## Title
Smokers' Strategic Responses to Sin Taxes: Evidence from Panel Data in Thailand



## Journal
Health Economics, 24(2)

## ISSN
1057-9230

## Authors
White, Justin S
Ross, Hana

## Publication Date
2015-02-01

## DOI
10.1002/hec.3004

Peer reviewed

Published in final edited form as:
*Health Econ*. 2015 February ; 24(2): 127–141. doi:10.1002/hec.3004.

# Smokers' Strategic Responses to Sin Taxes: Evidence from Panel Data in Thailand

**Justin S. White**[†] and **Hana Ross**[‡]

[†]University of California at Berkeley, USA

[‡]American Cancer Society, USA

## Abstract

In addition to quitting and cutting consumption, smokers faced with higher cigarette prices may compensate in several ways that mute the health impact of cigarette taxes. This study examines three price avoidance strategies among adult male smokers in Thailand: trading down to a lower-priced brand, buying individual sticks of cigarettes instead of packs, and substituting roll-your-own (RYO) tobacco for factory-manufactured cigarettes. Using two panels of microlevel data from the International Tobacco Control Southeast Asia Study, collected in 2005 and 2006, we estimate the effects of a substantial excise tax increase implemented throughout Thailand in December 2005. We present estimates of the marginal effects and price elasticities for each of five consumer behaviors. We find that, controlling for baseline smoking characteristics, socio-demographics, and policy variables, quitting is highly sensitive to changes in cigarette prices, but so are brand choice, stick-buying, and use of RYO tobacco. Neglecting such strategic responses leads to over-estimates of a sin tax's health impact, and neglecting product substitution distorts estimates of the price elasticity of cigarette demand. We discuss the implications for consumer welfare and several policies that mitigate the adverse impact of consumer responses.

### Keywords

tobacco taxation; compensating behavior; price effects; cigarettes; Thailand

## 1. INTRODUCTION

### 1.1. Motivation

Despite the overwhelming evidence that tobacco taxes affect smoking behavior (Chaloupka and Warner, 2000; IARC, 2011), the policy has not been without its detractors. One commonly raised objection is the potential regressivity of tobacco taxes, whereby poor smokers bear a disproportionate share of the financial burden (Colman and Remler, 2008). A less studied challenge to cigarette taxes is the compensatory behavior of smokers. A rational consumer will weigh the expected benefits of quitting against the expected physical,

Justin S. White (Corresponding author), Health Services and Policy Analysis Program, 247C University Hall, University of California, Berkeley, Berkeley, CA 94720, Phone: +1 (617) 510-9952, Fax: +1 (510) 643-6981 (c/o Ghada), jswhite@berkeley.edu.
Hana Ross, Managing Director, International Tobacco Control Research, American Cancer Society, 250 Williams Street, 6th Floor, Atlanta, GA 30329, hana.ross@cancer.org

psychic, and social costs of ending the dependence, both discounted to the present.[1] Many studies confirm that a price increase alters this calculus, spurring some smokers to cut consumption or quit altogether, consistent with the tax's intended public health impact (Tauras and Chaloupka, 1999; Laxminarayan and Deolalikar, 2004; Goel, 2007).

Other consumer responses may undermine the potential of tobacco taxes to lessen smoking-related harm. This study considers the extent to which—controlling for smoking characteristics, socio-demographics, and policy variables—a tax increase in Thailand induced smokers to behave in one of three ways: 1) switching to a cheaper cigarette brand, 2) purchasing cigarettes by the stick rather than by the pack, and 3) substituting from manufactured cigarettes to handrolled tobacco. Neglecting these consumer responses may cause researchers and policymakers to overestimate the health impact of the tax and, in the case of product substitution, to distort estimates of the price elasticity. Some past studies, detailed below, have examined these compensating behaviors, but only a handful have tracked their adoption in less-developed countries and none have looked at the breadth of outcomes considered here.

This study makes several contributions. We track the compensatory behaviors resulting from a substantial increase in the cigarette excise tax in Thailand. We find large behavioral responses to the tax. Consumers adopt all three compensatory behaviors: substitution toward cheaper brands, substitution toward buying cigarettes by the stick, and substitution toward handrolled tobacco. To our knowledge, we present the first econometric evidence that price influences cigarette package size, namely the decision to buy cigarettes by the stick. Our results are especially applicable to countries where: the sale of individual sticks is common or multiple pack sizes are available; a large share of smokers use non-cigarette products; or a large price spread exists between discount and high-end cigarette brands. In other words, the findings apply to much of the developing world.[2] The paper closes with a discussion of the implications for consumer welfare and setting tobacco policy.

### 1.2. Behavioral responses to taxation

This subsection reviews selected price avoidance strategies that smokers undertake in response to cigarette taxes and that fail to improve the consumers' health. First, some smokers lower their tobacco consumption, but regulate the intensity with which they smoke each cigarette in order to maintain the dose of nicotine (Benowitz, 1999; Adda and Cornaglia, 2006). A smoker may inhale smoke more deeply or cover the ventilation holes with his or her mouth or fingers (Benowitz et al., 1986; Kozlowski, Pope, and Luz, 1988). Intake of nicotine, tar, and carbon monoxide would not decrease proportionately with cigarette consumption. The difficulty in measuring these behaviors has prevented researchers from tracking them on a population level. An important exception is Adda and

[1]Recent literature challenges the rational addiction hypothesis. Smokers display signs of present bias and projection bias (Levy, 2010) and seek out commitment devices to counter self-control problems (Khwaja, Silverman, and Sloan, 2007; Giné, Karlan, and Zinman, 2010), including in Thailand (White, Dow, and Rungruanghiranya, 2013).

[2]For example, many developing countries have a high prevalence of non-cigarette products, such as the use of smokeless tobacco and bidis in South Asia, waterpipes in the Middle East and North Africa, and pipes, handrolled tobacco, and kreteks in Southeast Asia (Eriksen, Mackay, and Ross, 2012), and countries throughout the developing world have a large price spread between the cheapest and most sold brands, indicative of some scope for brand substitution (WHO, 2009, Appendix VI).

Cornaglia (2006) who use a marker of nicotine intake in a large sample of smokers to measure this compensatory behavior, finding that tax increases lead smokers to adjust their intensity of smoking. We lack such granular data.

Second, a smoker may switch to another brand of cigarettes following a price increase. Some evidence suggests that smokers switch to brands with higher levels of nicotine or tar in order to maintain levels of nicotine intake while smoking less (Evans and Farrelly, 1998). In developing countries, where smokers may be highly price-sensitive, increased cigarette prices may compel a smoker to switch to a lower-priced brand (Tsai et al., 2005; White et al., 2013), especially in places where a large price spread exists across different brands. This *down-trading* limits the effectiveness of tobacco taxes in discouraging participation (López, 2002), and allows existing smokers to maintain daily intake without incurring higher costs. In some cases, down-trading entails switching from licit to illicit cigarettes. The production and distribution of illicit cigarettes as a supply-side response to cigarette taxation increases the availability of illicit cigarettes and influences the purchasing decisions of smokers (Merriman, 2010; Stehr, 2005).[3] However, an increase in the specific excise tax on cigarettes may lead to substitution toward more expensive brands, or *up-trading*. This type of tax increase reduces the relative price of high- versus low-quality cigarettes, in effect shifting demand to the untaxed product attribute, quality (Barzel, 1976; Sobel and Garrett, 1998; Espinosa and Evans, 2013). As we discuss later, specific and *ad valorem* taxes have different effects on the relative price of premium and discount cigarette brands and, thus, lead to different predictions about the expected direction of brand substitution.

