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# IMPLEMENTATION OF QUANTITY RESTRICTIONS AND THE EFFECT ON MARKET POWER

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Abstract

In this paper the difference between firm-specific and market quotas as two kinds of quantity restrictions used as a regulatory tool and their effect on market power is stressed. It is argued that the use of the specific type of quantity restriction depends on who seeks the quantity restrictions. It is shown that for a range of capacities, firm-specific quotas first-order stochastically dominate market quotas. That is, firm-specific quotas yield higher expected prices (greater market power), relative to market quotas, for a range of capacities.

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Introduction:

The existing literature in Regulation[1] and the International Trade theory[2] has analysed the welfare implications of quotas. The standard text book treatment of quotas is done by drawing a vertical line at the level of the quantity restriction, irrespective of the type of quantity restriction used. In Trade theory the same method is used for the treatment of import licenses (firm-specific quotas), or Voluntary Export Restraints (henceforth, VER's/market quotas). The effect of these restrictions on individual firm capacities is not taken into account. As a result the effect on market supply is not taken into account and the resulting strategic implications and effects on market power are overlooked[3]. In this paper I look at the specific manner in which quantity restrictions are implemented and the effect on market supply. It is shown that this has important strategic implications for an oligopolistic market structure.

Quantity restrictions can be divided into two types. How they are implemented varies substantially and depends on several observable and non-observable factors. The two fundamental kinds of restrictions are ones that affect individual firm capacity and the others that restrict the total amount sold in a market by all the firms. I call the first type of restriction Firm-Specific Quotas as the affect is on the amount that any individual firm can produce and sell (as is in the case of licenses). The second, I call Market-Quotas as they affect the total sales of a group of companies in a geographically dilineated section[4](i.e., Voluntary Export Restrictions). I differentiate between the two based on the different types of competitive behavior they generate[5].

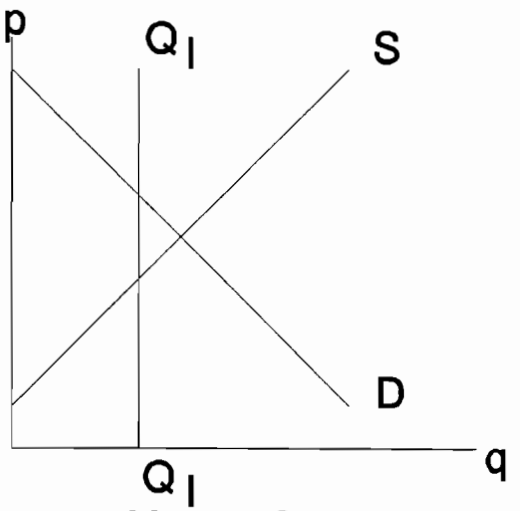
Firm-specific quotas can be implemented through licenses issued to specific importers (in the U.S. licenses for import of wines are issued along these lines). Each importer is given a

maximum quantity of the good it can import. In planned economies each firm is allocated a specific quota for output that it has to meet. Firm-specific output restrictions have been used in innovative ways, especially in agricultural markets (cotton, corn, rice, tobacco, hogs, milk and wheat) in the U.S.. A new generation of pollution permits is also of the firm-specific kind (although the permits are tradeable between firms)[6].

The implementation of firm-specific quotas has been especially innovative in the agricultural markets in the U.S.. For example, since individual producers' output cannot be curtailed, it is the shippers who are licensed (the government can control interstate commerce in the U.S.). Regional co-operatives (voluntary organizations) then allocate the crop shares to the individual farmers. Other policies involved reducing acreage via reduction in planted land (this was justified under land conservation). The Marketing Agreements granted by the U.S. Secretary of Agriculture were such that output could be either restricted by acreage redution, or by licensing shippers. Another recourse, used in agricultural markets, is by curtailing land use (under soil conservation as individual farmer's ouptut cannot be directly curtailed). These are examples of indirect and innovative manners in which firm-specific quantity restrictions have been imposed. In-fact, in agricultural markets in the United-States majority of the quantity restrictions are of the firm-specific kind. Some other ways in which firm-specific output restrictions are imposed is by issuing licenses to import (wine imports), or issuing license to install a maximum capacity to produce a good (prevalent in planned economies, such as India). Allocating tasks within an organization, such as a firm, is also of the firm-specific type. The task is broken up into parts, each of which is then assigned to an individual group.[7]

