Are Minimum Quality Standards Acting as Nontariff Trade Barriers?

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Governments throughout the world frequently permit producers of agricultural commodities to undertake collective action. Enhancement or maintenance of product quality is often cited as a justification. The Agriculture Marketing Agreement Act (AMAA) of 1937, for example, authorized the formation of federal marketing orders that allow U.S. producers of a particular agricultural commodity in a specific region of the country to act collectively. Marketing orders can impose quality regulations and inspections, perform production and processing research, control the volume of product brought to market and/or conduct other supply-management practices. Producers of fruit, vegetables, or other specialty crops enter into marketing order agreements voluntarily. In order to implement or amend a marketing order, a two-thirds or larger majority by number or volume of production is required (USDA, 2007).[1]

In 1954, the AMAA was amended to include section 8e, which specifies that imports are subject to the same quality standards, regulations, and other provisions as are imposed upon domestic production by a marketing order. According to the USDA (2007):

> section 8e quality requirements are intended to (1) develop dependable markets for products by ensuring consumer satisfaction and encouraging repeat purchases, (2) promote buyer satisfaction and increased sales for those commodities by ensuring that only acceptable quality products are in the U.S. market place, and (3) help avoid market disruption associated with poor quality offerings.

Due to the seasonality of agricultural production, most foreign production complements, rather than competes, with domestic production. In order to comply with the General Agreement on Tariffs and Trade (GATT) Article III requirement that imports are not held to higher standards than domestic production, section 8e requirements are only in effect when domestic production is being produced, regulated, and shipped (USDA, 2007).

[1] A three-fourths majority is required by California citrus producers.

Both foreign and domestic shipments of commodities regulated under marketing order legislation must be inspected and obtain certification before reaching domestic marketing channels. If a shipment does not meet the requirements necessary for importation, handlers have three options: (i) recondition the shipment for re-inspection, (ii) re-export the shipment, or (iii) send the shipment to an exempt use. Product imported to the U.S. for processing, animal feed, charity or relief, certified seeds, or government agencies is exempt from section 8e requirements (USDA, 2007).

Of the 31 marketing orders currently operating under the federal statutes, 29 have some combination of grade, size, quality, or maturity provisions authorized or in effect (USDA, 2007).[2] Currently, 16 of the 31 commodities regulated under federal marketing order statutes are subject to section 8e requirements of the AMAA. Among this group, 16 have altered these requirements at least once over the previous 10 years (AMS, 2006).

Heterogeneous growing conditions and differential access to production and quality-enhancing technologies and skilled labor could create substantial disparities in domestic vs. foreign producers' abilities to produce a product with a given level of quality. Additionally, due to the perishable and fragile nature of many agricultural products, the time and physical stress involved in shipment can also act as a disadvantage for importers. Such factors may enable a marketing board to strategically select the product attributes to regulate such that they favor domestic producers, making compliance with a MQS more difficult for importing countries. In these cases federal marketing order boards could set quality regulations that reduce or eliminate import competition, thus acting as restraints on trade and constituting nontariff trade barriers.

The goal of this paper is to analyze the impacts of a MQS imposed by a federal marketing order, or similar producer organization, in a model that incorporates contemporary methodology from the

[2] 25 of the federal marketing orders have minimum grade standards in place, 25 have size regulations in authorized or in effect, and 3 have general "quality" regulations in effect.

general economics literature on MQS, the key characteristics of agricultural production, and the endogenous nature of the decision of whether or not to adopt a MQS. In the theoretical model, I incorporate the Mussa-Rosen (1978) specification for consumer preferences for quality and characterize the supply side of the model with a simple ex ante distribution of low- and high-quality production. Further, I allow the ex ante quality distribution to be altered by producers undertaking actions to enhance product quality at a cost.

The theoretical model unfolds in two stages. Given producers' ability to act collectively via authorizing legislation, the domestic industry chooses whether or not to impose a MQS in stage 1 based upon a profit maximization criterion. In stage 2, individual producers make production decisions independently. Because product attributes regulated by marketing programs are often visual (e.g., size, blemishes, cosmetic defects, etc.) and, thus, observable to consumers, we retain the perfect information assumption utilized in the general economics literature on MQS (e.g., Ronnen, 1991; Crampes and Hollander, 1995; Ecchia and Lambertini, 1997) and the more recent papers on MQS in agricultural industries (e.g., Bockstael, 1984; Chambers and Pick, 1994).

In a free-trade scenario when the quality distribution is immutable, an advantage for the domestic country in producing high quality relative to the foreign country increases the domestic country's' incentive to impose a MQS. Because more of the costs of the MQS in terms of foregone sales of low-quality product are borne by the foreign country, the domestic country is able to capture a larger share of the advantage of removing the self-selection constraint due to its greater share of H product. Additionally, the model predicts that if the domestic country is able to drive the foreign country out of the market by using a raising-rivals'-cost strategy, consumer welfare will necessarily decline relative to both the no-MQS scenario and the MQS scenario where both domestic and foreign countries produce. Because the foreign country exiting causes a reduction in the high-quality product available on the market, the price of the high-quality product increases and fewer consumers are served. Additionally, the deadweight loss (DWL) to society is larger when the foreign country is driven out of the market because, in addition to the destruction of the low-quality product due to the imposition of the MQS, the high-quality product from the foreign country no longer reaches consumers, thereby increasing the DWL associated with the domestic country imposing a MQS when the foreign country is driven out of the import market.

The empirical evidence surrounding the impacts on trade from standards in general is extremely limited (Maskus and Wilson, 2000), and empirical research specifically related to affects of MQS on trade patterns is essentially nonexistent. To test if changes in MQS imposed by federal marketing orders are influencing trade patterns, I describe a double-hurdle version of a gravity equation model estimable using disaggregate commodity-level data. Gravity-equation models have been widely used in the empirical literature on the determinants of bilateral trade flows.

