The Compensative Effects of Tobacco Leaf Price Changes on Tax Revenue in China

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Abstract: Tobacco production in China is influenced by a government-set procurement price for tobacco leaf, and an excise tax on tobacco leaf revenue. This study examines the increase in the procurement price needed to keep tax revenue constant in the face of a 50% reduction in the tax rate. This "compensative effect" is important because reductions in the tax rate are contemplated and tobacco tax revenue is a major source of funding for rural communities. Based on an equilibrium-displacement model of China's tobacco sector, results suggest the "Compensated Effect Elasticity" (CEE) is between 1.0 and 2.5. This means a 50% cut in the tax rate would necessitate an increase in the procurement price of between 50% and 125%. Sensitivity analysis indicates CEE is most sensitive to the retail demand and input substitution elasticities and least sensitive to oligopoly power and returns to scale.

Key words: tobacco leaf, tax rate, procuring price, compensative effects

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China is the world's largest consumer of cigarettes. According to a 2002 national survey, about 36% of China's population age 15 and over are smokers, or approximately 350 million people (Yang 2004). China is also the world's largest producer of tobacco leaf. In 2000, China produced 2.24 million tones of tobacco, or about one third of world production (Mackay and Eriksen, 2002). The Chinese government plays an important role in tobacco production through the State Tobacco Monopoly Administration (STMA) and the China National Tobacco Company (CNTC). STMA sets overall government policies on tobacco, including the allocation of tobacco leaf production quotas among the provinces, and production quotas for cigarettes (Hu *et al*., 2007). One of STMA's key policy interventions is to set the procurement price of tobacco leaf in order to control tobacco production. These prices are set according to the production location and quality[1].

CNTC is an organization that implements STMA's tobacco production policy. By law, CNTC is the only legitimate buyer of tobacco leaf. The procurement of tobacco leaf is one of the CNTC's monopolistic functions. Other agencies or individuals are not allowed to purchase tobacco leaf without the CNTC's approval.

Cigarette production is an important source of revenue for the central government, accounting for some 10% of total receipts. At the provincial level local governments rely on tobacco taxes to fund services, especially in the major tobacco-growing regions of Yunnan, Guizhou, Henan and Sichuan. Prior to 1999 the tax on tobacco leaf was 31% compared to an 8% tax on other farm products. In 1999, the tobacco leaf tax rate was reduced to 20%. To make up

[1] Every year, the STMA announces a list of 200 prices, covering five production regions and four grading categories; each quality category includes more than ten detailed purchase prices.

for lost tax revenue, STMA at the same time increased the procurement price. In 2006, the central government cancelled all agriculture taxes except on tobacco.

Some argue the government should cancel the tobacco leaf tax because it is unfair for the farmers who grow tobacco. So the Chinese government faces a dilemma: if they keep the tax they anger rural constituents; if they kill the tax they lose an important source of revenue. In this study we analyze a compromise solution: namely, a simultaneous lowering of the tax rate and increase in the procurement price to keep tax revenue constant. The question of how much the procurement price needs to be increased to offset the loss in tax revenue associated with a reduction in the tax rate has not been addressed in the scholarly literature.

The purpose of this research is to determine the relative effects of an incremental change in the procurement price and the tax rate on tax revenue. A secondary objective is to determine the marginal effects of these variables on cigarette consumption, production, price, and farm revenue.

The research objectives are accomplished by specifying an equilibrium-displacement model (EDM) of China's tobacco sector. The EDM used in this paper originally was developed by Muth (1965) and by Gardner (1975). Since then studies have generalized Muth's and Gardner's basic models to include imperfect competition (Holloway (1991), Azzam (1998), McCorriston *et al.* (1998), Kinnucan (2003)) and non-constant returns to scale (McCorriston (2001); Weldegebreil (2004)). The model used in this study is similar to Kinnucan's (2004) in that it includes imperfect competition in both the output market for the finished good and an input market for raw material. It differs from Kinnucan's model, however, in that it relaxes the assumption of constant returns to scale. To our knowledge, this is the first application of a Muth-type model that includes both oligopoly and oligopsony power and non-constant returns to scale.

