Chapter 28

QUANTITATIVE RESTRICTIONS IN EXPERIMENTAL POSTED-OFFER MARKETS

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1. Introduction

Despite the prevalent use of quota restrictions, little experimental work exists on the effect on market performance of quotas. In this chapter I first elaborate on the different types of quota that can exist and how they are applied in the real world. This is then followed by the some experimental results.

1.1. Quotas

The effect of a particular quantity restriction depends on how it is applied. There are two ways to impose quantity restrictions. First, a quantity restriction can be imposed at the level of a firm such that the firm as a unit can only sell up to a maximum of the quantity allowed under the quota. This has been known to occur both in planned and market economies; wine imports, production of hops, or peanuts in the U.S. economy are some examples of this kind. Quantity restrictions of this kind can be called "firm-specific" quotas. The second kind of quota occurs when a quantity restriction is imposed on a group of firms in a market or upon an importing/exporting country. For example, voluntary export restraints (VERs) that put an upper bound on the total amount of the good that can be sold by a group of firms from a country fall in this category. Given that under such quotas the incentive to defect is very high (as is evidenced by the marketing agreements in the U.S. in the 1930s) innovative ways have been devised so that they end up functioning like firm-specific quotas. For example, in the marketing agreements that are prevalent in the U.S., the quotas are assigned to co-operatives at the state level. The co-operatives then assign quotas to the individual members on the basis of past history.[1] In the end, the effect is *as if* firm-specific quotas were being used. Thus, many of the quota applications end up being as the firm-specific kind. Further, firm-specific quotas are of greater interest as they increase market power of incumbent firms.

[1] This is made possible because the federal government can regulate inter-state and not intra-state commerce. As a result the federal government regulates the inter-state flow while the co-operatives assign in state quotas.

Handbook of Experimental Economics Results, Volume 1

DOI: 10.1016/S1574-0722(07)00028-5

2. Quota Experiments

Plott (1983) was among the first ones to study quota restrictions. He studied the effect of (pollution) standards in the presence of externalities in a Double-Oral auction market. The maximum pollution that all the sellers could 'produce' in the market was fixed.[2] In his experiments, Plott observed that prices showed little or no tendency to converge when standards were used. Therefore, the standards approach was not as efficient as using a tax policy for pollution but was more efficient than using no policy at all.

Kujal (1994) conducted experiments where he studied whether non-binding/binding firm-specific quantity controls affect market performance in the same way as price ceilings. These experiments were important for the many reasons. Earlier experiments on price controls had shown consistent qualitative properties (see Isaac and Plott, 1981; Smith and Williams, 1981; and Coursey and Smith, 1983). The removal of price ceilings resulted in prices jumping upwards after the removal of controls. Further, price controls have an impact on market performance even after their removal (see Isaac, 1988 for a good discussion on remnants of regulation). Thus, because prices and quantities are sometimes used as alternative modes of regulation, it is important to study whether the qualitative results carry across the two different modes of regulatory control.

In his experiments, Kujal (1994) found that after the removal of firm-specific quantity controls there was no evidence of a discontinuous jump in prices (neither in the experiments with binding quotas or "BQ," nor in the experiments with non-binding quotas or "NBQ"). However, tests on aggregate data show that quotas do affect prices. Tests on individual experimental data were mixed. Further, a surprising property of prices was observed in these experiments. Prices converged from below the competitive[3] equilibrium. This result contradicted the well-established empirical regularity that price convergence is from above the competitive equilibrium in posted-offer markets. Thus, the asymmetric distribution of surplus, or the imposition of quotas themselves, affected price convergence in the quota experiments. Further, given that the experimental design had market power price convergence for both the BQ and NBQ experiments was from below the non co-operative equilibrium. However, as the experiments progressed prices converged to the Nash Equilibrium.

Quota experiments also showed interesting behavioral characteristics. Efficiencies in the short run were lower than that observed in the price control experiments. This is important because if the effect on market efficiency is not the same in the short run then one needs to be careful in employing these two alternative modes of regulatory control.[4] From the experimental evidence it seems that, given the quotas, the sellers take some time to find the market price. However, under price controls it seems much

[2] This kind of quota restriction would come under market quotas where the total quantity for a group of sellers is fixed.

