How Do Smokers Respond to Cigarette Taxes? Evidence from China's Cigarette Industry*

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Abstract

This paper examines how Chinese smokers respond to tax-driven cigarette price increases by estimating a discrete choice model of demand for differentiated products, using annual nationwide brand-level cigarette sales data in China from 2005 to 2010. We allow for substitutions between different cigarette brands and also incorporate key features of rational addiction theory into the model. Results show that the overall own-price elasticity for cigarette at the brand level is −0.805 in China, and that high-price brands have greater own-price elasticities than low-price brands. We find tax-induced substitution towards low-price cigarettes as well as high-tar cigarettes, and that tax hikes encourage within-class substitution more than across-class substitution. These results have important policy implications for the potential impacts of cigarette taxation.

Keywords: cigarette demand, discrete choice models, substitution, cigarette tax

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1. Introduction

Cigarette smoking is widely regarded as a leading cause of preventable illness and death in the world. Most countries have implemented various policies to reduce smoking, such as price increases through higher taxes, advertising and promotion bans, smoking restrictions, consumer education campaigns, and smoking cessation therapies. Numerous studies have shown that cigarette taxation is one of the most effective strategies (e.g. Keeler et al., 1993; Sung et al., 1994; Chaloupka and Warner, 2000), which can not only directly discourage the consumption of cigarette by price increase, but may also be earmarked for other publicly-funded tobacco interventions (Chaloupka et al., 2001; Tsai et al., 2003).

As the largest producer and consumer of cigarettes in the world, China had an estimated 301 million adult smokers and the smoking prevalence among adult men attained 52.9% in 2010 (Li et al., 2011). About two million people in China die from smoking-related diseases each year (WHO, 2010). To address this critical public health concern, China's government has endeavored to control tobacco use through various channels, but with limited success(Hu, 2006; Kenkel et al., 2009). Compared to other countries, cigarette prices are very low in China (WHO, 2010); moreover, the government has not implemented strong pricing and taxation measures to reduce cigarette smoking. There is considerable uncertainty about the likely success of cigarette taxation in China. First, there is limited evidence on Chinese consumers' sensitivity to cigarette prices and other behavioral responses. Second, the Chinese government has been cautious on major cigarette taxation overhaul since raising tobacco taxes may have a negative impact on employment and tax revenues from the tobacco industry, due to reduced cigarette consumption (Bishop et al., 2007; Hu et al., 2010).

To shed light on this issue, the present study examines how Chinese smokers respond to tax-driven cigarette price increases by estimating a discrete choice model of demand, using annual nationwide cigarette sales data on more than 75 cigarette brands during 2005 to 2010. Our approach makes several contributions to the literature. First, unlike prior studies, we allow for product differentiation in this market. Second, we employ brand-level data. These two features of our empirical model allow for substitution across cigarette brands and help us to quantify smokers' brand-switching behaviors. Third, we estimate not only own-price but cross-price elasticities of cigarette consumption as well at the *brand* level. Using the estimate parameters from the demand model, we then conduct numerical simulations to investigate the potential impact of proposed tax increases on cigarette sales, government revenue from cigarette taxes, and total tar and nicotine intakes.

There are several reasons to model the cigarette market, especially China's cigarette market, as one consisting of differentiated products. There are more than 100 cigarette brands in China which differ significantly in terms of quality and price. Treating cigarettes as differentiated products allows us to better understand that, when faced with price changes, consumers can not only choose the quantities of cigarette to smoke (e.g. choose smoking or not smoking; or choose more or less cigarettes to smoke), but may also choose different kinds of cigarettes to smoke (e.g. switch to less expensive brands when cigarette prices increase). As a result, we are able to calculate own-price as well as cross-price elasticities across cigarette brands. Therefore, given a tax-induced increase in cigarette prices, our model is able to account for substitution across different cigarette brands, and examine a richer set of smoker responses to cigarette price increases.

What responses might one expect to observe with tax-induced cigarette prices increases? First, smokers may try to maintain the number of cigarettes consumption and control the tax-induced financial burden by switching to less expensive brands of cigarettes (Wiltshire et al., 2001; Tsai et al., 2005). Second, since cigarette smoking is addictive, there may be another important type of compensating behavior that is biological. Cigarette taxes are levied per unit, independent of cigarette yields of nicotine (which is the major psychoactive agent in tobacco) and tar (which is associated with taste). A tax increase would lead to an increase in the price per unit of tar and nicotine in low-yield brands, relative to high-yield brands. Thus, when faced with the forced reductions in the number of cigarettes consumed, smokers may compensate by switching to cigarettes higher in tar and nicotine content to maintain their current levels of tar or nicotine intakes. As health risks of smoking are correlated with average daily tar and nicotine intake (e.g. Stellman and Garfinkel, 1989), such tax-induced compensating behavior may undermine the effectiveness of cigarette taxation with regard to the health of smokers (Harris, 1980).

A number of recent studies have shown significant evidence of smokers' compensatory behavior in response to tax changes using individual-level data from the US or Taiwan (Evans and Farelly, 1998; Farelly et al., 2004; Tsai et al., 2005; Adda and Cornaglia, 2006; Abrevaya and Puzzello, 2012; and Adda and Cornaglia, 2012). However, very few studies in the literature on cigarette demand have treated cigarettes as differentiated products. Three notable exceptions are Tan (2006), Cilliberto and Kuminoff (2011), and Qi (2013). They apply differentiated product models to study the cigarette market in the US. However, these studies focus on the effects of major policy changes on firms' behaviors. In contrast, we focus on the demand side, studying the effects of tax-induced increases in cigarette prices on consumers' smoking behaviors.

By studying cigarette demand in China, this paper is also related to a growing empirical literature on the effects of price on cigarette demand in low- and middle-income countries, a topic of considerable policy interests given the growth in cigarette consumption in many of these countries. It is widely argued that smokers in developing countries are likely to be more sensitive to the price of cigarettes than those in developed countries (Warner, 1990), given their relatively low initial smoking, low incomes (Warner, 1990) and education levels (Chaloupka et al., 2000). Consistent with this argument, studies on Papua New Guinea (Chapman and Richardson, 1990), and Bulgaria (Sayginsoy and De Beyer, 2002) report estimated price elasticities that range from -0.8 to -1.42, considerably higher in magnitude than the average estimates of about -0.4 (with a narrower range -0.3 to -0.5) for the

US and other industrialized countries (Warner, 1990; Lance et al., 2004; Wilkins et al., 2004). The limited studies focusing on smokers in China find a wide range of price elasticities of cigarette consumption. Lance et al. (2004) find that the price elasticity is low, with a range of 0 to -0.15 in China, using longitudinal household and community survey data in China. However, Bishop et al. (2007) obtain an elasticity estimate of -0.5 using individual data in urban China in 1995. Chen and Xing (2011) use another household survey data covering eight provinces in northern China from 1999 to 2001 and find an overall price elasticity ranging from -0.35 to -0.82, depending on different model specifications.

