Chapter 5
Tax, price and adult tobacco use

Introduction

Two broad types of data have been used in international studies of the demand for cigarettes, namely aggregate data and survey data. In general, it is easier and less costly to collect aggregate data than individual or household survey data. Both types of data have their advantages and drawbacks. The previous chapter presents the evidence from studies employing time-series or pooled time-series cross-sectional aggregate data. This chapter reviews the evidence from studies using individual-level and household-level survey data to examine the effects of tax and price on the demand for tobacco products among adults. Studies that focus on tobacco demand among young people are reviewed in Chapter 6 and tobacco demand among the poor in Chapter 7.

Individual-level and household-level cross-sectional data are collected in large nationally representative (or sometimes regionally representative) surveys. Depending on the nature of the survey and the size of the questionnaire, researchers are able to gather a vast array of information about the survey respondents. Some surveys are designed with a focus on tobacco (e.g. the Global Adult Tobacco Survey), while other surveys are more generic, and incorporate questions about tobacco use as part of the greater whole (e.g. National Health and Nutrition Examination Survey in the USA). In some cases the same respondents are interviewed again in subsequent waves of the survey. Such surveys are called longitudinal, panel or cohort surveys and are particularly useful in seeing how individuals' tobacco use behaviours change over time.

Analyses that employ survey data to study the demand for tobacco products are based on the same theoretical framework discussed in Chapter 4. However, studies that have used survey data can answer more nuanced questions than studies that have used aggregate data. For example, studies based on aggregate data, which are usually derived from tax paid sales data, cannot determine *why* tobacco consumption falls in response to an increase in tobacco product prices. Is it because fewer people are using these products (i.e. a decrease in smoking prevalence), because those who use tobacco are consuming less (i.e. a decrease in smoking intensity), or some combination of the two? Studies based on survey data are better able to address these questions. The most common approach, described in more detail below, is to separate individual tobacco consumption decisions into different stages, e.g. the decision to initiate smoking, the decision to continue smoking, the decision about how much to smoke when being a smoker, and the decision to quit smoking. With individual-level data, and especially with longitudinal individual data, these questions can be answered not only for the whole population, but also for different socioeconomic and demographic groups, such as those defined by gender, age, education, income, race/ethnicity or other factors.

Studies based on aggregate data often find that the correlation between independent variables is high. The high degree of correlation complicates the estimation process and can result in unstable estimates (coefficients) and wide confidence intervals. In contrast, the correlation between independent variables in a cross-sectional analysis of survey data is generally lower, resulting in smaller standard errors and more stable coefficients.

Studies based on aggregate data often suffer from simultaneity bias, as market-level price and quantity are jointly determined through the

interaction of supply and demand. Thus, the price variable may be endogenous. Standard Hausman tests can be used to test whether price is endogenous. If this is indeed found to be the case, price endogeneity can be corrected using instrumental variables methods. However, when using survey data, the problem of price endogeneity is less of a concern because no individual tobacco user or potential user consumes enough to influence the market price. Thus, from the perspective of any individual, the price variable is exogenously determined. This simplifies the estimation process.

However, while individual or household survey data have some clear advantages relative to aggregate data, they also have several limitations. First, the survey data are subject to reporting biases, in that people tend to underreport tobacco use and consumption (Warner, 1978; Slattery *et al.*, 1989; Gallus *et al.*, 2011). Typically researchers assume that people underreport their consumption by the same percentage of their actual consumption. This is a strong assumption, and to the extent that it is violated, it will bias the estimated coefficients. Second, many macro-level determinants of the demand for tobacco, like advertising expenditures and/or advertising restrictions, availability of tobacco products, and the strength of anti-tobacco (or pro-tobacco) sentiment, are often not captured in the surveys. If information on these determinants are not obtained from other sources, the coefficient estimates may be biased due to omitted variables.

This chapter reviews several issues related to the impact of taxation of cigarettes and other tobacco products, and tobacco products prices, on tobacco use among *the adult population*. In the following section, the estimation techniques applied in studies based on survey data are discussed in some detail. This is followed by a comprehensive review of the evidence on the impact of price on cigarette smoking among adults, including the impact of price on smoking prevalence and intensity. A similarly comprehensive but shorter review of the relatively scarce evidence on price and non-cigarette tobacco use follows. This is followed by a discussion of the existing empirical literature on smoking cessation. The chapter concludes with a discussion of the more limited research on the relationships of tax and price with other outcomes related to tobacco use for adults, including attitudes and perceptions about prices of tobacco products.

Empirical strategies for estimating demand with individual-level data

Data

Individual- and household-level data, usually obtained from surveys, rely on self-reported measures of tobacco use. The measures of tobacco use typically collected in surveys include information on the prevalence and intensity of tobacco use and sometimes on tobacco consumption histories. Two basic types of surveys are typically employed when examining the impact of price or tax on adult tobacco use: cross-sectional and longitudinal. A cross-sectional survey is used to gather information on a population at a single point in time, and many cross-sectional surveys are repeated regularly. Often, researchers use pooled cross-sectional data. Pooled cross-sections combine multiple cross-sections at a single point in time (such as comparing cross-sections of the populations of multiple countries). They can also be a single cross-section over time with data collected at multiple time points, such as studying a sample from a single country over a period of multiple years (this form of pooled cross-sectional data is often referred to in the literature as repeated cross-sectional data). Pooling different cross-sections has the benefit of a larger sample size (or a higher number of subjects studied) beyond what would be available in a single cross section, thus allowing researchers to examine different determinants of tobacco use over time like prices of tobacco products and tobacco control policies by studying a sample at multiple time points. Longitudinal data, on the other hand, follows each subject (either an individual or household) over time. The advantage of longitudinal data is that changes in individual (or household) tobacco use measured as smoking prevalence and intensity can be examined, and the impact of price or tax on tobacco-use transitions such as tobacco initiation and cessation can be quantified.

Measuring the price of tobacco products

In contrast to aggregate databased studies, studies that rely on survey data can consider many more variables in the analysis. For example, individual (or household) characteristics such as disposable income, age, gender, level of education, employment status, marital status, family structure, religiosity and various other socioeconomic and demographic characteristics can be incorporated in the analysis.