Model

The conceptual framework consists of vertically linked markets for tobacco leaf at the farm level and manufactured cigarettes at the retail level. At farm level, farmers produce tobacco leaf to sell to local legal agencies and these agencies purchase tobacco leaf at a price set by the government. Government imposes a tax based on the procurement price. The manufacturing firms use tobacco leaf and other inputs to produce cigarettes and sale them in a retail market.

Specification

Consider the manufacturing industry that combines tobacco leaf *a* with a bundle of marketing inputs *b* to produce cigarettes *x*. The industry's production function is given by:

$$x = f(a,b) \tag{1}$$

Consumer demand for cigarettes is separable from other goods such that substitution effects can be ignored. The retail demand function for *x* is given by:

$$x = D(P_x) \tag{2}$$

where P_x is the retail price of cigarettes.

The manufacturing firms exercise oligopoly power in the *x* market and oligopsony power in the *a* market. The first-order conditions for maximum profit of manufacturing firms with respect to *a* and *b* are[2]:

$$P_a(1+\Omega) = P_x f_a(1+\Psi) \tag{3}$$

$$P_b = P_x f_b(1+\Psi) \tag{4}$$

[2] Here are the optimality conditions at industrial level. Actually we can get the optimality conditions at firm level directly: $P_a(1+\frac{\theta_i}{\varepsilon_a}) = P_x f_{ai}(1+\frac{\xi_i}{\eta})$, $P_b = P_x f_{bi}(1+\frac{\xi_i}{\eta})$. Following Habtu Tadesse Weldegebriel (2004), in the manner of Bhuyan and Lopez (1997), the optimality conditions at firm level can be weighted by the firm's market share. Summing over all firms, their aggregate analogues can be obtained as Eq (3) & (4).

where f_a and f_b are the marginal products of a and b and P_a and P_b are the prices of a and b. The parameter $\Psi = \xi / \eta$ is a Lerner index that denotes oligopoly power where η is the retail demand elasticity and $\xi \in [0,1]$ is the output conjectural elasticity ($\xi = 0$ for perfect competition and $\xi = 1$ for pure monopoly). The parameter $\Omega = \theta / \varepsilon_a$ is a Lerner index that denotes oligopsony power where ε_a is the supply elasticity for a, and $\theta \in [0,1]$ is the input conjectural elasticity ($\theta = 0$ for perfect competition and $\theta = 1$ for pure monopsony).

The input supply functions for a and b are:

$$P_a = P_s + T \tag{5}$$

$$P_b = h(b) \tag{6}$$

where P_s is the procurement price of tobacco leaf set by the government. The supply equation for the b input is specified in inverse form to facilitate derivation of the reduced form to be presented later. The variable T is an endogenous variable which represents per unit tax imposed by government on tobacco leaf and decides by:

$$T = tP_s \tag{7}$$

where t is the tobacco leaf tax rate.

The equations of tax revenue and farmers' revenue are given by:

$$TR = Ta \tag{8}$$

$$FR = P_s a \tag{9}$$

The system contains nine equations in nine endogenous variables ($P_x, P_a, P_b, x, a, b, T, TR, FR$) and two exogenous ($P_s, t$) as well as four parameters ($\xi, \theta, \eta, \varepsilon_a$). Because procurement price P_s is an exogenous variable, which indicate ε_a is infinite, $\Omega = \theta / \varepsilon_a$ will equal zero although the manufacturing firms have oligopsony power

($\theta \neq 0$).