The Model

I consider a vertically differentiated commodity which can either be high-quality (H) or low-quality (L), where consumers always prefer H over L. Total output, *X,* is exogenous (e.g., it is based upon prior planting decisions). The exogenous ex ante share of total output that is low quality is denoted as γ, where $0<\gamma<1$. Thus, the ex ante amounts of H and L product are $(1-\gamma)X$ and γX, respectively. Costs of producing output are sunk and do not enter into the analysis.

Although total output is exogenous, producers are often able to undertake activities to increase the proportion of H product by enhancing or "transforming" ex ante L product to H.[3] We assume that product that would be L in the absence of quality-enhancing activities can be transformed by the

[3] Examples of transformation include the application of pesticides to reduce pest damage, thinning of fruit to increase size, and delaying harvest to increase ripeness.

industry into H product through a convex "transformation cost function", which for simplicity we model in quadratic form,

(1) $$C(T) = 0.5\beta T^2 ,$$

where $T \in [0, \gamma X]$ is the amount of L product transformed to H, and β, $0 < \beta < \infty$, is a parameter that calibrates the marginal cost of quality enhancement.[4] For example, β would depend upon the nature of the product and availability and cost of quality-enhancing inputs, such as herbicides and pesticides, and other complementary inputs, such as labor.

Although suppliers, through quality enhancement, can choose the proportions of H and L products that they produce, I assume they cannot choose the magnitude of the quality of either the H or L product. Consequently, the quality level of the H product, q_H, is normalized to 1.0, the quality of the L product is $q_L = \alpha$, where $\alpha < 1$, and, hence, α is the relative quality level of the L product.[5]

Following Mussa and Rosen (1978), there is a continuum of consumers in the market who are indexed by a taste parameter for quality, θ, and who are uniformly distributed on [0, 1] with density, *D*, normalized to 1.0. Each consumer derives utility from only the first unit of the commodity that she purchases. A consumer with taste parameter θ has utility $U(\theta, q) = \theta q$ and surplus $CS_H(\theta, P) = \theta - P$ from consuming a unit of the H product or $CS_L(\theta, \alpha, p) = \theta\alpha - p$ from consuming a unit of the L product, where *P* represents the price of the H product and *p* represents the price of the L product. Based on these utility functions, we can identify a type of demand function for each product based solely upon consumers' willingness to pay for the H and L products in isolation.

[4] Much of the contemporary literature on MQS uses this cost specification to represent the cost associated with augmenting quality (e.g., Ronnen, 1991; Ecchia and Lambertini, 1997; Maxwell; 1997; Valletti, 2000; Zhou, Spencer, and Vertinsky, 2002).

[5] This assumption is a simplification for modeling purposes, but may hold literally in instances when quality designations are based upon standards set by government or by the producer organization itself, and consumers utilize those standards as proxies for true quality.

These functions express the individual rationality (IR) condition that no consumer will purchase a product that yields her negative net utility:

(2) $$Q_H^{IR} = 1 - P, \quad Q_L^{IR} = \alpha(1-p).$$

These functions lack much significance when both the H and L products are on the market, but they are important in this paper because we are studying the implications of eliminating the L product from the market through a MQS.

When no MQS is imposed, consumers can choose freely between the H and L products and may also elect to consume neither. This aspect of self selection constrains pricing for the H product in a way that may make it advantageous for an industry to impose a MQS. To study consumer choice in the Mussa-Rosen framework, note that the consumer who is indifferent between consuming the H product and the L product is represented by taste parameter $\tilde{\theta}^0 = \dfrac{P-p}{1-\alpha}$, while the consumer who is indifferent between consuming the L product and not consuming the product at all, and accordingly obtaining $CS_L = 0$, is represented by $\bar{\theta} = \dfrac{p}{\alpha}$. Note that in general the condition determining the location of $\tilde{\theta}^0$ is a self-selection condition in the sense that this consumer is indifferent between consuming H and L product and obtains positive surplus from either choice: $CS_H(\tilde{\theta}^0, P) = CS_L(\tilde{\theta}^0, p) > 0$, whereas the location of $\bar{\theta}$ is determined by an IR condition because the consumer with taste parameter $\bar{\theta}$ obtains $CS_L(\bar{\theta}, p) = 0$.

The respective demands for the H and L products that account for the presence of both products on the market and consumers' ability to choose are:

(3) $$Q_H = 1 - \tilde{\theta}^0 = 1 - \frac{P-p}{1-\alpha}$$

(4) $$Q_L = \tilde{\theta}^0 - \bar{\theta} = \frac{P-p}{1-\alpha} - \frac{p}{\alpha}.$$

Inverting the system of equations comprised of (3) and (4) results in the indirect demand functions:

(5) $$P = 1 - Q_H - \alpha Q_L,$$

(6) $$p = (1 - Q_H - Q_L)\alpha.$$

It is assumed throughout that the potential demand for the commodity exceeds the sum of the exogenous output, which implies $X < 1$, given that the total number of consumers in the market is normalized to 1.0. Thus, X has the interpretation of the product's market penetration, i.e., the share of consumers who purchase the product in the no-MQS equilibrium.

Asymmetric Exogenous Quality, Perfectly Competitive Markets, and Trade

I consider a case where a domestic industry (D) faces competition from an importing country (F). For simplicity, both countries are assumed to have equal shares of the total production, X, such that $X_D = X_F = X/2$, but there is no reason to expect that different market shares between domestic and foreign producers should play an important role in decision making regarding a MQS. However, differences in land quality, weather conditions, and access to technology may cause countries to produce different distributions of H and L products, so in this scenario, I allow D and F to have different proportions, γ_D and γ_F of L product. Although I make no assumptions about the magnitude of γ_D relative to γ_F, the case of most direct relevance is $\gamma_F > \gamma_D$ because the D country producers can choose to regulate those product attributes where they have an advantage relative to outside competitors.