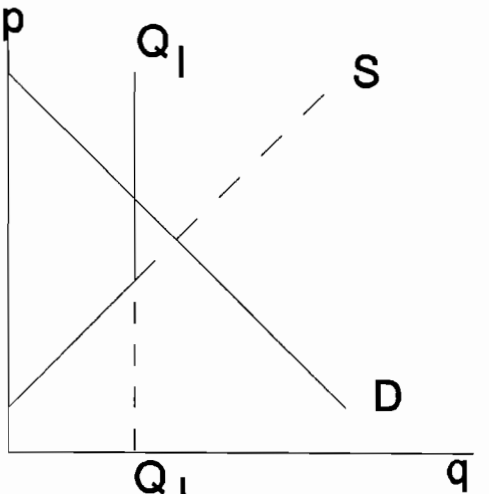
Examples of market quotas are VER's[8] and the earlier Marketing Agreements in U.S.

Figure-1a




Market Quotas

Figure-1b




Firm-Specifc Quota

agriculture. Under a VER a country voluntarily (or, through bilateral negotiation) chooses to restrict it's exports to a certain aggregate amount. Another example are export quotas issued to countries (not to individual firms) where the individual firms can compete for their share of the quotas. As a result the capacity of the individual firm is not curtailed. However, the total amount that can be sold in the market is restricted. An important consideration in this case is that as the quantity-restriction is imposed on a single country, competition from other countries is not eliminated. That is, Japan is under VER's, however, the competition from within the U.S. and Europe is not affected. Other examples are in agricultural markets in the U.S. in the early 20$^{th}$ century. In Florida, in the formative years of agricultural policy, there was an initial attempt at using market quotas in the market for oranges.[9]

Now, how do these quantity restrictions affect the way quotas shoule be treated? As earlier mentioned, in the usual treatment of quotas a vertical line is drawn at the level of the quantity restriction. If the competitive outcome for a market is Q and the level of quotas is $Q_l \leq Q$, a vertical line is drawn at $Q_lQ_l$, the level of the quotas (Fig.1). The assumption is that the total quanitity restriction ($Q_l$) under firm-specific and market quotas is the same. Market quotas, which limit only total sales, are represented by drawing a vertical line at $Q_l$ (fig-1a), everything else remaining the same. However, with firm-specific quotas licenses are issued to individual firms (for maximum sales or, maximum capacity) limiting total capacity. As a result the market supply curve is vertical at the total quota level $Q_l$ (fig-1b). This results in the 'swing' to the left of the supply curve at $Q_l$. The type of the quantity restrictions affects the treatment of the MC curve in a fundamentally different way. In markets where firms behave strategically (i.e., oligopolies) one cannot expect to find the same price outcomes for equivalent quantity

restrictions.

<Figure-1a and -1b here>

1-b. Choice of Quantity Restrictions:

Under what circumstances do we find a specific kind of quantity restriction? It will depend on the group seeking, or imposing, the quantity restriction. Market quotas may be used where limiting a firms' capacity is not an available recourse. A good example is VER's on Japanese imports of cars. The U.S. government cannot exert control over the Japanese firms. The voluntary nature of the VER arrangements make them a politically palatable solution than the direct 'imposition' of such quantity restrictions. As capacities, or outputs, in foreign economies are not controllable the flow of the goods is restricted into the domestic market. Firm-specifc quotas can only be imposed when sales of firms, or their capacities, can be directly controlled.

In the absence of such limitations to the imposition of quantity restrictions, what determines the type of quantity restriction that should be used in each particular case? It is shown that the answer to this question depends on who seeks to impose the quantity restriction. If the quantity restriction is imposed in response to pressures from a domestic interest group, the choice of the restriction will be of the firm-specific kind. Since, this type of restriction gives the firm market power. A good example are the quantity restrictions obtained by U.S. agricultural farmers.

Firm-specific quotas could be also used in economies with limited resources. If scarce resources in an economy need to be allocated then limiting firm capacities may be a reasonable recourse. Of course, the assumption is that the benefit from limiting resource usage exceeds the

costs that are imposed on consumers in the form of higher prices and lower output. To economize on resource usage we may not want firms to operate at excess capacity (due to quotas). This could be a reason why firm-specific quotas are a prevalent mode of control in many underdeveloped planned economies.

