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ECONOMIC WELFARE EFFECTS OF THE FDA REGULATION OF TOBACCO PRODUCTS ON TOBACCO GROWERS

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Abstract: The Family Smoking Prevention and Tobacco Control Act of 2009 (FSPTCA) became federal law on June 22, 2009, authorizing the U.S. Food and Drug Administration (FDA) to regulate the manufacturing and marketing of tobacco products in the country. This study examines the potential economic welfare implications for tobacco farms using the Equilibrium Displacement Model. Results suggest that the FDA regulation of tobacco products could induce a significant fall in domestic cigarette sales, leading to a significant loss in tobacco revenue and economic benefits. Therefore, despite the fact that tobacco growers are excluded from FDA authority in the FSPTCA of 2009, they are indirectly and adversely affected.

JEL Classifications: D22, D43, Q12, Q18

Keywords: cigarettes, tobacco farms, FDA, regulation

INTRODUCTION

The Family Smoking Prevention and Tobacco Control Act of 2009 (FSPTCA) became federal law on June 22, 2009, authorizing the U.S. Food and Drug Administration (FDA) to regulate the manufacturing and marketing of tobacco products in the country.

The tobacco control act has two principal components—manufacturing and marketing. The manufacturing component of the act allows FDA to issue rules and regulations aimed at reducing or eliminating harmful or potentially harmful ingredients or otherwise modifying the design and characteristics of tobacco products if it is determined that such regulation is appropriate to protect the public health.

The marketing component of the act allows FDA to issue rules and regulations pertaining to labeling, advertising, promotion, distribution and sale of tobacco products. It is aimed at limiting accessibility to tobacco products, particularly among teenagers, through advertisement bans in some facilities and during sport and other similar events, informing the public about the health risks associated with smoking. The act also allows the FDA to require manufacturers to

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disclose the contents of tobacco products and use explicit and conspicuous labels of prominent warnings on packages as well as instituting additional tobacco product standards.

As the issuance of all the rules and regulations on the manufacturing and marketing of tobacco products is finalized, they are expected to be comprehensive and to reduce the use of tobacco products, particularly among young smokers. The Congressional Budget Office (CBO) estimates that over the next ten years adult and underage smoking prevalence will decline by 2 per cent and 13 per cent, respectively.

The FSPTCA excludes tobacco leaf from being regulated by FDA. Yet, it can be argued that tobacco growers will be affected indirectly through the decrease in domestic sales of tobacco products. The level of impact on tobacco growers, however, depends on how manufacturers intend to address the costs of compliance with the regulation. As oligopolists, cigarette manufacturers have the options to absorb all or part of the associated costs and pass the remaining part onto smokers as higher prices. Since the price elasticity of the demand for cigarettes depends on the reaction of rivals to changes in price and output, the decision on how much of the cost to pass onto consumers has important implications. Each firm would have to figure out what per cent of the cost it is willing to absorb and what per cent of the cost it would have to pass onto consumers in the form of higher prices, thereby mitigating the reduction in domestic sales of its respective brands. While the decision to pass or absorb part of the costs may not necessarily have adverse economic implications for the manufacturers in terms of revenue, the reduction of domestic cigarette sales as a result of higher cigarette prices could reduce manufacturers' purchases of tobacco leaf, and hence tobacco revenue. The fact that the industry is operating in an oligopolistic market structure makes the effect of the reduction in cigarette sales on tobacco farms more pronounced.

This paper aims to analyze the potential welfare effects of the FDA regulation of the manufacturing and marketing of tobacco products on tobacco growers at a given level of oligopoly/oligopsony market power. The remainder of the paper is organized as follows. The next section presents the cigarette industry's pricing and non-pricing marketing strategies. Section 3 parameterizes the Equilibrium Displacement Model and derives the empirical model, accounting for the oligopolistic/oligopsonic structure of the industry. Section 4 presents two plausible scenarios in which the FDA regulation could affect domestic cigarette sales and hence manufactures' purchases of tobacco. Section 5 presents estimates of the effects of the FDA regulation of tobacco products on manufacturers and tobacco farms in the imperfectly competitive market (oligopoly/oligopsony) vis-à-vis perfectly competitive market. The final section presents the conclusion.

2. TOBACCO INDUSTRY

In the tobacco industry, there are five major cigarette companies (Altria Group, Reynolds American Inc., Lorillard, Commonwealth Brands, and Liggett) controlling more than 90 per cent of all sales in the US (Maxwell, 2007). Altria Group is the largest manufacturer, accounting for almost one-half of the cigarette market. R.J. Reynolds and Lorillard Tobacco Co. are the industry's second and third largest manufacturers with market shares of 27.8 per cent and 9.7 per cent, respectively while Commonwealth Brands and Liggett are the industry's fourth and fifth largest manufacturers with market shares of 3.7 per cent and 2.4 per cent, respectively.

In order to determine whether and if so how the FDA regulation could reduce tobacco consumption and by extension the demand for tobacco, it is important to understand the pricing and non-pricing marketing strategies of the tobacco industry.