Stage 2: Prices in the Presence and Absence of the MQS

I begin with the simplest case where the exogenous distribution of H and L quality is immutable and cannot be altered by production practices in either country. The profits for producers in country *i* when a MQS is not imposed are

$$\pi_i^0 = 0.5[P^0(X - \gamma_i X) + p(\gamma_i X)] \text{ for } i = D, F .$$

From (5) and (6), substituting the exogenous quantities in place of Q_H and Q_L yields the equilibrium prices:

$$P^0 = 1 - 0.5X[2 - (\gamma_D + \gamma_F)(1-\alpha)]$$

$$p = (1 - X)\alpha$$

where the superscript 0 denotes the no-MQS equilibrium. The price of the L product, p, is determined by the market-clearing or individual-rationality constraint that the marginal consumer is just willing to purchase the L product, while the H price, P^0, is determined by the self-selection condition that the marginal consumer of the H product is indifferent between consuming the H product at P^0 and the L product at p.

The implementation of a binding MQS in this model eliminates the L product from the market, making it worthless. In the presence of the MQS, P is no longer determined by the self-selection condition given by (5), but rather, the market clearing condition given by (2). Under a MQS, the profits are

$$\pi_i^1 = 0.5[P^1(X - \gamma_i X)] \text{ for } i = D, F$$

where $P^1 = 1 - 0.5X[2 - \gamma_D - \gamma_F]$ is found by replacing the exogenous volume of high-quality production into (2) and solving for P.

Stage 1: The Implementation Decision

An increase in either country's proportion of L product increases the price of the H product for a given *X*, with or without a MQS, and, thus, causes the other country's profit to increase, ceteris paribus. In this, the exogenous quality-level scenario, the change in country i's profits from imposing the MQS is $\Delta\pi_i = (P^1 - P^0)(1-\gamma)(X/2) - p\gamma(X/2)$ for i=D, F. $\Delta\pi_i$ depends on two offsetting effects: (i) the *price effect*, which is the change in revenue that results from the MQS-induced price increase for the H product, and (ii) the *wastage effect*, which is the revenue lost from being unable to sell the L product under the MQS.

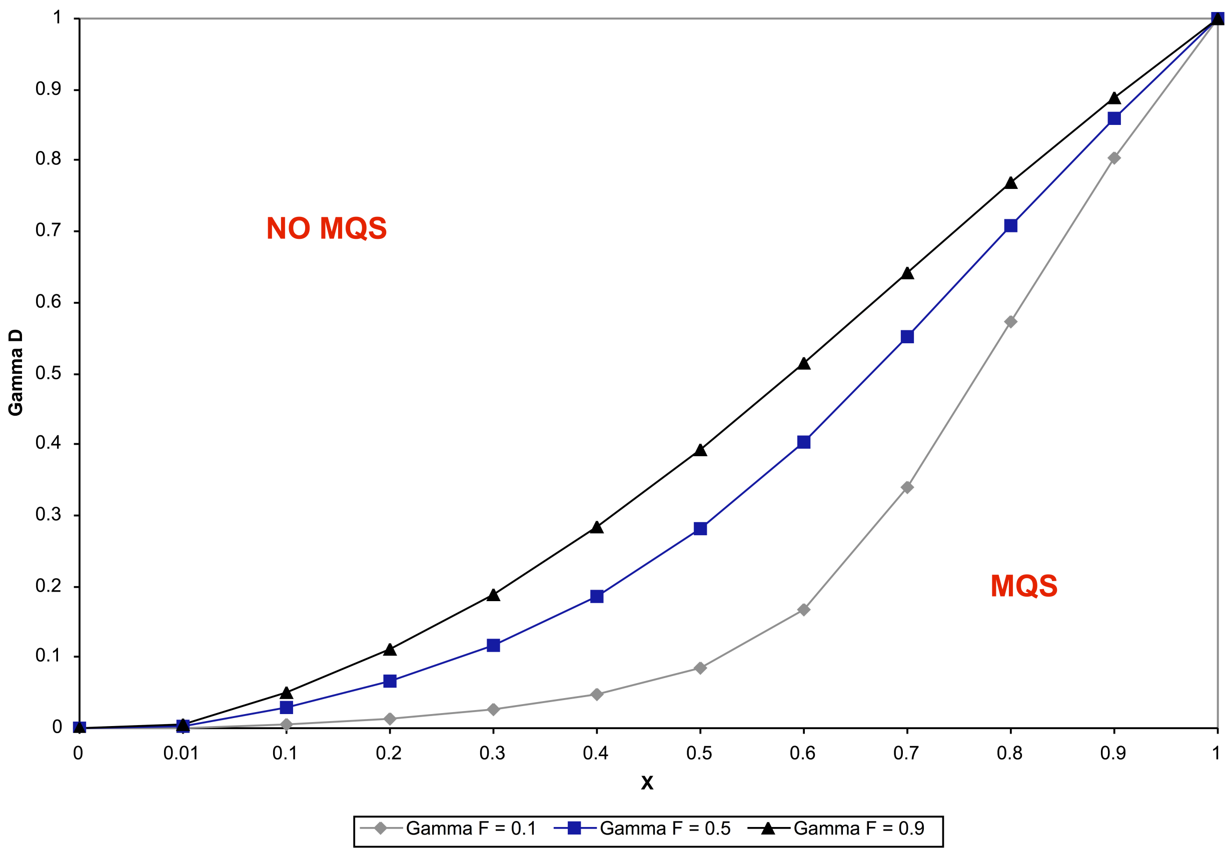
The price effect of the MQS on profits is always positive, while the wastage effect causes producer profits to decline. The sign of the difference in the price effect and the wastage effect determines whether or not it is optimal for domestic producers to impose a MQS in this setting. It should also be noted that the profit levels are not symmetric due to the asymmetry in the proportions of the L product in each country. Consequently, the D country could impose a MQS, based upon a profit maximization criterion that would be harmful to the F country.

