward, 2026). Furthermore, research is generally to *preventing* collusion, and little is dedicated to *detecting* collusion from bidder behavior in these auctions (Cramton and Schwartz, 2002).

For these reasons, most screens discussed in the literature cannot be easily applied to Swiss TRQ auctions. That is not to say that no screen is applicable. I will propose a screen derived from screens on the variance of market shares.

7.3 Halal as a Control Group

Halal and Kosher auctions take place simultaneously and are governed by the same regulations. Consequently, any differences in bidding behavior will primarily be caused by each group prefering different cuts of meat, which alters how they value the underlying import quotas. This makes the halal auction a useful, although not perfect, control group for the kosher auction.

Because the two auctions are so similar, but result in completely different prices, allows me to use the halal auctions as a control group to ask: Is the near-zero price anomaly in the Kosher sector driven by a collusive market sharing agreement, or by a purely competitive structural difference in quota demand?

7.4 Collusive mechanisms

7.4.1 Simulated Auctions

Despite the literature on this topic being scarce, there are still methods I can adapt. Before I can present them, I need to show why they work by explaining how a possible cartel would function. The most efficient way would be for the cartel to simply run a one to one copy of the state auction. Since in a competitive auction the state collects the entire quota rent, the cartel can simply simulate the auction, and base their bids in the real auction of the result of the simulated auction[10]. Although clever, it would be extremely difficult to keep secret and is rather unlikely.

7.4.2 Market Segmentation

A more realistic option is market segmentation. The cartel agrees explicitly or tacitly to limit the quantity of bids. Unlike in a simulated auction, this doesn't happen by regularly recalculating fair shares, but more arbitrarily, such as the largest firm declaring a certain share always belongs to them, and to punish anybody that tries to compete for it. This also allows for larger firms to force collusion on smaller firms. Although this method is less efficient, meaning benefiting firms who have their set share higher than it would be in a competitive auction, it is much easier to implement, it also does not require explicit collusion by all parties. The cartel simply needs to signal to outside bidders that competing for the cartel's share will result in the cartel outbidding you for the entire supply of licenses in the next auction. Ogur (1978) and Caves and Porter (1978) describe how market shares should be more stable under collusion.

Collusion by means of a simulated auction would be almost completely impossible to detect by simpler screens, but would be much easier for traditional investigatory methods to detect. A more rudimentary market sharing arrangement however would be difficult for a cartel to hide in bidding data, as market shares would be more consistent over time compared to a competitive auction, which is what the rest of this paper will focus on.

7.5 Chosen Method

Since I only have access to public data of the auctions, my options are limited.[11] However, to check whether a possible cartel is fixing market shares, only the final outcomes are needed, as well as a control group. For this, I compare three results, from

[10] For example, bidders could reduce all their bids by some agreed factor

[11] I applied for bidding data, but because anonymization was not possible, my application was rejected.

the halal, kosher and high-quality beef auctions, using the test proposed by Harrington (2008) and implemented by Geist and von Blanckenburg (2011). However, my dataset of the auction results has a distinct advantage over theirs. Geist and von Blanckenburg requested quarterly market shares changes from the German Federal Statistical Office (GFSO), but for data protection reasons, were not able to acquire said data. Instead, they used the average of market share changes of a firms in each period t. I can calculate market shares from the published auction results by dividing each firms quantity won by the total quantity available.

I calculate each firm's market share in each period, as well as the logarithmic change in market share with the formula given in Equation 4. I use the logarithmic change in market share over the absolute or percentage change in market share for two reasons: The absolute change in market share understates variance for small firms, and the percentage change in market shares is not symmetric[12].

$$\Delta \ln(\text{Share}_{it}) = \ln\left(\frac{\text{Amount Won}_{it}}{\text{Total Quota}_{t}}\right) - \ln\left(\frac{\text{Amount Won}_{i,t-1}}{\text{Total Quota}_{t-1}}\right) \tag{2}$$

If a cartel was distributing market shares among its members, one expect to see a leptokurtic distribution. However, to compare the distributions of market share changes in each auction, I use the Kolmogorov-Smirnov test, since it allows me to test for statistical significance, and it is agnostic towards how the distributions actually look like[13]

I employ a Kernel Density Estimation (KDE). A KDE transforms discrete scattered observations into a continuous curve by placing a localized probability density function, or a kernel, over every single observation.