2.1. Pricing Strategy

As the price elasticity of demand facing a given firm in the tobacco industry depends on the reaction of rivals to changes in price and output, pricing is often implemented based on a coordinated decision behavior, particularly when the whole industry faces increased costs of regulation or taxes or other regulatory burden. Note that coordination as used here does not require explicit agreements because such agreements could constitute a violation of antitrust laws. It is achieved through strategic individual firms' decisions based on observed and anticipated decisions by rivals. An increase in price by one firm while other firms are keeping their prices constant results in a substitution effect away from the firm which has increased price, thereby making demand relatively more elastic. The increase in price would lead to a fall in total revenue that accrues to the firm which has increased price. On the other hand, a decrease in price by one firm will prompt other firms to match the decrease to avoid a loss of market share so that the demand for the cigarettes of all the firms become relatively more inelastic, leading to a fall in total revenue accruing to all firms. This suggests that a move by an individual tobacco firm to reduce cigarette price independently will neither increase market penetration nor increase total revenue.

Therefore, the plausible way manufacturers may encourage further consumption to the detriment of the FDA regulation is if they can coordinate their output decisions to reduce prices. But, given the regulatory burden of the legislation, they have no economic reason to do so. They would rather coordinate their output decisions to increase prices in order to offset the resulting loss in revenue. They can do so because the demand for cigarettes is inelastic.

In light of the FDA regulation, two things appear to be at play, working against each other as far as the pricing strategy is concerned. The first one is regulations associated with advertising and the second one is the cost of compliance with regulations, and assessment of user fees on manufacturers to finance the operation of the newly created Center for Tobacco Products. Advertising restrictions can have an unintended effect of increasing sales because the reduction in advertising expenditure may allow manufacturers to lower prices. In fact, the consequence of advertising restrictions depends on the nature of the advertising.

In 2005, the five major cigarette manufacturers spent over 13 billion in advertisement and promotion of which nearly three-fourth was spent on price discounts paid to cigarette retailers or wholesalers to reduce the cost of cigarettes to the consumer and the remaining was spent on coupons for discounted cigarettes, and retail value-added promotions such as "buy one, get one free" (Federal Trade Commission, 2007).

As to the user fees and costs of compliance with new regulations, it is more likely that all the manufacturers are going to pass part of their shares of the user fees onto consumers by increasing the price of their respective brands. However, if one company chooses not to pass its shares of the fees at all for a strategic reason such as gaining market share, it may end up hurting everybody including itself by inducing them to follow suit. Therefore, the user fees are likely to

be effective in decreasing sales and by extension tobacco production. Finally, since the price elasticity of demand for cigarettes by youth is higher than adults, the increases in price of cigarettes through imposition of user fees and increased costs of compliance with regulations may help to further reduce consumption by reducing smoking prevalence among the youth. Every 10 per cent increase in the price of cigarettes reduces youth consumption by 7 per cent (Federal Trade Commission 2007).

2.2. Non-pricing Strategies

Non-price strategies are marketing methods that do not involve a change in price. They involve advertising, labeling and other marketing strategies to attract new consumers and/or to maintain brand loyalty among current consumers. The effectiveness of the FDA regulation in reducing consumption depends on how the new rules would make it more difficult for the cigarette firms to utilize non-pricing strategies to market their products. For instance, one of the rules that FDA may issue and enforce could be restricting the introduction of new products that are appealing to potential smokers. Another rule may involve changes in labels and labeling. Explicit and conspicuous display of prominent and graphic warnings on 50 per cent of the front and back side of the cigarette package may persuade consumers to be less willing to purchase cigarettes and quit smoking over the long run. Schneider et al. (1981) has found that labels providing information that depict negative health consequences of smoking has been an important factor in the decrease of cigarette consumption. Other measures such as restrictions on advertising and sales promotions could also have significant effects on tobacco use (Saffer and Chaloupka 2000; Farrelly et al. 2003). Although manufacturers maintain that advertising merely enhances the market share of a particular brand without recruiting new smokers, some sources including the U.S. Department of Health and Human Services, Institute of Medicine and the World Health Organization have found that tobacco advertising significantly increased tobacco sales (Roemer 1993; Lynch and Bonnie 1994; Jha and Chaloupka 1999). Given the comprehensiveness of the provisions included in the current bill, it is likely that some reductions in consumption and by extension tobacco production are to be expected by dampening the effectiveness of the marketing strategies of the industry such as development of new tobacco products that are appealing to new smokers and denying access to facilities and locations where the new products could receive more attention and promotion.

3. MODEL

The empirical model consists of a system of equilibrium displacement equations of tobacco demand and cigarette supply, which are derived from the first order conditions of profit maximization by a representative cigarette manufacturing firm operating in an oligopoly-oligopsony market structure.

3.1. Derived Demand for Tobacco

Considering the oligopoly-oligopsony market structure in which the cigarette industry operates in the cigarette and tobacco markets, respectively, the profit function of a representative cigarette manufacturing firm can be given as:

$$\pi_i = f(Q)Q_i - g(X) X_i - C_i(Q) Q_i, \quad (1)$$

where $f(Q)$ is the industry's cigarette inverse demand function; Q_i is quantity of cigarette output of the representative firm; $g(X)$ is the industry's tobacco inverse supply function; X_i is quantity of tobacco purchases of the representative firm; C_i is other costs per unit of output, including the cost of compliance with the FDA regulation.