Most of the above literature has treated cigarettes as a homogenous good so that consumers can only choose to smoke fewer cigarettes when cigarette prices increase. Therefore, they tend to overestimate the magnitude of own-price elasticity of cigarette demand (i.e. underestimate the price sensitivity) because they do not allow for smokers' substitution behaviors. Chen and Xing (2011) is the first study to control for smokers' choice of cigarettes quality when estimating price elasticity of cigarette demand in China. They measure a household's choice of different cigarette quality by calculating the unit costs of cigarettes that the household consumes (i.e. total expenses on cigarettes divided by the total quantity of cigarette consumption). In our study, we define differentiation in cigarettes at the *brand* level in terms of differentiation in brand characteristics (e.g. price, nicotine, tar, and carbon-dioxide yields). Therefore, we allow for more specific measures of differentiation in cigarette quality than the unit-value measure, and are able to obtain more realistic substitution patterns of cigarette demand, enhancing the accuracy of our policy simulations.

In addition, we incorporate key features of rational addiction theory (Becker and Murphy, 1988; Ciliberto and Kuminoff, 2011) into our model. Thus in our model, consumers' smoking decisions are affected not only by the characteristics of cigarette brands, but also by their past cigarette consumption as well as their expectations with respect to future cigarette prices.

The remainder of the paper is organized as follows. Section 2 briefly describes the institutional background of China's tobacco industry and cigarette taxation policies. Section 3 describes the data used in this paper. Section 4 introduces our econometric model and estimation strategy. Section 5 presents our empirical findings, and Section 6 concludes.

2. Industry Background

China is the largest producer and consumer of tobacco products in the world, where thirty percent of the world's cigarettes are consumed. China's tobacco industry is tightly regulated by the government, with farming, production, distribution, sales, and marketing of all tobacco and tobacco products in China are under the control of China National Tobacco Corporation (CNTC), a state-owned monopoly. The State Tobacco Monopoly Administration (STMA) is the regulatory agency in charge of enforcing related policies for tobacco and cigarette products in China. Although the CNTC and the STMA were intended to be two separate entities in principle, in practice they function as one organization with two name plates, performing both functions of management and regulation.

CNTC has approximately 40 cigarette manufacturers with locations in every province in China except Tibet. These manufacturers are responsible for cigarette production, while the distribution sector of CNTC is in charge of cigarette sales. STMA directly sets and controls the retail price of every cigarette brand in China through its licensing system because only licensed retailer can legally sell cigarettes in China.

There are over 100 domestic cigarette brands in the market (Li et al., 2010). Foreign brands have been introduced into the market since China entered the World Trade Organization in 2001, but they only account for about 3 percent of the Chinese market. Figure 1 shows that the top 50 best-selling cigarette brands account for 54.7 to 88.3 percent of all cigarettes sales in China in a given year from 2005 to 2010.

[Insert Figure 1 here]

Figure 2 depicts the evolution of market shares of several best-selling cigarette brands in China during the period 2005-2010. It reveals that the Chinese cigarette market has two key features. First, it is much less concentrated than those in other developed countries. For example, the best-selling brand of 2010 in China, Hongtasha, comprise only 6.2% of the market, whereas the most popular cigarette in the US, Marlboro, had a 42% share of the US retail market in the same year. Second, from Figure 2 we can also see that the market shares of those popular brands have been increasing steadily from 2005 to 2010. For example, the market share of Hongtasha has increased four-fold, becoming the brand with the highest growth rate. It suggests that although there are many brands competing in China's cigarette market, the top brands have indeed been gaining market share and market power during the period 2005-2010. Thus, this industry has become more concentrated during the period of our study.

[Insert Figure 2 here]

Within each brand there are also multiple varieties differing in terms of price and quality.. The price of a pack of 20 cigarettes is relatively low, with a median 6 RMB, which is less than $1 US.[1] According to the quality of tobacco leaves and the price of cigarettes, Chinese cigarettes are classified into five grades (grade 1 to grade 5, and higher is better) by the CNTC.

The cigarette tax in China consists of a specific excise tax and an ad valorem tax. Before May 2009, the specific excise tax was 0.06 RMB per pack, the same for all cigarettes. The ad valorem tax rate had two tiers: 30% for cigarettes with a producer price[2] less than 5 RMB per pack, called class B cigarettes which include cigarettes of

[1] The yearly average exchange rate for 2010 is that 1 US dollar=6.78 Chinese Yuan RMB.

[2] Producer price is the internal price the distribution sector of CNTC pays to its manufacturers.

grades 1 and 2, and 45% for cigarettes with the producer price higher than or equal to 5 RMB per pack, called class A cigarettes which include cigarettes of grades 3, 4 and 5.

[Insert Table 1 here]

In May 2009, there was an adjustment to the cigarette tax rate schedule, announced by the Chinese government. As shown in Table 1, the specific excise tax of 0.06 RMB per pack remained unchanged. But the ad valorem tax rates were raised to 36% and 56% and the price band separating the two tiers was increased to 7 RMB per pack from 5 RMB per pack. Most cigarettes sold are subject to the 36% ad valorem excise. In addition, a new 5% excise was added at the wholesale level for all cigarettes. At the same time, the government also required the CNTC to absorb all of the tax increase from its profits and not pass it on to consumers. Thus, the 2009 tax adjustment has not served as a tobacco control measure, but a transfer from CNTC to the government, which has not increased the retail prices of cigarettes to consumers (Gao et al., 2012).

Studies have shown that the total cigarette tax burden in China was about 35-40 percent of the retail price level under the tax schedule in effect before May 2009 (Sunley, 2008; Hu et al., 2008). Even if the 2009 tax increase were translated into higher retail prices, Hu et al. (2010) suggest that the new tax rate at the retail price level would be only 43.4%, which is still far below the world median level of 65-70%. Relative to other developed countries, these studies imply that the Chinese government has not implemented increased cigarette taxes as an aggressive tobacco control policy, possibly reflecting concerns about smokers' potential responses to tax-induced increases in cigarette price as well as its potential impacts on government tax revenue and the tobacco industry (Hu et al., 2010).

3. Data and Variables

In this study we use annual nationwide cigarette sales data at the brand level from 2005 to 2010, which comes from multiple sources. This section describes the data sources, and how study variables are defined and constructed.

3.1 Cigarette Brand Sales

We obtain cigarette sales data from two sources: *Global Market Information Database* and *China Tobacco Year Book* 2005-2010. The former tracks the sales data of various cigarette brands in China from 2005 to 2010, while the latter mainly collects the sales data of the top 50 best-selling cigarette brands in China. We combine these two sources of sales data and exclude brands having tiny market shares (less than 0.1 percent). Thus, we obtain 49 to 65 brands each year and 348 brand-year observations from 2005 to 2010.