Third, a smoker may substitute toward a cheaper tobacco product. Cross-price effects on tobacco use have been found in a number of contexts (Guindon et al., 2011; Hanewinkel, Radden, and Rosenkranz, 2008; Pekurinen, 1989; Ohsfeldt, Boyle, and Capilouto, 1997; Wangen and Biørn, 2006). In Thailand, nearly half of all smokers roll their own cigarettes from loose tobacco (Young et al., 2008). Roll-your-own (RYO) tobacco is believed to be an inferior good in Thailand (Young 2006),[4] whereby some smokers switch to RYO tobacco as its price decreases relative to the price of manufactured cigarettes. For example, falling income levels in the aftermath of the Asian financial crisis of the 1990s contributed to a large share of cigarette users in Thailand taking up RYO tobacco (Dalvey Group, 2004).

Fourth, smokers may buy cigarettes by the stick rather than by the pack or carton. Wertenbroch (1998, 2001 advances one possible motivation, namely as a form of self-rationing among “sophisticated” smokers who are aware of a self-control problem. Self-rationing is likely a second-order consideration in our context. Rather, credit-constrained smokers often substitute individual sticks for packs in order to delay or avoid trying to quit smoking, especially in countries where this practice is legal or common.[5] One illegal vendor of ‘loosies’ in New York City puts it succinctly, “The tax went up, and we started selling 10 times as much. [The city’s mayor] thinks he’s stopping people from smoking. He’s just

[3]In our survey data, enumerators reported that all respondents had packs with a standard warning label and a valid tax stamp or security ink, and the data do not include any other measures of use of illicit cigarette consumption.
[4]For clarity, this paper reserves the term “cigarette” for the manufactured product, in contrast to roll-your-own tobacco, which is not manufactured.
[5]Selling individual sticks is also likely to facilitate smoking initiation by lowering the start-up costs.

turning them onto loosies" (Goldstein, 2011). The academic literature has tended to overlook this phenomenon. In one notable exception, a small study in the Philippines finds two countervailing trends among people switching to singletons: it allowed some smokers to continue to consume the same brand even if they deemed a pack too expensive, and it prompted others to switch to imported brands as the absolute price difference between a single domestic and a single imported cigarette was smaller than the price difference for whole packs (Chen, 1997). Many countries ban the sale of individual sticks, but Thailand continues to allow the practice.

### 1.3. Tobacco Pricing and Tax Structure in Thailand

The Thai government heavily regulates the tobacco industry, exercising price controls over manufactured cigarettes. The Excise Department administers an *ad valorem* tax on cigarettes and sets a ceiling on retail prices for each price segment. The excise tax rate has steadily increased from 60% of wholesale price in 1994 to 85% in 2010 (Visaruthvong, 2010). In contrast, roll-your-own tobacco is taxed at negligible levels, with no excise tax for native-grown loose tobacco and a specific excise tax of 1 baht (USD 0.029) per kilogram for most non-native loose tobacco.

The Thai government estimates that smoking prevalence among men declined from 44% in 2003 to 39% in 2006 (Thailand NSO, 2007). Researchers have yet to give a full accounting of the reasons for this dip, although simulations attribute 61% of the decline in smoking from 1991 to 2006 to taxation (Levy et al., 2008). Our study isolates the effect of a substantial tax increase during this period on changes in smoking behavior in Thailand.

From 2001 to 2005, nominal cigarette prices and the corresponding excise tax rate did not budge—real prices fell with rising inflation. Not surprisingly, tobacco sales and consumption grew each year during this period, according to industry data (ERC, 2007). In December 2005, the government increased the cigarette excise tax from 75% to 79% of wholesale price.[6] Subsequently, the mean cigarette price increased 9.0% and the most popular brand rose an average of 13 percent, both in real terms. The difference in these two figures point to variation in firms' pricing response to the tax increase. All brands passed on the tax increase to consumers, but some used the tax as an opportunity to pass through additional costs. This paper tries to identify the effect of the tax using producer-level and geographic variation. Overall, the policy translates to a rise in the cigarette tax as a percentage of retail price from 63.7% to 68.8%.[7]

## 2. STUDY DESIGN AND METHODS

### 2.1. Empirical Model

We use two panel estimation approaches to identify consumers' responses to Thailand's tax increase in January 2006: models with community-specific random intercepts and with

[6]The excise tax rate on cigarettes rose again to 80% of wholesale price in September 2007 and to 85% in 2009.

[7]In addition to the excise tax, the retail price on all cigarettes includes a health tax of 2% on the excise tax yield, a local tax of about 2 Baht per pack, and a value-added tax of 7%. Imported cigarettes are also subject to an import tariff rate of 5% for ASEAN Free Trade Area (AFTA) member countries, which covers the vast majority of imports. See Sarntisart (2003) for an example of how to calculate the tax rate.

individual fixed effects. Breusch-Pagan tests of independence indicated that, for all outcomes, these panel data approaches are preferred to pooled ordinary least squares (OLS). In both approaches, we capture the characteristics that influence quitting and then the characteristics that influence consumption in submodels conditional on continuing to smoke at wave 2. Unlike some studies (e.g., Laxminarayan and Deolalikar, 2004; Wangen and Biørn, 2006), we model these processes separately to avoid the assumption that variables affect participation and consumption in the same way. All analyses are restricted to adult smokers and are clustered by each of the 16 markets, defined as province by urbanicity.[8] Standard errors are corrected for a general, unknown form of heteroskedasticity using a Huber-White sandwich estimator (White, 1980).

The first approach using community-level random effects assumes that unobserved variation is normally distributed and uncorrelated with observed predictors. The random effects model has several advantages. It is more efficient than a fixed effects model and allows for the inclusion of time-invariant predictors of interest. A series of heteroskedasticity-robust Hausman tests of random versus fixed effects at the community and individual levels for each submodel reveal that the random effects model is inconsistent for models of cigarette consumption and brand choice and consistent for the model of stick-buying. For comparability with the fixed effects models, we estimate the random effects models as linear probability models. Logit models yielded similar estimates. OLS estimation of Equation (1) determines the probability of each smoking behavior. Step 1 of the first approach derives the probability of quitting from the following latent variable formulation:

$$QUIT^{*}_{ijt}=\beta_1+\beta_2\Delta PRICE_{ijt}+\beta_3 PRICE_{ij(t-1)}+X_{ij}\gamma+\varsigma_j+\varepsilon_{ijt} \quad (1)$$

where the propensity for quitting smoking at time *t* for individual *i* living in community *j* is a function of the change in cigarette price, the baseline price, a set of baseline characteristics, a community-specific random intercept, and random error $\varepsilon_{ijt}$ (distributed normal). The socio-demographic characteristics and policy constraints captured by the vector *X* are detailed below. The random intercept $\varsigma_j \sim N(0, \psi)$ accounts for unobserved heterogeneity between communities, where communities are defined as the survey's primary sampling unit.