In the paper it is shown that if the firms compete in prices market quotas do not change the fundamental structure of the market. That is, price outcomes are not affected by the imposition of market quotas. This could be the reason that whenever market quotas were imposed in the early years of agricultural regulation they could never be sustained. As Hoffman and Libecap (1991) put it,

*"In response to agricultural distress, farmers acted collectively to achieve both voluntary and governmental solutions. Collective action to restrict output and raise prices suffers from the "free-rider" problem. Each farmer benefits from the others' output restrictions but maximizes profits by cheating on the joint agreement." p.399*

This is the known classic argument used to explain the instability of cartels. That is, individual output restrictions cannot be successfully imposed by the central authority. Each firm gains by defecting and thus a cartel price cannot be sustained. Firms must compete in prices for such a scenario to occur. The intent to form such cartels implies that the individual incumbents lacked market power. Other conditions such as product hetrogeniety, access to shipping ports, etc.., also play an important role[10]. This brings us to an important observation. If there are producers of substitute good, foreign and domestic, the firms' market power is further diminished. Moreso with the VER's, as they are discriminatory by nature. The firms at the receiving end of the restraints do not gain any additional market power. This is because aggregate capacity is not affected by market quotas. As a result, VER's do not transfer an equivalent amount of 'rent' to the foreign supplier (relative to firm-specific output limits)[11].

The use of firm-specific vs. market quotas as regulatory (planning) tools in a price/quantity choice setting is the focus of attention. It is shown that the non-cooperative price outcomes for a symmetric oligopoly producing a homogenous good will not be the same. Also, for the case where a pure strategy equilibrium exists, the pure strategy price with firm specific quotas will be greater than the pure strategy outcome with market quotas in the case of the competitive outcome. For the Cournot outcome in pure strategies both quantity restrictions yield the same price outcomes. For the case where the pure strategy outcome does not exist, we show that with firm specific-quotas the non-cooperative price distribution function with firm-specific quotas has an upward bias (or, a higher lower bound for the equilibrium mixed distribution) relative to the distribution functions obtained with market quotas. Finally, for the case where equilibrium in mixed strategies exists, firm-specific quotas first order stochastically dominate market quotas. That is, the expected price under firm-specific output limits is greater than the expected price under market quotas.

The paper is organized as follows, Section-2 has the model and the calculations for the equilibrium distribution functions followed by the stochastic dominance proof for firm-specific and market quotas. Section-3 is the conclusion.

## 2. The Model:

I present a simultaneous-move pricing oligopoly model. This is analogous to the Posted-Offer (henceforth PO) auction trading institution in market experiments. In a PO institution sellers first choose prices simultaneously, and the buyers are then randomly selected and make purchases. The sellers make price and quantity choices. At the beginning of the period a seller

makes price choices and then chooses the number of units it wants to sell at the selected price. If the buyer purchases the good the trade occurs at the posted prices. The period ends when all the buyers have finished purchasing the good.

Consider an oligopoly; the firms are symmetric and produce a homogenous good. Sellers select price simultaneously and share demand in the event of a tie. Sellers have constant marginal costs up to capacity, and the intersection of the total seller capacities and the demand determines the competitive price.

There are two alternative regulatory mechanisms, one with firm-specific quotas and the other with market quotas. With firm specific quotas a limit is imposed on the individual firms' capacity (licensing), or on the amount it can sell (quotas allocated for oranges, grapes, milk, etc.., in U.S.A. are of this kind). With market quotas the total output of the market is constrained at a level established by the quota (limiting automobile imports, pollution permits are organized in the following manner (see Plott (1983)).

Equivalent quota mechanisms are used in the sense that the total output restriction specified under market quotas always equals the sum of the firm-specific quotas. We also assume that the quotas are specified such that the aggregate quantity is always less than the total seller capacity (i.e., the quotas are an effective constraint).

Let there be n sellers, each with capacity $X_i$, $i=1,2,\ldots,n$[12]. Let the constant marginal cost be c up to capacity and the maximum willingness to pay for the good be m upto quantity Q. Let the total sellers' capacity (or sales) permissible under firm-specific quotas be $Q_f$, such that each seller has an equal share of $q_f$, $nq_f = Q_f$. Also assume that the quotas are specified such that the total amount of the quotas is less than or equal to the competitive outcome Q.