Figure 1 depicts isoprofit contours, constructed by equating domestic producer profits with and without a MQS, given alternative proportions of L product produced by F. In the parameter space that lies above an isoprofit contour a MQS reduces domestic profits (i.e., $\Delta\pi_D < 0$), while in the parameter space below an isoprofit line a MQS increases domestic industry profits (i.e., $\Delta\pi_D > 0$). The figure demonstrates the proposition that, in a free-trade scenario, an advantage for the D country in producing high quality relative to the F country enlarges the parameter space when the D country wishes to impose a MQS because more of the costs of the MQS in terms of foregone sales of L product are borne by the F country, while the D country is able to capture a larger share of the advantage of removing the self-selection constraint due to its greater share of H product.

Consumers are necessarily harmed by the imposition of the MQS in the exogenous-quality scenario. The price of the H product unambiguously increases, causing the surplus of the H consumers to decrease. Individuals who consumed the L product in the absence of the MQS do not consume the product in the presence of the MQS and thereby receive zero surplus.

The deadweight loss (DWL) associated with the imposition of the MQS in the exogenous-quality scenario is the sum of the surplus lost by L product consumers and the loss in seller revenue associated with the elimination of the L market.

Figure 1. Isoprofit Contours when Product Quality is Asymmetric.



MQS as a Raising-Rivals'-Cost Strategy

Raising rivals' costs (RRC) refers to the notion that firms may be able to induce rivals to exit or to compete less aggressively by raising their costs and may include actions that raise the costs of inputs or cause detrimental regulations to be imposed (Salop and Scheffman, 1983, 1987). Such strategies may be profitable even if they raise the predatory firm's costs if they raise rivals' costs by more. The D country producers may also be able to use a MQS as a strategic tool to gain advantage by harming international competitors through a type of raising-rivals'-costs phenomenon.

In the present context a MQS has a RRC effect under the section 8e requirement by (a) preventing the sale of L product and (b) inducing sellers to transform more L product to H than they otherwise would do in those environments when quality enhancement is possible.

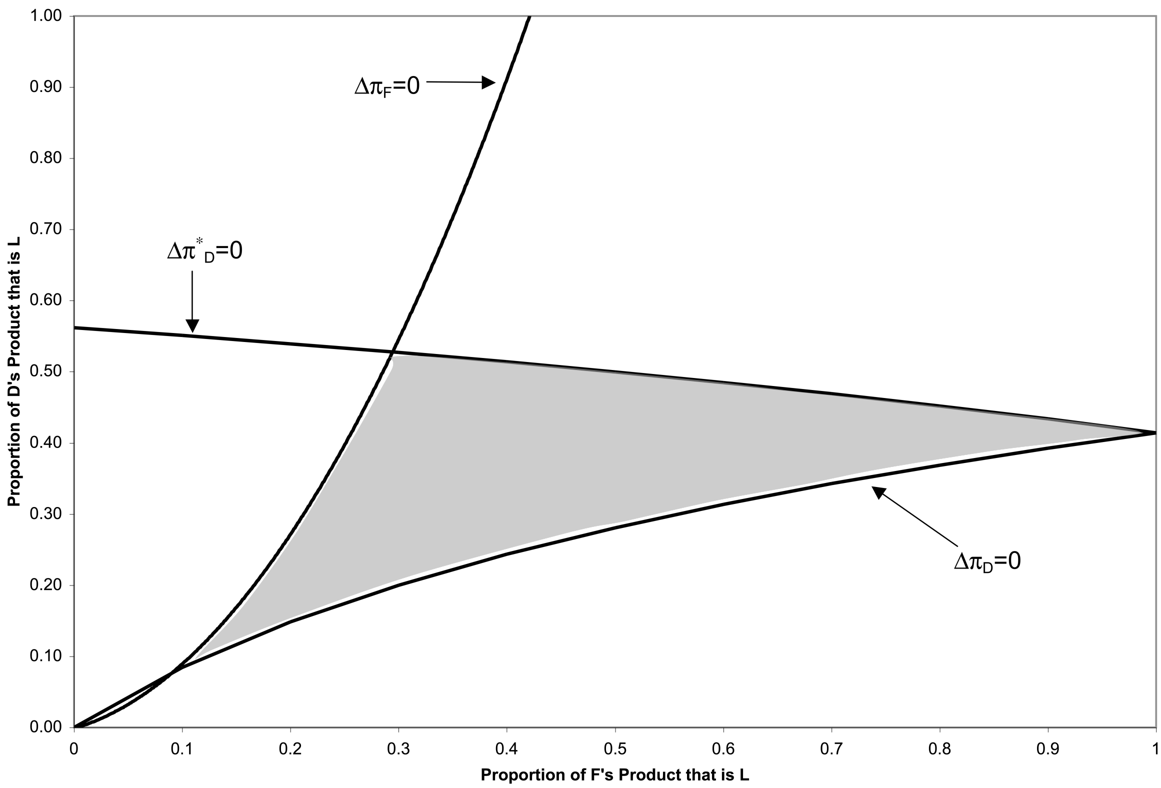
The RRC phenomenon may be especially important in an international trade context because of the well-documented fact that the decision to export involves significant sunk start-up costs (Krugman, 1989; Dixit, 1989; Roberts and Tybout, 1995). Campa (1993) showed empirically that the magnitude of sunk costs significantly deters firms entering into export markets. Thus, a rational response by a domestic agricultural industry to trade liberalization and the evolution of potentially competing industries in other countries may be to impose a MQS that reduces the variable profits from trade of potential international competitors. The MQS is sufficient to deter international competition if the discounted variable profit stream from entering exportation to the D country in the presence of the MQS is less than the sunk start-up costs.