Step 2 of the first approach specifies separate models of the probability of each of four behaviors, conditional on smoking at wave 2: cigarette consumption, brand choice (brands in low-price versus high-price segments), the package size of cigarettes last purchased (packs or cartons versus individual sticks), and tobacco product type (manufactured cigarettes versus roll-your-own tobacco). The propensity for each behavior is represented as follows:

$$(BEHAVIOR^{*}_{ijt}|QUIT_{ijt}=0)=\beta_1+\beta_2 PRICE_{ijt}+X_{ij}\delta+\varphi_j+u_{ijt} \quad (2)$$

[8]Standard asymptotic tests can over-reject with a small number of clusters (Cameron, Gelbach, Miller, 2008). We also ran our regressions with standard errors clustered at the community level (n = 36), and the statistical significance across models was nearly identical, providing some assurance that overly tight confidence intervals are not a major problem in our sample.

which includes the same baseline covariates, a community-specific random intercept ($\phi_j$), and an error term ($u_{ijt}$). The equations for three of four outcomes are implemented using a linear probability model. The fourth behavior—tobacco product type—is modeled as a multinomial logit function to account for three tobacco product types: cigarette use only, RYO tobacco use only, and use of both cigarettes and RYO tobacco. Likelihood ratio tests indicated that none of these outcome categories should be combined ($\chi^2 > 200$, $p < 0.001$ for all pairs of alternatives). Maximum likelihood estimation of the multinomial random effects model is performed using adaptive quadrature (with 30 integration points), which leads to stable results relative to most other integration methods (Rabe-Hesketh, Skrondral, Pickles, 2005).

The second estimation approach captures how changes in price affect behavior using a fixed effects estimator. Unlike the random effects estimator that uses within- and between-community (and thus, within- and between-market) variation in cigarette prices across waves, the fixed effects estimator relies only on within-community (and thus, within-market) variation to identify the quasi-experimental effects of the tax increase. As such, fixed effects estimators are less susceptible to omitted variable bias than are random effects estimators. Given two time periods, the fixed effects estimator is equivalent to including a first differences model. Individual fixed effects remove the effect of all influences that vary between individuals and between time-specific events that affect the outcome, and identifies behavioral changes using within-person price variation. We implement the fixed effects specifications as linear probability models.[9] As before, submodels are estimated conditional on quit status. The multinomial model of tobacco product type is not compatible with the fixed effects approach, and is only estimated using random effects.

A drawback of the person-level fixed effects estimator in this context is that it may lead to noisy results because of the limited sample size and the large number of degrees of freedom used in estimation. For comparison, we also present a community fixed effects model that isolates the effects of within-community price variation. Communities are nested within markets, and so this model only uses within-market price variation. If the community fixed effects model has much smaller standard errors than the person-level model, it would imply that the latter lacks sufficient power for inference.

We report price coefficients as marginal price effects and price elasticities for ease of interpretation.[10]

### 2.2. Data and Variables

This study employs the first two waves of the International Tobacco Control Southeast Asia Survey. The survey draws respondents using a stratified, multi-stage sampling design, in which the primary strata consist of Bangkok and the four regions of Thailand (Hammond et al., 2008). Two provinces were selected within each region. A secondary stratification

[9]A fixed effects logit model would drop all observations that have the same outcome (e.g., a person who smokes in both waves), because the fixed effect would be a perfect predictor for that group. This estimator is not feasible with the present sample size. The linear probability model produces constant marginal effects and unbounded predicted probabilities, but is consistent and easy to interpret.

[10]In the multinomial logit models, the marginal effects of choice alternatives sum to zero because their probabilities sum to one.

consisted of urban and rural districts within each province.[11] Survey questions were identical across the two rounds, although socio-demographic information was only collected at baseline. Baseline information was collected from January to February 2005 during in-person interviews with Thai adults age 18 and older. The follow-up survey was conducted August to September 2006. Of those interviewed in wave 1, interviewers re-contacted 78% in wave 2. This sample attrition is comparable to many other household surveys fielded in developing countries (Alderman et al., 2000). Compared to those interviewed in both waves, non-responders tended to be older, less educated, and more rural, and as a result more likely to use RYO tobacco that costs less on average. The magnitude of these differences is small; selective attrition should not greatly bias the results.

The survey was limited to regular smokers, defined as individuals who smoked at least weekly and smoked more than 100 cigarettes in their lifetime. Our analysis excludes female respondents, who comprise a small, possibly non-representative portion of the sample, only 5.3% of continuing smokers. In addition, cultural norms in Thailand may lead some women to systematically under-report their tobacco use. Overall, 1,436 men were interviewed in both waves. After implementing complete case analysis, the balanced panel includes 1,422 men.

The analysis includes five dependent variables: 1) quitting, 2) daily cigarette consumption, 3) decision to buy cigarettes by the pack rather than by the pack, 4) price segment of the cigarette brand most frequently purchased, and 5) type of tobacco product. Quitting is based on self-reported smoking status at wave 2. Other dependent variables are limited to continuing smokers. Cigarette consumption is defined as average self-reported daily intake, including factory-made and handrolled cigarettes. The variable for buying packs or cartons versus individual sticks—is generated from self-reports. Brand choice is based on self-reports of the most commonly smoked brand at each wave.[12] We divided brands into three price segments, or price tiers, based on a review of industry sources (ERC, 2007). Due to the small percentage of smokers who selected the most expensive tier (about 1% in each wave), we combined the mid- and high-price tiers. Respondents reported use of cigarettes, RYO tobacco, or both. The models for brand choice and package size include only the subset of smokers who used factory-manufactured cigarettes at both waves, excluding RYO tobacco users. Thus, these analyses have smaller starting populations. Similarly, a sub-analysis of RYO cigarettes includes only those individuals who smoked cigarettes at wave 1, excluding all others.

Our models include two measures of market cigarette prices and one measure of market RYO tobacco prices. The tobacco price variables are constructed from self-reported prices, scaled to the equivalent of a standard 20-cigarette pack, and reported as real prices in 2005 baht.[13] Substantial price variation exists across waves, brands, and manufactured versus

[11]We do not adjust our estimates for the multi-stage sampling design. As Solon, Haider, and Wooldridge (2013) describe, weighting is only appropriate for estimating causal effects under certain circumstances.

[12]The results are robust to an alternative definition of brand choice, using the brand last purchased, rather than the brand most commonly smoked. The pairwise correlation coefficient between last brand purchased and brand most often purchased approached 0.79 ($p < 0.001$), indicating strong brand loyalty and minor measurement error. Any classical error in variables would bias the relevant coefficient toward zero, understating the true effect.

RYO products. We assume that these market prices are exogenous to individual consumers. The market is defined as the mean province-byurbanicity price of cigarettes in a given wave. Our first measure of cigarettes prices, used in our econometric models of quit status, cigarette consumption, and choice of tobacco product is the overall mean market price of cigarettes. Those models also include a measure of the mean market price of RYO tobacco. Missing at baseline, the price of RYO tobacco was generated using the average change in the price of pipe tobacco in Thailand between the two time points, based on data from the Economist Intelligence Unit (EIU, 2007). Many users of RYO tobacco grow their own product or smoke unbranded, locally grown leaf, yielding more stable prices over time, which are less sensitive to the factors shifting cigarette prices. The small price change for RYO tobacco made loose tobacco a relatively better bargain than cigarettes following the tax increase.