Following Applebaum (1982), the necessary first order conditions of profit maximization problem (Eq. 1) can be expressed in elasticity form at the industry level such that the oligopolistic pricing behavior can be expressed as in Eq. (2) where the equilibrium wholesale price of cigarette can be related to the industry's marginal cost of cigarette production, involving tobacco prices, and other costs including the costs of compliance with the FDA regulation.

$$W(1-\theta/\eta) = M + aP (1 + \mu/\varepsilon) = MC, \quad (2)$$

where θ and μ are the industry's output and input conjectural elasticity; η is the absolute value of the price elasticity of the demand for cigarettes; ε is the price elasticity of the supply of tobacco; M is per-unit cost of other inputs, including the cost of the compliance with the FDA regulation and a is the amount of tobacco needed to produce one pack of cigarettes.

Totally differentiating Eq. (2), the percentage change in the wholesale price of cigarette can be given by

$$d\text{Ln}W = \frac{\Gamma}{(1+\delta)} \phi d\text{Ln}R + \frac{\varepsilon}{(1+\delta)\Pi} \gamma_{oc} d\text{Ln}M + \frac{\Omega}{(1+\delta)\Pi} \gamma_{dt} d\text{Ln}P, \quad (2')$$

where ϕ represents the percentage change in initial equilibrium cigarette sales due to an exogenous demand shift induced, for example, by a shift in smokers' attitude towards smoking; $\delta = -\kappa\theta/(\eta - \theta)$ represents the change in mark-up following changes in the wholesale cigarette price; $\kappa = \partial\text{Ln}\eta / \partial\text{Ln}W$ represents the change in the elasticity of demand for a given change in the wholesale price of cigarette; $\Gamma = (-\theta/\eta - \theta)v$ represents the change in the mark-up following changes in cigarette sales induced by the FDA regulation; $v = \partial\text{Ln}\eta / \partial\text{Ln}Q/W$; $\tau = \partial\text{Ln}\varepsilon / \partial\text{Ln}P$ represents the change in the price elasticity of the supply of tobacco leaf for a given change in tobacco price; γ_{dt} is the cost share of tobacco in the wholesale price of cigarette; γ_{oc} is the cost share of other inputs in the wholesale price of cigarette, including the cost of compliance with FDA regulation; $\Pi = \varepsilon + \gamma_{dt}\mu$ and $\Omega = \varepsilon + \mu(1-\tau)$.

Assuming that the FDA regulation will not result in cigarette stocks, the market-clearing identity for cigarettes can be given by

$$d\text{Ln}Q + \beta d\text{Ln}Q_d + (1 - \beta)d\text{Ln}Q_e, \quad (3)$$

where $d\text{Ln}Q$ is the percentage change in total domestic cigarette production; β is the proportion of domestic cigarette sales; $d\text{Ln}Q_d$ is the percentage change in the quantity of domestic cigarette sales; $(1-\beta)$ is the proportion of exported cigarettes and $d\text{Ln}Q_e$ is the percentage change in the quantity of exported cigarettes.

Assuming that the FDA regulation will not result in tobacco stocks, the market-clearing identity for tobacco can be given by:

$$d\text{Ln}X = \alpha d\text{Ln}X_d + (1 - \alpha) d\text{Ln}X_e, \quad (4)$$

where $d\text{Ln}X$ is the percentage change in total domestic tobacco production; α is the proportion of domestic tobacco production purchased by domestic cigarette manufacturers; $d\text{Ln}X_d$ is the percentage change in domestic tobacco purchased by domestic cigarette manufacturers; $(1-\alpha)$ is the proportion of exported tobacco and $d\text{Ln}X_e$ is the percentage change in the quantity of exported tobacco.

Also, assuming that the scale elasticity of domestic tobacco with respect to cigarette production is unity¹, the percentage change in the quantity of domestic tobacco purchased by domestic manufacturers can be given by

$$d\text{Ln}X_d = \omega d\text{Ln}P + d\text{Ln}Q, \quad (5)$$

where ω is the own price elasticity of the domestic demand for tobacco.

Given the above assumptions, the derived demand for tobacco under oligopoly / oligopsony can be derived through repeated substitution as

$$d\text{Ln}X = \lambda d\text{Ln}P + \left(\alpha\beta - \frac{\alpha\beta\eta\Gamma}{1+\delta} \right) \phi d\text{Ln}R + \frac{\alpha\beta\eta\gamma_{cc}\varepsilon}{(1+\delta)\Pi} d\text{Ln}M, \quad (6)$$

where $\lambda = \left[\alpha\omega + (1-\alpha)\omega_e + \frac{\alpha\beta\eta\gamma_{dt}\Omega}{(1+\delta)\Pi} \right]$ is the price elasticity of the derived demand for U.S. tobacco and ω_e is the own price elasticity of the export demand for tobacco.

Now, equating Eq. (6) with the supply of tobacco equation given as $\varepsilon d\text{Ln}P = d\text{Ln}X$ where ε is the price elasticity of the supply of tobacco, reflecting the supply response of tobacco to market prices, the proportional change in tobacco price due to the FDA regulation under oligopoly–oligopsony market can be given by

$$d\text{Ln}P = \frac{\alpha\beta[(1+\delta) - \eta\Gamma]}{(1+\delta)(\varepsilon + \lambda)} \phi d\text{Ln}R + \frac{\alpha\beta\eta\gamma_{cc}\varepsilon}{(1+\delta)\Pi(\varepsilon + \lambda)} d\text{Ln}M. \quad (7)$$

In a perfectly competitive market in both the cigarette and tobacco markets, Eq. (7) would reduce to

$$d\text{Ln}P = \frac{\alpha\beta}{(\varepsilon + \lambda)} \phi d\text{Ln}R + \frac{\alpha\beta\eta\gamma_{cc}}{(\varepsilon + \lambda)} d\text{Ln}M, \quad (7.1)$$

where $\lambda = [\alpha\omega + \alpha\beta\eta\gamma_{dt} + (1-\alpha)\omega_e]$.