It is shown that when the aggregate capacity is greater than Q, then if a pure strategy outcome exists the equilibrium price outcome under firm-specific quotas (p=) m is always greater than the pure strategy outcome under market quotas (p=) c. For capacities less than or equal to Q the same monopoly outcome under the two forms of quantity restrictions is obtained. When the Nash outcome in pure strategies does not exist the equilibrium distribution of non-cooperative prices with firm-specific quotas has an upward bias. That is, the cdf under firm-specific quotas First-Order Stochastically dominates (henceforth FSS) the cdf under market quotas. This implies that the expected prices under firm-specific output limits are greater than the expected prices under market quotas.

First, pure strategy outcomes are shown and then the equilibrium distribution function in mixed strategies is derived and it is shown that the cdf under firm-specific quotas first-order stochastically dominates the cdf under market quotas.

(i) Pure Strategy Outcome:

In this we get two cases. The first where the pure strategy outcome is the monopoly price (m) for both modes of controls. The second, where licenses yield the monopoly outcome and VER´s yield the competitive outcome (c, c<m).

Case a:

The competitive outcome, c, is the pure strategy Nash with market quotas, and that m is the pure strategy outcome with firm-specific quotas for each firms' capacity greater than or equal to Q.

This is easily shown, all that needs to be shown is that any seller with the highest price

has zero sales. That is, a unilateral price increase from the competitive equilibrium will never be profitable and the competitive equilibrium will be the Nash equilibrium in pure strategies (fig.2). We can show that if $X > Q$ (n greater than, or equal, to 2) then no high priced seller has positive sales and thus for any size of market quotas (with no constraints on individual firm capacity) the competitive outcome, c, will be a pure-strategy Nash outcome.

Case b:

In this case the capacity of all the firms before the restrictions are imposed, $n X = Q$ (fig.2). Thus, if the restrictions are imposed at the aggregate level Q, the monopoly price (m) is the dominant strategy outcome. Each seller can unilaterally raise it's price and sell all of it's output. This is the only case where the two modes of controls yield the same outcomes and the transfer of "rents" to the home and the foreign producers is the same ((m-c).Q).

The mixed-strategy[13] equilibrium distribution function is now derived.

The Equilibrium Distribution Function:

Define the profit function for the high price and the low price seller. A high price seller would sell the residual demand, while all low price sellers sell all their units X. Thus, we define the high and low price sellers profit function,

(1) $$\Pi_{Hi}(p_i) = [p_i - c] [Q - (n -1) X]$$

(2) $$\Pi_{Li}(p_i) = [p_i - c] X.$$

Now, determine the upper and lower bound of the region in which the sellers will

randomize. This is done by calculating the range in which their expected profits remain the same. The upper bound is easily shown to be m (buyer marginal valuation) as the profit function $\Pi_{Hi}$ is maximized at m. Thus, denoting $V_i$ to be the supremum of expected profits of seller i, we can write, $V_i = \Pi_{Hi}(m)$ and $(V_i)$ is decreasing in n. Now, assuming that all the other sellers use a common equilibrium pricing distribution, $G_j(p)$, we can write the probability that seller i has the highest price as

(3) $$G_{Hi}(p_i) = [G_j(p_i)]^{(n-1)}, \text{ thus, } G_j = [G_{Hi}]^{1/(n-1)}.$$

Now, calculating the sellers expected profit function $V_i$ for (n=) 2 sellers we get:

(4) $$V_i = G_{Hi}(p_i)\, \Pi_{Hi}(p) + [1 - G_{Hi}(p)]\, \Pi_{Li}(p) \qquad \text{for } i=1,2.$$

Solving (3) for the probability function and substitute $V_i = \Pi(i)$

(5) $$G_{Hi}(p) = \{\Pi_{Li}(p) - G_{Hi}(p)\}/\{\Pi_{Li}(p) - \Pi_{Hi}(p)\}.$$

Substitute $G_{Hi}(p)$ and $G_{Li}(p)$ in (5), and we get,

(6) $$G_{Hi}(p) = [(p-c)\, X - (m-c)\, (Q - (n-1)\, X]/[(p-c)\, (nX-Q)].$$

Writing $G_j = [G_{Hi}]^{1/(n-1)}$ for n sellers (from (3)), we get

(7) $$G_j(p) = [\{(p-c)\,X - (m-c)\,(Q-(n-1)\,X\}/\{(p-c)\,(nX-Q)\}]^{1/n-1}.$$

Which is the symmetric equilibrium distribution function.