[3] The competitive equilibrium is defined as the price that gives 100% total surplus.

[4] This is related to the question raised by Weitzman (1974) where he asks why quantities, and not prices, are the preferred modes of control for internal transfer of firms.

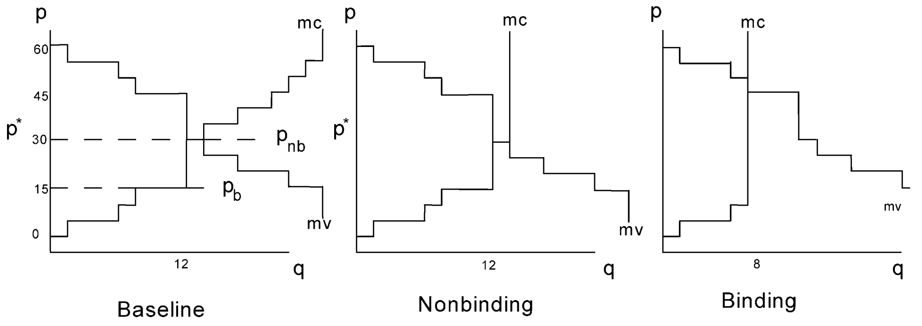

Figure 1. Marginal cost and marginal valuations.

easier to locate the profit maximizing quantity. The answer to this lies in the manner in which the two market controls affect seller search space. This is discussed later in the chapter.

3. Experimental Design

The experiments used the posted-offer exchange mechanism.[5] There were three different experimental designs: (I) the baseline (with no quantity restrictions); (II) nonbinding quota experiments (the sum of seller capacities equals the total quantity sold at the competitive outcome); and (III) binding quota experiments (the sum of the seller capacities is less than the competitive volume under the baseline design). In designs (II) and (III) the quotas were removed midway in period 10.

Five experiments were run for each treatment. Each experiment had four sellers and four buyers. Seller prices were arranged in ascending order with the seller with the lowest price selling first. The buyers were queued randomly to purchase the goods after the sellers post the prices. The next period would start after all the buyers had stopped purchasing the good. A buyer could purchase a unit of the good as long as the purchase price did not exceed the seller valuation of the good. As the focus of the paper was to study seller behavior due to the imposition of the quota buyers were simulated. The buyers revealed perfectly and accepted zero profit.

(I) Baseline (BSL) experiments (Figure 1): This design was characterized by four sellers and four buyers each capable of buying and selling five units each. Assuming everyone prices at the competitive equilibrium, the surplus was divided between the buyers and sellers symmetrically.

[5] For details on the functioning of the posted offer institution see Ketcham, Smith, and Williams (1984).

(II) Non-binding quotas (NBQ) (Figure 1): In this design, the sum of sellers' total capacity equals thirteen. This leaves the competitive price and the quantity unchanged from the baseline experiments.[6]

(III) Binding quota experiments (BQ) (Figure 1): The sum of sellers' capacity equals eight. The competitive outcome is in a 5-cent range, 15–20 cents above the competitive equilibrium in the NBQ/BSL design. Binding quotas distribute the total surplus in the favor of sellers.

The subjects receive a special announcement that quantity controls will be in effect when appropriate. If any seller attempts to violate the quota restriction this will result in the rejection of the sellers' offer until the output constraint (quota) is satisfied. Subjects are also told that their capacity is determined by a central authority. This announcement is made to all the subjects. They are also given individual (private) announcements that state their capacities. The announcement at the start of the experiment reads: "*Your capacity is determined by a central authority. Your capacity is .... Please make sure that the number on the screen coincides with the capacity stated*."

One period prior to the removal of quotas, the subjects are told about the forthcoming change in capacity. Subjects are told individually what their "new" capacities are. Everyone knew that individual capacities have been changed, however, individual capacity changes are private information. The announcement read as follows: "*The central authority has now decided to change your capacities. You now have a capacity of FIVE units. Please make sure that the monitor screen shows the correct amount*." The purpose behind the announcement was to emulate an environment where a regulatory authority decides on individual capacities.