I use the Epanechnikov kernel function, defined as:

$$K(u) = \frac{3}{4}(1-u^2) \text{ for } |u| \leq 1 \tag{3}$$

where u represents the distance of any point on the x-axis from an actual data observation.

The adopted approach falls under the category, "Does the Behavior of Suspected Colluding Firms Differ from that of Competitive Firms?", since I am comparing an

[12] A 10% increase followed by a 10% decrease does not end back at the starting value.

[13] Meaning it could also detect collusion if market shares were more volatile under collusion.

auction suspected of collusion, the kosher TRQ auctions, to one that is not, the halal TRQ auctions.

7.6 Data Constraints and Alternative Methodology

If bidding data were available, it would be possible to attempt to detect collusion by using the distribution of prices paid by bidders. However, this is only effective if bidders do not cleverly scale their bids. If cartel members agreed to scale their bids with a factor $\gamma < 1$, the distribution of bids would remain exactly the same.

For a price-variance screen, Imhof et al. (2018) uses the kurtosis to measure if bids converge. Kurtosis measures the *tailedness* of a distribution. Higher kurtosis means a distribution has more *fatter* tails. Negative excess kurtosis is called *platykurtic* and positive excess distribution *leptokurtic*. Kurtosis is sometimes mistakenly referred to as *peakedness*, because a leptokurtic distribution is "spikier", but the kurtosis statistic is driven by the outliers in the tails of the distribution. The kurtosis statistic is defined as:

$$Kurt(b) = \frac{n(n+1)}{(n-1)(n-2)(n-3)} \sum_{i=1}^{n} \left(\frac{b_i - \mu_b}{\sigma} \right)^4 - \frac{3(n-1)^2}{(n-2)(n-3)} \tag{4}$$

If bids converge due to price fixing, then the kurtosis statistic will be higher. (Imhof et al., 2018) additionally uses skewness as a screen for collusion:

$$Skew(b_t) = \frac{n}{(n-1)(n-2)} \sum_{i=1}^{n} \left(\frac{b_{it} - \mu_t}{s_t} \right)^3 \tag{5}$$

While the skewness may indicate some collusion when applied to the distribution of bids, it is not very helpful when looking at the distribution of changes in market share. Skewness measures the asymmetry of distributions, and since market share changes in any period must add up to zero, skewness of the market share changes reveals how the market is evolving, whether it is becoming more concentrated or not. It is not useful as a screen for collusion in this case.

7.7 The Kolmogorov-Smirnov Test

Although I can track each firm's market share over time unlike Geist and von Blanckenburg (2011), I cannot do a Kolmogorov-Smirnov test (K-S test) to compare competitive and cartel period distributions. Instead, I can use the test to compare the distribution from the Halal and Kosher auctions. The Kolmogorov-Smirnov test compares two samples to

examine if you can reject the null-hypothesis that both samples are drawn from the same distribution. It is defined as:

$$D = \sup_x |F_0(x) - F_1(x)| \tag{6}$$

where $F_0(x)$ and $F_1(x)$ are two distribution functions. The statistic simply takes the largest absolute difference between the two functions at all x's.

7.8 Hypothesis

If kosher auctions exhibit near zero prices because of collusion, and the collusion takes the form of market segmentation, the K-S test will show that the KDE of the market share changes in kosher and halal auctions do not come from the same distribution.

8 Results

8.1 Visual Intuition

The results of the KDE estimations of the logarithmic change in market share for halal and kosher auctions are given in Figure 3 and Figure 4 respectively. Both show leptokurtic distributions.[14] The KDE of the high-quality beef auctions on the other hand, tracks the normal distribution very closely.

So far, it would seem like the hypothesis of collusion in the kosher auction is supported by the data. However, visual examination is not rigorous evidence, which is why the next step is comparing the K-S statistics.

8.2 Kolmogorov-Smirnov Test

Table 3 shows the results of the K-S statistics. The p-value for the two-sample test between halal and kosher auctions is 0.545, meaning I fail to reject the null hypothesis that they are drawn from the same behavioral population. As a result, I can reject the theory that bidders in the kosher auctions are colluding and the bidders in the halal auctions are not. The possibility that both auctions are cartelized is still possible, but unlikely, as explained above.