Of course, the mere fact that a MQS may be sufficient to deter entry by a foreign competitor does not mean that it is in the interests of the D country's producers to impose it. The relevant comparison for the D country producers is their profit in a free-trade equilibrium with no MQS relative to their profit in an autarkic equilibrium with a MQS. The RRC phenomenon and the D country's decision calculus are illustrated in figure 2. The figure is drawn for parameter values of *X* = 0.5 (split equally between D and F producers) and $\alpha = 0.5$, but the general principles illustrated by the figure apply for other values of *X* and α. The curve $\Delta\pi_D = 0$ depicts (γ_D, γ_F) combinations that hold the D producers' profit constant in the presence or absence of a MQS. All combinations of (γ_D, γ_F) that lie below the curve represent distributions of L product between D and F that would cause the D producers to impose a MQS. This curve is increasing in γ_F,reflecting the proposition noted earlier that a MQS is more beneficial for the D country, the higher the proportion of F country production that is low quality.

The similar curve that holds the F producers' profit constant is labeled $\Delta\pi_F = 0$. Thus, a MQS reduces the foreign producers' variable profits for all (γ_D, γ_F) combinations that lie to the right of this curve, and, thus, this parameter space represents the region where a MQS has a RRC effect. Finally, the curve labeled $\Delta\pi_D^* = 0$ represents (γ_D, γ_F) combinations where domestic producers' profits are the same in a free-trade equilibrium with no MQS and an autarkic MQS equilibrium, where the latter equilibrium would result from the MQS deterring entry by foreign producers. Thus, all (γ_D, γ_F) combinations that lie below $\Delta\pi_D^* = 0$, above $\Delta\pi_D = 0$, and to the right of the $\Delta\pi_F = 0$ curve (i.e., the shaded area in figure 2) represent market configurations where the D producers could impose a MQS due to its RRC effect but otherwise would not elect to impose it, because the D producers' profits are lower under the MQS in this parameter space in a free-trade equilibrium. Of course, without making additional assumptions about the magnitude of the F producers sunk costs of exportation, we cannot state which market configurations in the shaded area deter foreign competition. The key point is that in the presence of exporter sunk costs, the range of market conditions when the D country wishes to impose a MQS is expanded, with the extent of the expansion being dependent upon the magnitude of the sunk costs.[6]

If D is able to drive F out of the market by using a RRC strategy, consumer welfare will necessarily decline, relative to both the no-MQS scenario and the MQS scenario where both D and F produce. Because F exiting causes a reduction in the H product available on the market, the price of the H product increases and fewer consumers are served. Additionally, the DWL to society is larger when F is driven out of the market because, in addition to the destruction of the L product due to the imposition of the MQS, the H product from F no longer reaches consumers. Thereby increasing the DWL associated with D imposing a MQS when F is driven out of the import market.

Figure 2. Raising Rivals' Costs



[6] Although it plays no role in this analysis, worth noting is that domestic industries may also be able to pursue policies that increase these costs for exporters.

Symmetric Endogenous Quality Enhancement, Perfectly Competitive Markets, and Trade

In this scenario, I consider the imposition of a MQS in a model where quality enhancement is endogenous and D and F interact in a perfectly competitive market setting. To simplify this case, I assume complete symmetry between the D and F producers: (i) each country has half of the total exogenous output ($X^D = X^F = X/2$), (ii) the shares of L product available to each country are the same ($\gamma_D = \gamma_F = \gamma$), and (iii) each is equally efficient at transforming L product to H ($\beta_D = \beta_F = \beta$).

Stage 2: Prices and Production in the Presence and Absence of the MQS

To derive the supply curve for quality enhancement when the two countries engage in trade, differentiate the cost function of each country to obtain its marginal cost, which due to symmetry is $MC(T) = \beta T$ for both D and F. Quality enhancement also involves an indirect or opportunity cost in the no-MQS case because each unit of L product transformed to H cannot be sold in the L market at price *p*. Thus, the full marginal cost of transformation in the no-MQS equilibrium is $\beta T + p$. The competitive market optimum for transformation, T^0, is determined by $P^0(T^0) = \beta T^0 + p$. Solving for T^0 yields $T^0 = (P^0 - p)/\beta$ where $P^0 - p$ is the price premium for selling H product rather then L. However transformation is limited by each countries ex ante availability of L product, $\gamma(X/2)$. To find the level of *P* where the total available quality of L product is transformed, solve $2\gamma(X/2) = (P^0 - p)/\beta$. Thus, the market supply of transformation in the free trade case is

(7)
$$T = \begin{cases} 2(P^0 - p)/\beta & if \quad (P^0 - p) < \gamma\beta(X/2) \\ \gamma X & if \quad (P^0 - p) \geq \gamma\beta(X/2) \end{cases}.$$

Equating (7) with the demand for quality enhancement yields the total amount of L product transformed to H product collectively by D and F in competitive equilibrium (subscript "C") with no MQS (superscript "0"):

$$T_C^0 = \frac{2(1-\alpha)[X-1-\gamma X]}{2\alpha-\beta-2} \leq \gamma X.$$[7]

Because D and F have symmetric costs, each transforms the same amount of product: $T_C^0/2$. T_C^0 is the socially optimal level of transformation because it equates producers' cost of enhancing product quality with consumers' willingness to pay for H product instead of L. From (5) and (6), the prices for the H and L products in the competitive equilibrium with no MQS are

$$\begin{aligned} P_C^0 &= 1 - X[1-\gamma(1-\alpha)] - T_C^0(1-\alpha) \\ &= \frac{[X+\alpha\gamma X-\gamma X-1]\beta + 2\alpha(1-\alpha)(X-1)}{2\alpha-\beta-2}, \end{aligned}$$

$$p_C = (1-X)\alpha,$$

respectively.

Imposition of a MQS alters the market in a fundamental way. As a consequence of preventing the sale of the L product, consumers are no longer able to substitute between L and H products, eliminating the self-selection constraint on the market. Instead the conditional that determines the equilibrium price for the high-quality product is the market-clearing or willingness-to-pay constraint given in (2). The market's supply of quality enhancement is also altered by the MQS because transformation of L product to H no longer involves the opportunity cost of selling the product as L. Thus, the market's inverse supply curve is no longer shifted vertically up by p_C subject to the

[7] While it is possible that the entire amount of ex ante L product is transformed to H, $T_C^0 = \gamma X$, the relevant case to this discussion is when $T_C^0 < \gamma X$. If $T_C^0 = \gamma X$, imposition of the MQS is irrelevant because all product is transformed from L to H without imposition of a standard.

constraint $T \leq \gamma X$. Therefore, from the perspective of the industry, imposing a MQS raises the market's demand for transformation and reduces the marginal cost of transformation.