3.1. Market equilibrium

Before the discussion of the experimental results it will be in order to discuss the "predicted" market equilibrium (as the non-cooperative price is not the competitive price) in the experiments. The competitive equilibrium has been defined as the price that gives efficiency of 100% for the following reasons. The experimental design gives market power to the sellers. Looking at Figure 1, and Table 1, it is easy to see that if all the sellers charge a price of 30, sellers 2 and 3 can each gain by selling at a price 9 cents higher (1 cents less than the two high cost units of sellers 1 and 2). At this price configuration, the two other sellers sell 3 units at 30 each. Now, sellers 1 and 2 can each charge 4 cents above the competitive equilibrium and sell all their units thereby getting higher profits. Thus, no seller charges a price of 30, as it is always profitable to deviate from this price for all sellers. This implies that a unique Nash equilibrium in prices does not exist due to the asymmetric allocation of the out-of-equilibrium units for the sellers. It is for this reason the competitive equilibrium is defined to be at 30, i.e., the price that maximizes total market surplus. Further, note that a similar analysis applies for the non-binding quota experiments.

[6] The effect of such restrictions on price outcomes is discussed in detail later.

Table 1
Marginal cost and marginal valuations

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Buyer 1	60	55	45	20	20
Buyer 2	55	50	45	25	15
Buyer 3	55	50	45	25	15
Buyer 4	60	55	45	30	20
Seller 1	00	05	15	30	40
Seller 2	05	10	15	35	45
Seller 3	00	05	15	35	55
Seller 4	05	10	15	40	50

Educated guesses on price can be made to show the approximate price equilibrium in the experiments. This is useful because it gives us a price prediction for the experiments. If a seller prices at 45 the minimum amount he or she sells is 2 units. The gain (30) dominates the loss on the unsold unit (15). Now assume that everyone prices at 45. At this price some sellers gain by lowering the price and selling 4 units. In fact all sellers gain by lowering their price and selling additional units. It is important to determine at what price is each seller willing to lower his or her price such that the net gain from undercutting and selling more is positive. This can be done individually for all the sellers. Seller 4 only finds it profitable to undercut until the price reaches 40 but not below. The maximum the seller gains from undercutting is 56, from pricing at 44 and selling 4. Now, sellers 2 and 3 can price at 39, sell 4 units and gain 36 cents (which is greater than the 30 gained from selling 2 units). The only seller who will undercut them at this price is seller 1 because he or she has the only available extra unit at 30. Seller 4 will never undercut below 40 cents and sellers 2 and 3 never undercut below 37.5 cents. (With a gain of 7.5 cents on each unit, selling 4, it makes them indifferent between pricing at 45 and pricing at 37.5.) Now, all we need to do is to see if seller 1 wants to price below 37.5. At any price below 37.5, selling 4 units, seller 1 earns less ($7 \times 4 = 28$) than the 30 cents he or she would earn at a price of 45. Hence, we know that no seller prices below 38 cents (as prices in decimals are not admitted). This simple exercise gives us an idea that the approximate range of equilibrium prices lies in [38, 45].

4. Experimental Results

Results are reported from five experiments: for the baseline, binding quotas and non-binding quotas.

In the non-binding quota and binding quota experiments, two results are of interest. The number of contracts remains well below the competitive level of 12 and as a result efficiency levels are lower in the earlier periods (Figure 2). After the non-binding quotas are removed, output in the subsequent periods remains lower and slowly starts to con-