Of particular importance to this research is the role of tobacco prices in affecting adult tobacco demand. As increases in tobacco taxes are

expected to increase tobacco prices, tobacco taxes are a policy mechanism with which governments can affect adult consumption of tobacco (see Chapter 2 for a discussion on tobacco taxes and prices). As *IARC Handbooks of Cancer Prevention: Tobacco Control, Volume 12* points out (IARC, 2008), several sources of tobacco price data have been used in prior research. Some studies have used cigarette prices that are collected in retail outlets or reported by households/individuals that use scanner-based technologies that utilize universal product codes (UPCs). The major advantages of using prices collected using scanner technology is that brand- and package-specific information can be extracted, and that the final purchase price will capture the presence of sale promotions affecting price. Unfortunately, there is limited availability of this technology in many countries, particularly in low- and middle-income countries. Even in high-income countries, these systems typically do not provide comprehensive geographic coverage. Moreover, even in covered areas, some outlets that sell tobacco products do not participate in scanner data collection efforts, generating tobacco price data that may not be completely representative of all tobacco sales.

Another approach to obtain tobacco price information is to use observational data collection methods in which trained individuals visit tobacco vendors and collect price information by observing what the posted prices are, asking the vendor what the price is when the price is not posted, and sometimes purchasing the product. These prices typically produce the same measure of price and account for price-related promotions. Observational data collection involves several limitations, including limited geographic coverage, and the use of a convenience sample of stores (i.e. inadequate sample frame and hence a sample that may not be representative of all retail stores). Use of data collected with this approach can also create an aggregate price measure that does not account for the share of sales of the brands collected and the share of sales from different types of outlets.

The final method to collect tobacco prices is through the use of mail and telephone surveys. These surveys are conducted on tobacco product vendors, the general population and the population of smokers. The surveys on tobacco vendors face limitations similar to the observational data collection methods described above.

Information obtained in population surveys is useful in developing aggregate measures of price (such as at the national or subnational levels). However, the use of individual's self-reported price in analyses to examine the respondent's smoking behaviour may be problematic due to the endogeneity of this price variable. That is, holding other things constant, heavy smokers may be more likely to consume cheaper brands of cigarettes, purchase cigarettes in greater quantities, look for lower-priced retailers, engage in tax-avoiding behaviours, and take advantage of price promotions than individuals who smoke fewer cigarettes. Treating an individual's self-reported price as an exogenous variable in an equation that examines his or her tobacco consumption will lead to a biased (over-) estimate of the impact of price on consumption.

In some analyses, efforts have been made to derive cigarette prices from household expenditure surveys that collect expenditure information on a wide variety of goods and services including tobacco products. Price is typically derived by dividing household consumption expenditures on tobacco products by the total amount/quantity of these products consumed. In addition to the endogeneity problems discussed above, there are other reasons why these price measures should be used with caution. First, one member of the family typically reports total household expenditures on tobacco and quantity purchased, leading to potential reporting errors. The extent of reporting errors depends on how well informed the individual is about the consumption expenditures and quantities purchased by other household members. Caution should also be used because sometimes only broad information on tobacco expenditures and amount purchased are collected, while only composite prices that combine all tobacco products can be generated. Finally, it is very important to account for the effects of inflation when evaluating the impact of tobacco prices on tobacco demand and demand-related outcomes when multiple years of data are employed, given that inflation can significantly affect the price of tobacco products relative to the price of other goods and services.

Methods

When using individual-level survey data, economists have traditionally used a two-part model of demand developed by Cragg (1971), in which tobacco prevalence and tobacco intensity are modelled separately. The rationale for the two-part model is that a person faces two sequential decisions. First, s/he has to decide whether or not to consume tobacco. Then, among those who have decided to consume tobacco, there is a decision on how much

tobacco to be consumed. The first decision is a dichotomous decision and is typically estimated using a probit or logit specification (logistic regression models). For the second decision, on how much tobacco to be consumed, ordinary least squares (OLS) techniques (linear regression models) on a log-transformed dependent variable are usually used. The resulting price elasticity derived from the first step is known as the price elasticity of prevalence, whereas the resulting price elasticity from the second step is known as the price elasticity of intensity. Combining the price elasticity of prevalence and the price elasticity of intensity will yield the total price elasticity of tobacco demand.

A potential problem with the standard approach of estimating the second part of the two-part model is that the estimates have to be retransformed back from log scale to original scale. The retransformation factor that is employed in the retransformation process must reflect any heteroscedasticity in the conditional smoking equation if the derived elasticities are to be consistent. An alternative estimator that Blough, Madden and Hornbrook (1999), Manning and Mullahy (2001) and Tauras (2006) proposed is the generalized linear model (GLM). While OLS models estimate expectation of the log-transformed variable $E(\ln(Y|X))$ and then require retransformation back to $\ln(E(Y|X))$, GLM models directly estimate $\ln(E(Y|X))$ and consequently obtain expectation $E(Y|X)$ directly and thus preclude the need to retransform[1].

While the two-part technique discussed above is the most frequently used method to estimate tobacco prevalence and intensity demand equations using survey data, numerous other methods have been employed. Due to limited computing power, some early studies used a linear probability model (i.e. an OLS technique) instead of limited dependent variables techniques for the first part of the two-part model. Other researchers have combined both separate models of the two-part model into a one-part model and apply an OLS regression. The limitation of this approach is that researchers cannot disentangle the effects of changes in prices or taxes on tobacco prevalence and intensity—a distinction that is often very important for policy-making purposes. Other researchers have used sample selection models, such as Heckman's (1979) two-step correction model. Heckman's model corrects the second part of the two-part model for self-selection by using a transformation that is the predicted probability of each individual to use tobacco as an additional variable in the second equation. Still other researchers reformulate the tobacco demand equation into latent consumption (i.e. latent demand) instead of the actual consumption. As the latent demand measures willingness to consume tobacco, those individuals who hate tobacco would likely make negative scores for willingness to consume. Since negative latent demand is reflected by zero actual consumption, the dependent consumption variable is left censored at zero. Tobit models have been used by researchers to account for the censored nature of the tobacco consumption data. Finally, numerous extensions to Cragg's (1971) model have been proposed and employed to examine the determinants of both prevalence and intensity of tobacco use. This class of models has become known as double-hurdle models (Jones, 1989). A thorough discussion on the variants of the double-hurdle models can be found in Jones and Yen (2000).

Researchers have also used longitudinal data to examine the impact of price or tax on tobacco-use transitions such as tobacco initiation, tobacco use escalation, and tobacco cessation. Both discrete-time and continuous-time hazard models have been used to estimate the equations specified for those tobacco-use transitions. The discrete time model usually takes the form of a probit or logit specification to estimate the probability of making a transition from one discrete state to another (such as from non-smoking to smoking) between waves of data collection. Cox's (1972) partial likelihood method has also been used to estimate continuous hazard models. Cox's (1972) model is appealing because it examines the effects of the covariates on tobacco use without making any assumptions about the underlying baseline hazard. Other researchers have used continuous time parametric models that have assumptions about the shape of the baseline hazard.