Adjusting (7) to account for the absence of the opportunity cost of selling the L product and equating this modified version with the demand for quality enhancement under a MQS yields the total amount of L product transformed to H collectively by D and F in the competitive equilibrium in the presence of an MQS. When the constraint on L product available to transform does not bind, the solution is the following:

$$\hat{T}_C^1 = \frac{2[1 - X + \gamma X]}{\beta + 2}.$$

To include the possibility that the ex ante level of L product limits the amount transformed, the level of transformation in the presence of the MQS in the free-trade competitive equilibrium is

$$T_C^1 = \min\{\hat{T}_C^1, \gamma X\}.$$

Each country transforms half of this total, $T_C^1 / 2$, given their symmetry. Substituting T_C^1, into (5) with $Q_L = 0$ yields the equilibrium price for the H product in the presence of the MQS:

$$P_C^1 = \begin{cases} \dfrac{\beta[1 - X + \gamma X]}{\beta + 2} & if \quad T_C^1 < \gamma X \\ 1 - X & if \quad T_C^1 \geq \gamma X \end{cases}.$$

The difference in the amount of product transformed in equilibrium is

$$T_C^1 - T_C^0 = \frac{2\alpha\beta[X - 1 - \gamma X]}{(\beta + 2)(2\alpha - \beta - 2)} > 0.$$

Thus, countries transform more of the L product to H when a MQS is imposed. Since T_C^0 is the socially optimal level of transformation, the increased level of transformation induced by the MQS is excessive for a societal viewpoint and is one source of welfare loss that results from the implementation of a MQS. The second source of societal loss results from producers' inability to sell and consumer's inability to consume the L product that is not transformed to H in equilibrium. While producer profits must increase for the MQS to be imposed, consumer welfare necessarily decreases due to the price increase.

Stage 1: The MQS Implementation Decision with Endogenous Quality Enhancement

The profits for producers in country *i* in the no-MQS and MQS equilibria are

$$\pi_i^0 = 0.5[P_C^0(X - \gamma X + T_C{}^0) + p_C(\gamma X - T_C{}^0) - 0.25\beta(T_C{}^0)^2] \text{ for } i = D, F$$

$$\pi_i^1 = 0.5[P_C^1(X - \gamma X + T^1) - 0.25\beta(T^1)^2] \text{ for } i = D, F .$$

The D industry will choose to implement a MQS if $\Delta\pi_D = \pi_D^1 - \pi_D^0 > 0$. It is helpful to breakdown the overall impact into components. The price effect when quality-enhancement is possible is the change in revenue that results from the MQS-induced change in the price of the H product that would have been produced and sold in the no-MQS equilibrium, $0.5(P_C^1 - P_C^0)[(1-\gamma)X + T_C^0]$. The wastage effect is the revenue lost from L product that is not transformed under the MQS, $-0.5\,p(\gamma X - T_C^1)$. A third component, called the quality-enhancement effect, is the change in revenue generated from the sale of the incremental H product created by the additional transformation under the MQS, $0.5(P_C^1 - P_C^0)(T_C^1 - T_C^0) - 0.25\beta[(T_C^1)^2 - (T_C^0)^2]$. The profitability of the implementation of the MQS for D depends on the sign of the sum of the three effects.

Assuming no raising-rivals'-cost effect such that the F country continues to export to D, a necessary condition for the D producers to impose a MQS is that P rise, because the wastage effect is always negative. However, raising-rivals'-costs considerations may arise in this trade case as well, even though the D and F industries are modeled as symmetric, so long as the F producers incur fixed costs of exporting that the D producers do not incur. Similar to the trade model with no quality enhancement, market configurations that reduce the domestic (and foreign) producers' profits in the MQS equilibrium with trade may increase the D producers' profits if the loss of variable profits causes the foreign producers to exit the market.

Empirical Methodology

In this section I describe a double-hurdle version of a gravity equation model to test if changes in MQS imposed by federal marketing orders are influencing trade patterns. Gravity-equation models have been widely used in the empirical literature on the determinants of bilateral trade flows. Gravity-equation specifications suggest that the value of trade between two countries is positively related to the per capita GDP of the two countries and inversely related to the geographic distance between the two locations. Although initially the empirical specification was ad hoc, Leamer and Stern (1970) showed that there was an acceptable theoretical foundation for the common empirical specification.

The empirical evidence surrounding the impacts on trade from standards in general is extremely limited (Maskus and Wilson, 2000), and empirical research specifically related to affects of MQS on trade patterns is essentially nonexistent. Increasingly stringent international food safety standards have prompted a few studies (e.g., Otsuki et al., 2001; Anders and Caswell, 2006) investigating the trade impact of these standards using gravity equations. As the costs associated with compliance with these standards is not necessarily trivial and imports not meeting the standards are rejected and returned to the importing country, applications in this area are not far removed from the MQS situation. Due to data limitations, the few studies in this area have used indicator variables to account for changes in stringency of standards. Otsuki et al. (2001) used the level of the standard (i.e., maximum level of aflatoxins) as an independent variable, initiating the use of a continuous variable in a gravity equation setting to determine how alterations of the standard influence trade flows.