The second measure of cigarette prices is the average market price of a consumer's brand in a given wave.[14] One issue that arises in calculating the brand-specific price is that the self-reported price at wave 2 is endogenous if a person's brand choice at that time reflects the brand-specific changes in price. Some studies using micro-level data have used an endogenous price measure (e.g., Tsai et al., 2005).[15] To circumvent this endogeneity problem, we use the brand-specific mean market price at wave 2 of the brand smoked at wave 1, which is plausibly exogenous to the smoker.[16] One could argue that smoking patterns exhibit a high inter-temporal correlation, implying that tobacco prices at a given point in time are endogenous. While this logic may hold for baseline prices, the price change of the baseline brand is the result of an exogenous shock that each consumer must take as given. However, our brand-specific price measure may still be endogenous to the extent that tobacco producers passed through more of the excise tax to consumers who were expected to be less price-sensitive. This reverse causality would lead us to overstate the effect of the tax on price avoidance behavior. We cannot observe the *ex ante* price sensitivity of consumers, but manufacturers do not appear to have differentially set the pass-through rate for smokers in different price segments of the market. For example, the dominant low-price brand (Wonder) increased its price by 12.0% following the tax. The other five most popular brands, all belonging to the mid-price segment and listed in descending order of popularity, raised their prices by 12.7% (Krongthip), 6.9% (Saifon), 11.2% (L&M), and 13.1% (Krungtong). Producers' pricing strategy likely reflects competitive considerations more than the expected price response of consumers.

Table 1 provides basic descriptive statistics. We selected background characteristics for inclusion in the analysis based on their significance in previous studies and their hypothesized association with the compensating behaviors under consideration. Smoking characteristics include average daily cigarette consumption at baseline and the type of

[13]For RYO tobacco, a per-pack cigarette equivalent equals the price of a tobacco packet divided by the number of days per packet, divided by cigarettes per day, and multiplied by 20.

[14]The regression results using a modal brand-specific price are virtually identical. The pairwise correlation coefficient between the mean and modal brand-specific prices is 0.933 ($p < 0.001$).

[15]Still others have used cross-sectional data to try to describe the compensatory behavior of smokers (Ohsfeldt, Boyle, and Capilouto, 1997).

[16]Another valid approach might use the entire set of market prices. The data requirements of that approach are more demanding, and the sample size used here is not sufficiently large.

tobacco used at baseline (mainly RYO tobacco or not). The theory of health capital suggests that an individual's demand for health—and by extension, behavioral—decisions about smoking—is related to age, education, and income (Grossman, 1972). Age also captures the duration of time a person has smoked (Pearson's $\rho$ of 0.93), which is a predictor of a person's level of addiction. A large literature shows that a socio-economic gradient exists for health behaviors, including smoking decisions, where socio-economic status (SES) is typically proxied by educational attainment and family income (Cawley and Ruhm, 2011; Cutler and Lleras-Muney, 2010; Grossman and Kaestner, 1997). We control for categorical educational attainment (primary or less, secondary, beyond secondary), annual household income at baseline in 100,000 baht, and baseline residence in an urban area.

Finally, environmental factors, often in the form of anti-tobacco policies, contribute to consumption patterns. These factors include a person's exposure to tobacco industry advertising, exposure to anti-tobacco media campaigns, and policies restricting smoking at home and at work. Smoking regulations may increase the time costs of smoking, alter smoking norms, and increase awareness of smoking-related harms.

## 3. RESULTS

Many men in the sample altered their smoking behavior across waves (Table 1; transition probabilities not shown): 12.7% of all smokers quit; 50.1% of all smokers decreased consumption and 19.9% increased consumption by more than one cigarette; 8.3% of cigarette users switched to a cheaper brand and 3.5% switched to a more expensive brand; and 21.7% of cigarette users switched from buying cigarettes by the pack to buying cigarettes by the stick and 3.1% switched from sticks to packs. Moreover, 19.1% of cigarette-only smokers at baseline transitioned to some use of RYO tobacco at wave 2, compared to 9.4% of RYO users who transitioned to some use of manufactured cigarettes, and nearly two-thirds (63.7%) of mixed users at wave 1 used RYO tobacco only at follow-up. Table 1 also indicates that the market price for cigarettes increased 3.0 baht (9.1%) across waves; brand-specific market prices increased 2.3 baht (6.6%) across waves; and RYO tobacco prices remained relatively flat (decline of 0.3 baht) across waves.

Table 2 shows the output from the multivariate estimation of the correlates of quitting (Models 1–2) and daily cigarette consumption (Models 3–6). An increase in price is significantly associated with an increased probability of quitting, according to the community random effects models with and without controls (Models 1–2). A 10-baht price increase—about one-quarter of the price of a pack of the most popular brand—translates into a 1–2% point (roughly 10–20%) increase in the probability of quitting. The elasticity of quitting with respect to tobacco prices appears to fall between 0.2 and 0.4. Prior estimates of the price elasticity of smoking prevalence in low- and middle-income countries cover a fairly uniform distribution from 0 to 1 (IARC, 2011).

Thailand's tax increase appears to have led some smokers to quit smoking, but it did not alter the smoking intensity of continuing smokers (Table 2, Models 3–6). The marginal effect of cigarette prices on consumption is small and of the wrong sign for two of four models. When we restrict the sample to cigarette users at both waves (i.e., those who we

would expect to be most responsive to the cigarette tax), the results remain similar (data not shown). Nicotine dependence may impede the ability of long-time smokers to compensate for the price increase by decreasing cigarette intake. We do not have data on the price elasticity of smoking initiation, but the combined price elasticity of quitting and intensity are in line with prior work on the unconditional demand for smoking in developing countries (IARC, 2011).[17]

Table 3 provides the main results for the price effect on smokers' package size last purchased (Models 1–4) and brand choice (Models 5–8). We find that smokers are significantly more likely to purchase cigarettes by the stick as the market price for cigarettes increases. The community random effects models (Models 1 and 2) and community fixed effects model (Model 3) suggest a strong relationship, with a 4.7 to 6.5% point increase in purchasing sticks following a 10-baht increase. The individual fixed effects model yields a marginal price effect of similar magnitude, but the coefficient is no longer significant at the 5% level. The standard error more than doubles between the community and individual fixed effects models, suggesting that the imprecision may result from limited power to detect the effect. The price elasticity estimates range from roughly 1.0 to 1.3, implying that a 1% increase in cigarette prices corresponds to a 1.0–1.3% increase in the probability of purchasing individual sticks.

We find that smokers are also significantly more likely to purchase a low-priced brand as price increases (Models 5–8). A 10-baht increase in prices leads to roughly a 7–8% point increase in the likelihood of trading down to a cheaper brand, and this relationship holds across all models, including the individual fixed effects model. Brand choice is highly price-elastic, such that a 1% price increase corresponds with a 9–10% increase in the probability of down-trading.