3.2. Derived Supply of Cigarettes

From Eq. (4) and (5), the relation between tobacco price and cigarette output can be given by

$$d\text{Ln}P = \frac{\alpha}{[\varepsilon + \alpha\omega + (1-\alpha)\omega_e]} d\text{Ln}Q. \quad (8)$$

Now, substituting Eq. (8) for $dLnP$ into Eq. (2'), the derived supply of cigarettes under oligopoly–oligopsony market can be given as:

$$dLnW = \frac{\Gamma}{(1+\delta)} \phi dLnR + \frac{\gamma_{oc}\epsilon}{(1+\delta)\Pi} dLnM + \frac{\gamma_{dt}\Omega}{(1+\delta)\Pi} \left\{ \frac{\alpha}{[\epsilon + \alpha\omega + (1-\alpha)\omega_e]} \right\} dLnQ, \quad (9)$$

where $\gamma_{dt}\alpha\Omega/(1+\delta)\Pi[\epsilon + \alpha\omega + (1-\alpha)\omega_e]$ is the inverse price elasticity of the derived supply of cigarettes.

Incorporating the demand equation of cigarettes into the derived supply equation, the proportional change in domestic wholesale price of cigarette under oligopoly–oligopsony market due to, for example, an increased awareness of the health risks associated with smoking and increased cost of compliance with the FDA regulation can be given by

$$dLnW = \frac{\alpha\beta\gamma_{dt}\Omega + \Gamma\Theta\Pi}{(1+\delta)\Pi(\epsilon + \lambda)} \phi dLnR + \frac{\gamma_{oc}\epsilon\Theta}{(1+\delta)\Pi(\epsilon + \lambda)} dLnM, \quad (10)$$

where $\Theta = \epsilon + \alpha\omega + (1-\alpha)\omega_e$.

Using Eq. (7) and Eq. (10), the elasticity of price transmission from the manufacturing sector to the tobacco production due to the demand shift induced by increased awareness of the health risks in the presence of oligopoly/oligopsony market power can be given as:

$$\rho^R = \frac{dLnP/dLnR}{dLnW/dLnR} = \frac{\alpha\beta[(1+\delta) - \eta\Gamma]\Pi}{\Gamma\Pi\Theta + \alpha\beta\gamma_{dt}\Omega}. \quad (11)$$

Eq. (11) provides for the elasticity of tobacco leaf price with respect to the change in the wholesale price of cigarette due to the demand-side effect of the FDA regulation (e.g., increased awareness of the health risks associated with FDA regulation).

Similarly, the elasticity of price transmission from the manufacturing sector to the tobacco production due to the supply shift induced by cost of compliance with FDA regulation can be given as:

$$\rho^M = \frac{dLnP/dLnM}{dLnW/dLnM} = \frac{\alpha\beta\eta\Pi}{\epsilon\Theta}. \quad (12)$$

Eq. (12) provides for the elasticity of tobacco leaf price with respect to the change in the wholesale price of cigarette due to the supply-side effect of the FDA regulation (cost of compliance with FDA regulation).

Eq. (10), Eq. (11) and Eq. (12) constitute the basic analytical solutions to estimate both the demand-side and supply-side effects of the FDA regulation of tobacco products. On the output or cigarette side, first, the percentage change in cigarette price ($dLnW$) is calculated using Eq. (10). Second, the percentage changes in quantity of domestic cigarette sales ($dLnQ_d$) and exports

($d\ln Q_e$) are calculated using elasticity equations. Third, Eq. (3) is used to calculate the percentage change in total cigarette output in the U. S. ($d\ln Q$).

On the input or tobacco leaf side, Eq. (11) and Eq. (12) are applied to estimate the effect of the changes in wholesale cigarette price and cigarette sales on the tobacco market (changes in tobacco price) followed by estimation of the changes in domestic manufacturers' purchases of tobacco, tobacco exports, revenue and producer surplus using the appropriate equations presented in the model section.

From Eq. (11) and Eq. (12), it can be seen that the elasticity of price transmission from the manufacturing sector to the tobacco production due to the demand shift is a function of both the oligopoly parameter (θ) and oligopsony market power parameter (μ) while the elasticity of price transmission from the manufacturing sector to the tobacco production due to the supply shift is a function of only the oligopsony market power parameter (μ).

4. SCENARIOS

There are two plausible scenarios in which the FDA regulation could affect domestic cigarette sales, potentially leading to a decrease in manufactures' purchases of tobacco. One is through raising public awareness about the health risks associated with smoking thereby potentially reducing smoking initiation or cutting down on consumption, and the other is through increasing the marginal cost of cigarette production, leading to an increase in cigarette prices. The first scenario is referred to as demand-side effect and the second scenario is referred to as supply-side effect.