In order to ascertain the aggregate effect of the implementation of, or a change in, a MQS for a particular commodity, I propose to estimate a gravity model for total trade flows as follows:

$$\ln(EX_{ijt}) = \gamma_j + \lambda_t + (\gamma\lambda)_{jt} + \beta_1 \ln(GDP_{it}) + \beta_2 \ln(GDP_{jt}) + \beta_3 \ln(DIST_{ij}) + \\ \sum_{h=1}^{n} \beta_{4h}(STND_{it}) + \beta_5 \ln(ER_{ijt}) + \beta_6 \ln(FCR_{ijt}) + \sum_{l=1}^{L} \beta_{6l}(TP_{ij}) + \sum_{m=1}^{M} \beta_{7m}(SS_{it}) + \varepsilon_{ijt}$$

where EX_{ijt} is the value of a particular commodity exported to country i (the U.S.) from country j at time t, γ_j are exporting country fixed-effects, λ_t are time fixed-effects, $(\gamma\lambda)_{jt}$ is the time-importer interaction effect, GDP_{it} and GDP_{jt} is the Real Per Capita Gross Domestic Product of the U.S. at time t and exporting country j at time t, respectively, $DIST_{ij}$ is the geographical distance between the U.S. and country j, $STND_{it}$ represents n indicator variables to account for changes in MQS, ER_{ijt} is the exchange rate between the U.S. and country j at time t, FCR_{ijt} accounts for total currency reserves, TP_{ij} represents L indicator variables to account for longstanding trade relationships, SS_{it} is a set of indicator variables to account for non-strategic seasonal variations in MQS, and ε_{ijt} is an independent and identically distributed log normal error term with mean zero. This model specification can be estimated for each of the commodities for which production occurs under the auspices of a federal marketing order and where MQS have changed within the previous 10 year period.

Incorporating exporting country fixed-effects into the gravity equation specification will absorb all time-invariant, country-specific characteristics (Matyas, 1997). The inclusion of year fixed-effects into the empirical specification will capture cyclical influences (i.e., business cycles) common across all countries in the sample (Kandogan, 2004). Because variations in trading volumes could emanate from unobservable differences across countries or time, the inclusion of fixed-effects for each of these components will absorb the variation in import volume not attributable to the covariates included in the empirical specification. Historical trade relationships can create trade dependencies among countries and thereby act as nontariff barriers that could affect importers' responses to changes in regulations. Finally, exporter-time fixed effects will capture any time-varying, country-specific characteristics such as factor endowments or cultural or political factors that contribute to determining trade flows (Baltagi et al., 2003). Because it is impossible to include all of the covariates that influence the value of imports of a particular commodity from one country to another, not including the main and first-order interaction fixed-effects could create bias emanating from the omission of variables.

The value of the importing country's GDP acts as a proxy for its buying power while the exporting country's GDP acts as a proxy for its production capacity (Kandogan, 2004). Consequently, as either importing or exporting country GDP increases, the value of imports is also anticipated to increase. Ceteris paribus, it is expected that increases in the exchange rate will cause the value of imports to decline because the relative price of imported goods in terms of domestic goods is increasing.

Matyas (1997) was the first to incorporate total foreign currency reserves into the gravity equation specification to act as a measure of exchange rate stability. It is expected that as the level of total currency reserves increases, exchange rates are likely to be increasingly stable, and the value of imports is predicted to increase. Because distance between importing and exporting countries acts as a proxy for shipping costs, the coefficient on the distance variable is expected to be negative, as shipping costs are increasing in the distance that products must travel. Due to the perishability and bulkiness of most agricultural commodities, I would expect transportation costs, and thereby distance, to be a significant consideration for importers.

Many fruit and vegetable federal marketing orders enforce varying degrees of quality requirements throughout the year. These regulations are imposed due to the seasonality associated with production and are not frequently adjusted. Consequently, these indicator variables are included separately from the MQS regulation indicator variables (SS_{it}) to account for seasonal variations in imports which are strategic on the part of importers to take advantage of seasonal variations in the stringency of requirements.[8]

In some cases it may be necessary to be concerned with the potential simultaneity bias associated with the inclusion of the MQS regulation indicator variable(s) because federal marketing order boards have incentive to implement or increase stringency of MQS when imports are high. Given the significant lags associated with adjusting production practices and the time lapse between the submission of regulatory standards and their approval, I believe it unlikely that standards and trade performance will be determined simultaneously and therefore the estimates obtained from the empirical specification will not be biased from this source.

The use of the level of the standard as opposed to utilizing indicator variables to account for changes in the stringency of standards was pioneered by Otsuki et al. (2001). Due to the panel nature of the data and the presence of statistical variation in the MQS set by federal marketing boards, it will be possible for me utilize this variable specification. In situations where the change in the MQS was small, the original specification could be implemented.

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[8] The ecological cycle and perishable nature of agriculture commodities usually dictate that products are picked, packed, and shipped based on planting decisions made well in advance of harvest. Therefore, for fruits and vegetables there is little room for the strategic inventory decisions within a planting period.

Theory suggests that the imposition of excessively stringent MQS will cause importers to reduce shipments for inspection to reduce their costs. Consequently, if the coefficient(s) on the MQS variable(s) are negative and significant, then increasingly stringent MQS have a negative impact on the value of imports. This is an indication that foreign producers' products are not able to meet the MQS or that they are shipping less product in response to the regulation change, thereby implying that the MQS are generating a barrier to trade. It should be noted that the coefficient estimate(s) on the MQS variable(s) are not constrained and therefore could indicate that standards are either trade enhancing or trade detracting (Beghin and Bureau, 2001).

Issues in Estimation

Most gravity-equation models use ordinary least squares to estimate a simple log-linear model and omit the observations for which the dependent variable is zero. As most studies employing gravity equation specifications seek to explain aggregate bilateral trading patterns, only a small fraction of the total number of observations must be omitted from estimation due to zero values.[9] When considering disaggregated data in terms of either region (e.g., Zahniser et al., 2002) or commodity (e.g., Hillberry, 2002) the number of observations where no trade flows are observed increase substantially. The seasonality associated with agricultural production in particular generates many observations where the value of imports is zero. When there are a large number of observations for which no trade flows are observed, the error term describing the data-generating process cannot be assumed to be symmetric (Hillberry, 2002). Consequently, estimating only positive trade flow

[9] Hillberry (2002) shows that, when the data contain a small proportion (1.9%) of observations where no trade flows are observed, omitting those observations and estimating the simple log-linear model with ordinary least squares is statistically equivalent to using a double-hurdle model to correct for the observations where no trade flows are observed.

observations when a significant proportion of the observations are omitted will cause estimates to suffer from sample selection bias.