Table 4 shows the effect of tobacco prices on choice of tobacco product using a multinomial logit regression with community random effects. In Model 1, higher cigarette prices are associated with reduced use of cigarettes and greater use of RYO tobacco among the full sample of smokers. Likewise, higher RYO tobacco prices decrease the chances of consuming RYO tobacco and increase the chances of using cigarettes and of using a mixture of RYO tobacco and cigarettes, although none of those estimates are significant. Restricting the sample to cigarette smokers at baseline (Model 2), cigarette prices strongly relate to a reduction in cigarette use and an increase in sole and mixed use of RYO tobacco. A 10-baht increase in cigarette prices reduce cigarette use by 24% points and increase sole use of RYO tobacco by 12% points and mixed use by 12% points. The cross-cigarette price elasticities are particularly large: 9.2 for sole RYO use and 3.7 for mixed use. The positive cross-price elasticities suggest that both mixed use and RYO tobacco are substitute goods for cigarettes.

Uptake of sole use of RYO tobacco is not related to its own-price effect. This finding may stem from the relatively stable mean price of RYO tobacco over time and the small number of smokers who jumped directly from only buying cigarettes to only buying RYO tobacco. Mixed use typically serves as a conduit during this transition. Thus, it is not surprising that

[17]For demand $Y$, the price elasticity of unconditional demand is: $\eta E(Y) = \eta \Pr(Y>0) + \eta E\,(Y\,|Y>0\,)$

smokers are more likely to choose mixed use when RYO prices increase (RYO price elasticity of 0.12).

## 4. DISCUSSION

This paper describes the price-minimizing consumption decisions of smokers in Thailand. A substantial increase in Thailand's cigarette excise tax rate made smokers more likely to quit smoking, exhibiting the potential of tobacco taxation to improve public health. Yet, our analyses also indicate that many Thai smokers muted the health impact of the cigarette price increase by altering their consumption patterns: switching to cheaper brands, purchasing loose cigarettes instead of packs, and smoking cheaper substitutes, namely RYO tobacco. The price increase due to Thailand's tobacco excise tax increase significantly influenced all of these behaviors.[18]

The welfare consequences of smokers' strategic responses depend on the economic model being applied. The standard rational addiction model (Becker and Murphy, 1988) assumes that smokers fully account for the personal costs of smoking, such that any compensating behavior is consistent with utility maximization. Evidence drawn from more recent models that capture individuals' behavioral biases—such as present bias derived from time-inconsistent preferences and projection bias derived from underestimating the degree to which preferences will change in the future—indicate that smoking may be welfare-reducing (Gruber and Köszegi, 2001; Levy, 2010), implying that compensating behavior is harmful to consumers who are naïve about future smoking behavior. Given sufficiently large behavioral biases or externalities, the government has a stake in setting public policy that takes into account compensating behavior.

A new finding emerging from this analysis is the strong positive relationship between price and the substitution of packs in favor of individual sticks. More research is needed to understand whether this decision is a detour or a shortcut on the path to cessation. In our sample, 18% of those who last bought sticks at wave 1 had quit by wave 2, compared to 12% of those who last bought packs (data not shown). Thus, at least for some, the decision to quit smoking involves a period during which smokers purchase sticks. On the one hand, stick-buying may facilitate cessation. Khwaja, Silverman, and Sloan (2007) provide evidence that stick-buying can function as a self-control mechanism. They present data that 27% of U.S. smokers in their sample admit to purchasing packs instead of cartons in order to limit consumption. On the other hand, smokers may turn to buying individual sticks after encountering higher prices as a way to delay cessation. In our sample, stick-buying allowed many smokers to continue using the same brand, with three-quarters of those who switched to sticks remaining loyal to the same brand across waves.[19] Consumption patterns related to

[18]We also examined how the price responsiveness varies according to baseline socio-demographic characteristics, based on interactions of tobacco price with age, income, and education. The estimates were too noisy to detect any reliable patterns, perhaps due to the sample size.

[19]If stick-buying represents a stalling tactic, policymakers in Thailand and elsewhere could ban and enforce the ban on the sale of individual sticks. One alternative motivation of such a ban is to ensure that smokers are exposed to the health warnings on the label of packs. Adolescents, who have less access to disposable income, may be especially prone to purchasing cigarettes by the stick, but this group also tends to know less about the dangers of smoking, making the missed warnings potentially deleterious.

the purchase of individual sticks are not well researched and are in need of more attention from investigators.

As some observers note, the trend toward higher quit rates in the industrialized world has yet to occur in many developing countries (Abdullah and Husten, 2004). The abundance of very cheap cigarettes, even adjusting for differences in cost of living, may be one promoter of low quit rates (Blecher and Van Walbeek, 2009). Down-trading to cheaper cigarettes is the most price-elastic of the behaviors we examined. The tax structure plays an important role in the desirability of this compensatory behavior. Whereas an *ad valorem* tax increase makes cheap brands relatively cheaper, an increase in a specific excise tax diminishes the cost advantage of trading down to a cheaper brand. Thailand's price controls lead its *ad valorem* tax to function more like a specific tax, in practice; even still, had Thailand increased its specific excise tax rather than its *ad valorem* rate, we expect that brand-switching would have been less pronounced.

Most RYO tobacco is exempt from Thailand's excise tax on cigarettes. If the Thai government wants to make further inroads into curbing tobacco use, then one policy direction may involve raising the specific tax for RYO tobacco. Our results indicate that smokers' choice of tobacco type is highly price-sensitive, and smokers frequently oscillate between RYO tobacco during bad economic times and cigarettes when their luck improves. To counter a similar problem in India where bidis are under-taxed, Sunley (2008) recommends prohibiting the sale of unbranded products, requiring the reporting of sales of processed bidi tobacco to the government, and equalizing the excise tax rate on bidis to that of micro non-filter cigarettes. Similar tactics may be effective in Thailand.

This study had several limitations. Thailand implemented two other tobacco control reforms between the survey waves, the introduction of pictorial warnings on tobacco packages and a ban on point-of-sale advertising, both of which could confound the ability to isolate price effects. The survey questionnaire did not provide a robust control for the impact of warning labels on quitting or switching to RYO tobacco. The best available evidence points toward the new pictorial warnings raising awareness of labels but not demonstrably changing behavior. Although men were more likely to notice the new pictorial labels than the old text labels, the frequency with which respondents noticed the labels did not relate to daily cigarette consumption nor to the decision to purchase cigarettes by the stick versus by the pack and did not alter the magnitude of the price effects in these models.[20] The introduction of the warning labels would also not be expected to affect smokers' choice of price tier. As for the point-of-sale ban, its most likely effect would be to attenuate smoking initiation. Smokers in the sample initiated the habit nearly three decades earlier on average, which makes it less likely that the ban would directly influence such veteran smokers, especially because the ban was selectively followed.[21] Another concern is that the 22% of respondents

[20]We added as a covariate for the frequency with which a person noticed the warning labels, using indicator variables for the four possible responses: never, once in a while, often, or very often. The indicator variables were not jointly in community random effects or community fixed effects models of daily consumption among cigarette users or quantity last purchased. We also ran alternate specifications using a dummy variable for noticing the warning labels often or very often and for noticing the warning labels very often.

[21]According to ITC data, 17% of adults and 53% of youth reported having seen cigarette packages displayed in retail establishments after the point-of-sale advertising ban went into effect.

lost to follow-up did not attrite randomly. Although significant differences existed in some baseline characteristics between those lost and those interviewed in both waves, the magnitude of these differences was small, and those characteristics are controlled for in our model.