Since not smoking, the outside good in our model, is also a choice same as each cigarette brand for consumers, we need to redefine the market to incorporate the option of not smoking, and adjust the market share for each cigarette brand (including not smoking) with respect to the market size under this market definition. Our definition of market is the potential cigarette market in China, and the size for this market is the number of cigarette would be sold if all population aged 15 and above[3] are smokers.

We use various sources to estimate the above potential market size for cigarette consumption in China. We first collect information on smoking participation in China. The major sources of such information are two waves of the *Analysis Report of National Health Services Survey in China* conducted by the Ministry of Health of China in 2003 and 2008, respectively, and the *Global Adult Tobacco Survey China* (GATS China) conducted in 2010 by WHO. The first two surveys by the Ministry of Health estimate that the prevalence of smoking in the Chinese population aged 15 and above was approximately 26.0% in 2003 and 25.8% in 2008, and GATS China

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[3] China tracks smoking prevalence among adults aged 15 or older, and use it to calculate smoking participation rate.

estimates indicate that smoking prevalence was 28.1% in 2010. We then infer smoking prevalence rate in other years of our study period 2005-2010 by interpolating the average growth rate in smoking prevalence from 2003 to 2010 using these three available numbers. Therefore, assuming that the number of cigarettes consumed in each year is the same for every smoker, we construct our measure of relative market share for each brand by dividing its observed market share by the smoking prevalence rate in each year, which is the market share of each cigarette band (including the option of not smoking) relative to the size of the potential cigarette market we have defined above.

[Insert Table 2 here]

3.2 Brand Price and Characteristics

The data on cigarette prices and characteristics are obtained from STMA. For cigarette price, this dataset contains the suggested retail price per pack for each variety within each cigarette brand. However, since we only have cigarette sales data at the brand level, we use the average price of all the varieties within each brand as the brand price. All prices are deflated to RMB in 2005. As summarized in Table 2, the descriptive statistics show that the average retail price for a pack of 20 cigarettes is about 7.85 RMB in our sample, but varies substantially by brand, ranging from 1.9 RMB to 42 RMB.

For each cigarette brand in our sample, we have four variables for brand characteristics.[4] The first three variables measure tar, nicotine and carbon monoxide (CO) yields of each cigarette brand, respectively, defined as milligrams per cigarette. Both tar and nicotine are associated with the sensory experience of cigarette smoking. More specifically, tar content influences the taste of cigarettes, while nicotine is the major psychoactive agent in tobacco responsible for the addictive properties of cigarettes. Again, although we have variety-specific data for these three measures, we

[4] The values for all the four characteristics of not smoking are defined as zero.

use the average content across different varieties within each brand as the brand-level yields to match our market share data at the brand level. Similar to the U.S. cigarette market (Evans and Farrelly, 1998), we find little price difference between low- and high-yield cigarettes.[5] The last variable measuring brand characteristics is the number of varieties within each brand, and on average, each brand includes 6 to 7 varieties as shown in Table 2.

Compared to class B (lower-tier) cigarette brands, class A (higher-tier) brands have slightly greater market shares and more varieties within the brand class. Moreover, the tar yield of class A cigarette brands is higher than that of class B brands.

3.3 Rational Addiction

The rational addiction literature suggests that there is a dependence of smokers' current smoking behavior on their *past* cigarette consumption (Chaloupka, 1991; Becker et al., 1994), and that smokers are forward-looking with respect to future prices of cigarettes (Gruber and Köszegi, 2001; Coppejans et al., 2007). To capture these features,, we construct two variables.

The first variable measures smoking addiction of an individual consumer. Ideally, we should have an addiction measure that is brand-specific. However, we do not have data on the number of smokers for each brand. Therefore, we construct an addiction measure that is year-specific but the same for all cigarette brands in a given year as follows. First, we obtain the estimated number of smokers in each year, according to smoking prevalence rate and population data from the *Chinese Population Census*.

[5] For example, the average price of cigarettes with nicotine greater than or equal to 1.1mg/cigarette (high yield) is 7.72 RMB/pack with a standard deviation of 7.43 RMB/pack (224 observations), and the average price of cigarettes with nicotine less than 1.1mg/cigarette (low yield) is 8.08 RMB/pack with a standard deviation of 4.21 RMB/pack (124 observations). Statistical testing using the standard *t* tests revealed no significant price differences between high- and low-yield cigarettes in China, which is consistent with the findings in the US (Evans and Farrelly, 1998).

Then, we calculate the average smoking intensity per person in each year by dividing the annual total cigarette sales by the estimated number of smokers. We use this measure of smoking intensity at year $t-1$ as the measure for addiction at year t. Furthermore, we normalize the addiction measure to 1 in 2005.

The second variable is constructed to measure consumers' expectations about the future cigarette prices. As cigarette prices are regulated by STMA in China, the prices of most cigarette brands change little over time during our study period. Therefore, we calculate the sales-weighted average price at the manufacturer level and use changes in this measure to reflect consumers' expectations about cigarette price trends. Following Ciliberto and Kuminoff (2011), we construct a binary variable that is equal to 1 if, for any particular manufacturer, the sales-weighted average price of all of its cigarette brands in period t is higher than that in period $t-1$, and equal to zero otherwise. It is implicitly assumed here that smokers predict future cigarette prices based on past price changes, i.e. current price increases could signal an increasing price trend in the future, which is consistent with Gruber and Köszegi (2001) and Sloan et al. (2003).

4. Empirical Methods

In this study, we follow Berry's (1994) theoretical framework by modeling cigarettes as differentiated products rather than a homogenous good, and estimating the demand for cigarettes in China using brand-level sales data. In our model, consumers not only choose between smoking and not smoking, but also make choices among different brands when choosing cigarettes. We are able to obtain cross-brand substitution patterns which could not be identified in previous studies based on models treating cigarettes as homogenous goods.

4.1. Model

We use a nested logit model to model consumers' demand for differentiated cigarettes and obtain the demand parameters. The nested logit model has the advantage over the simple logit model in that it is not subject to the traditional problem of independence from irrelevant alternatives (IIA). The nested logit model allows consumers' tastes for cigarette brands to be correlated across different alternatives while preserving the assumption that consumers' tastes have an extreme value distribution (McFadden, 1981; Berry, 1994).

We model a consumer's cigarette purchase decision in a sequential fashion. More specifically, at the top level of the decision process, a consumer has to decide to smoke cigarettes or not. After deciding to smoke, the consumer's second-level decision is to choose from among cigarette brands with different quality/price tiers. According to the official classification criteria of the CNTC, we group cigarettes into two classes, $g = 1, 2$, corresponding to higher-tier (class A) and lower-tier (class B) cigarettes, respectively. At the lowest level, the smoker chooses the cigarette brand to purchase given the cigarette class that has been chosen. To summarize, each consumer i chooses among $J + 1$ alternatives (including not smoking) according to the above decision process, where J denotes the number of cigarette brands available in China's cigarette market in a given year.