(ii) Mixed Strategy Distribution Outcomes:[14]

To rule out the competitive outcome as a Nash outcome in pure strategies it is assumed that seller capacity $X < Q$, and that, $[n-1]\,X < Q < n\,X$, for n sellers. The inequality implies that a seller can unilaterally raise it's price and still have positive sales. The second inequality implies excess capacity at all prices above c. We retain the assumptions about constant seller costs and constant buyer marginal valuation.

The lower limit of the distribution $G_j(p)$ is obtained by setting $G_{Hi}(p) = 0$ at the lower bound. (Note, $G_{Hi}(p) = 1$ at the upper bound $p = m$.) Solving (7) for $G_j(p)=0$ we get the lower bound of the non-cooperative price distribution. Thus,

(8) $$p_{min} = [(m-c)\,Q_d/X] - (n-1)\,(m-c) + c.$$

Now, we use (8) to show that the lower bound, $p_{min}$, of the distribution $G_j(p)$ with firm specific quotas, $p_f$, is always below the lower bound, $p_{min}$, of the distribution ($G_j(p)$) with market quotas (note, $p_{min}$ is unchanged with market quotas as sellers capacities are not restricted). This is shown by substituting $X = q_f$ in (8) for firm specific quotas (Note, X remains unchanged with market quotas). We get,

(9) $$p_f = [(m-c)\,(Q_d/q_f)] - (n-1)\,(m-c) + c.$$

Note, the first term on the right hand side in (8) is greater than the first term in the right hand side of (9). All other terms being the same, $p_f < p_{min}$, for all $q_f < X$. Thus, the lower bound of the equilibrium mixed strategy distribution with market quotas is less than the (lower bound) with firm-specific quotas.

To show that the cumulative distribution function with binding quotas, $G_f(p)$, (first-order) stochastically dominates G(p), the cdf for market quotas we need to show that $G_f(p) \leq G(p)$ $\forall\ q_f \leq X$, with a strict inequality for at one p. Substituting $q_f$ in (7) we get:

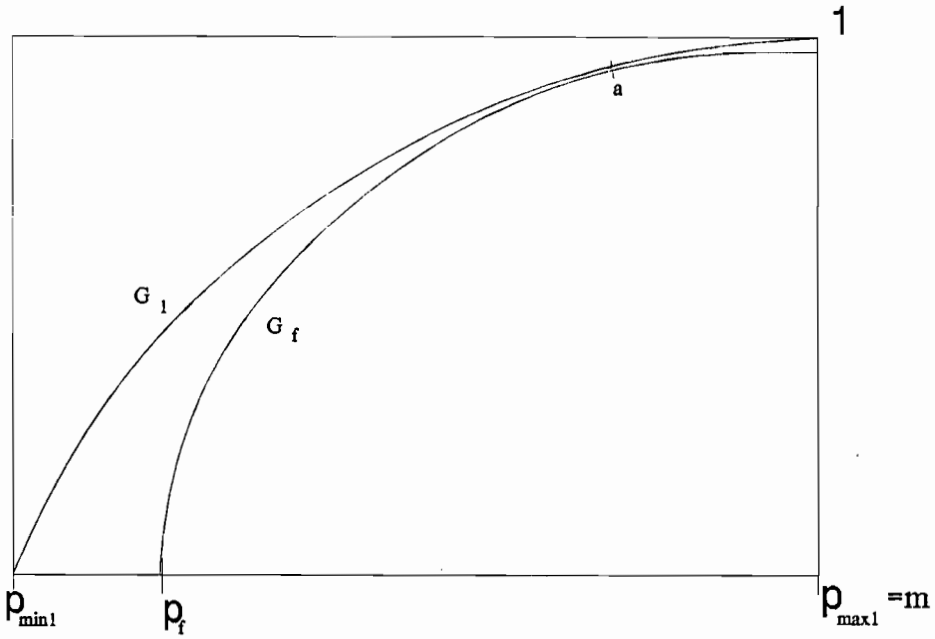
(10) $$G_f(p) = \{(1/(nq_f - Q))[q_f/(p-c))((p-c)+(n-1)(m-c))-Q((m-c)/(p-c)]\}^{1/(n-1)}.$$

For market quotas we retain (7). It simplifies to:

(11) $$G(p) = \{(1/nX-Q))[X/(p-c))((p-c)+(n-1)(m-c))-Q((m-c)/(p-c)]\}^{1/(n-1)}$$

Raising both sides to the power of (n-1) and comparing (10) and (11) it is clear that the first term on the right hand side of (10) is greater than the first term on the right side of (11), given $q_f < X$. Also, the second term for (10) is smaller than the second term for (11). It is not possible to show that $G^f(p)$ first order stochastically dominates G(p) in this framework. In the following section we derive an alternative proof of stochastic dominance.