Following Gardner (1975), we totally differentiate the system of equations (1) to (9) and express them in percentage changes as follows:

$$x^* = \alpha a^* + \beta b^*$$

(1')

$$x^* = \eta P_x^* \tag{2'}$$

$$P_a^* = \frac{1+\mu}{1+\delta} P_x^* + \frac{1}{1+\delta}[(\rho-1) - \frac{1+\sigma(\rho-1)}{\sigma\rho}\beta]a^* + \frac{1+\sigma(\rho-1)}{(1+\delta)\sigma\rho}\beta b^* \tag{3'}$$

$$P_b^* = (1+\mu)P_x^* + \frac{1+\sigma(\rho-1)}{\sigma\rho}\alpha a^* + [(\rho-1) - \frac{1+\sigma(\rho-1)}{\sigma\rho}\alpha]b^* \tag{4'}$$

$$P_a^* = (1-\tau)P_s^* + \tau T^* \tag{5'}$$

$$P_b^* = \frac{1}{\varepsilon_b} b^* \tag{6'}$$

$$T^* = P_s^* + t^* \tag{7'}$$

$$TR^* = T^* + a^* \tag{8'}$$

$$FR^* = P_s^* + a^* \tag{9'}$$

where the asterisked variables indicate relative change (e.g. $x^* = dx/x$); $\alpha = S_a(1+\frac{\theta}{\varepsilon_a})/(1+\frac{\xi}{\eta})$ is the factor a's cost share inclusive of oligopsony and oligopoly rent, hereafter referred to as the 'value share' term[3]; $\beta = S_b/(1+\frac{\xi}{\eta})$ the factor b's value share; α and β are also the output elasticity with $\alpha + \beta = \rho$, where ρ is the (short-run) returns to scale measure with greater than (equal to, less than) unity representing increasing (constant,

[3] The term 'value share' is suggested by Waterson (1980) and used in Kinnucan's (2003) paper.

decreasing) returns to scale[4]; σ is the Hicks-Allen factor substitution elasticity; $\tau = T / P_a$ is the tobacco leaf tax expressed as a fraction of the initial equilibrium buyer's price[5]; ε_b is the supply elasticity for marketing services. Parameter $\mu = -\varpi\xi / (\eta + \xi)$ represents the changes in the mark-up following changes in the retail price caused by the exogenous shock, where $\varpi = \partial \ln \eta / \partial \ln P_x$ represents the changes in the elasticity of demand for a given change in the retail price. Parameter $\delta = -\lambda\theta / (\varepsilon_a + \theta)$ represents the changes in the mark-down following changes in the farm input price caused by the exogenous shock, where $\lambda = \partial \ln \varepsilon_a / \partial \ln P_a$ represents the changes in the elasticity of supply for a given change in the farm input price.

In this study, all parameters are assumed to be positive except demand elasticity. Retail demand is downward sloping ($\eta < 0$); cigarette industry technology exhibits variable proportions ($\sigma > 0$). Importantly, the farm-share term $S_a = P_a a / P_x x$ is evaluated at the initial equilibrium point, as is τ in Eq. (5').

As in Sumner's (1985) and Kinnucan's (2003) paper, the approach of Muth is used in solving the system of the equation (1) to (9) for proportional changes in endogenous variables in response to exogenous changes in tobacco leaf tax rate and procuring price. In other words, all the endogenous variables can be expressed as a function of the tobacco leaf tax rate and the procurement price.

Compensative effect

The question to be investigated is to determine the compensative effects of the tobacco leaf price when the tax rate decreases. So, we substitute (7') into (8') and let $TR^* = 0$ and we get:

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[4] If $\rho = 1$ (constant return to scale), $\alpha + \beta = 1$. This result is same as Kinnucan's $k_a + k_b = 1$ (see Kinnucan,2003, Appendix A for proof)

[5] $t = T / P_s$ is the tobacco leaf tax expressed as a fraction of the initial procurement price. The relationship between t and τ is $\tau = t / (1 + t)$

$$TR^* = P_s^* + t^* + a^* = 0 \tag{10}$$

P_s and t are exogenous variables which are controlled by government. In order to keep tax revenue constant ($TR^* = 0$), the key point is how a^* changes in response to the tobacco leaf price and the tax rate, which actually depends on demand elasticity of tobacco leaf. For this purpose, next section we will derive the 'demand' curve for tobacco leaf.