4.1. Demand-side Effects of the FDA Regulation of Tobacco Products

The FDA rules associated with, for example, the disclosure of the contents of cigarettes, display of textual and graphic warning labels on cigarette packages and advertisements, depicting the negative health consequences of smoking may help raise public awareness about the health risks associated with smoking and result in persuading potential smokers not to initiate smoking, and current smokers to quit or cut down on smoking. Under this scenario of the effect of FDA regulation, the likelihood of smoking initiation could decrease as the FDA regulation limits potential smokers' exposure and access to cigarette advertisement and other marketing practices. Also, when current smokers become more aware of the health risks of smoking through stronger warning labels and bans on characterization of some cigarettes as "light" or "mild" cigarettes, they may quit or cut down on smoking. In this scenario, the overriding factor in the reduction of cigarette sales is not the increase in price but rather the change in attitude towards smoking. The CBO estimated that the regulation could reduce the prevalence of smoking by 2 per cent among adults and 11 per cent among teenagers. Based on these and other statistics related to smoking, it can be estimated that domestic cigarette sales could decline by nearly 10 per cent. In a perfectly competitive market scenario in which firms are assumed to have a constant marginal cost of production and operate under constant returns to scale, there will be little or no change in the price of cigarettes. In the imperfectly competitive market, however, there will be an increase in price to maintain revenue because of the price inelasticity of the demand for cigarettes and the oligopolistic nature of the industry that would allow market power exertion in the cigarette market.

In both cases, as current smokers cut down on consumption of cigarettes and potential smokers refrain from initiating smoking, manufacturers make fewer cigarettes than before, thus resulting in tobacco farmers contracting and selling less tobacco leaf at each price point, shifting the demand curve of tobacco leaf leftward. With downward sloping demand curve and upward sloping supply curve, the decrease of the tobacco price and the accompanying decrease of the quantity of tobacco would result in the loss of producer surplus. The magnitude of loss of the producer surplus depends on the price elasticity of supply and demand.

4.2. Supply-side Effects of the FDA Regulation of Tobacco Products

In contrast to the demand-side effects, the supply-side effects are associated with increased costs to the cigarette manufacturers due to compliance with the FDA regulation, including user fees and potential expenses on modification or retrofitting of processing and manufacturing equipments, adoption of new technologies to reduce nicotine and reduce or eliminate other ingredients or modify the design and characteristics of tobacco products as well as to test, monitor and evaluate the use of inputs and chemical residues in tobacco leaf at the farm level.

The effect of the FDA regulation on tobacco farms depends on how manufactures intend to address the cost of compliance issues that involve whether or not they are willing to absorb the costs themselves or pass it along to consumers as higher prices. In fact, as oligopolists, they can pass or absorb part of it depending on the degree of coordination among the companies in pricing. In the event of the cigarette makers passing part of it onto smokers, there will be some smokers quitting or cutting down on smoking because they can no longer afford paying higher prices for cigarettes, leading to the reduction of domestic cigarette sales and hence manufactures' purchase of tobacco leaf.

5. RESULTS

This section presents estimates of the potential effects of the FDA regulation of tobacco products on manufacturers and tobacco farms of the FDA regulation of tobacco products in the imperfectly competitive market (oligopoly/oligopsony) vis-à-vis perfectly competitive market. In the imperfectly competitive market, it is assumed that the FDA regulation of tobacco products prompts manufacturers to exercise more market power. The market power is implied by conjectural elasticity of ($\theta = \mu = 0.342$) due to Barnett, Keeler and Hu (1995), representing modest departure from perfect competition. The average estimate of the market power index (based on Eq. 2'), representing the degree to which the industry can set output price above marginal cost in the event of absorbing the cost of the regulation is 1.59. This implies that the percentage mark-up of price over marginal cost is 59 per cent of the increase in costs of cigarette production due to compliance with the FDA regulation. Potential expenses that could increase the costs of cigarette production may include modification or retrofitting of processing and manufacturing equipments to reduce or eliminate harmful or potentially harmful ingredients or modify the design and characteristics of tobacco products as well as to test, monitor and evaluate the use of inputs and chemical residues at the farm level.

The estimates of the demand-side and supply-side effects of the FDA regulation of tobacco products are based on the parameter and variable values presented in Tables 1 and 2.

Table 1
Parameters Along their Definitions, Values and Sources

Parameters	Definition	Values	Sources
θ	Cigarette conjectural elasticity	0.342	(Barnnett, Keeler and Hu 1995)
μ	Tobacco leaf conjectural elasticity	0.342	Set equal to the output conjectural elasticity following Schroeter (1988)
η	Wholesale price elasticity of the demand for cigarettes	0.3	(Brown, 1995)
ϵ	Price elasticity of the supply of tobacco leaf	7.0	(Fulginiti and Perrin, 1993)
η_e	Wholesale price elasticity of export cigarettes	-3.0	(Sumner and Wohlgenant, 1985)
β	Proportion of cigarette sales in the domestic market	75%	Predicted from data in USDA/ERS (2007)
α	Proportion of domestic tobacco leaf production purchased by domestic cigarette manufacturers	60%	Predicted from data in USDA/ERS, 2007)
ω	Price elasticity of the domestic demand for tobacco leaf	-1.46	(Rezitis et al. 1998)
ω_e	Price elasticity of the export demand for domestic tobacco leaf	-3.0	(Brown and Martin, 1996)
a	Input-output coefficient (i.e., the amount of tobacco needed to produce one pack of cigarettes)	0.034 lbs/ pack	(Womack, 2003)
γ_{dt}	Tobacco leaf cost share in the cigarette wholesale price	1.2%	Calculated as (0.034 lbs/pack*60% domestic tobacco*\$1.865 /lb)/\$3.1