Researchers still have much to learn about the mechanisms underlying strategic responses to sin taxes. One critical question is which types of smokers are most likely to exhibit strategic behavior. Heterogeneous responses would have implications for ongoing debates regarding the potential regressivity and incidence of sin taxes. Future studies of cigarette taxes might also attempt to model simultaneously the decisions of brand choice and tobacco type, in order to tease out how factors differentially affect these two behaviors. Another fruitful approach might use the entire set of available prices. In both regards, the present study was limited by sample size. Longitudinal studies from other settings, in particular those with longer panels, also would help elucidate the dynamics of the trends described here. Although some aspects of compensation are context-specific, such as the type of product substitution —RYO tobacco, in the case of Thailand—the general patterns may hold across contexts. As the evidence base in this area of tobacco research grows, policymakers would do well to design policies that address the nuances of smokers' consumption decisions.

## Acknowledgments

We thank Evan Blecher, William Dow, Geoffrey Fong, Rita Hamad, Teh-wei Hu, Nigar Nargis, Sophia Rabe-Hesketh, Kenneth Train, and seminar participants at the 2007 IHEA annual meeting for helpful comments. We also thank the editor Don Kenkel and three anonymous referees for their constructive feedback. All errors are our own. The ITC-SEA Project is supported by grants P50 CA111236 (Roswell Park Transdisciplinary Tobacco Use Research Center) and R01 CA100362 from the U.S. National Cancer Institute, Canadian Institutes of Health Research (79551), Ontario Institute for Cancer Research, Thai Health Promotion Foundation, and the Malaysian Ministry of Health.

## References

Abdullah ASM, Husten CG. Promotion of smoking cessation in developing countries: A framework for urgent public health interventions. Thorax. 2004; 59(7):623–630. [PubMed: 15223875]

Adda J, Cornaglia F. Taxes, cigarette consumption, and smoking intensity. American Economic Review. 2006; 96(4):1013–1028.

Alderman, H.; Behrman, JR.; Kohler, H-P.; Maluccio, JA.; Watkins, SC. Discussion Paper 96. International Food Policy Research Institute; 2000. Attrition in Longitudinal Household Survey Data: Some Tests for Three Developing Country Samples. Available at: http://www.ifpri.org/sites/default/files/publications/fcnbr96.pdf [Accessed on: February 20, 2012]

Barzel Y. An alternative approach to the analysis of taxation. Journal of Political Economy. 1976; 84(6):1177–1197.

Becker G, Murphy K. A theory of rational addiction. Journal of Political Economy. 1988; 96(4):675–700.

Benowitz NL. Nicotine Addiction. Primary Care. 1999; 26(3):611–631. [PubMed: 10436290]

Benowitz NL, Jacob P III, Kozlowski LT, Yu L. Influence of smoking fewer cigarettes on exposure to tar, nicotine, and carbon monoxide. New England Journal of Medicine. 1986; 315(21):1310–1313. [PubMed: 3773954]

Blecher EH, Van Walbeek CP. Cigarette affordability trends: An update and some methodological comments. Tobacco Control. 2009; 18:167–175. [PubMed: 19179369]

Cameron AC, Gelbach JB, Miller DL. Bootstrap-based improvements for inference with clustered errors. Review of Economics and Statistics. 2008; 90(3):414–427.

Cawley, J.; Ruhm, CJ. IZA Discussion Paper Series No. 5728. 2011. The economics of risky health behaviors.

Chaloupka, FJ.; Warner, KE. The economics of smoking. In: Culyer, AJ.; Newhouse, JP., editors. Handbook of Health Economics. Vol. 1. 2000. p. 1539-1627.

Colman GJ, Remler DK. Vertical equity consequences of very high cigarette tax increases: If the poor are the ones smoking, how could cigarette tax increases be progressive? Journal of Policy Analysis and Management. 2008; 27(2):376–400.

Cutler DM, Lleras-Muney A. Understanding differences in health behaviors by education. Journal of Health Economics. 2010; 29(1):1–28. [PubMed: 19963292]

The Dalvey Group. [Accessed on 6/23/08] Amazing Thailand. Tobacco Journal International. 2004. Available at: http://lists.essential.org/pipermail/intl-tobacco/2004q3/001120.html

Economist Intelligence Unit. Global Pipe Tobacco Prices. 2008. Available for purchase at: http://www.eiu.com/

ERC Group. World Cigarette Survey 2007. Vol. 5. Asia & Far East; 2007. Available for purchase at: http://www.erc-world.com/

Eriksen, M.; Mackay, J.; Ross, H. The tobacco atlas. 4. Atlanta, GA, USA: American Cancer Society; 2012.

Espinosa J, Evans WN. Excise taxes, tax incidence, and the flight to quality: Evidence from scanner data. Public Finance Review. 2013; 41(2):147–176.

Evans WN, Farrelly MC. The compensating behavior of smokers: Taxes, tar, and nicotine. RAND Journal of Economics. 1998; 29(3):578–595. [PubMed: 11794360]

Giné X, Karlan D, Zinman J. Put your money where your butt is: A commitment contract for smoking cessation. American Economic Journal: Applied Economics. 2010; 2(4):213–235.

Goel RK. Costs of smoking and attempts to quit. Applied Economics. 2007; 39:853–857.

Goldstein, J. The New York Times. Apr 4. 2011 A Cigarette for 75 Cents, 2 for $1: The Brisk, Shady Sale of ‘Loosies’.

Grossman M. On the concept of health capital and the demand for health. Journal of Political Economy. 1972; 80(2):223–255.

Grossman, M.; Kaestner, R. Effects of Education on Health. In: Behrman, JR.; Stacey, N., editors. The Social Benefits of Education. Ann Arbor, MI: University of Michigan Press; 1997.

Gruber J, Köszegi B. Is Addiction ‘Rational? Theory and Evidence. Quarterly Journal of Economics. 2001; 116(4):1261–1303.

Guindon, GE.; Nandi, A.; Chaloupka, FJ.; Jha, P. NBER Working Paper No. 17580. 2011 Nov. Socioeconomic Differences in the Impact of Smoking Tobacco and Alcohol Prices on Smoking in India. 2011

Hammond D, Kin F, Prohmmo A, et al. Patterns of smoking among adolescents in Malaysia and Thailand: Findings from the International Tobacco Control Southeast Asia Survey. Asia Pacific Journal of Public Health. 2008; 20(3):193–203. [PubMed: 19124313]

Hanewinkel R, Radden C, Rosenkranz T. Price increase causes fewer sales of factory-made cigarettes and higher sales of cheaper loose tobacco in Germany. Health Economics. 2008; 17:683–693. [PubMed: 17948225]

IARC [International Agency for Research on Cancer]. Effectiveness of tax and price policies for tobacco control. 2011; Chapter 5:137–200.

Kenkel D. Health behavior, health knowledge, and schooling. Journal of Political Economics. 1991; 26:313–325.