Estimation issues

A central issue to consider when estimating empirically cigarette-demand equations for adults is how to account for tobacco sentiment or the social acceptability of smoking. Indeed, accounting for this condition is important because it may be the sentiment towards tobacco that is driving changes in tobacco consumption and in tobacco taxes as well as in other tobacco control policies. If not controlling for tobacco sentiment, this overlook may result

[1] Y is the dependent variable, X is a vector of explanatory variables, ln is a natural logarithm transformation, and $E(Y|X)$is the expectation of Y conditional on X.

in an omitted variable bias that produces a spurious negative relationship between price or tax and tobacco demand. This spurious negative relationship results in price elasticity estimates that are biased away from zero.

Several strategies have been put forth to account for antismoking sentiment in adult smoking equations. One approach that can be applied to cross-sectional data, pooled cross-sectional data and longitudinal data is to include a variable as an explanatory variable in the cigarette demand equation to capture the economic importance of tobacco growing and production in the area (such as a state, region, province, etc.) where the individual/household resides. To the extent that residing in a tobacco producing location proxies for positive sentiment towards tobacco, the inclusion of these variables in the regression model will mitigate some bias generated by the omitted variables on the price elasticity estimates.

Another approach that can be applied to pooled cross-sectional and longitudinal data is to use location-specific dummy variables as covariates. The use of location-specific dummies will help to eliminate all time-invariant, unobserved and location-specific heterogeneity. To the extent that sentiment towards tobacco within a location is time-invariant during the period under investigation, then including those explanatory dummy variables will eliminate bias on the price elasticity estimates due to the omitted variables. The use of location-specific dummy variables relies on within-location variation in cigarette prices or taxes over time (as opposed to inter-location differences in prices and taxes) to quantify the effect of price on consumption. However, for the location-specific dummy variable approach to be viable, researchers must use multiple years of cross-sectional data—one year of cross-sectional data would result in perfect multicollinearity between the location specific taxes (or prices) and the dichotomous location indicators. Moreover, even if multiple years of data are employed, there must be reasonable variation in tax (or price) over time within locations to avoid collinearity issues with the tax (or price) variable.

The final approach that has been used is to approximate the magnitude of anti-tobacco sentiment within a location using individual's attitudes towards smoking and beliefs about tobacco control policies from survey data. The derived tobacco sentiment variable would then be included as an explanatory variable in the tobacco demand equation. Some caution should be used with this approach because the derived tobacco sentiment variable may be endogenous, particularly if the same survey data are used both to estimate the tobacco demand equations and to derive the tobacco sentiment variable.

It is also important to control for other tobacco control policies in the tobacco demand equations to avoid an omitted variable bias. The omission of other tobacco control policies will bias the price elasticity estimates away from zero if both tobacco prices and tobacco control policies affect tobacco consumption and they are correlated to each other. One potential limitation of including tobacco prices and tobacco control policies simultaneously in the same equation is multicollinearity. That is, as part of a comprehensive tobacco control effort, governments may increase tobacco taxes and impose stronger restriction on tobacco consumption simultaneously. If both the tax and policy levers are pulled simultaneously, it may become difficult to disentangle the individual effects of taxes from those effects of other tobacco control policies on tobacco consumption.

It is also important to account for tax avoidance opportunities to purchase tobacco products when estimating tobacco demand equations using individual-level data (see Chapter 8 for a more complete discussion of tax avoidance and evasion). Cross-border shopping opportunities created by substantial differences in tax rates or other factors that determine prices across political jurisdictions are one form of tax avoidance. If opportunities to purchase less expensive tobacco exist but are not accounted for in the specification of the demand equation, biased price elasticity estimates may result, as the full price elasticity estimates in absolute value will tend to be understated. That is, individuals living close to a border of a lower-price location may in fact purchase tobacco from the lower-priced jurisdiction. The price they pay for tobacco bought is smaller than the price that is assigned to those individuals simply on the basis of their residence.

Numerous strategies have been put forth to address cross-border purchases using individual-level data. Several main strategies can be named: first, including a covariate that represents the lowest price of tobacco in a neighbouring jurisdiction; second, including a covariate that represents the weighted average price of tobacco (or average price differential) in all neighbouring jurisdictions where the weights are based on the populations close to the borders; third, omitting all individuals who reside in locations that are within a certain distance from the border of a lower-priced jurisdiction; fourth, running separate regressions

on individuals who reside in locations where the tax difference between any neighbouring jurisdiction and their own is below and above a certain threshold; and fifth, including a covariate that represents the distance to the lowest tax location in the area. While imperfect, these efforts have significantly reduced the biases in price elasticity estimates.

Summary

Using individual or household-level survey data to analyse the impact of tax and price on the demand for tobacco products has several advantages over the use of more aggregated data, including the ability to disentangle the impact of tax and price on prevalence, initiation, uptake, cessation and intensity. At the same time, using survey data introduces several empirical challenges that, if not accounted for, can produce biased estimates of the impact of tax and price on tobacco use.

Evidence on the impact of tax and price on the demand for tobacco products among adults

Identification of relevant studies

For the review contained in this chapter, a systematic search was conducted to identify all publications providing evidence on the effects of price and tax on tobacco consumption among adults, using individual-level or household-level data on adults. A MEDLINE search in PubMed up to February 2010 was performed using the string "(price[title] OR prices[title] OR elasticity[title] OR elasticities[title] OR tax[title] OR taxes[title] OR fiscal[title]) ("lung cancer"[title] OR smoking[title] OR cigarette[title] OR cigarettes[title] OR tobacco[title]) adults." Two members of the Working Group selected the papers identified by this search strategy that reported original data on the issue. Moreover, we checked the reference lists of the identified articles, a meta-analysis (Gallet and List, 2003), a comprehensive review of the literature (Chaloupka and Warner, 2000), a review on developing countries from Guindon *et al.*, (2003), and World Bank publications on tobacco (such as the papers in the World Bank's Health, Nutrition, and Population (NHP) working paper series). Many relevant and appropriate articles were added later based on the references of the articles read. No study was excluded a priori because of weaknesses in design and/or data quality. Studies reporting estimates only on youth, adolescents and young adults were not considered for the present chapter, as these are reviewed in detail in Chapter 6. Similarly, studies that focus on differences in responses based on income, socioeconomic status, or related factors are not discussed in this chapter, as these are comprehensively reviewed in Chapter 7.

Systematic review of the scientific literature: Impact of tax and price on the prevalence and intensity of adult tobacco use

In contrast to the studies based on aggregate data, studies based on survey data did not begin to emerge until the early 1980s. Prior to this time, the computing power necessary to conduct econometric and other statistical analyses of large survey data was not generally available to researchers. As survey data and the computing power needed to analyse them became more widely accessible to researchers, this began to change and the earliest studies of demand for cigarettes and other tobacco products based on survey data began to appear. Continued growth in and access to computing power, particularly in the past decade, led to the development of more sophisticated econometric methods and software, allowing for more sophisticated analyses of larger and more complex survey data and a tremendous increase in the number of studies based on survey data.