Two classes of econometric models have been used to estimate gravity equation models to account for the zero observations and their effect on empirical estimates. Since the dependent variable, the value of imports, is continuously distributed when trade flows are positive but is zero with some positive probability, Zahniser et al.(2002) utilized a tobit model to guard against sample selection bias and to ensure that trade flow predictions are positive. Hillberry (2002) argues that there is no basis to assume that there is a relationship between the positive observations and those observations for which no trade flows occur, which is an underlying implication of sample-selection models. Consequently, Hillberry estimated commodity-specific gravity equations using a double-hurdle model originally proposed by Cragg (1971). Cragg suggested that there are instances where the decision to act and the degree of response to the decision are not closely related. For example, it is easy to imagine that the decision to export is not directly related to the amount of product which is exported.

To account for this phenomenon empirically, Cragg suggests utilizing two independent equations to determine (a) the probability associated with observing positive import value and (b) the value of imports conditional on some positive import value being observed. In the original rendition of the model, the first equation is a standard probit model to determine the probability associated with observing a positive import value given the independent variables. The second equation is a truncated regression model which places a lower bound on the error distribution. This specification is referred to as a double-hurdle model because, in order to observe a positive value for the dependent variable, it must be that (i) the decision was affirmative (i.e., a country chooses to enter the export market) and (ii) a positive amount is chosen given the previous decision (i.e., a country must choose to export a positive amount of the commodity given that the decision was made to enter the export market).

Estimating the two equations separately generates parameter estimates that do not depend on some assumed relationship between the decision to import and the amount which a country chooses to import. Due to the aggregate nature of the data, it is not possible to discern individual firm decisions regarding the decision to export. Consequently, there is no reason to assume that the aggregate decision to export (i.e., all of the firms in one country deciding individually not to export) is related to the amount exported if firms individually choose to export. In order to observe a positive value of imports from a particular nation, the relevant trade conditions (e.g., tariffs, quotas, distance, etc.) must be favorable. Given that the trade conditions induce individual firms to decide to enter the export market, each will decide on the amount to export, which will depend on individual-firm characteristics (e.g., capacity, technology, labor, etc.). Therefore, the decision to enter the export market will not necessarily be directly related to the sum of the individual firm decisions regarding the amount exported. Thus, a double-hurdle model is more favorable then a tobit model in this context.

The error terms of the two regressions that comprise the double-hurdle model are often assumed to be normally and independently distributed. However, in order to overcome the inconsistency of estimates caused by heteroskedasticity or nonnormality of error terms, adjustments to the original specification must be made. To adjust for heteroskedastic errors within this model specification, it is common to choose the functional form and variables to include in the function to allow the variance of the errors to differ across observations (Newman et al., 2003). To allow for nonnormality of error terms in this maximum likelihood estimation framework, an inverse hyperbolic sine (IHS) transformation of the dependent variable is often used (Yen and Jensen, 1996). Originally posited by

Burbidge, Magee, and Robb (1988) the IHS can be utilized on random variables that can take on any values.[10]

Data

The bilateral trade volume data utilized in this study are from the Foreign Agriculture Service (FAS) database developed and maintained by the United States Department of Agriculture (USDA). This data are available on a monthly basis from January 1989 to September 2007 at the Harmonized Trade System (HTS) 10-digit code level. The Gross Domestic Product (GDP) data, both real and nominal, are provided by the USDA Economic Research Service (ERS) and are available on an annual basis. The International Financial Statistics Branch of the International Monetary Fund and the Financial Statistics Branch of the Federal Reserve Board provide the real country monthly average exchange rate data, in local currency per real U.S. dollar with 2000 as the base. The data on individual country longitude and latitude coordinates and their distances from the U.S. was provided by the Centre d'Estudes Prospectives et d'Informations Internationals (CEPII). CEPII uses the "main city" of each country, usually the capital city unless the capital did not have a sufficient population to warrant the designation of the economic center, to calculate distances measures using the greater circle distance formula. This data set also provides information regarding common languages, colonization, and common borders.

Conclusion

Although volume-control provisions and promotion programs implemented by marketing orders have been studied extensively, little attention has been given to minimum quality standards (MQS).

[10] An alternative approach would be to use semiparametric estimation techniques so that distributional assumptions and transformations would be unnecessary.

Yet, the high incidence of utilization of the section 8e provisions, coupled with high degree of variability of standards exhibited over the previous 10 years, and the seeming opportunities to use these provisions to gain strategic advantages serve to motivate further research on how these MQS are influencing trade patterns. This question is of direct policy relevance as trade negotiations focus increasingly on nontariff barriers.

A significant amount of work on the economic implications of MQS has been conducted during the past two decades. However, virtually all of this research is theoretical in nature, and in some cases, has little relevance to the types of regulations that domestic agricultural industries can impose under the auspices of federal marketing orders. This paper has studied the impacts of a MQS imposed by an agricultural industry under the auspices of marketing order legislation in a free-trade environment. The theoretical model incorporates contemporary methodology from the general economics literature on MQS, the key characteristics of agricultural production, and the endogenous nature of the decision of whether or not to adopt a MQS. The theoretical model suggests that MQS that domestic producers choose to impose will be detrimental to societal welfare and their foreign competitors.

An empirical specification was also proposed to test whether not augmentations to MQS imposed by U.S. producers via federal marketing orders affect bilateral trade flows. A double-hurdle version of a gravity equation model was developed to test if changes in MQS imposed by federal marketing orders are influencing trade patterns based upon disaggregate, commodity-level data.

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