Khwaja A, Silverman D, Sloan F. Time preference, time discounting, and smoking decisions. Journal of Health Economics. 2007; 26(5):927–949. [PubMed: 17574694]

Kozlowski LT, Pope MA, Luz JE. Prevalence of the mis-use of ultra-low-tar cigarettes by blocking filter vents. American Journal of Public Health. 1988; 78(6):694–695. [PubMed: 3369602]

Laxminarayan R, Deolalikar A. Tobacco initiation, cessation, and change: Evidence from Vietnam. Health Economics. 2004; 13:1191–1201. [PubMed: 15386650]

Levy DT, Benjakul S, Ross H, Ritthiphakdee B. The role of tobacco control policies in reducing smoking and deaths in a middle income nation: results from the Thailand SimSmoke simulation model. Tobacco Control. 2008; 17:53–59. [PubMed: 18218810]

Levy, MR. [Accessed on: June 6, 2011] An empirical analysis of biases in cigarette addiction. Working paper. 2010. Available at: http://people.rwj.harvard.edu/~mlevy/cigarettes.pdf

López Nicolás A. How important are tobacco prices in the propensity to start and quit smoking? An analysis of smoking histories from the Spanish National Health Survey. Health Economics. 2002; 11:521–535. [PubMed: 12203755]

Merriman D. The Micro-Geography of Tax Avoidance: Evidence from Littered Cigarette Packs in Chicago. American Economic Journal: Economic Policy. 2010; 2(2):61–84.

Pekurinen M. Demand for tobacco products in Finland. British Journal of Addiction. 1989; 84:1183–1192. [PubMed: 2819275]

Ohsfeldt RL, Boyle RG, Capilouto E. Effects of tobacco excise taxes on the use of smokeless tobacco products in the USA. Health Economics. 1997; 6:525–531. [PubMed: 9353656]

Rabe-Hesketh S, Skrondal A, Pickles A. Maximum likelihood estimation of limited and discrete dependent variable models with nested random effects. Journal of Econometrics. 2005; 128(2): 301–323.

Ross H, Driezen P, Sirirassamee B, Kin F. Cigarette purchasing behavior in Thailand and Malaysia: Comparative analysis of a semi-monopolistic and a free-market structure. Global Public Health. 2009; 4(6):588–599. [PubMed: 19548160]

Sobel RS, Garrett TA. Taxation and product quality: New evidence from generic cigarettes. Journal of Political Economy. 1997; 105(4):880–887.

Solon, G.; Haider, SJ.; Wooldridge, J. NBER Working Paper No. 18859. 2013 Feb. What are we weighting for?. 2013

Sarntisart, I. Economics of tobacco control paper No. 15. Washington, DC: World Bank; 2003. An economic analysis of tobacco control in Thailand.

Stehr M. Cigarette Tax Avoidance and Evasion. Journal of Health Economics. 2005; 24(2):277–297. [PubMed: 15721046]

Sunley, EM. India: The Tax Treatment of Bidis. New York: Bloomberg Philanthropies; 2008.

Tauras, JA.; Chaloupka, FJ. Working Paper. National Bureau of Economic Research; Cambridge, MA: 1999. Determinants of smoking cessation: An analysis of young adult men and women. Report No. 7262

Thailand National Statistical Office. Health and welfare survey. Vol. 2003. Bangkok: National Statistical Office of Thailand; 2007. p. 2006Data available at: http://web.nso.go.th/eng/ [Accessed on June 23, 2008.]

Tsai YW, Yange CL, Chen CS, Liu TC, Chen PF. The effect of Taiwan's tax-induced increases in cigarette prices on brand-switching and the consumption of cigarettes. Health Economics. 2005; 14:627–641. [PubMed: 15791675]

Visaruthvong, C. Thailand Tobacco Tax Report Card. Southeast Asia Tobacco Control Alliance; 2010. Available at: http://seatca.org/dmdocuments/Thailand%20Tax%20Report%20Card%202010.pdf [Accessed on May 10, 2011]

Wangen, KR.; Biørn, E. Statistics Norway, Discussion Paper No. 312. 2001. Prevalence and composition of tobacco consumption—A discrete choice analysis based on panel data.

Wangen KR, Biørn E. How do consumers switch between close substitutes when price variation is small? The case of cigarette types. Spanish Economics Review. 2006; 8:239–253.

Wertenbroch K. Consumption self-control by rationing purchase quantities of virtue and vice. Marketing Science. 1998; 17:317–337.

Wertenbroch, K. [Accessed on October 6, 2011] Self-Rationing: Self-Control in Consumer Choice. 2001. INSEAD Working Paper No. 2001/63/MKT. Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=296954

White H. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. Econometrica. 1980; 48:817–838.

White JS, Dow WH, Rungruanghiranya S. Commitment contracts and team incentives: A randomized controlled trial for smoking cessation in Thailand. American Journal of Preventive Medicine. 2013 Forthcoming.

White JS, Li J, Hu T, Fong G, Jiang Y. The effect of cigarette prices on brand-switching in China: A longitudinal analysis of data from the ITC China Survey. Tobacco Control. 2013 Forthcoming. 10.1136/tobaccocontrol-2012-050922

WHO [World Health Organization]. Technical report. Geneva, Switzerland: WHO Press; 2009. WHO report on the global tobacco epidemic, 2009.

Young D, Borland R, Hammond D, Cummings KM, Devlin E, Yong HH, O'Connor RJ. Prevalence and attributes of roll-your-own smokers in the International Tobacco Control (ITC) Four Country Survey. Tobacco Control. 2006; 15(Supp III):76–82.

Young D, Yong HH, Borland R, et al. Prevalence and correlates of roll-your-own smoking in Thailand and Malaysia: Findings of the ITC-South East Asia Survey. Nicotine and Tobacco Research. 2008; 10(5):907–915. [PubMed: 18569766]

**Table 1**

Descriptive statistics

| | Wave 1 Mean (SD) | Wave 2 Mean (SD) | Difference in means | *t*-test of (1) vs. (2) (*p*-value) | *N* |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| *Dependent Variables* | | | | | |
| Quit (vs. not) | -- | 0.127 | -- | -- | 1,422 |
| Cigarettes per day | 14.27 (8.50) | 11.94 (8.43) | −2.33 | <0.001 | 2,172 |
| Price tier | | | | | |
| Tier 1 (low-price brands) | 0.261 | 0.305 | 0.044 | 0.142 | 912 |
| Tier 2 (mid price brands) | 0.726 | 0.689 | −0.037 | 0.216 | 912 |
| Tier 3 (high-price brands) | 0.013 | 0.007 | −0.007 | 0.315 | 912 |
| Package size | | | | | |
| Stick | 0.073 | 0.259 | 0.186 | <0.001 | 904 |
| Pack | 0.914 | 0.721 | −0.192 | <0.001 | 904 |
| Carton | 0.013 | 0.020 | 0.007 | 0.435 | 904 |
| Product type | | | | | |
| Manufactured cigarettes only | 0.408 | 0.376 | −0.032 | 0.099 | 2,470 |
| RYO tobacco only | 0.338 | 0.500 | 0.162 | <0.001 | 2,470 |
| Both | 0.254 | 0.125 | −0.130 | <0.001 | 2,470 |
| *Independent Variables* | | | | | |
| Price of manufactured cigarettes per pack, in 2005 baht | 33.20 (1.80) | 36.22 (2.54) | 3.03 | <0.001 | 2,844 |
| Brand-specific price of manufactured cigarettes per pack, in 2005 baht | 33.93 (4.90) | 36.17 (4.58) | 2.25 | <0.001 | 2,470 |
| Price of RYO tobacco per pack- equivalent, in 2005 baht | 3.62 (1.46) | 3.28 (1.48) | -0.34 | <0.001 | 2,844 |
| Annual household income, in 100,000 baht | 1.15 (2.08) | -- | -- | -- | 2,844 |
| Age | 48.0 (13.6) | -- | -- | -- | 2,844 |
| Education | | | | | |
| Primary or less | 0.764 | -- | -- | -- | 2,844 |
| Secondary | 0.159 | -- | -- | -- | 2,844 |
| Beyond secondary | 0.077 | -- | -- | -- | 2,844 |
| Urban | 0.255 | -- | -- | -- | 2,844 |
| Exposure to tobacco advertising | 0.139 | -- | -- | -- | 2,840 |

| | Wave 1 Mean (SD) | Wave 2 Mean (SD) | Difference in means | *t*-test of (1) vs. (2) (*p*-value) | *N* |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Exposure to anti-tobacco messages | 0.431 | -- | -- | -- | 2,840 |
| Smoking restrictions at home or work | 0.530 | -- | -- | -- | 2,844 |

Note: Continuous variables include a standard deviation; categorical variables do not. *N* represents the number of person-year observations available for each variable. Column (4) presents two-tailed *t*-tests for a linear combination of coefficients.