The proportional change in the total derived 'demand' for tobacco leaf is obtained by dropping Eq (5') and (7')[6] and solving the remaining equations simultaneously for a^* to yield:

$$a^* = E_{a^* p_a^*} P_a^* \tag{11}$$

where $E_{a^* p_a^*} = \dfrac{\eta(1+\delta)[(\rho-1)\sigma\varepsilon_b\beta - \varepsilon_b\alpha - \sigma\rho] + (1+\mu)(1+\delta)\sigma\rho\varepsilon_b\beta}{-\eta[(\rho-1)\rho\varepsilon_b - \beta + \sigma(\rho-1)\alpha] - (1+\mu)\rho(\rho\varepsilon_b + \sigma\alpha)}$ is the derived demand elasticity for tobacco leaf.

According to Eq. (10), to determine the compensative effect, we need to know how a simultaneous change in the tax rate and the procurement price will affect demand for a when the demand price effect are taken into account. For this purpose, we substitute Eq. (5') and Eq. (7') into Eq. (11) to obtain the reduced-form equation for tobacco leaf quantity:

$$a^* = E_{a^* p_a^*} P_s^* + \tau E_{a^* p_a^*} t^* \tag{12}$$

Eq. (12) indicates the net effects of the changes in the exogenous variables on the equilibrium quantity of the tobacco leaf. P_s^*'s coefficient in Eq. (12) equals to derived demand elasticity and t^*'s coefficient is proportional to the derived demand elasticity. These coefficients, which are properly interpreted as reduced-form elasticity, are important to determine the compensative effect.

[6] We want to treat tobacco leaf price and tax as temporarily exogenous.

Using the proportional changes in the demand quantity for tobacco leaf resulting from the exogenous changes in the tax rate and procurement price, the proportional change in the tax revenue is found with Eq. (13):

$$TR^* = (1 + E_{a^* p_a^*})P_s^* + (1 + \tau E_{a^* p_a^*})t^* \tag{13}$$

Setting TR^* equal zero, Eq. (13) may be expressed alternatively as:

$$t^* = 0, \qquad \text{if } E_{a^* p_a^*} = -1 \tag{13a}$$

$$\overline{P}_s^* = \frac{1 + \tau E_{a^* p_a^*}}{1 + E_{a^* p_a^*}}(-t^*) = C_p(-t^*), \qquad \text{if } E_{a^* p_a^*} \neq -1 \tag{13b}$$

where $C_p = \dfrac{1 + \tau E_{a^* p_a^*}}{1 + E_{a^* p_a^*}}$ is the scale parameter of the compensative effect. The absolute value of the parameter C_p indicates how big the compensative effect is. The smaller absolute value of the scale parameter means that the price has a bigger compensative effect on the tax revenue.

When the derived demand for tobacco leaf has the unity elasticity ($E_{a^* p_a^*} = -1$), in Eq.(13a), the compensative effect don't make sense. Eq. (13b) shows the compensative effect which means how much the price should change to keep the tax revenue neutral if the tax rate changes. The derived demand elasticity $E_{a^* p_a^*}$ plays an important role in Eq. (13b). If the demand for tobacco leaf is inelasticity ($-1 < E_{a^* p_a^*} < 0$), the coefficient $C_p > 0$, which means the price should increase if the relative change of tax rate decrease 1%[7]. If the demand for tobacco leaf is more elasticity ($E_{a^* p_a^*} < -1$), the coefficient $C_p < 0$[8], which indicates the price should decrease if the relative change of tax rate decrease 1%.

Effects on retail market

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[7] Tax rate decrease indicates $t^* < 0$, while tax rate increase means $t^* > 0$.

[8] To get this result $C_p < 0$, the $E_{a^* p_a^*}$ actually have to satisfy the condition $-\dfrac{1}{t} < E_{a^* p_a^*} < -1$. However, in practice, $E_{a^* p_a^*}$ can't be very big, so here we just limit $E_{a^* p_a^*} < -1$.