Figure-2



(iii) Proof of Stochastic Dominance[15]:

Given that the cdf's are continuous and non-decreasing, and that the lower bound of the non-cooperative price distribution for market quotas $p_{min} < p_f$ (from (8) and (9)) and both, G(p) and $G_f(p)$ have a common upper bound, m. For $G_f(p)$ to first-order stochastically dominate G(p) it must lie on, and below at least at one point, G(p) everywhere in the range $[p_f,m]$. That is, for the cdf's G(p) and $G_f(p)$, p the random variable, if $G_f(p)$ first-order stochastically dominates G(p) if for all p, $G(p) \geq G_f(p)$, with a strict inequality for at least one p.

If $G_f(p)$ does not First Order Stochastically dominate G(p) then the solution to the equality $G_f(p)=G(p)$ must be at least a quadratic (fig.3). That is, if the cdf's intersect at one point in the interval $[p_f,m)$, then the solution to the equality above must be at c, and at m. Hence, if the solution to the difference $G_f(p)-G(p)=0$ is unique (point of intersection m or any point outside the interval $[p_f,m]$) we know that $G_f(p)$ cannot intersect G(p) anywhere in the interval $[p_f,m)$ and must lie below it everywhere. Thus, if we can show that the solution to the difference $G_f(p)-G(p)=0$ is unique it would show (weak) stochastic dominance. This is shown by taking the first difference of $G_f(p)$ and G(p). We have,

$$(12) \qquad \{[(p-c)X-(m-c)(Q-(n-1)X)]/[(p-c)(nX-Q)]\} =$$

$$\{[(p-c)q_f-(m-c)(Q-(n-1)q_f)]/[(p-c)(nq_f-Q)]\}$$

Simplifying, we eliminate (p-c) from the denominator on both sides.

$$(13) \qquad \{[(p-c)X-(m-c)(Q-(n-1)X)]/(nX-Q)\} =$$

$$\{[(p-c)q_f-(m-c)(Q-(n-1)q_f)]/(nq_f-Q)\}.$$

Crossmultiplying and solving (13),

(14) $(p-c)X(nq_f-Q)-(m-c)(nq_f-Q)(Q-(n-1)X)=(p-c)q_f(nX-Q)-(m-c)(nX-Q)(Q-(n-1)q_f)$.

Rearranging terms we get a unique solution to (14),

(15) $p=c+\{(m-c)[(nq_f-Q)(Q-(n-1)X-(nX-Q)(Q-(n-1)q_f)]/[X(nq_f-Q)-q_f(nX-Q)]\}$.

(Note, it only needs to be shown that the solution to $G_f(p)=G(p)$ is unique to prove FSS.)

Now, given that $G_f(p)$ FSS[16] $G(p)$ then we know that an outcome of (weak) FSS is that a (weakly) dominating random variable has a (weakly) higher expected value.[17] Thus, we can expect higher prices with firm-specific output limits relative to market quotas.[18]

It is also easily shown that $P_{min}$ is decreasing in $q_f$ and will tend to the competitive outcome as $q_f$ increases: $q_f \rightarrow X$ ($p_f$ decreases at a decreasing rate in $q_f$). Another interesting result arising from (9) is that both $p_{min}$ and $p_f$ decreases in n at a constant rate of -(m-c) with a lower bound at m=c.

Thus firm specific quotas raise the lower bound of the non-cooperative price distribution. The lower bound decreases at a decreasing rate with respect to the (size of the) individual firm quotas (capacities) and at a constant rate with respect to the number of the incumbent firms. Also, that the expected prices under firm-specific quantity restrictions are greater than the expected prices under market quotas.