We assume that the utility of consumer i derived from purchasing the cigarette brand j at period t is determined by the following equation

$$u_{ijt} = x_{jt}\beta - \alpha p_{jt} + \varphi a_t + \phi p^e_{j,t+1} + \xi_{jt} + \gamma_{it}(\sigma) + (1 - \sigma)\varepsilon_{ijt} \qquad (1)$$

Where x_{jt} is a vector of the observed characteristics of cigarette brand j at period t; p_{jt} denotes the price of cigarette brand j at period t; a_t is our measure of smokers' degree of smoking addiction, proxied by the number of cigarettes an average smoker consumes in period $t - 1$; and $p^e_{j,t+1}$ is a binary variable that measures smokers' expectation about the price change at period $t + 1$. β, α, φ, and η are structural parameters to be estimated. As implied by rational addiction theory, we expect that $\varphi > 0$ and $\phi < 0$.

In equation (1), ξ_{jt} represents the attributes of cigarette brand j at period t that are observed by consumers and firms, but unobserved by the econometrician, such as firms' advertising efforts. ε_{ijt} represents consumers' idiosyncratic tastes for brand j at period t. We assume that ε_{ijt} is an identically and independently distributed extreme value over each brand $j = 1, 2, \cdots, J$ and period $t = 1, 2, \cdots, T$. σ denotes the nested logit parameter which captures the correlation of consumers' tastes between different cigarette brands within the same group. Finally, γ_{it} is a random variable with a unique distribution such that the additive term $[\gamma_{igt}(\sigma) + (1-\sigma)\varepsilon_{ijt}]$ also follows extreme value distribution.

The utility from the decision not to smoke cigarettes is given by

$$U_{i0t} = \gamma_{i0t}(\sigma) + (1-\sigma)\varepsilon_{i0t} \qquad (2)$$

We let $\delta_{jt} \equiv x_{jt}\beta - \alpha p_{jt} + \varphi a_t + \phi p^e_{j,t+1} + \xi_{jt}$, which is the mean utility level of brand j at period t,. Consumer i is assumed to choose the alternative j among all $J+1$ alternatives that yields the highest level of utility. As noted by Berry (1994), the market share of brand j at period t, denoted by s_{jt}, is determined by the following equation:

$$s_{jt} = \frac{e^{\delta_{jt}/(1-\sigma)}}{D_{gt}^{\sigma}[1+D_{gt}^{1-\sigma}]} \qquad (3)$$

where

$$D_{gt} = \sum_{j \in M_{gt}} e^{\delta_{jt}/(1-\sigma)} \qquad (4)$$

and M_{gt} is the set of brands in group g at period t. Note that there are three groups in each period: higher-tier (class A) cigarette brands ($g = 1$), lower-tier (class B) cigarette brands ($g = 2$) and the outside option (not smoking, $g = 0$).

Following Berry (1994), the log transformation of relative brand share gives our estimating equation as follows:

$$ln(s_{jt}) - ln(s_{0t}) = x_{jt}\beta - \alpha p_{jt} + \varphi a_t + \phi p^e_{j,t+1} + \sigma\, ln(s_{jt|gt}) + \xi_{jt} \quad (5)$$

where s_{0t} is the market share of the outside alternative, and $s_{jt|gt}$ is the market share of cigarette brand j in the group g at period t.

(6)After obtaining estimates of the demand parameters, we are able to calculate the own-price and cross-price elasticities of demand for each brand. The own-price elasticity of demand for brand j at period t, is given by

$$\eta_{j,j,t} = \frac{\partial s_{jt}}{\partial p_{jt}}\frac{p_{jt}}{s_{jt}} = \alpha p_{jt}\left(\frac{\sigma}{1-\sigma}s_{jt|gt} + s_{jt} - \frac{1}{1-\sigma}\right),\ \ j \in M_g; g = 0, 1, 2 \quad (6)$$

The cross-price elasticity of demand between brands j and k at period t is given by

$$\eta_{j,k,t} = \frac{\partial s_{jt}}{\partial p_{kt}}\frac{p_{kt}}{s_{jt}} = \alpha p_{kt}\left(\frac{\sigma}{1-\sigma}s_{kt|gt} + s_{kt}\right),\ \ j \neq k, j \in M_g, k \in M_h, g, h = 0,1,2 \quad (7),$$

When $g = h$, we obtain the within-class-cross-price elasticity of demand from equation (7). Otherwise, equation (7) becomes $\alpha p_{kt} s_{kt}$, which is the cross-class-cross-price elasticity of demand.

4.2. Estimation and Identification

Inspecting equation (5), we are confronted with potential endogeneity of some of the regressors, due to the brand-specific unobserved attributes ξ_{jt}. As ξ_{jt} captures other important features of brand j at period t that are observed by the consumers and firms but not by the econometrician, it may be correlated with the current and future prices of brand j. For example, if the high quality of a particular cigarette brand is correctly perceived by consumers and the firm, it is able to induce higher willingness to pay so that the firm can charge a higher price and also achieve a greater market share. Therefore, ξ_{jt} may be correlated with p_{jt}. Since consumers form their expectations about future price change based on current prices, expected future price $p^e_{j,t+1}$ may also be correlated with ξ_{jt}. Furthermore, as a function of p_{jt}, brand j's within-market share $s_{jt|gt}$ is also correlated with ξ_{jt}. Thus, The three terms, p_{jt}, $p^e_{j,t+1}$ and $s_{jt|gt}$, may be endogenous in equation (5).

Following the literature (e.g. Berry et al. 1995; Petrin, 2002), we can assume that the observed brand characteristics x_{jt} (including cigarette yields of tar, nicotine and CO, and number of varieties within brand j) are uncorrelated with the brand-specific unobserved attributes ξ_{jt} in equation (5). As the addiction measure a_t is determined at period $t-1$, it can also be treated as exogenous.

To address these endogeneity concerns, we employ a generalized method of moments (GMM) to estimate the parameters in equation (5). The moment condition is

$$E(\xi|Z) = 0 \qquad (8)$$

where Z is the matrix of instrumental variables for the three endogenous variables, p_{jt}, $p^e_{j,t+1}$ and $s_{jt|gt}$.

Let θ denote the vector of parameters to be estimated in equation (5), and define $G(\theta) \equiv Z^{'}\xi(\theta)$. Hansen (1982) shows that the optimal GMM estimators are defined by choosing

$$\hat{\theta} = \underset{\theta}{argmin}\, G(\theta)^{'}WG(\theta) \qquad (9)$$

where W is a symmetric positive definite weighting matrix that may be chosen optimally to minimize the variance of $\hat{\theta}$. We start with using identity matrix as the starting point of W to obtain the consistent initial estimates of the parameters and the optimal weighting matrix. Then, we continue to estimate the model using the new weighting matrix.