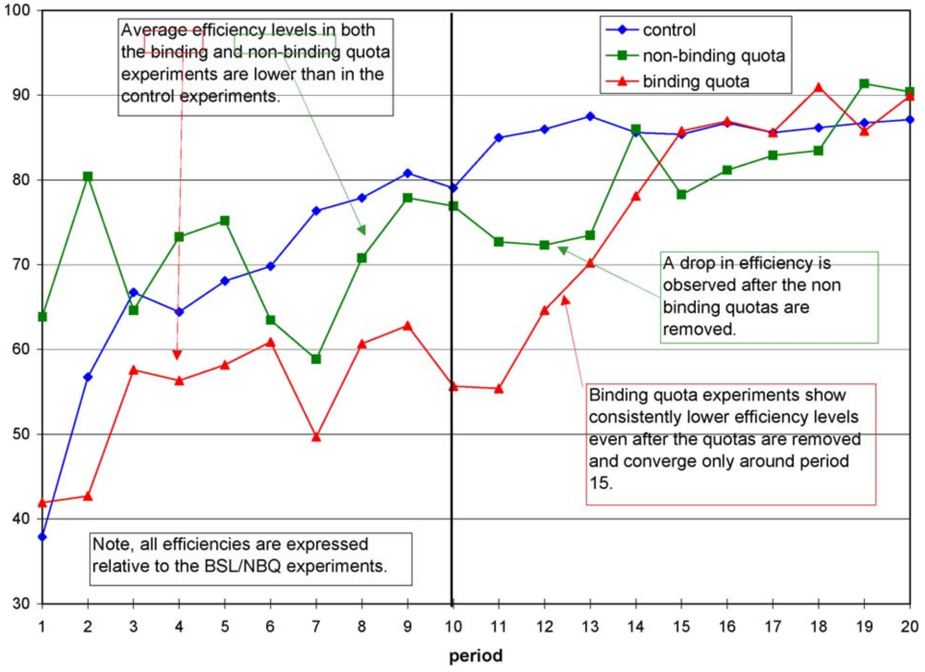

Figure 2.

verge to the competitive equilibrium. Similar results are also obtained for the binding quota experiments. Low output realization is reflected in low efficiency levels observed in the binding quota experiments (Figure 2). This is reminiscent of what Isaac (1988) calls remnants of regulation and is also observed in the price control experiments (see, Coursey and Smith, 1983; Isaac and Plott, 1981; and Smith and Williams, 1981).

In the binding quota experiments, when the quotas are in effect the average contracted price converges from below the competitive equilibrium (Figure 3). This result contradicts the well-established empirical regularity of posted-offer markets where the contract price converges from below the competitive equilibrium. However, if instead we use posted prices to study price convergence (Kujal, 1992) price convergence is observed from above the competitive equilibrium (Figure 4). Moreover, as economic theory predicts, posted prices it seems reasonable to use posted prices to study institutional characteristics.

Looking at efficiencies we see that experiments with binding quotas show a tendency toward lower surplus realization even after the quantity controls are removed. However, by the end of period, fifteen efficiencies for the baseline, non-binding quota experiments and binding quota experiments converge. It is clear that both binding and non-binding quotas clearly affect market performance after their removal. (This result is also reflected in all the price control experiments where a discontinuous jump in prices was

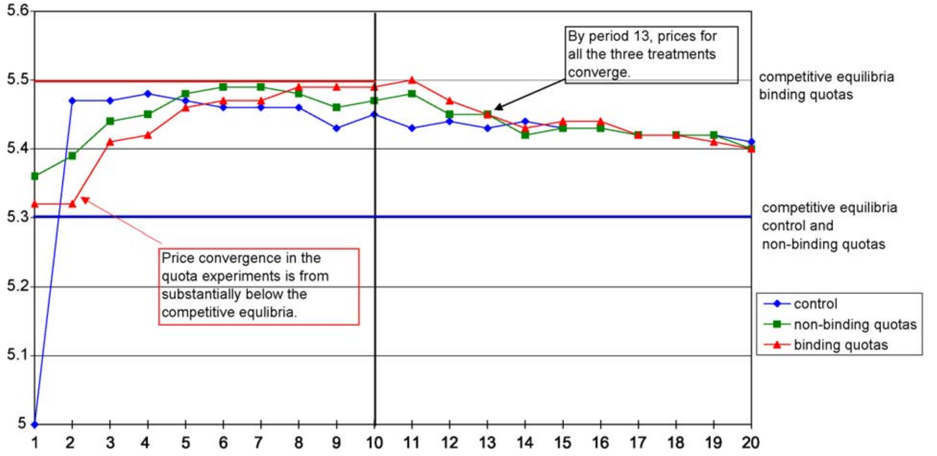

Figure 3.