Table 2
Variables Along with their Definitions, Values and Sources

Variables	Definition	Values	Source
Q	Total quantity of cigarette output	17.6 billion packs	Calculated from USDA/ERS (2007)
Q_d	Quantity of domestic cigarette sales	17.25	(Maxwell, 2009)
W	Wholesale price of cigarettes	\$3.10 per pack	National Conference of State Legislatures (NCSL)
X	Total domestic tobacco production	800.5 m lbs	USDA/NASS data cited in Tobacco Farm Quarterly Magazine (2009)
P	Tobacco leaf price	\$1.865/lb	USDA/NASS data cited in Tobacco Farm Quarterly Magazine (2009)

5.1. Estimates of Demand-side Effects

Table 3 provides estimates of the potential effects of the FDA regulation of tobacco products on the wholesale price of cigarette and revenue of an estimated 10 per cent decline in domestic cigarette sales in imperfectly competitive market vis-à-vis perfectly competitive market.

In the perfectly competitive market, the 10 per cent decrease in domestic sales would cause the demand curve to shift leftward by the same amount because the industry's marginal costs are assumed constant and the supply curve is horizontal (i.e., perfectly price elastic). Price would remain almost the same.

In the case of the imperfectly competitive market, however, the wholesale price of cigarette would increase by 8.5 per cent because of the oligopolistic market power of the cigarette industry. As domestic cigarette sales decline by 10 per cent, manufacturers tacitly coordinate pricing decisions and raise prices by 8.5 per cent. As a result, the total decrease in cigarette sales will be 12.5 per cent as opposed to 10 per cent in the case of no market power (Table 3). The additional 2.5 per cent (i.e., above the 10 per cent) decrease in domestic sales occurs because of the actions of the cigarette industry (i.e., tacit price coordination and price increase). Note that the per centage change in the wholesale price of cigarette ($dLnW$) was estimated using the first expression on the right hand side of Eq. (10).

Table 3
Percentage Changes in the Equilibrium Wholesale Price of Cigarette Due to an Estimated 10 per cent Decrease in Domestic Cigarette Sales Prompted by the FDA Regulation

Variables	Perfectly competitive market ($\theta = 0$)	Imperfectly competitive market ($\theta = 0.342$)
Domestic wholesale price	-0.00	8.48
Domestic sales	-10.00	-12.54
Total output	-7.50	-9.41
Gross revenue	-7.5	-0.93
Market power premium(\$/pack)	0.00	0.26

Note: • The per centage change in the wholesale price of cigarette ($dLnW$) was calculated using the first expression on the right-hand side of Eq. (10).
 • The per centage change in overall cigarette output in the U.S. was calculated using Eq. (3)
 • The market power premium was calculated by taking the difference between the per centage increase in the wholesale price of cigarette in the imperfectly competitive market and perfectly competitive market and multiplying it by the average wholesale price of cigarette.
 • Manufacturers may charge an additional \$0.26 for every pack of cigarettes sold in the domestic market to make up for the loss in revenue associated with the 10 per cent decline in sales prompted by the regulation.
 • The calculation is based on a linear supply and demand functions.

The 8.5 per cent increase in the wholesale price of cigarette multiplied by the average wholesale price of cigarette will provide the average value of the additional benefit that accrues to the industry as the result of their market power. This is referred to as market power premium. Using \$3.1 per pack as the average wholesale price, the market power premium would be \$0.26 per pack (8.5 per cent \times \$3.1 per pack). This suggests that manufacturers may charge an additional \$0.26 for every pack of cigarettes sold in the domestic market and make up for the loss in revenue associated with the decline in sales caused by the regulation. Despite the estimated 12.5 per cent decrease in domestic sales, manufacturers' revenue would decline by just less than 1 per cent. In contrast, if they were operating in a perfectly competitive market, they would see their revenue declining by 7.5 per cent. Note that they can increase revenue because the demand for cigarettes is inelastic.

Table 4 provides the potential effects (%) of the FDA regulation on tobacco price, domestic manufacturers' purchases and revenue due to the 12.5 per cent decrease in domestic cigarette sales in the imperfectly competitive market versus the 10 per cent decrease in the perfectly competitive market. Since the FDA regulation does not directly affect tobacco farms, the effect of the regulation on tobacco farms was estimated by calculating first the percentage change in

tobacco leaf price ($dLnP$) due to the change in the wholesale price of cigarette ($dLnW$) using Eq. (11). Recall that Eq. (11) provides for the elasticity of tobacco leaf price with respect to cigarette wholesale price. Once the per centage change in tobacco leaf price ($dLnP$) was determined using Eq. (11), then the per centage change in quantity of domestic tobacco leaf purchases ($dLnX_d$) and exports ($dLnX_e$) were calculated using the appropriate elasticity equations. Then, Eq. (4) was used to calculate the per centage change in total tobacco leaf output in the U.S. Finally, the per centage change in gross tobacco leaf revenue was calculated by taking the sum of the per centage changes in tobacco leaf price ($dLnP$) and total tobacco leaf production ($dLnX$).