Besides the compensative effect, it is necessary to know the effects on the retail price and quantity, because China has ratified the WHO Framework Convention on Tobacco Control (FCTC) and promise to adopt effective tobacco policies to reduce cigarette consumption.

Solution of the system results in the equation for proportional changes in retail price as follows:

$$P_x^* = E_{p_x p_s} P_s^* + \tau E_{p_x p_s} t^* \tag{14}$$

where $E_{p_x p_s} = \dfrac{(1+\delta)(\sigma+\varepsilon_b)\alpha\rho}{\eta[(\rho-1)\rho\varepsilon_b - \beta + \sigma(\rho-1)\alpha] + (1+\mu)(\rho\varepsilon_b + \sigma\alpha)}$

Following Gardner (1975), P_s^*'s coefficient can be interpreted as the elasticity of price transmission under imperfect competition market if the price of a kept at legislated by means of production control. Here is the general expression of the price transmission elasticity which considers the changes of the market power and returns to scale. When the $\rho = 1$ (constant returns to scale) and $\mu = \delta = 0$, this elasticity can be simplified to Gardner's expression[9]. In order for a percentage marketing margin to remain unchanged, $E_{p_x p_s}$ must equal one. Otherwise, a production control program that raises tobacco leaf supply price P_s will change the marketing margin.

Substituting Eq. (14) into Eq. (2'), the percentage change in retail quantity in response to exogenous variables is given by:

$$x^* = \eta E_{p_x p_s} P_s^* + \eta\tau E_{p_x p_s} t^* \tag{15}$$

t^*'s coefficient in Eq. (15) is proportional to the P_s^*'s. Under the given initial value $\tau = 0.17$, this imply that the relative changes of the procuring price have bigger effects on the

[9] Gardner's expression under perfect competition is $E_{p_x \bar{p}_a} = \dfrac{S_a(\sigma+\varepsilon_b)}{\varepsilon_b + S_a\sigma - S_b\eta}$. Here S_a and S_b are the relative share of a and b.

equilibrium quantity of the cigarettes than the relative changes of the tax rate. For the tobacco controlling, it indicates that procuring price control is more effective than the tax rate to reduce cigarette consumption.

Simulation

In this section we use the model together with the estimates of the parameter values to simulate quantitative effects of the changes in the tobacco leaf procuring price and tax rate. In 2006, the base year for our analysis, the total tobacco leaf tax revenue is 4.1 billion *yuan* and farmer's revenue is 20.5 billion *yuan*[10]. Next, we will compute the compensative effects under different scenario; then, we simulate the effects of a 50% decrease in tax rate (which means tax rate reduced from 20% to 10%) and a corresponding increase in procurement price on endogenous variables.

Parameterization

The parameter values used in the simulations are listed in Table 1. Cigarette demand elasticity estimates from prior studies are used in the model. Estimates of the retail price elasticity range from -0.35 (Hu and Mao, 2002) to -0.84 (Bai and Zhang, 2005). Hu and Mao (2002) get the demand elasticity -0.35 for short run and -0.66 for long run using time series data from 1980-1997; Cai (working paper, 2008), using time series data from 1985-2004, gets the demand elasticity -0.72 for long run; Bishop *et al*. (2007) get the value -0.50 using cross section data at county level; The largest estimate is -0.84 obtained by Bai and Zhang (2005). Based on these estimates we selected -0.5 for the baseline value.

Previous studies have paid little attention to market power in China's tobacco industry. Cai use NEIO model and time series data from 1985-2004 to estimate the output conjectural elasticity

[10] The data of tax revenue come from web of State Administration of Taxation and the value of farmers' revenue computed using the formula in Table 1.

and the results show that the average value of ξ is 0.28 (Cai, 2008). This estimate was used for the baseline and sensitivity analysis was conducted over using the range 0.1 to 0.4. Because CNTC is the only legitimate buyer of tobacco leaf, CNTC has monopsony power and thus we set $\theta = 1$.