For each brand j at each period t, we have two sets of instruments. The first set of instruments includes the sum of cigarette characteristics (tar, nicotine and CO) of other brands produced by the same manufacturer in the same year. The second set of instruments includes the sum of cigarette characteristics (including tar, nicotine, and CO) of all brands produced by other competing manufacturers in the same year. The rationale for using these instruments follows from the optimal pricing in oligopoly models: products facing good substitutes tend to have low markups and thus low prices relative to cost, while products with fewer substitutes tend to enjoy high markups and thus can charge relatively high prices relative to cost. In a differentiated product model as in this study, the similarities between products are measured by the similarity in product characteristics. Therefore, characteristics of other competing brands serve as the valid instruments since they are correlated with product prices (and therefore, with-in market share and expected future prices) , but uncorrelated with product unobserved attributes ξ_{jt}, since product characteristics are assumed to be exogenous. Furthermore, in oligopoly models, markups respond differently to own and rival products. Therefore, to achieve optimality, we use two sets of instruments to distinguish between the characteristics of products produced by the same multi-product firm and characteristics of products produced by competing firms[6].

We also use an additional instrumental variable for p_{t+1}^{e}, which is a binary indicator that is equal to 0 before 2009, and 1 after 2009, when there was an adjustment to the cigarette tax in China. The underlying idea is that the cigarette tax adjustment in 2009 was an exogenous event that imposed additional producer/wholesale taxes on all cigarette brands, and should be uncorrelated with unobserved brand-specific attributes ξ_{jt}. Although the additional tax increase was required by the government to be absorbed from the firms' profits and has not been passed along to the retail price, it may have affected the way the smokers formed their expectations on *future* cigarette prices, perhaps believing that price increases will continue and that firms will be unable to absorb all of these increases. We test the validity of our instruments in section 5.

[6] These types of instruments have been widely used in the empirical industrial organization literature to estimate the demand for differentiated products in many markets (Bresnahan, 1987; Berry et al. 1995. 1999; Petrin, 2002; Nevo, 2000, 2001).

5. Empirical Results

5.1 Estimates for Demand Parameters

Table 3 presents the estimation results from the cigarette demand equation (5) with the log of relative market shares as the outcome variable.

[Insert Table 3 here]

Column (1) of Table 3 presents the OLS estimates for the logit specification of equation (5), which assumes no correlation of consumers' tastes over cigarette brands ($\sigma = 0$), and includes brand prices, smoking intensity, expected price change, four indicators for brand characteristics and a set of year and manufacturer dummies as the regressors. The OLS estimate shows that the price coefficient, which measures the semi-elasticity of demand [7], has a positive value of 0.012 but is statistically insignificant. Column (2) presents the OLS estimates of the nested logit specification of our demand model, which allows one constant correlation of unobserved consumer tastes σ to overcome the IIA problem, and adds the log of within-group market share as the covariate. This estimation result also gives a positive but statistically insignificant estimate of coefficient on price. The positive OLS coefficients on price in both the logit and nested logit estimations suggest upward-sloping demand curves, which provide strong evidence for the endogeneity of cigarette price.

In columns (3) and (4), we adopt 2SLS and GMM estimations, respectively, to control for possible endogeneity in equation (5). The reliability of the IV estimates depends on the validity of the instruments. To test the instruments, we first examine the explanatory power of the instruments, conditional on the included exogenous variables in the first stage regressions for cigarette price p_{jt}, expected price change $p^e_{j,t+1}$, and within-group market share $s_{jt|gt}$. As shown in the bottom of column (3), the F-statistics of the first stages suggest that the instruments are strong (significant at

[7] The semi-elasticity of demand measures the percentage change in the quantity demanded of cigarettes with regards to a unit change in its price.

the 1% level) for each of three endogenous variables. Second, since we have more instruments than endogenous variables, we also perform tests for overidentification restriction. The J-statistics are 5.105 for the 2SLS estimation in column (3), and 5.196 for the GMM estimation in column (4), which suggests that the exogeneity of our instruments cannot be rejected at the 10% level.

As shown in column (3), the 2SLS estimate of coefficient on price is -0.026, and is statistically significant at the 5% level. However, the 2SLS estimation may be subject to bias due to misspecification of functional forms of instrumental variables, when the linear approximations of endogenous variables (e.g. price) on the instrument variables are not precise (Berry, et al. 1995; Xiao, 2008). Therefore, in column (4), we proceed with the GMM estimation as suggested in Berry et al. (1995) and Petrin (2002). The GMM estimate of the price coefficient is -0.021, very similar in magnitude to the 2SLS estimate, but has a higher level of statistical significance (at the 1% level). Both the 2SLS and GMM estimates suggest that cigarette demand is a downward-sloping demand curve.

In column (4), the GMM estimate for the constant correlation of unobserved consumer tastes σ is 0.750, indicating that consumer tastes are positively correlated over different cigarette brands within the same class. This implies that cigarettes within the same class are better substitutes for each other than cigarettes across classes; and when cigarette prices increase, smokers are more likely to switch brands (within the group $\mathrm{g} = 1$ or $\mathrm{g} = 2$) than to quit smoking (across groups).

Consistent with the addictive nature of cigarette consumption, the smoking intensity of an average person (a_t) has a significant and positive impact on the cigarette sales. The coefficient on expected price increase ($p^e_{j,t+1}$) has the anticipated negative sign and is statistically significant, suggesting that smokers may be forward looking with respect to cigarette pricing (Gruber and Köszegi, 2001).

The estimates on brand characteristics show that the concentration of tar is significantly positively correlated with the relative market share of each brand, after controlling for the effect of price. This suggests that smokers are likely to prefer cigarettes with higher tar concentration, which is associated with more intense cigarette flavor. This finding provides some evidence for smokers' compensating behavior in terms of switching from low-tar to high-tar cigarettes when they are forced to consume fewer cigarettes. The coefficient on the nicotine and CO concentrations are statistically insignificant across all specifications in columns (1) to (4). This may simply reflect that these two yields are highly correlated with tar concentration. Finally, the estimate for the number of varieties within each brand is also insignificant in each model specification.

5.2. Demand Elasticities

Table 4 summarizes the own- and cross-price elasticities of demand by year and class based on the GMM parameter estimates in column (4) of Table 3.[8] The sales-weighted average own-price elasticity across all brands and years is −0.805, which is larger in magnitude than the estimates of price elasticities (around −0.5) in other studies of China's cigarette market in the 1990s (e.g. Hu and Mao, 2002; Lance et al., 2004; Bishop et al., 2007). This may reflect that those prior studies have treated cigarettes as a single homogenou product and thus do not allow for substitution between different brands of cigarettes (e.g. between expensive or cheap cigarettes, or between high- and low-tar cigarettes). Our estimate is close to that in Chen and Xing (2011) who attempt to estimate the price elasticities of cigarettes after netting out the heterogeneous quality effect of cigarette demand, and find the price elasticity of cigarette demand in the range of −0.81 to −0.35, based on urban household survey data from 1999 to 2001.

[Insert Table 4 here]

[8] The estimates are short-run elasticities in the sense that they are calculated holding the (expected) future prices constant.