Table 4
Percentage Changes in Equilibrium Tobacco Price and Quantity Due to an Estimated 10 Per cent Decrease in Domestic Cigarette Sales Prompted by the FDA Regulation

Variables	Perfectly competitive market ($\theta = 0$)	Imperfectly competitive market ($\theta = 0.342$)
Farm price	-0.50	-0.62
Domestic purchases	-6.77	-8.50
Exports	1.49	1.87
Total production	-3.47	-4.35
Revenue	-3.97	-4.98

Note: • The per centage change in tobacco leaf price ($dLnP$) was determined using Eq. (11).
 • The per centage changes in domestic tobacco purchases ($dLnX_d$) and tobacco exports ($dLnX_e$) were calculated using elasticity equations.
 • The per centage change in total tobacco production in the U.S. ($dLnX$) was calculated using Eq. (4)
 • Tobacco revenue was calculated by taking the sum of the per centage changes in tobacco price ($dLnP$) and total tobacco leaf production ($dLnX$)
 • The calculation is based on a linear supply and demand functions.

In the imperfectly competitive market, the 12.5 per cent decline in cigarette sales would result in a 0.62 per cent decrease in tobacco equilibrium price and an 8.5 per cent decrease in manufacturers' purchase of tobacco. While the export demand for domestic tobacco increases by 1.87 per cent, it will not be enough to offset the decrease in domestic manufacturers' purchase of tobacco. As a result, the total quantity of tobacco production will decline by 4.35 per cent, which is higher than the 3.47 per cent in the perfectly competitive market. The tobacco revenue will decline by nearly 5.00 per cent in the imperfectly competitive market, amounting to nearly \$74.0 million and growers will lose \$9.1 million in producer surplus. Part of the loss in producer surplus would constitute deadweight loss and part of it would be captured by cigarette manufacturers. Nonetheless, manufacturers as "consumers" of tobacco leaf would lose more than they gain because the demand for tobacco is less elastic than the supply of tobacco. In terms of individual farms, on average each farm would cut down on tobacco leaf supply by 2,147 lbs, or reduce tobacco acreage by about an acre. Each tobacco farm would lose about \$ 4,550 in gross revenue and about \$560 in producer surplus.

5.2. Estimates of Supply-side Effects

Table 5 presents the effects of an estimated 30 per cent increase in costs of cigarette production due to compliance with FDA regulation. The estimates of the supply-side effects were determined

in a similar way as in the case of the demand-side effects presented in the previous section. That is, first the per centage change in cigarette price ($d\ln W$) due to the 30 per cent increase in cost of production was calculated using the second expression of Eq. (10). Once the per centage change in the wholesale price of cigarette ($d\ln W$) was determined, then the per centage changes in quantity of domestic cigarette sales ($d\ln Q_d$) and exports ($d\ln Q_e$) were calculated using elasticity equations. Then, Eq. (3) was used to calculate the per centage change in total cigarette output in the U.S. Finally, the per centage change in gross cigarette revenue was calculated by taking the sum of the per centage changes in cigarette price ($d\ln W$) and total cigarette output ($d\ln Q$).

Results indicate that a 30 per cent increase in the cost of cigarette production due to compliance with the FDA regulation would increase the wholesale price of cigarette by 38.23 per cent in the imperfectly competitive market compared to a 24.0 per cent increase in the perfectly competitive market (Table 5). The increase in the wholesale price of cigarette would lead to an 11.47 per cent decline in domestic sales in the imperfectly competitive market compared to a 7.2 per cent in the perfectly competitive market.

Table 5
Percentage Changes in Equilibrium Cigarette Price Due to an Estimated 30 Per cent Increase in the Cost of Cigarette Production in Compliance with the FDA Regulation

Variables	Perfectly competitive market ($\theta = 0$)	Imperfectly competitive market ($\theta = 0.342$)
Domestic wholesale price	24.00	38.23
Domestic sales	-7.20	-11.47
Total output	-5.40	-8.60
Gross revenue	18.60	29.63
Market power premium(\$/pack)	0.00	0.44

Note: • The percentage change in the wholesale price of cigarette ($d\ln W$) was calculated using the second expression on the right-hand side of Eq. (10).
• The percentage changes in domestic sales ($d\ln Q_d$) and tobacco exports ($d\ln Q_e$) were calculated using elasticity equations.
• The percentage change in overall cigarette output in the U.S. was calculated using Eq. (3)
• Manufacturers may charge an additional \$0.44 for every pack of cigarettes sold in the domestic market to make up for the loss in revenue associated with an estimated 30 per cent increase in the cost of cigarette production due to compliance with the FDA regulation.
• The calculation is based on a linear supply and demand functions.

As a consequence of the fall in cigarette sales, manufacturers' purchase of domestic tobacco leaf would decline by 7.77 per cent in the imperfectly competitive market compared to 4.88 per cent in the perfectly competitive market (Table 6). Similarly, the price of tobacco leaf would decrease by 0.57 per cent in the imperfectly competitive market compared to 0.36 per cent in the perfectly competitive market. While tobacco exports increase in both market structures, they are not enough to offset the decline in domestic manufacturers' purchase of tobacco. As a result, the total tobacco production would decline by nearly 4 per cent in the imperfectly competitive market compared to 2.5 per cent in the perfectly competitive market. Similarly, tobacco revenue would decline by 4.55 per cent in the imperfectly competitive market, amounting to nearly \$68.0 million and growers would lose \$8.3 million in producer surplus. In terms of

individual farms, on average each farm would cut down on tobacco leaf supply by 1,963 lbs, or reduce tobacco acreage by just less than an acre. Each tobacco farm would lose about \$ 4,163 in gross revenue and \$513 in producer surplus.