Because the government controls the supply price of the tobacco leaf we set the farm supply elasticity to $\varepsilon_a = \infty$. The marketing services' supply elasticity was set to ε_b= 2, a value that seem to be preferred by Gardner (1975) and Kinnucan (2003). Because Wohlgenant (1985) argues that the substitute elasticity should be less than one, σ is set to between zero and 0.6. The farm cost share parameter is set to $S_a = 0.1$ based on data from STMA.

Results

To establish a baseline we set $\xi = 0.28$ to indicate oligopoly power, $\rho = 1$ to indicate constant returns to scale and $\varepsilon_b = 2$ to indicate marketing services supply elasticity. Table 2 gives the results of the compensative effect calculated using equation (13b).

According to equation (13b), the scale parameter C_p indicates the percentage increase in the procurement price required to keep tax revenue constant when tax rate is reduced by 1%. For example, if $\eta = -0.5$ and $\sigma = 0.2$, C_p = 1.29, which means the procurement price must increase 1.29% per 1% reduction in the tax rate. Results in Table 2 imply that an increase in either the demand elasticity or the substitution elasticity will lead to a smaller compensative effect except under fixed proportions[11]. For example, if σ= 0, which means fixed proportion, the results are 1.16 when $\eta = -0.35$ and 1.085 when $\eta = -0.84$, a 6.4% reduction. However, if $\sigma = 0.2$, the corresponding range is from 1.311 to 1.318, a 0.57% growth. For the value of

[11] The bigger value of the scale parameter means that the price has a smaller compensative effect on tax revenue.

$\sigma = 0.4$ and $\sigma = 0.6$ the increase rates are 14% and 41% respectively.

Sensitivity analysis

To show the effects of returns to scale and market power on the compensative effect, we conducted sensitivity analysis by setting $\eta = -0.5$ and $\varepsilon_b = 2$ and varying $\rho, \xi,$ and σ as indicated in Table 3. Specifically, we varied the substitution elasticity σ between 0 and 0.6 and the returns-to-scale parameter ρ between 0.8 and 1.1. The conjectural elasticity ξ is varied between 0.1 and 0.4 to assess market power. The retail demand and farm supply elasticities are not affected by the exogenous shock and thus we set $\mu = \delta = 0$.

The results indicate that an increase in σ or ξ weakens the compensative effect, while an increase in ρ strengthens the compensative effect.

Turning to market power, σ is a pivotal parameter. In particular, if $\sigma < |\eta| = 0.5$, which implies that inputs a and b are gross complements (see, e.g. Alston and Scobie, 1983), the compensative effects become smaller as the conjectural elasticities increase. For example, in scenario 1, where $\rho = 0.8$, if $\sigma = 0.2$ the scale parameters range from 1.275 when $\xi = 0.1$ to 1.575 when $\xi = 0.4$, a 24% increase. The procurement price would need to increase more to compensate for the reduction in tax revenue when the industry has more oligopoly power. Conversely, if $\sigma > |\eta| = 0.5$, which means that inputs a and b are gross substitutes, the compensative effects became bigger when conjectural elasticity increases. For example, in scenario 1 where $\rho = 0.8$, if $\sigma = 0.6$ the scale parameters range from 2.209 when $\xi = 0.1$ to 2.110 when $\xi = 0.4$, a 4.5% decrease.

Although increasing returns enhances the compensative effect, it also accelerates the growth speed of the scale parameters caused by increasing substitute elasticities. For example, in the case

of $\xi = 0.2$, the scale parameters range from 1.087 to 2.198 when $\rho = 0.8$, a 102% growth, while the results range from 1.053 to 2.148 when $\rho = 1.1$, a 104% growth. Furthermore, the increase of returns to scale will reduce the growth speed of scale parameters caused by increasing conjectural elasticities. In particular, in the scenario of $\sigma = 0.2$, the results range from 1.275 to 1.575 when $\rho = 0.8$, a 23.6% growth, while the results range from 1.246 to 1.386 when $\rho = 1.1$, a 11.3% growth.