As was true for the demand studies based on aggregate data, most of the earliest demand studies based on survey data were conducted in the USA, but studies based on US data are also the most prevalent. This is true for many reasons, including several ones described in Chapter 4. First, a variety of high-quality, nationally representative surveys that collect information on tobacco use have been conducted for many years in the USA, such as the National Health and Nutrition Examination Surveys, the National Health Interview Survey, the Tobacco Use Supplement to the Current Population Survey, several state-specific surveys (e.g. the California Tobacco Survey). Second, the academic researchers who conduct these studies have access to high-powered computing technology through their universities and to the public and private funding sources that provide the financial research resources needed. Finally and perhaps most importantly, as with the aggregate demand studies based on state-level data, the cross-sectional differences in state and local taxes and prices of tobacco products as well as the frequent changes in national, state and local taxes provide considerable variation in taxes and prices needed to most effectively conduct this type of research.

As survey data and access to sufficient computing power have become more widely available in

several countries, including many low- and middle-income countries, demand studies based on individual or household-level survey data have been produced for a growing number of countries. Table 5.1 provides a detailed summary of the existing evidence on the demand for tobacco products from studies that are based on survey data. Studies are organized by country, with those from the USA presented first, followed by those from other high-income countries, and then by those from low- and middle-income countries. Within a certain country, studies are presented chronologically, from oldest to most recent. Table 5.1 also includes details on each identified study including the data used in the study, basic information on the theoretical and empirical approach, estimates of price elasticities for overall demand, prevalence (often referred to as participation in this literature) and intensity (often referred to as conditional demand). In addition, for studies that estimate demand for various subpopulations, the estimated elasticities for these populations are presented. The narrative review below follows the organization of the table, providing a discussion of seminal studies or those that are unique in some other way, rather than a discussion of each of the studies contained in the table. However, it limitedly discusses differences in price elasticities based on age or income or socioeconomic status, as these are discussed more fully in subsequent chapters.

United States of America

Lewit and Coate (1982) published the first analysis of cigarette demand based on individual-level survey data from the USA. They analysed data on 19 266 respondents ages 20–74 years from the 1976 wave of the National Health Interview Survey. They used prices matched to the survey data on the basis respondents' state of residence. Using a two-part model, they first estimated the impact of price on the decision to smoke and then the impact of price on cigarette consumption among smokers. In addition to estimating price elasticities for the overall sample, they also produced separate estimates for subsamples based on age groups (20–25 years, 26–35 years, and older than 35 years) and sex. Lewit and Coate (1982) obtained an overall price elasticity for their full sample of −0.221, with a prevalence elasticity of −0.135 and an intensity elasticity of −0.037.

Given the potential for tax avoidance through cross-border shopping for cigarettes, Lewit and Coate (1982) restricted their sample to respondents for whom the price in the area where they resided was lower than the price in nearby jurisdictions. For this restricted sample, they obtained an overall price elasticity of cigarette demand of −0.416, with a prevalence elasticity of −0.264 and an intensity elasticity of −0.103. The differences between the two sets of estimates clearly illustrate how failing to account for opportunities for tax avoidance can bias price elasticity estimates. In addition, Lewit and Coate (1982) found that smoking was more responsive to price among younger persons than among older persons, with overall price elasticities of −0.89, −0.47, and −0.45 for persons having ages 20–25, 26–35, and over 35, respectively. Similarly, they found that the effect of price on the decision to smoke among younger persons accounted for more of the overall impact of price on cigarette demand than it did among older persons (prevalence elasticities of −0.74, −0.44, and −0.15 for the three age groups, respectively). Finally, they found that men, particularly younger men, were more responsive to changes in cigarette prices than were women.

Mullahy (1985) built on the Lewit and Coate (1982) analyses by estimating cigarette demand models that accounted for the addictive nature of tobacco use. Mullahy (1985) assumed myopic behaviour, such that individuals' current cigarette consumption depended on their past cigarette consumption and that smokers ignored the future consequences of their smoking decisions. Applying two-part methods to data from the 1979 US Health Interview Survey, Mullahy (1985) estimated separate demand equations for men and women. He obtained a total price elasticity of −0.47, similar to that of Lewit and Coate (1982), and found that men were somewhat more price-sensitive than women.

A few years later, Chaloupka (1990, 1991 and 1992) produced a series of papers that applied Becker and Murphy's (1988) rational addiction model to examine adult cigarette demand (ages 17–73 years). He used individual-level, cross-sectional survey data from the Second National Health and Nutrition Examination Survey, conducted from 1976 to 1980. He used information on smoking at the time of the survey, smoking one year before the survey, and past smoking. He applied two-stage least squares models that accounted for the endogeneity of past and future smoking in the rational addiction model. He matched prices to the survey databased on an individual's area of residence, with the price measure accounting for potential cross-border shopping by averaging prices in the individual's own state and lower prices in nearby states.

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
USA						
Lewitt & Coate (1982) USA	Cross-sectional Health Interview Survey (HIS) 1976 N=28 033 (20–74 yrs) Analysis sample: Entire: n=19 266 Restricted: n=11 052 (20–74 yrs)	Two models were considered: i) an OLS (ordinary least squares); ii) a two-part model: 1) OLS; 2) OLS Adjusted for family income, education, age, sex, marital status, health status, race/ethnicity, family size, employment status, region and urbanicity Demand equations were estimated across three age groups in the restricted sample by another two-part model: 1) a logit; 2) an OLS Price: composite price in cents per pack of cigarettes a consumer faces in his immediate area	**Entire sample** -0.221 **Restricted sample** *Overall* -0.416 **By age (in years)** *20–25* -0.89 *26–35* -0.47 *>35* -0.45 **By sex and age (in years)** ***Males*** *20–25* -1.401 *26–35* -0.320 *>35* -0.658 ***Females*** *20–25* -0.302 *26–35* -0.577 *>35* -0.118	**Entire sample** -0.135 **Restricted sample** *Overall* -0.264 **By age (in years)** *20–25* -0.74 *26–35* -0.44 *>35* - 0.15 **By sex and age (in years)** ***Males*** *20–25* -1.276 *26–35* -0.292 *>35* -0.246 ***Females*** *20–25* -0.136 *26–35* -0.388 *>35* + 0.066	**Entire sample** 0.037 **Restricted sample** *Overall* -0.103 **By age (in years)** *20–25* -0.20 *26–35* -0.04 *>35* -0.15 **By sex and age (in years)** ***Males*** *20–25* -0.171 *26–35* + 0.029 *>35* -0.204 ***Females*** *20–25* -0.025 *26–35* -0.134 *>35* -0.077	Restricted sample was obtained by deleting from the full sample individuals in Primary Sample Units where the own average price was greater than the price within the 20-mile band
Mullahy (1985) USA	National Health Interview Survey, 1979 N= 13 794 (≥ 17 yrs)	A two-part model: 1) a probit; 2) an OLS and instrumental variables method	**Overall** -0.47 **By sex** *Men* -0.56 *Women* -0.39			Cigarette demand was estimated based on a myopic demand model. The results supported the hypothesis that cigarette smoking is an addictive behaviour
Chaloupka (1990) USA	Cross sectional NHANES II (1976–1980) N=28 000 (6 months to 74 yrs) Analysis sample: 14 305 (17–73 yrs) Men: n=6569 Women: n=7736	Two-stage least squares model for current cigarette consumption Adjusted for real family income, education, age, age2, race, marital status, employment status	**Long-run price elasticity** *By sex* *Men* -0.55 to -0.69 *Women* +0.37 to 0.63			Ranges of elasticity estimates obtained according to different rates of depreciation on the addictive stock