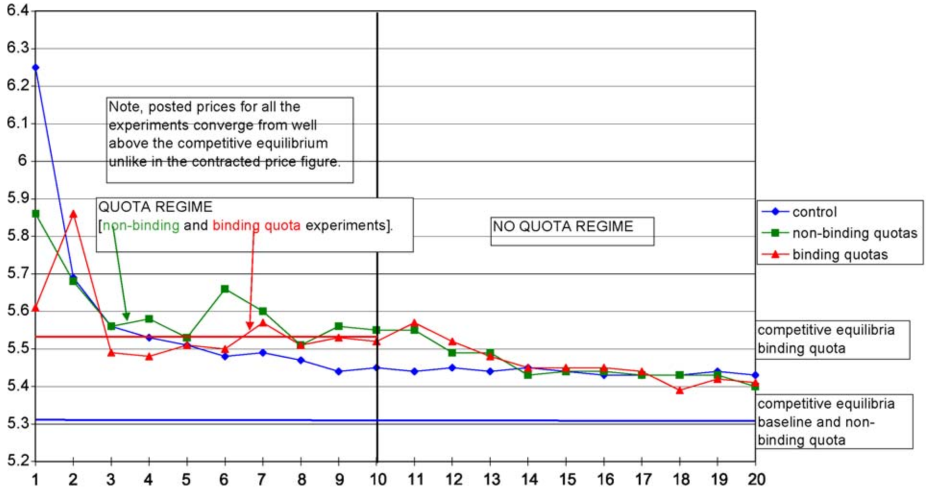

Figure 4.

witnessed after the removal of the price controls.) It is clear that market controls affect market performance even after their removal in our static framework.

5. Conclusion

Quota experiments have shown two interesting results. First, as was also seen in the price control experiments, both non-binding and binding quantity controls tend to affect institutional performance even after their. This lends support to the "remnants of regulation hypothesis" (Isaac, 1988). Second, in the case of binding quotas, average contract price convergence is observed from below the competitive equilibrium. This result goes against the observed empirical regularity of price convergence from above the competitive equilibrium in posted offer markets.

Unlike price control experiments, no discontinuous jump in prices is observed after the quotas are removed in either posted offer or oral double auctions. Another surprising characteristic of the binding quota experiments is that sellers have low efficiency levels on the average. This is observed despite the fact that the surplus distribution favors the sellers. It is evident that quotas, binding or non-binding, affect market performance while they are in place and after they have been removed.

References

Coursey, Don, Smith, Vernon L. (1983). "Price controls in a posted offer market". American Economic Review 73 (1), 218–221.

Isaac, R. Mark (1988). "Remnants of regulation". In: Libecap, Gary (Ed.), Advances in The Study of Entrepreneurship, Innovation and Economic Growth, vol. 2. JAI Press, Greenwich, CT, pp. 173–191.

Isaac, R. Mark, Plott, Charles R. (1981). "Price controls and behavior of auction markets: An experimental examination". American Economic Review 71 (3), 448–459.

Ketcham, Jon, Smith, Vernon L., Williams, Arlington (1984). "A comparison of posted-offer and double auction pricing institutions". Review of Economic Studies 51 (4), 595–614.

Kujal, Praveen (1992). "Asymmetric surplus distribution and the price convergence path in posted-offer markets: A note". Economics Letters 39 (1), 33–36.

Kujal, Praveen (1994). "Firm specific output limit in a posted-offer market: Distributive and efficiency effects". Journal of Economic Behavior and Organization 25 (2), 257–269.

Plott, Charles (1983). "Externalities and corrective policies in experimental markets". The Economic Journal 93 (369), 106–127.

Smith, Vernon L., Williams, Arlington (1981). "On non-binding price controls in a competitive market". American Economic Review 71 (3), 467–474.

Weitzman, Martin L. (1974). "Prices vs. quantities". Review of Economic Studies 41 (4), 477–491.