Effects on the retail market

To show the effects of the tobacco leaf tax rate and procurement price changes on the retail market, tax revenue and farmers' revenue, we set $\eta = -0.5$, $\sigma = 0.2$, and $\xi = 0.28$ as baseline values. We vary ρ between 0.9 and 1.1 to assess the sensitivity of results to returns to scale. In the simulations, a 50% tax cut (from 20% to 10%) is entertained, and the procurement price is increased by the amount necessary to keep tax revenue constant. For example, when $\rho = 0.9$, a 50% tax cut would necessitate a 65.7% increase in the procurement price to keep tax revenue constant. Table 4 gives the simulation results:

In the case of $\rho = 0.9$, a 50% decrease in tax rate will increase the equilibrium quantity of the cigarettes by 0.9%, whereas a 65.7% increase in procurement price will decrease the equilibrium quantity of the cigarettes by 7.1%. The total (or net) effect on equilibrium quantity is a 6.2% decrease. The effect of a 50% decrease in tax rate on tax revenue is equivalent to a 65.7% increase in the procurement price with opposite sign, which reflects the compensative effect. Thus, tax revenue is unaffected. The tax decrease increases equilibrium tobacco leaf quantity 2.3% and the procurement price increase reduces equilibrium leaf quantity 18.0% for a net effect of -15.7%. However, because the increase in the procurement price exceeds the

reduction in equilibrium quantity, farm revenue increases by 50%. Model simulations, therefore, suggest a 50% compensated reduction in the tax rate would increase farm revenue by an equivalent percentage. In 2006 tobacco grower revenues was ￥20.5 billion. The absolute revenue gain, therefore, would be approximately ￥10.25 billion.

The simulation results also indicate that the increase of the returns to scale can reduce the effects of the tax rate and price on the retail market, but it doesn't affect the total effect of the farmer's revenue. For example, the equilibrium quantity of the cigarettes will reduce 5.8% under $\rho = 1$ and 5.5% under $\rho = 1.1$, however the farmer's revenue doesn't change.

Concluding Remarks

The basic theme of this paper is that the increase of the tobacco leaf's procurement price can compensate the tax revenue reduction caused by the decrease of the tax rate. Building on this theme, we develop the model of oligopoly-oligopsony power and varying returns to scale in a multi-stage production system that includes fixed proportions technology as a special case. Results indicate that the derived demand elasticity plays an important role in determining the compensative effects. In particular, in the case of constant returns to scale the derived demand elasticity for tobacco leaf mainly depends on the values of the retail demand elasticity and the substitution elasticity. Therefore, an increase of the values of both retail demand elasticity and substitution elasticity will lead to the more elasticity in demand for tobacco leaf and therefore result in the smaller compensative effect.

The sensitivity analysis results show that the increase of σ and ξ will weaken the compensative effect，while increase of returns to scale can enhance the compensative effect. The market power does influence the compensative effect, however, the factor substitution elasticity

play a pivotal role. Specifically, if $\sigma < |\eta| = 0.5$, which implies that inputs a and b are gross complements, the compensative effects become smaller when the conjectural elasticities increase. Conversely, if $\sigma > |\eta| = 0.5$, which means that inputs a and b are gross substitutes, the compensative effects became bigger when the conjectural elasticity increases.

Under the assumption that tobacco leaf and marketing services are gross complements ($\eta > \sigma = 0.2$) and the market power doesn't change ($\xi = 0.28$), the reduction of the tax revenue which results from a 50% decrease in tax rate can be compensated by a 65.7% to 64% increase in tobacco leaf procuring price. In the case of constant returns to scale, the effects on equilibrium quantity of the cigarettes and the farmer's revenue are significant. A 50% decrease in tax rate and a 64.7% increase in procuring price will lead to a 5.8% decline in the equilibrium quantity of the cigarette and a 50% increase in the farmers' revenue, which are consistent with WHO FCTC's principles. For the effects of returns to scale, the results suggest that the increase of the returns to scale can week the effects of the tax rate and the procurement price on the retail market, but it doesn't affect the total effect on farmer's revenue.