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Chaloupka (1990) (contd) USA		Cigarette price: state-specific weighted average price. Cigarette price and excise tax adjusted for the national monthly consumer price index and a local price index				
Chaloupka (1991) USA	Cross sectional NHANES II (1976–1980) N=28 000 (6 months to 74 yrs) Analysis sample: 14 005 (17–73 yrs)	Two-stage least squares model for current cigarette consumption Adjusted for real family income, education, age, age2, race, marital status, employment status Cigarette price: state-specific weighted average price. Cigarette price and excise tax adjusted for the national monthly consumer price index and a local price index	**Long-run price elasticity** ***Overall/Full sample*** -0.274 to -0.359 ***Ever smokers*** -0.348 to -0.482 ***Current smokers*** -0.296 to -0.890 ***By education*** *<high school* -0.587 to -0.618 *≥high school* +0.135 to +0.268 ***By age (in years)*** *17–24* -0.103 to +0.050 *25–64* -0.315 to -0.454 *65–73* -0.029 to +0.166			Ranges of elasticity estimates obtained according to different rates of depreciation on the addictive stock
Wasserman *et al.* (1991) USA	Repeated cross sectional NHIS (1970 to 1985) N=207 647 [seven surveys] Analysis sample: 84 301 (either >17 yrs or >20 yrs, depending on year of survey)	Two models were considered: 1) Two part model: i) logistic regression (smoking prevalence); ii) simple OLS (smoking intensity) 2) Generalized linear model (GLM) with an iterative weighted least squares technique Adjusted for income, education, age, gender, family size, marital status, race, , cohort of birth, interactions of age and sex, interactions of birth cohort and sex, and regulation index Price: weighted average state-specific price	**Two-part model** ***By survey year*** *1970*: +0.072 *1974*: -0.013 *1976*: -0.057 *1979*: -0.124 *1980*: -0.147 *1983*: -0.217 *1985*: -0.263 **GLM** ***By survey year:*** *1970*: +0.059 *1974*: -0.017 *1976*: -0.055 *1979*: -0.112 *1980*: -0.131 *1983*: -0.188 *1985*: -0.226 *1988*: -0.283	**Two-part model** ***By survey year*** *1970*: +0.059 *1974*: +0.002 *1976*: -0.028 *1979*: -0.074 *1980*: -0.098 *1983*: -0.139 *1985*: -0.171	**Two-part model** ***By survey year*** *1970*: +0.013 *1974*: -0.015 *1976*: -0.029 *1979*: -0.050 *1980*: -0.057 *1983*: -0.078 *1985*: -0.092	**Income elasticity obtained from the GLM** ***By survey year*** *1970*: +0.051 *1974*: +0.01 *1976*: +0.021 *1979*: +0.007 *1980*: +0.002 *1983*: 0.013 *1985*: 0.023 *1988*: 0.038 Predicted elasticities for year 1988 might not be valid

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Chaloupka (1992) USA	Cross sectional NHANES II (1976–1980) N=28 000 (6 months to 74 yrs) Analysis sample: 14 005 (17–73 yrs)	Two-stage and restricted two-stage least squares model for current cigarette consumption Adjusted for real family income, gender, education, age, age^2, race, marital status, labour force status & state clean indoor laws Cigarette price: state-specific weighted average price. Cigarette price and excise tax: adjusted for the national monthly consumer price index and a state-specific price index	**Long-run price elasticity** ***Overall/Full sample*** -0.268 to -0.322 ***Ever smokers*** -0.344 to -0.422 **By sex** *Men* -0.425 to -0.505 *Women* +0.852 to +1.410 **Restricted model** *Overall/Full sample* -0.308 to -0.357 *Ever smokers* -0.326 to -0.433			Ranges of elasticity estimates obtained according to different rates of depreciation on the addictive stock
Ohsfeldt & Boyle (1994) USA	Cross-sectional CPS (1985) n=100 000 in file Analysis sample: only men (≥16 yrs) (n not reported)	Multivariate regression (for (i) snuff use, (ii) chewing tobacco use, and (iii) any smokeless tobacco use) Adjusted for per-capita income, education, state population characteristics (residence, race, religious denomination, and divorce rate), men aged 16–17, and existing state tobacco regulation Price of smokeless tobacco products: border-adjusted state smokeless tobacco average excise tax		**Tax elasticity** ***Snuff*** -0.41 to -0.61 ***Chewing tobacco*** -0.56 to -0.63 ***Smokeless tobacco (both snuff and chewing tobacco)*** -0.55		Ranges of tax elasticities obtained according to both full and restricted models Cross-tax elasticities of demand for smokeless tobacco with respect to the cigarette tax: +0.39 to +0.62 (see Table 5.3)
Hu *et al.* (1995) USA California	Cross-sectional (pooled surveys) California BRFSS (1985–1991) N=13 531 (≥18 yrs)	Two-part model: 1) logistic model; and 2) OLS Adjusted for income, sex, age, ethnicity, education, family	-0.46 (after being controlled for "other health behaviours")	-0.54 (overall) -0.33 (after being controlled for "other health behaviours")	-0.22 (overall) -0.20 (after being controlled for "other health behaviours")	