[14]Figure 4 shows nicely why leptokurtic distributions are caused by outliers in the tails. Probability mass is allocated to the two heavy tails, hollowing out mid-range values and forcing the center into a sharper peak.

Running the two-sample Kolmogorov-Smirnov test between the Halal and HQB auction segments yields a combined p-value of 0.134. Consequently, I fail to reject the null hypothesis of identical distributions at any standard significance level, indicating that the quarter-to-quarter market share adjustments within the Halal sector are statistically indistinguishable from the HQB market. Running the test between Kosher and HQB auctions does yield a significant result, with a p-value of 0.008. So while I can reject the null of identical distributions in this case, it is weak evidence for collusion.

Table 3: Two-Sample Kolmogorov-Smirnov Test Matrix Across Swiss Meat Auctions

Market (Group 1)	Benchmark (Group 2)	Combined D Statistic	Corrected p-value
Kosher	Halal	0.0981	0.545
Halal	HQB	0.1125	0.134
Kosher	HQB	0.1380	0.008

Notes: The null hypothesis for each pairwise comparison states that the empirical cumulative distribution functions (ECDFs) of symmetric logarithmic market share changes ($\Delta \ln(Share)$) are drawn from identical underlying populations. HQB denotes the High-Quality Beef auction.

8.3 Low Sample Size

Because halal and kosher auctions happen infrequently compared to HQB auctions, and with far fewer bidders, the sample size for the market share changes is much smaller. While this is not a fixable problem, it necessitates a cautious interpretation of the resulting trends, as smaller datasets are inherently more sensitive to outliers and shocks.

8.4 Interpretation

The results of the K-S test strongly points against collusion as an explanation of near-zero prices in kosher auctions. Instead, the significant result in the test between kosher and HQB auctions can be easily explained by the weakness of the HQB as a control group, as well as an oversupplied quota. It should not be surprising that a very competitive auction does not have the same distribution of market share changes as an auction where the quota volume offered is much larger than the demand for imports.

The fact that the K-S test between the HQB and the halal market share distribution is not significant is somewhat unexpected. Despite structural differences in the number of bidders, the price of the underlying good, the fact that not all HQB TRQs are auctioned

off, which may reasonably distort bidding behavior, the results are remarkably similar, indicating that both auctions are very competitive.

As mentioned above, the most compelling reason for the near-zero prices in kosher auctions is simply that the quota volume far outstrips the demand for quotas. Only 56% of kosher beef TRQs were actually used to import beef, whereas for high-quality beef and halal beef, the utilization was 99.9% and 98% respectively.