The own-price elasticities for class A cigarettes had an increasing trend in magnitude during 2005 to 2010, while there was no clear pattern for class B cigarettes. The results in Panel I also reveal that the own-price elasticities are greater in magnitude for class A cigarettes than for class B cigarettes in each year as well as on average. This implies that smokers using low-priced cigarettes are less responsive to price changes than smokers using high-priced cigarettes, which is consistent with findings by Cummings et al. (1997) in the US and Li et al., (2010) in China. The intuitions behind these results are twofold. First, smoking is addictive, and therefore smokers have a tendency to keep the level of cigarette consumption unchanged when cigarette prices increase. Smokers of high-priced cigarettes can opt for low-priced brands when cigarette prices increase, while smokers of low-priced cigarettes cannot. As a result, high-priced cigarette brands may exhibit higher own-price elasticities. Second, due to budget constraints, smokers that are more heavily addicted may tend to consume cigarettes with lower prices, and at the same time, they are also less likely to quit smoking. This may also lead to less price sensitivity among users of low-priced cigarettes.

Panels II and III in Table 4 present the within- and cross-group cross-price elasticities, respectively. The estimated within-group cross-price elasticities have an overall average of 0.146 across all years and groups, and range from 0.105 to 0.195, and they are higher for class B cigarettes than for class A cigarettes. These results imply that the substitution effects between different brands are stronger among low-priced (class B) cigarette brands than among high-priced (class A) brands.

As shown in Panel III, the estimated cross-group cross-price elasticities vary from 0.016 to 0.049, with a sales-weighted average of 0.024 across years and groups, which is much smaller in magnitude than the within-group cross-price elasticities. This suggests that smokers are more likely to switch cigarette brands within each group than across groups when cigarette prices change. Meanwhile, we also find that the cross-group cross-price elasticities are larger in magnitude for class B brands than for class A brands, which suggests that the price change of more expensive (class A) brands has a larger positive impact on the sales of low-priced (class B) cigarettes than the price change of class B brands on class A brands.

5.3. Simulated Effect of a Tobacco Tax Increase

Tobacco taxes have been widely adopted as one of the most effective tobacco policies in many countries. In China, there has also been extensive discussion about raising cigarette taxes to reduce smoking prevalence. Many studies suggest that the ultimate goal of cigarette tax increase in China is to raise the specific excise tax to 4 RMB per pack, so that the total tax burden on cigarettes would meet the World Bank yardstick of two-thirds of the retail price level. Meanwhile, a feasible way to achieve this goal is first to raise the tax to 1 RMB per pack from the current level of less than 0.06 RMB per pack, and increase gradually to 4 RMB per pack, in order to alleviate the impacts to the cigarette industry (Hu et al., 2008; Sunley, 2009; Chen and Xing, 2011). Therefore, in this subsection, we simulate a cigarette tax increase by 1, 2, 3, and 4 RMB per pack, respectively, and calculate their impacts on cigarette consumption, government tax revenues, and total tar and nicotine intake, based on our estimated demand equations for cigarettes in China.

Our demand estimates imply that, on average, cigarette demand is inelastic with sales-weighted own-price elasticity -0.805. While setting prices on the inelastic portion of the market demand curve is inconsistent with profit maximization (i.e. setting prices below the optimum level),[9] this may reflect the tight government regulation of China's cigarette industry. Although the CNTC itself is a virtual monopoly in the Chinese cigarette market, it cannot set prices freely in order to maximize profits[10]. Therefore, in the following simulations, we assume that the CNTC directly sets the retail prices of cigarettes at levels as directed by the

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[9] Ciliberto and Kuminoff (2011) also find inelastic own-price elasticities at the variety-level in the US.

[10] For example, when government increased the cigarettes tax, the CNTC was asked to absorb the tax increase and keep the retail price of cigarette unchanged.

government after the cigarette tax increase. For example, after implementing the proposed 1 RMB specific-tax hike, we assume that the CNTC would increase the retail price per pack by 1 RMB for each brand[11].

We consider four scenarios where the specific excise tax increases by 1, 2, 3, and 4 RMB per pack, respectively. Cigarette sales were approximately 11.90 billion packs in 2010 and 10.83 billion packs on average during the period 2005-2010. The simulated results in Table 5 show that cigarette sales would be reduced by 8.8 percent, a reduction of 7.37 billion packs when 1 RMB excise tax is levied. Our estimates are smaller in magnitude than those in other studies of Chinese smokers (e.g. Hu et al., 2010; Chen and Xing, 2011), which give no consideration for substitution effects due to price increases and therefore tend to overestimate the potential effect of a cigarette tax increase on cigarette consumption. Moreover, an excise tax of 2, 3 or 4 RMB per pack would result in cigarette sales reductions of 12.8 percent, 22.8 percent and 32.7 percent, respectively.

[Insert Table 5 here]

As shown in rows (3) and (4), an increase in the tax level of 1, 2, or 3 RMB per pack would increase total tax revenue from cigarettes by 3.5 percent (100.87 billion RMB), 4.4 percent (116.80 billion RMB), and 5.1 percent (151.15 billion RMB) respectively. However, a 4 RMB excise tax per pack would lead to a decrease in total tax revenue of 1.5 percent, which is about 41.67 billion RMB.

In addition to the quantity of cigarette consumption, we are also interested in simulating the potential effect of a cigarette tax increase on other risk factors associated with smoking—the total intakes of tar and nicotine. Because taxes are independent of tar and nicotine content, smokers may compensate by switching to

[11] Ciliberto and Kuminoff (2011) use the cigarette minimum prices mandated by each State in the US as the marginal costs cigarette brands with inelastic own-price elasticities. However, there are no similar measures as minimum prices in China that can help us to identify marginal costs. Meanwhile, the virtual monopoly of the CNTC makes our assumption of perfect retail price mandate very reasonable.

cigarettes that are higher in tar and nicotine content. As expected, we find that, although total tar intake would be reduced as cigarette consumption declined due to tax-induced price increases, the decrease in the total intake of tar would be 2-3 percent less than the total reduction in cigarette sales, and such differences are all statistically significant at the 95% level. Moreover, as excise taxes are raised, the average tar levels per cigarette[12] would rise by 2.76%, 2.60%, 3.92% and 5.23% for the specific tax of 1, 2, 3, 4 RMB per pack, respectively. This tax-induced compensating behavior is consistent with the findings of Evans and Farrelly (1998).

In contrast, we do not find such tax-induced compensating patterns for nicotine. The simulation results show that tax increases would cause total nicotine intake to decrease by about 8.7% to 35.6% for different tax hikes, similar to the percentage change in cigarette consumption, while the average nicotine level per cigarette would have little change.