**Table 2**

Price effects on quitting and cigarette consumption

| | Quit (1) | Quit (2) | Cigs/day (3) | Cigs/day (4) | Cigs/day (5) | Cigs/day (6) |
|---|---|---|---|---|---|---|
| Manufactured cigarette price change | 0.0089** (0.0037) | 0.0147*** (0.0036) | | | | |
| Manufactured cigarette price at baseline | −0.0011 (0.0045) | −0.0045 (0.0045) | | | | |
| RYO tobacco price change | 0.0211* (0.0112) | 0.0150 (0.0103) | | | | |
| RYO tobacco price at baseline | 0.0054 (0.0037) | 0.0010 (0.0040) | | | | |
| Manufactured cigarette price | | | −0.0217 (0.1437) | −0.0402 (0.1429) | 0.0572 (0.1642) | 0.0389 (0.1671) |
| RYO tobacco price | | | −1.0168*** (0.2814) | −1.0232*** (0.2637) | −0.1051 (0.6707) | −0.1422 (0.6793) |
| Manufactured cigarette price elasticity | 0.2133** (0.0886) | 0.3527*** (0.0828) | −0.0590 (0.3911) | −0.1108 (0.3928) | 0.1551 (0.4442) | 0.1040 (0.4469) |
| RYO tobacco price elasticity | −0.0572* (0.0311) | −0.0408 (0.0281) | −0.2855*** (0.0794) | −0.2917*** (0.0773) | −0.0281 (0.1802) | −0.0374 (0.1801) |
| Baseline covariates | | X | | X | X | |
| Community random effects | X | X | X | X | | |
| Community fixed effects | | | | | X | |
| Person fixed effects | | | | | | X |
| Mean of dependent variable | 0.1266 | 0.1266 | 13.11 | 13.11 | 13.11 | 13.11 |
| Number of observations | 1,422 | 1,422 | 2,172 | 2,172 | 2,172 | 2,172 |
| Number of random/fixed effects | 36 | 36 | 36 | 36 | 36 | 1,089 |

Note: OLS regression coefficients are reported as marginal effects and elasticities. Robust standard errors, in parentheses, are clustered at the market level. Baseline covariates are listed in Table 1. The quit models use cross-sectional data. The consumption models use the full panel data.

* p<0.10,

** p<0.05,

*** p<0.01

**Table 3**

Price effects on package size and brand choice

| | Sticks (1) | Sticks (2) | Sticks (3) | Sticks (4) | Price Tier (5) | Price Tier (6) | Price Tier (7) | Price Tier (8) |
|---|---|---|---|---|---|---|---|---|
| Brand-specific cig. price | 0.0065*** (0.0023) | 0.0049*** (0.0019) | 0.0047** (0.0020) | 0.0075 (0.0058) | −0.0812*** (0.0033) | −0.0815*** (0.0034) | −0.0815*** (0.0034) | −0.0757*** (0.0050) |
| Brand-specific price elasticity | 1.2844** (0.5056) | 0.9896*** (0.3836) | 0.9962** (0.4324) | 1.5944 (1.2163) | −9.8803*** (0.5415) | −10.0820*** (0.4365) | −10.0557*** (0.4161) | −9.3420*** (0.6193) |
| Baseline covariates | | X | X | | | X | X | |
| Community random effects | X | X | | | X | X | | |
| Community fixed effects | | | X | | | | X | |
| Person fixed effects | | | | X | | | | X |
| Mean of dependent variable | 0.1659 | 0.1659 | 0.1659 | 0.1659 | 0.2829 | 0.2829 | 0.2829 | 0.2829 |
| Number of observations | 904 | 904 | 904 | 904 | 912 | 912 | 912 | 912 |
| Number of random/fixed effects | 36 | 36 | 36 | 452 | 36 | 36 | 36 | 456 |

Note: Regression coefficients for the price variable are reported as marginal effects and elasticities. Robust standard errors, in parentheses, are clustered at the market level. The sample is restricted to smokers of manufactured cigarettes in both waves. Models 1–4 show the results for the price effects on purchasing cigarettes by the stick, as opposed to by the pack, and Models 5–8 shows the results for selecting a brand from a high-price tier, as opposed to the low-price tier. Baseline covariates are listed in Table 1.

* p<0.10,

** p<0.05,

*** p<0.01

**Table 4**

Price effects on choice of tobacco product type

| | (1) | | | (2) | | |
|---|---|---|---|---|---|---|
| | **Cig only** | **RYO only** | **Both** | **Cig only** | **RYO only** | **Both** |
| Manufactured cigarette price | −0.0103 (0.0077) | 0.0176** (0.0075) | −0.0073 (0.0099) | −0.0236*** (0.0079) | 0.0119** (0.0055) | 0.0118 (0.0075) |
| RYO tobacco price | −0.0148 (0.0328) | 0.0054 (0.0253) | 0.0093 (0.0124) | −0.0032 (0.0193) | −0.0012 (0.0079) | 0.0044 (0.0129) |
| Manufactured price elasticity | −1.3927*** (0.4167) | 2.0829*** (0.3851) | −1.7433*** (0.5709) | −1.1334*** (0.3855) | 9.2493** (4.3585) | 3.6604 (2.5502) |
| RYO tob. price elasticity | 0.1746** (0.0748) | −0.1515** (0.0738) | −0.0262 (0.1085) | −0.0159 (0.0948) | −0.0802 (0.6087) | 0.1242 (0.3808) |
| Cigarette users at baseline | | | | X | X | X |
| Baseline covariates | X | X | X | X | X | X |
| Community random effects | X | X | X | X | X | X |
| Mean of dependent variable | 0.3919 | 0.4186 | 0.1895 | 0.8110 | 0.0507 | 0.1383 |
| Number of observations | 2,470 | 2,470 | 2,470 | 1,164 | 1,164 | 1,164 |
| Number of clusters | 36 | 36 | 36 | 36 | 36 | 36 |

Note: The price coefficients from multinomial logit models with community random effects are reported as marginal effects and elasticities. Robust standard errors, in parentheses, are clustered at the market level. Model 1 includes all smokers. Model 2 includes the subset of smokers who used factory-manufactured cigarettes at baseline and thus captures those who switched from cigarettes to RYO tobacco use or mixed use between waves. Baseline covariates are listed in Table 1.

* p<0.10,

** p<0.05,

*** p<0.01