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Hu *et al.* (1995) (contd) USA California		income, employment status, marital status, health status, "other health behaviours" (alcohol, exercise, and BMI) Price: average price (monthly price index of tobacco products for Los Angeles)				
Ohsfeldt *et al.* (1997) USA	Cross-sectional CPS (1985) n=100 000 in file Analysis sample: only men (16–64 yrs) (n not reported)	Logit regression model (for (i) cigarette use, (ii) snuff use, (iii) chewing tobacco use, and (iv) any smokeless tobacco use) Adjusted for real family income, age, marital status, race, ethnicity, employment status, education, occupation, metropolitan, religion, and tobacco control policy Price of smokeless tobacco products: border-adjusted state average smokeless tobacco excise tax		**Cigarettes** ***Overall*** -0.05 ***By age (in years)*** *16-24* -0.07 *≥25* -0.05 **Snuff** ***Overall*** -0.27 ***By age (in years)*** *16-24* -0.31 *≥25* -0.13 **Chewing tobacco** ***Overall*** -0.13 ***By age (in years)*** *16–24* -0.07 *≥25* -0.16 **Any smokeless tobacco** ***Overall*** 0.15 ***By age (in years)*** *16–24* -0.09 *≥25* -0.11		Cross-tax elasticities of demand for smokeless tobacco with respect to the cigarette tax: Snuff: +0.13 Chewing tobacco: +0.09 Any smokeless tobacco: +0.10 See Table 5.3
Evans & Farrelly (1998) USA	Cross-sectional (pooled surveys) NHIS supplements: 1979 (smoking) and 1987 (cancer control)	Two-part model: 1) probit (smoking prevalence); 2) OLS (cigarette demand) Adjusted for age,		**Pooled model 1979-87** ***Tax*** *Overall* -0.214 ***Price***	*Tax* *Overall* -0.330 **For 1987 NHIS** ***Tax***	The models describe compensating behaviours. Taxes reduce cigarette consumption, but do not affect daily tar and nicotine intake

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Evans & Farrelly (1998) USA (contd)	N=48 314 (≥18 yrs) Analysis sample: 1979 NHIS: n=24 092 1987 NHIS: n=22 043	age2, income, family size, region, sex, race, marital status, urban centres and education Two models for smoking intensity are considered: a pooled time-series cross-sectional regression, and a fixed effect model [controlled for state and year]. Three OLS models for smoking intensity by age group were estimated using only the 1987 data Cigarette prices per pack in constant 1982–1984 cents Cigarette excise taxes per pack (state and federal) in constant 1982–1984 cents		*Overall* –0.156 **Fixed effect model 1979-87** ***Tax*** *Overall* +0.160 ***Price*** *Overall* +0.344 ***Tax*** *By age (in years) for the 1987 data:* 18–24: -0.575 25–39: -0.434 40+: +0.142	*By age (in years)* 18–24: -0.223 25–39: -0.325 40+: -0.498 ***Price*** *Overall* –0.352 (using a two-stage least squares regression)	
CDC (Farrelly & Bray), (1998) USA	Cross-sectional (pooled six surveys 1976–1993) from NHIS Analysis sample: N=355 246 (≥18 yrs)	Two-part model for cigarette use: 1) probit (smoking prevalence); 2) OLS (smoking intensity) Adjusted for region of the country, real family income, education, sex, age, race/ethnicity, marital status, urbanicity and year of interview Price: state-specific average price adjusted for inflation	**Overall** -0.25 **By age (in years)** ***18–24*** -0.58 ***25–39*** -0.42 ***≥40*** -0.10 **By sex** ***Men*** -0.26 ***Women*** -0.19 **By income** ***Low*** -0.29 ***High*** -0.17 ***Missing*** -0.25 **By ethnicity** ***White*** -0.14 ***Black*** -0.32 ***Hispanic*** -1.89	**Overall** -0.15 **By age (in years)** ***18–24*** -0.37 ***25–39*** -0.25 ***≥40*** -0.06 **By sex** ***Men*** -0.18 ***Women*** -0.09 **By income** ***Low*** -0.20 ***High*** -0.05 ***Missing*** -0.23 **By ethnicity** ***White*** -0.05 ***Black*** -0.36 ***Hispanic*** -1.31	**Overall** -0.10 **By age (in years)** ***18–24*** -0.21 ***25–39*** -0.17 ***≥40*** -0.04 **By sex** ***Men*** -0.08 ***Women*** -0.10 **By income** ***Low*** -0.09 ***High*** -0.12 ***Missing*** -0.02 **By ethnicity** ***White*** -0.09 ***Black*** +0.04 ***Hispanic*** -0.58	

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Evans *et al.* (1999) USA	Cross sectional (pooled surveys) BRFSS (1985–1995) Analysis sample: N=812 185 (≥18 yrs)	Two-part model: 1) linear probability model; 2) OLS Adjusted for state and year effects, age, age2, sex, annual income, marital status, race, education, work status, and race/ethnicity Price: real tax in 1997 cents per pack	**Real tax** ***Overall*** -0.293 **Average of tax and lag tax** ***Overall*** -0.406	**Real tax** ***Overall*** -0.144 **Average of tax and lag tax** ***Overall*** -0.255	**Real tax** ***Overall*** -0.149 **Average of tax and lag tax** ***Overall*** -0.151	**Total income elasticity estimates** ***Real tax*** *Income missing* 0.65 *Lowest 50%* –0.32 *Next group* 0.17 **Average of tax and lag tax** *Income missing* 0.73 *Lowest 50%* 0.53 *Next group* –0.13
Ohsfeldt *et al.* (1999) USA	Cross-sectional (pooled surveys) CPS (1992–1993) Analysis sample: 165 653 males, either white or black (≥16 yrs) Nationally representative samples	Multivariate regression Adjusted for price (tax) of snuff, index of smoking regulation, family income, age, occupation and education, ethnicity, marital status, per capital income, poverty, unemployment rate, and religion Prices of cigarettes and snuff were mutually adjusted Price: real federal excise tax rate		**Cigarette use** ***Overall*** -0.15 ***By age (in years)*** *16–24* -0.22 *25–44* -0.11 *≥45* -0.07 **Snuff use** ***Overall*** -0.01 ***By age (in years)*** *16–24* -0.24 *25–44* -0.05 *≥45* +0.003		Cross-elasticities of demand for cigarettes and snuff were also analyzed. See Table 5.3 Laws restricting smoking in public places affect both cigarette and snuff use
Hersch (2000) USA	Cross-sectional (pooled surveys) CPS (1992–1993) Nationally representative samples of households Analysis sample: 25 726 men and 28 699 women (18–65 yrs)	Two-part model: 1) probit and 2) OLS Adjusted for real family earning/income, education, age, marital status, race, presence of children by age group, labour market status, and smoking restriction at work Price: average statewide price per		**Men** -0.54 ***By income*** *Low* -0.58 *Middle* 0.40 *High* -0.25 **Women** -0.38	**Men** -0.43 ***By income*** *Low* -0.60 *Middle* 0.44 *High* -0.13 **Women** -0.57	In both sexes, higher elasticity in more educated subjects