6. Conclusion

When countries propose increasing cigarette taxes to reduce smoking prevalence, it is vital to understand the behavioral changes of smokers as their responses to tax-induced price increases. To our knowledge, this paper is the first attempt to apply the discrete choice model of differentiated products to study China's cigarette market, and estimate own-price as well as cross-price elasticities of cigarette demand at the brand level. Based on annual nationwide sales data from 2005 to 2010, our results suggest that on average, cigarette demand is inelastic in China with a sales-weighted overall own-price elasticity of −0.805, and high-priced (class A) cigarettes have higher own-price elasticities than low-priced (class B) cigarettes.

This study confirms the importance of brand-switching behavior of smokers as their responses to tax-induced price increases, and identifies the substitution patterns

[12] To calculate the average tar/nicotine level per cigarette, we divide the total tar or nicotine intake by the total number of cigarette sales in each scenario.

in China's cigarette market. We find that substitution is more likely to occur among brands in the same class than across classes when cigarette prices change. The average within-class cross-price elasticity is 0.146, while the average across-class cross-price elasticity is only 0.024. We also demonstrate that Chinese smokers have a preference for cigarettes with higher concentration in tar, providing empirical evidence for smokers' compensatory behavior (Evans and Farelly, 1998; Farelly et al., 2004; Tsai et al., 2005; Adda and Cornaglia, 2006). In other words, smokers may not only switch to low-priced brands but also shift to high-tar cigarettes when cigarette prices increase. However, must be noted that, because we only have brand-level data, smokers' substitution behavior may still be underestimated, as they can switch among the varieties within the same brand.

Our results have important implications for the potential effects of cigarette taxation. Given a tax-induced price hike, previous studies only consider the options of reducing or quitting smoking and may thus overestimate the impact of excise tax policies on cigarette consumption. Incorporating smokers' brand-switching behavior, our simulation results show that the proposed 1-RMB-per-pack increase in specific tax will decrease on average 7.26 billion packs (about 8.69%) of cigarette consumption, and increase annual tax revenue by 99.38 billion RMB (about 3.46%). This suggests that raising taxes alone may not reduce smoking to the degree previously believed[13], but it will still be an effective policy instrument for controlling tobacco use and raising tax revenue in China.

The simulations also suggest that with an additional 1 RMB per pack excise tax increase, the average tar level per cigarette would increase by 2.72%, and total tar intake would be reduced 2-3 percentage point less than the reduction in cigarette consumption. Studies have shown that tar intake is the primary cancer-causing agent in cigarettes (Stellman and Garfinkel, 1989). Our findings indicate that smokers' tax-induced compensating behavior may undermine the effectiveness of increasing

[13] For example, previous studies show that an additional 1 RMB excise tax will lead to the reduction of cigarette consumption by 16.75% if the own-price elasticity is -0.80 (Chen and Xing, 2011), or by 9.25% if the own-price elasticity is -0.50 (Hu et al., 2010).

cigarette taxes as a policy instrument to promote public health, as current cigarette excise taxes are levied per pack, regardless of the tar content per cigarette. To maximize the health benefits of a cigarette tax increase (Harris, 1980), it would be more appropriate for the government to establish differential cigarette taxes based on tar and nicotine content of cigarettes in China.

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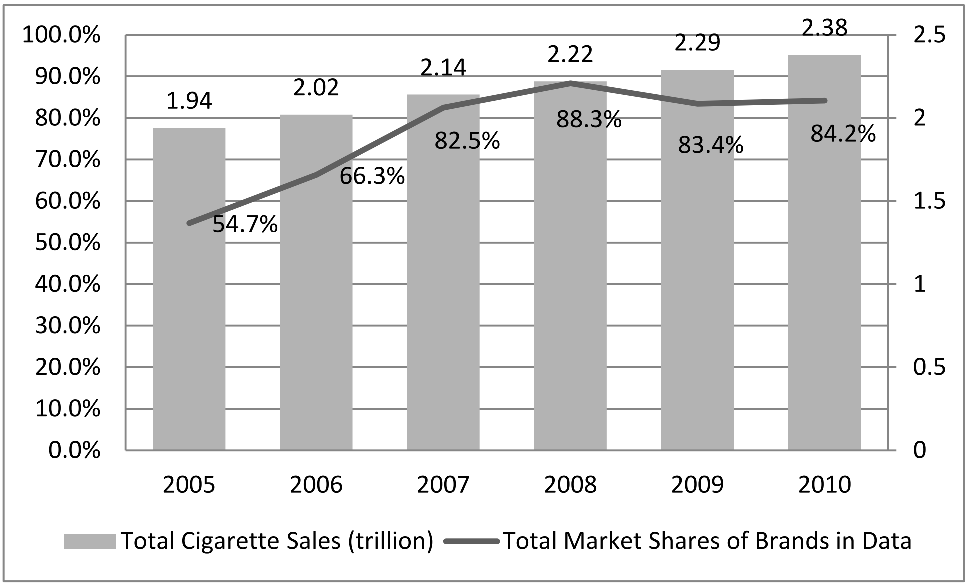
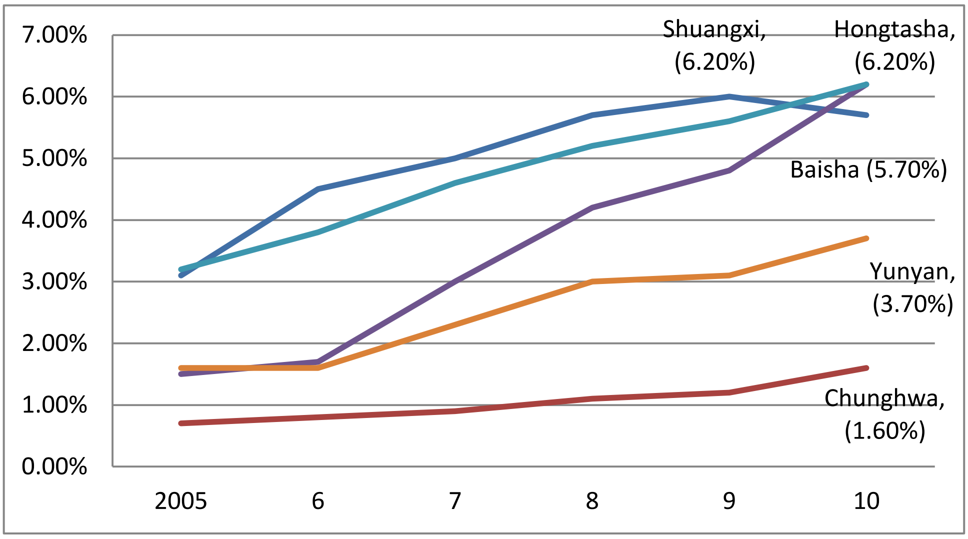
Figure 1. Cigarette Sales in China 2005-2010



Notes: Total cigarette sales in China are obtained from *China Tobacco Year Book 2005-2010*.

Figure 2 Market Shares of Popular Cigarette Brands in China 2005-2010



Note: Numbers in parenthesis are the highest market shares achieved during 2005 to 2010 for each brand.