Table 6
Percentage Changes in Equilibrium Tobacco Price and Quantity Due to an Estimated 30 per cent Increase in the Cost of Cigarette Production in Compliance with the FDA Regulation

Variables	Perfectly competitive market ($\theta = 0$)	Imperfectly competitive market ($\theta = 0.342$)
Farm price	-0.36	-0.57
Domestic purchases	-4.88	-7.77
Exports	1.07	1.71
Total production	-2.50	-3.98
Revenue	-2.86	-4.55

Note: • The per centage change in tobacco leaf price ($dLnP$) was determined using Eq. (12).
 • The per centage changes in domestic tobacco purchases ($dLnX_d$) and tobacco exports ($dLnX_e$) were calculated using elasticity equations.
 • The per centage change in total tobacco production in the U.S. ($dLnX$) was calculated using Eq. (4)
 • Tobacco revenue was calculated by taking the sum of the per centage changes in tobacco price ($dLnP$) and total tobacco leaf production ($dLnX$)
 • The calculation is based on a linear supply and demand functions.

5.3. Estimates of Combined Effects

Table 7 presents estimates of the combined effects (i.e., the demand-side and supply-side) involving an estimated 10 per cent decrease in domestic cigarette sales and an estimated 30 per cent increase in costs of cigarette production. Note that both the first and second expressions on the right hand side of Eq. (10) were used to estimate the per centage change in the wholesale price of cigarette.

Table 7
Percentage Changes in Equilibrium Cigarette Price Due to the Combined 10 per cent Decrease in Domestic Cigarette Sales and 30 per cent Increase in the Cost of Production

Variables	Perfectly competitive market ($\theta = 0$)	Imperfectly competitive market ($\theta = 0.342$)
Domestic wholesale price	24.00	46.71
Domestic sales	-17.20	-24.01
Total output	-12.90	-18.01
Revenue	11.09	28.70
Market power premium(\$/pack)	0.00	0.70

Note: • The per centage change in the wholesale price of cigarette ($dLnW$) was calculated using both the first and second expressions on the right-hand side of Eq. (10).
 • The per centage change in overall cigarette output in the U.S. was calculated using Eq. (3)
 • Manufacturers may charge an additional \$0.70 for every pack of cigarettes sold in the domestic market to make up for the loss in revenue associated with the 10 per cent decline in cigarette sales and an estimated 30 per cent increase in the cost of cigarette production due to compliance with the FDA regulation.
 • The calculation is based on a linear supply and demand functions.

Results indicate that the wholesale price of cigarette would increase by 46.71 per cent in the imperfectly competitive market, resulting in a 24.0 per cent decline in domestic sales, equivalent to over 4 billion packs of cigarettes (Table 7). The decline in cigarette sales would cause the price of tobacco to decrease by 1.2 per cent in the imperfectly competitive market, resulting in an 8.3 per cent decline in total production (Table 8). As a result, tobacco farms could lose over 9 per cent of the value of the tobacco farm sector (\$141 million in gross revenue).

Table 8
Percentage Changes in Equilibrium Tobacco Price and Quantity Due to the Combined 10 per cent Decrease in Domestic Cigarette Sales and 30 per cent Increase in the Cost of Production

Variables	Perfectly competitive market ($\theta = 0$)	Imperfectly competitive market ($\theta = 0.342$)
Farm price	-0.85	-1.19
Domestic purchases	-11.65	-16.27
Exports	2.56	3.57
Total production	-5.97	-8.33
Revenue	-6.82	-9.52

Note: • The per centage changes in this table are the sum of the per centage changes of the demand-side effects and supply-side effects presented in Tables 4 and 6.

• The calculation is based on a linear supply and demand functions.

Finally, it is important to note that the effect of the regulation on both cigarette and tobacco revenues is sensitive to changes in the values of several parameters, including the output conjectural elasticity, price elasticity of demand for cigarettes, price elasticity of the supply of tobacco, the proportion of domestic sales and the proportion of domestic tobacco leaf used in the domestically sold cigarettes.

6. CONCLUSION

The study has examined the potential demand- and supply-side effects of the FDA regulation of the manufacturing and marketing of tobacco products. Results suggest that the FDA regulation could have important welfare economic implications for tobacco farms. Considering the fairly large estimate of loss in tobacco revenue and producer surplus, it can be concluded that even if the legislation excludes tobacco farms from FDA authority, it can indirectly and adversely affect them through its effects on domestic cigarette sales.

Note

1. The assumption of unitary elasticity with regards to the production of cigarettes is based on the fact that tobacco is the limiting resource in cigarette production, implying that a change in cigarette production induces an equal proportional change in tobacco demanded, holding the price of tobacco constant. This assumption is also made based on the fact that the inputs other than tobacco used in cigarette production are fixed. There is little or no substitution between these fixed inputs and tobacco. This assumption has been used in studies such as Sumner DA and MK Wohlgenant (1985) who investigated effects of an increase in the federal excise tax on cigarettes. (*American Journal of Agricultural Economics*, 67 (2):235-242).

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