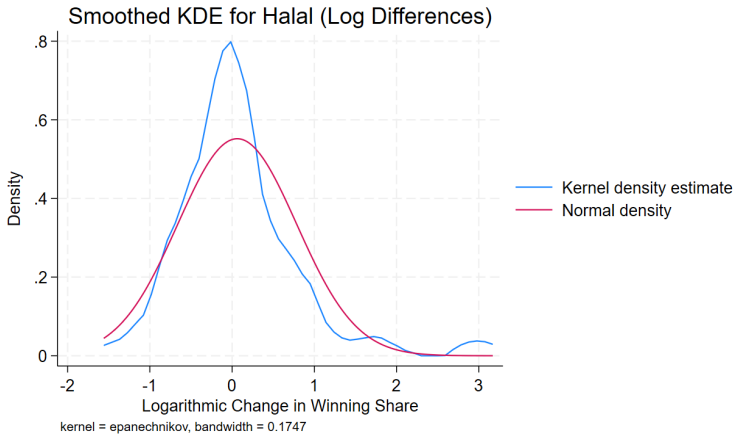

Figure 3: KDE of Market Share Changes, Halal auctions

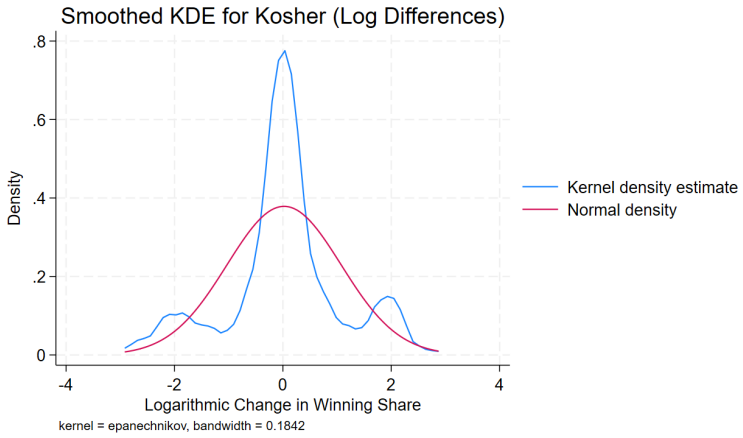

Figure 4: KDE of Market Share Changes, Kosher auctions

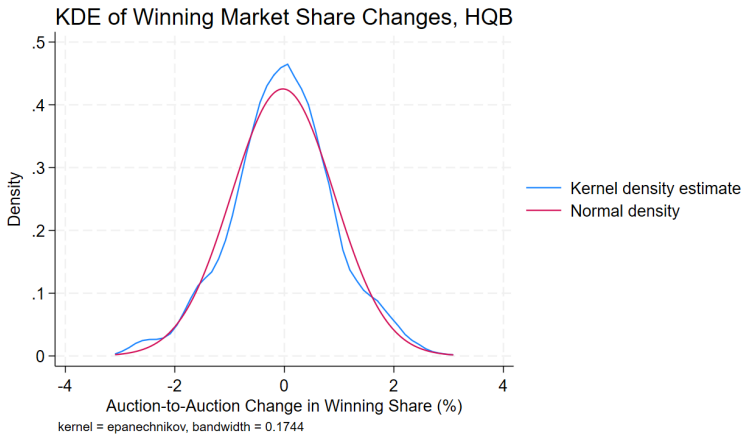

Figure 5: KDE of Market Share Changes, HQB auctions

8.5 Stable Market Shares in the Absence of Collusion

Before presenting the results, it is important to note that there are simple explanations why in the auctions, bidders frequently win very similar percentages of the overall number of licenses. I can illustrate this with the example Firm A[15] in the kosher beef auction. Its share of the market stays stable, however the absolute number of licenses it wins are almost identical in every auction.

A large, risk-averse firm will bid for more licenses than it expects to use as long as the price isn't prohibitive, to make sure that they can always import more goods in case of positive demand shocks. Always bidding for the same number of licenses not only protects it against uncertainty, but also lets it save time and money by not needing to extensively "prepare" for auctions. Since the total quantity is also largely consistent over time, this leads to stable market shares.

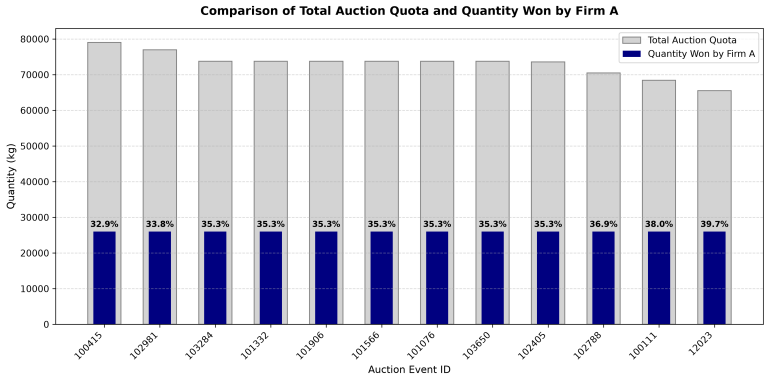

Figure 6: Market Share of Firm A Over Time

[15]Name anonymized

9 Conclusions

The low prices in the Swiss kosher TRQ auctions are not the result of collusion by kosher meat importers. Rather, they are due to the relative abundance of licenses available compared to demand for kosher meat. This is in line with the goal of the TRQ regulations, which is to provide "adequate supply" of meat to religious communities. However, this does not explain why this same result is not seen in the halal auctions. Despite the halal and kosher auctions being lumped together as ritually slaughtered meat, halal auctions are much more competitive, and have a binding quota. Why the government allocates more quotas than demanded for kosher auctions, but not for halal auctions, is unclear.

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I herewith declare that I have :

- composed the present paper without unauthorized aids and in my own words,
- observed the rules of conduct for scientific integrity,
- not already submitted this paper to obtain credit for other coursework at any university,
- in particular not drafted any parts of the text of this paper on the basis of proposals by artificial intelligence.

July 1, 2026

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Peter Birchler