Table 1 Cigarette Taxation in China Before and After May 2009

	Before May 2009	After May 2009
Specific excise tax per pack	0.06 RMB	0.06 RMB
Ad valorem excise tax rate		
Class A cigarettes	Price per pack ≥ 5RMB	Price per pack ≥ 7RMB
	45%	56%
Class B cigarettes	Price per pack < 5RMB	Price per pack < 7RMB
	30%	36%
Wholesale price tax	0%	5%

Table 2 Descriptive Statistics at the Brand Level

	Full Sample				High Tier Cigarettes (Class A)	Low Tier Cigarettes (Class B)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	Mean	S.D.	Min	Max	Mean	Mean	
Observed market share	0.013	0.014	0.001	0.062	0.016	0.010	***
Price per pack (RMB in 2005)	7.852	6.471	1.930	42.014	11.090	4.071	***
Tar (mg/cigarette)	11.657	1.238	5.780	13.580	12.103	11.221	**
Nicotine (mg/cigarette)	1.117	0.131	0.560	1.350	1.094	1.120	
CO (mg/cigarette)	11.830	1.198	7.880	14.00	11.967	12.122	
Num. of varieties within brand	6.875	3.952	2	12	7.024	6.493	
Smoking intensity (a_t)	1.128	0.106	1	1.283	1.128	1.128	
Expected price change (P^e_{t+1})	0.468	0.499	0	1	0.469	0.465	

Note: The last column indicates if column (5) and column (6) are significantly different based on the t test: * p<0.10, ** p<0.05, *** p<0.01.

Table 3 Parameter Estimates

	Logit	Nested Logit	Nested Logit	Nested Logit
	OLS	OLS	2SLS	GMM
	(1)	(2)	(3)	(4)
Price	0.012	0.005	-0.026**	-0.021***
	(0.009)	(0.004)	(0.010)	(0.005)
ln $(s_{jt\|gt})$		0.967***	0.671***	0.752***
		(0.023)	(0.101)	(0.153)
Expected price change (P_{t+1}^{e})	-0.015	-0.107***	-0.188***	-0.197***
	(0.031)	(0.013)	(0.048)	(0.065)
Smoking Intensity (a_t)	1.470***	1.683***	1.083***	1.152***
	(0.618)	(0.066)	(0.302)	(0.230)
Tar (mg/cigarette)	0.024	0.061**	0.040**	0.039***
	(0.016)	(0.015)	(0.019)	(0.009)
Nicotine (mg/nicotine)	-0.268	0.062	-0.159	0.092
	(0.684)	(0.161)	(0.382)	(0.239)
CO (mg/nicotine)	0.074	-0.138	0.163	0.127
	(0.076)	(0.272)	(0.471)	(0.339)
ln(number of varieties)	0.263	0.182	0.257	0.240
	(0.457)	(0.173)	(0.364)	(0.381)
Constant	-7.783***	-6.297***	-5.079***	-6.733***
	(0.893)	(1.128)	(1.644)	(1.013)
First-stage F statistics for Price			6.73	
			(P=0.000)	
First-stage F statistics for ln $(s_{jt\|gt})$			348.15	
First-stage F statistics for P_{t+1}^{e}			1267.91	
Over-identification test (Hansen's J)			5.105	5.196
			(P=0.403)	(P=0.393)
R^2	0.863	0.989	0.923	0.901
N	348	348	348	348

Note: The dependent variable is the log of relative market share $\ln(s_{jt}) - \ln(s_{0t})$. All specifications include the full sets of manufacturer and year dummies. Robust standard errors are in parentheses. * denotes statistical significance at 10% level, ** denotes statistical significance at 5% level, and *** denotes statistical significance at 1% level.

Table 4 Own- and Cross- Price Elasticities by Year and Class

Year\Class	Class A	Class B	Average
Panel I. Own-price elasticity by year and class			
2005	-0.837	-0.555	-0.774
2006	-0.852	-0.582	-0.765
2007	-0.864	-0.610	-0.784
2008	-0.905	-0.598	-0.825
2009	-0.928	-0.630	-0.814
2010	-0.919	-0.624	-0.803
Average	-0.902	-0.635	-0.805
Panel II. Within-class-cross-price elasticity by year and class			
2005	0.134	0.187	0.150
2006	0.156	0.195	0.165
2007	0.105	0.172	0.146
2008	0.108	0.144	0.122
2009	0.131	0.155	0.136
2010	0.120	0.149	0.127
Average	0.139	0.158	0.146
Panel III. Cross-class-cross-price elasticity by year and class			
2005	0.020	0.045	0.028
2006	0.016	0.049	0.026
2007	0.019	0.03	0.025
2008	0.018	0.042	0.026
2009	0.017	0.035	0.023
2010	0.021	0.040	0.024
Average	0.019	0.043	0.024

Note: Elasticities are sales-weighted average. Above elasticities are short-run elasticities in that the expectations for future cigarette prices are kept constant.

Table 5 Simulated Effects of Cigarette Tax Increases under Different Scenarios

	Cigarette Excise Tax Increase			
	1 RMB/pack	2 RMB/pack	3 RMB/pack	4 RMB/pack
ΔCigarette sales (billion pack)	-7.37	-10.89	-18.63	-29.82
	[-8.04, -6.74]	[-14.24, -9.76]	[-21.65, -17.02]	[-35.06, -26.89]
%ΔCigarette sales	-8.82%	-12.80%	-22.77%	-32.70%
	[-9.62%, -8.06%]	[-13.51%, -12.63%]	[-23.68%, -22.14%]	[-34.42%, -30.42%]
ΔTax (billion RMB)	100.87	116.80	151.15	-41.67
	[98.63, 106.22]	[112.12, 121.97]	[144.61, 157.27]	[-43.31, -40.55]
%ΔTax	3.51%	4.35%	5.12%	-1.49%
	[3.24%, 3.91%]	[4.16%, 4.55%]	[4.93%, 5.41%]	[-1.83%, -1.05%]
%ΔTotal tar	-6.33%	-10.52%	-19.84%	-29.32%
	[-6.82%, -5.81%]	[-11.75%, -9.90%]	[-21.24%, -18.24%]	[-30.70%, -26.67%]
%ΔAverage tar level per cigarette	2.76%	2.60%	3.92%	5.23%
	[2.51%, 2.94%]	[2.41%, 3.05%]	[2.90%, 5.03%]	[3.90%, 6.23%]
%ΔTotal nicotine	-8.65%	-12.50%	-19.88%	-35.62%
	[-5.28%,-10.95%]	[-8.23%, 16.13%]	[-24.35%, -14.84%]	[-40.84%, -30.92%]
%ΔAverage nicotine level per cigarette	0.51%	-0.78%	1.45%	-0.18%
	[-0.30%, 1.23%]	[-2.35%, -1.18%]	[-1.35%, 4.97%]	[-2.34%, 3.03%]

Note: All percentages are sales weighed. 95% confidence intervals based on 500 parametric bootstraps are in the parenthesis.