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Hersch (2000) (contd) USA		pack (generic cigarettes were included in the sample of cigarettes, and the prices reflected both state and federal taxes)		***By income*** *Low* -0.99 *Middle* 0.06 *High* +0.58 **Among workers** ***Men*** -0.28 ***Women*** -0.21	***By income*** *Low* -0.72 *Middle* 0.55 *High* -0.30 **Among workers** ***Men*** -0.46 ***Women*** -0.38	
Farrelly *et al.* (2001) USA	Cross sectional (pooled seven surveys 1976–1980, 1983, 1985, 1987–1993) from NHIS N=367 106 (≥18 yrs) Analysis sample: n=354 228 (≥18 yrs)	Two-part model for cigarette use: 1) probit (smoking prevalence); 2) OLS (smoking intensity) Adjusted for state, real family income, education, sex, age, race/ethnicity, family size, marital status, urbanicity, year of interview, and state-specific effects Price: state-specific average retail price adjusted for inflation	**Overall** -0.28 **By age (in years)** ***18–24*** -0.55 ***25–39*** -0.53 ***≥40*** 0.00 **By sex** ***Men*** -0.18 ***Women*** -0.32 **By income** ***Low income*** -0.43 ***High income*** 0.00 **By ethnicity** ***White*** -0.15 ***Black*** -0.35 ***Hispanic*** -0.93	**Overall** -0.13 **By age (in years)** ***18–24*** -0.30 ***25–39*** -0.25 ***≥40*** -0.02 **By sex** ***Men*** -0.03 ***Women*** -0.19 **By income** ***Low income*** -0.21 ***High income*** +0.01 **By ethnicity** ***White*** -0.08 ***Black*** -0.20 ***Hispanic*** -0.62	**Overall** -0.15 **By age (in years)** ***18–24*** -0.25 ***25–39*** -0.28 ***≥40*** -0.06 **By sex** ***Men*** -0.18 ***Women*** -0.13 **By income** ***Low income*** -0.22 ***High income*** -0.11 **By ethnicity** ***White*** -0.15 ***Black*** -0.15 ***Hispanic*** -0.31	Data and analysis are very similar to those of the previous papers
Farrelly *et al.* (2004) USA	Longitudinal analysis from COMMIT study (1988 and 1993) N=11 966 smokers (25–64 yrs) Wave of 1988: 3675 smokers (25–64 yrs)	Three linear fixed effects regression models for average cigarette smoked per day by age group Adjusted for race, sex, marital status, education, gross			**Price elasticity** ***By age (in years)*** *25–34* -0.235 *35–44* -0.115 *45–64* -0.110	Smokers respond to higher cigarette prices by reducing intensity, but also by switching to cigarettes with higher levels of tar and nicotine Tar elasticities: +0.041 to +0.364

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Farrelly *et al.* (2004) (contd) USA	Analysis sample (both waves): n=9087 smokers (25–64 yrs)	household income, clean air laws index, age, the year 1993, nicotine and tar Price: average price of all types of cigarettes at the state level				Nicotine elasticities: +0.035 to +0.306
Sheu *et al.* (2004)	Pooled survey data BRFSS (1996–1999) N=16 260 Analysis sample: n=11 180 (Whites, blacks and Hispanics from selected areas with available information on cigarette price) Cigarette price information from the Bureau of Labor Statistics 1996–1999	Zero-inflated negative binomial (ZINB) regression model1) logit and 2) negative binomial (NB) For comparison purpose, also the two-part model was considered: 1) logit; 2) NB or OLS Adjusted for race, age, sex, marital status, education, income, employment status, health status and year of interview Price: average price (monthly price index of tobacco products for Los Angeles, San Diego and San Francisco)		**ZINB** ***Logit*** *Overall* +0.135 **Two-part model** ***Logit*** *Overall* +0.056	**ZINB** ***NB*** *Overall* 0.459 **Two-part model** ***Overall*** *NB* -0.417 *OLS* 0.474	Given the relatively low smoking prevalence, price increases are becoming less effective for hard-core smokers to quit. Price increases may not be an effective strategy to let occasional smokers quit
Sloan & Trogdon (2004)	Cross-sectional (13 surveys pooled) Behavioural Risk Factor Surveillance System BRFSS (1990–2002) N=1 761 686 (≥18 yrs) Surveys representative samples of the US adult population	Probit (smoking prevalence) Adjusted for socioeconomic and demographic factors, ethnicity, health insurance and behaviour, tobacco control policies and border prices Cigarette price: state-specific weighted average real price		**By age (in years)** ***18–20*** -0.26 ***21–24*** -0.11 ***25–44*** -0.10 ***45–64*** -0.10 ***≥65*** -0.25		Review authors computed elasticity estimates based on the resulting marginal effects for smoking prevalence
Tauras (2004) USA	National Health Interview Surveys (NHIS) (1991, 1993, 1994) Age: 18–64 years	A three-part model: 1) a probit for a current smoker 2) a probit for a some-day smoker (conditional on current smoking)		**Average current smoking participation price elasticity** -0.265	**Average some-day smoking conditional demand elasticity** 0.375	For each part of the three-part model, three models were estimated. Estimated elasticities obtained for each part were: -0.333; -0.112; -0.328

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Tauras (2004) (contd) USA		3) a generalized linear model (GLM) with log link and gamma distribution for estimating average number of cigarettes consumed monthly among some-day smokers Explanatory variables: age, sex, real family income, race/ethnicity, education, marital status, metropolitan area, employment status, clean indoor index, and year of interview, price of a pack of 20 cigarettes and survey year Price: real annual, sales-taxed weighted average price for a pack of 20 cigarettes at state level		**Average price elasticity of some-day smoking participation conditional on current smoking** +0.860		0.904; 0.590; 0.977 -0.479; -0.202; -0.444
Tauras (2006) USA	Cross-sectional (pooled surveys) Tobacco Use Supplements to the CPS (1992–1999) Nationally representative surveys Analysis sample: N=545 603 (≥ 18 yrs)	A two-part model: 1) a probit (smoking prevalence); 2) a generalized linear model (GLM) with log-link and Gaussian distribution (smoking intensity) Adjusted for age, sex, real family income, race/ethnicity, education, marital status, metropolitan area, employment status, clean indoor index and year of interview Time and state fixed effects included in regressions Real price: average statewide price		**Overall** -0.120 to -0.129	**Overall** -0.071 to -0.073	Three different models were estimated according to whether the smoke-free law in each state was included More restrictive smoke-free air laws decrease average smoking by adults but have little impact on prevalence