According to economic theory, government controlling price will lead to the inventory problem. However, we ignore this issue for two reasons. First, STMA is a tobacco monopoly agency and has the full information about cigarette production. So STMA can set the quota to adjust the tobacco leaf production. Secondly, the supply of tobacco leaf is inelasticity due to the difficulty of transferring to other crops, which implies price increase cannot produce too much inventory.

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Table 1. Definition and Values of Parameters

Symbol	Definition	Value
η	Retail demand elasticity (absolute value)	0.35,0.5,0.84
σ	Factor substitution elasticity	0,0.2,0.4,0.6
ε_a	Tobacco leaf supply elasticity	∞
ε_b	Marketing services supply elasticity	2
ρ	Returns to scale	0.8,0.9,1,1.1
ξ	Output conjectural elasticity	0.1,0.2,0.3,0.4
θ	Input conjectural elasticity	1
τ	Tobacco leaf tax expressed as a fraction of the initial equilibrium farm price ($= T / P_a = \frac{t}{1-t}$, t is tax rate.)	0.17
S_a	Farmers' cost-share ($= P_a a / P_x x$)	0.1
FR	Farmers' revenue ($= P_s a = \frac{TR}{t}$)	¥20.5 billion
TR	Tobacco leaf tax revenue	¥4.1 billion

Table 2. Compensative Effect for Alternative Values of the Substitution Elasticity and Retail Demand Elasticity

		Substitution Elasticity (σ)			
		0	0.2	0.4	0.6
Demand Elasticity (η)	-0.35	1.160	1.311	1.497	1.732
	-0.5	1.087	1.294	1.606	2.131
	-0.84	1.085	1.318	1.699	2.434

Note: we assume $\mu = \delta = 0$ in response to the exogenous changes in tax rate τ and procurement price p_s .

Table 3. Sensitivity of the Compensative Effect to Conjectural Elasticity, Substitution Elasticity, and Returns to Scale

Returns-to-Scale Parameter	σ	Conectural Elasticities (ξ)			
		0.1	0.2	0.3	0.4
ρ = 0.8					
	0	1.062	1.087	1.141	1.381
	0.2	1.275	1.301	1.355	1.575
	0.4	1.609	1.628	1.670	1.814
	0.6	2.209	2.198	2.175	2.110
ρ = 0.9					
	0	1.052	1.072	1.116	1.294
	0.2	1.262	1.282	1.326	1.487
	0.4	1.593	1.607	1.636	1.732
	0.6	2.192	2.175	2.142	2.050
ρ = 1					
	0	1.045	1.062	1.097	1.238
	0.2	1.252	1.269	1.304	1.428
	0.4	1.582	1.591	1.612	1.677
	0.6	2.180	2.160	2.120	2.010
ρ = 1.1					
	0	1.039	1.053	1.083	1.197
	0.2	1.246	1.259	1.287	1.386
	0.4	1.573	1.579	1.594	1.637
	0.6	2.171	2.148	2.104	1.983

Table 4. Simulated Effects of a Simultaneous 50% Decrease in the Tobacco Leaf Tax Rate and 65.7% Increase in the Procurement Price on Cigarette Consumption, Cigarette Price, Tobacco Leaf Production, Tax Revenue, and Farm Revenue

Variables	$\rho = 0.9$			$\rho = 1$			$\rho = 1.1$		
	$\overline{P_s}^*$	t^*	total	$\overline{P_s}^*$	t^*	total	$\overline{P_s}^*$	t^*	total
x^*	-0.071	0.009	-0.062	-0.067	0.009	-0.058	-0.063	0.008	-0.055
P_x^*	0.141	-0.018	0.123	0.133	-0.017	0.116	0.126	-0.017	0.109
a^*	-0.180	0.023	-0.157	-0.169	0.022	-0.147	-0.161	0.021	-0.140
TR^*	0.477	-0.477	0.000	0.478	-0.478	0.000	0.479	-0.479	0.000
FR^*	0.477	0.023	0.500	0.478	0.022	0.500	0.479	0.021	0.500