Conclusion:

This paper presents an important observation. That, if the pre-regulation environment were competitive market quotas do not alter the competitive outcome. Firm-specific quotas at the free trade level will give the firms market power. Secondly, if domestic firms seek government intervention the choice of capacity constraint is the firm-specific kind[19]. This gives the incumbent firms market power resulting in stable cartels. This is highlighted by the nature of the quantity restrictions sought by the farmers in the United States.

We have shown that the selection of the type of quotas determines the equilibrium price supports and the expected prices for the choice of the quotas. The price distributions, with firm specific quotas, have an upward bias as is shown by the proof of stochastic-dominance. Thus, firm-specific output limits work to the benefit of the firms/individuals receiving the quotas. As firm-specific output limits affect firm capacities (directly or indirectly), we know that the incumbent firms have market power. This explains the reason as to why if the firm is given the choice of quantity restrictions it would rather choose firm-specific output limits. This is re-inforced by looking at the nature of the quantity restrictions imposed in the U.S. agricultural markets. Indirect, or direct, methods were used to ensure that the flavor of the quantity restrictions is of the firm-specific type. Thus, if we look at import licenses, they are issued to individual domestic importers. This eliminates all forms of outside (foreign) competition. However, quotas issued to foreign suppliers are mostly issued to countries and not to individual firms. That is, they are of the market kind, which should result in lower prices as the foreign suppliers still compete for their share of the quota. Also, market quotas have two interesting effects. First, as has been pointed out that they retain the competitive nature of the market given that the firms compete for their share of the quota. Second, it reduces the competition faced by

the domestic producers as it limits the total amount of the imports. These results are important in that they point out that the selection of the type of quotas, firm-specific or market, determines the price outcomes.

Also, regulators have to make the choice between rationing resources with care. As is shown market-quotas yield competitive outcomes, however, resources are not rationed. Whereas firm-specific output limits ration resources in turn sacrificing competition. Economies with scarce resources may have no recourse but to use firm-specific quotas in an effort to ration resources among various sectors. They may choose to sacrifice consumer welfare due to the resource constraints. Given the choice, the firms' will choose firm-specific output limits as it limits competition. In terms of market power market-quotas diminish (the recipient) seller market power and firm-specific quotas increase seller market power. Thus, if quantity restrictions need to be imposed keeping consumer welfare in mind market quotas do it best.

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1. Hoffman et.al. (1991) investigate the implementation and the development of U.S. agricultural policies in the 1920's.

2. In the planning literature the issue of the equivalence of prices and quotas has been analysed. Weitzman (1974) has studied the choice of the appropriate planning tools, prices or quantities, given the disconinuities in the cost and/or benefit functions. Weitzman, however, only considers market quotas.

3. Harris (1985) and Krishna (1989) have approached the similar problem. However, they do not model it as a capacity constrained oligopoly. This paper is similar in flavor to Harris's and Krishna's articles in this area.

4. A good example of this exists in the earlier Marketing Agreements in U.S. agriculture (Hoffman and Libecap).

5. The existing treatment of all kinds of quotas is of the market quotas kind.

6. Franciosi et. al (1993).

7. See Weitzman.

8. For a good analysis of the types of quantity restrictions that can be imposed see Hamilton (1985).

9. For reasons that are explained later in the paper this system of quotas did not perform the intended task.

10. Hoffman and Libecap, ibid.

11. One should note that if VER's are imposed on all foreign suppliers it will result in a greater increase in prices than when they are imposed on selective countries.

12. We drop the subscript i as the sellers are symmetric.

13. An equilibrium in mixed strategies can exist when the VER/License is imposed on a small proportion of sellers. For example, VER's are imposed on Japan (and, South Korea), but not on Europe. Similaryly, if licenses are issued to a small group of foreign sellers such scenarios, where equlibrium in mixed strategies exists (i.e., $(n-1)X > Q > n.X$) are possible.

14. For the interested reader, see Holt et. al. for detailed discussion about calculating equlibrium non-cooperative price distributions with discontinuities.

15. This proof was developed as a separate exercise by Kujal (1993).

16. We have shown that $G_f(p)$ (weakly) FSS $G(p)$ as we allow for $G(p)=G_f(p)$ at least at one point in the interval $[p_f, m)$.

17. Lippman and McCall, 1981, p.215.

18. Note, these results are easily extended to the case of a downward sloping demand.

19. This observation is not unique to this paper. It is shared by Hoffman et. al. in their analysis of Institutional Choice and Agricultural policies in the U.S.