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Franks *et al.* (2007) USA	Cross sectional (pooled surveys) BRFSS (1984–2004) N=over 2.6 million (≥18 yrs) Nationally representative telephone survey	Fixed-effects logistic regression (for smoking prevalence) Adjusted for sex, age, race/ethnicity, education (years of schooling), number of adults in the household, consumer price index, household income, survey year and state Pack price at the year preceding the survey year. Price elasticities were provided before and after the Master Settlement Agreement (MSA) Price: real state-specific cigarette tax		**By income quartile** ***Period 1984–1996*** *Lowest (95% CI)* -0.45 (-0.67, -0.22) *All other quartiles (95% CI)* -0.22 (-0.35, -0.10) ***Period 1997–2004*** *Lowest (95% CI)* -0.14 (-0.36, +0.08) *All other quartiles (95% CI)* -0.07 (-0.18, +0.05)		Using cigarette pack tax instead of pack price brought to greater differences between the two periods By income quartile: Period 1984–1996: Lowest: -0.07 All other quartiles: 0.06 Period 1997–2004: Lowest: 0.00 All other quartiles: 0.04
Stehr (2007) USA	Cross-sectional (pooled surveys) Behavioral Risk Factor Surveillance System BRFSS (1985–2000) N=1 339 459 (≥18 yrs) Men: n=571,631 Women: n=767,872	Two-part model for cigarette use: 1) probit (smoking prevalence); 2) log-log OLS (smoking intensity) Adjusted for gender-specific state fixed effects, income, education, sex, age, ethnicity, and year of interview Price: state-specific average cigarette tax	**Overall** 0.36 **Males** -0.26 ***Income (quartile)*** *1st*: -0.36 *2nd*: -0.11 *3rd*: -0.21 *4th*: -0.23 **Females** -0.51 ***Income (quartile)*** *1st*: -0.59 *2nd*: -0.30 *3rd*: -0.47 *4th*: -0.53	**Overall** -0.25 **Males** -0.16 ***Income (quartile)*** *1st*: -0.23 *2nd*: -0.07 *3rd*: -0.09 *4th*: -0.15 **Females** -0.40 ***Income (quartile)*** *1st*: -0.43 *2nd*: -0.25 *3rd*: -0.30 *4th*: -0.43	**Overall** -0.10 **Males** -0.09 ***Income (quartile)*** *1st*: -0.13 *2nd*: -0.03 *3rd*: -0.013 *4th*: -0.07 **Females** -0.12 ***Income (quartile)*** *1st*: -0.16 *2nd*: -0.05 *3rd*: -0.16 *4th*: -0.10	When gender-specific state fixed effects are included, women were twice as responsive to cigarette taxes
DeCicca & McLeod (2008) USA	Cross-sectional (5 surveys) BRFSS (2000–2005) Telephone interview; a representative sample of the US population Analysis sample: N=543 384 (45–64 yrs); 435 973 (45–59 yrs)	Two-way fixed effects models Adjusted for sex, age, race, education, income, marital status, health status, unemployment rate, state ban in workplaces and restaurants, and state-level effects Price: real monthly state-specific cigarette		**By age (in years)** ***Smoking all days*** *Overall* -0.21 to -0.22 *45–59* -0.29 to -0.31 ***Smoking some days*** *Overall*: 0.20 to -0.21 *45–59* -0.24 to -0.28		Sensitivity analyses (for 3 models and two age groups) resulted in almost identical elasticities Price elasticities of smoking prevalence by health status: Unhealthy: -0.54 Healthy: -0.11

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
DeCicca & McLeod (2008) (contd) USA		excise tax rates per pack in 2001 dollars		**By sex** ***Men*** -0.31 ***Women*** -0.27 **By education** ***Low*** -0.43 ***High*** -0.12 **By income** ***Low*** -0.39 ***High*** -0.09 **By health status** ***Unhealthy*** -0.54 ***Healthy*** -0.11		
Farrelly & Engelen (2008) USA	Cross-sectional (pooled surveys) BRFSS (1990–2006) N=over 2.5 million (≥18 years)	Replication of the previously described analysis (Franks *et al.*, 2007) in different periods Pack price at the year of the survey. Price elasticities provided before and after the Master Settlement Agreement (MSA)		**Total price elasticity** ***Before MSA (1990-1998)*** -0.22 (-0.15; -0.28) ***After MSA (1999-2006)*** -0.09 (-0.04; -0.13) ***By income quartile*** *Period 1990–1998* Lowest: -0.16 Middle 2: -0.34 Highest: -0.14 *Period 1999–2006* Lowest: -0.11 Middle 2: -0.06 Highest: -0.02		-0.22 (-0.15; -0.28) After MSA (1999-2006) -0.09 (-0.04; -0.13) By income quartile Period 1990–1998 Lowest: -0.16 Middle 2: -0.34 Highest: -0.14 Period 1999–2006 Lowest: -0.11 Middle 2: -0.06 Highest: -0.02
Franz (2008) USA	Cross-sectional (8 surveys from BRFSS (1993–2000) Analysis sample: N=1 000 013 (≥18 yrs)	Two models were considered: i) A simple OLS ii) A two part model: 1) OLS; 2)OLS Adjusted for sex, health status, age, race, education, marital status, income, region and year effects Price: state-level average real price of a pack of cigarettes	**Overall** -0.374 **By age (in years)** ***18–29*** -0.518 ***30–39*** -0.360 ***40–64*** -0.327 ***≥65*** -0.458	**Overall** -0.193 **By age (in years)** ***18–29*** -0.289 ***30–39*** -0.176 ***40–64*** -0.201 ***≥65*** -0.331	**Overall** -0.191 **By age (in years)** ***18–29*** -0.184 ***30–39*** -0.192 ***40–64*** -0.158 ***≥65*** -0.154	Overall price elasticity for cessation: 0.375

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Dinno & Glantz (2009) USA	Cross-sectional survey Tobacco Use Supplement (TUS) of the CPS (February 2002) N=54 024 A representative sample of the US population (15–80 years)	Two-part model: 1) fixed effect logistic regression (current smoking prevalence); 2) fixed effect linear regression (smoking intensity; cigarettes/day among current smokers) Adjusted for education, household income, sex, age, race/ethnicity, and clean indoor air law Price: state-specific average cigarette price		**States with average cigarette price per pack <$3.28** OR for an increment of 0.10 cents = 0.95 (95% CI 0.93; 0.97) OR for the highest vs. lowest price = 0.83 (95% CI 0.78; 0.88) **States with average cigarette price per pack ≥ $3.28** OR not significant (estimates not reported) **Price elasticity** ***For people living in states with price ≤$3.28*** -0.41 ***For people living in states with price ≤$3.17*** -0.99	**States with average cigarette price per pack < $3.17:** A change of 1.16 cigarettes/day (95% CI-0.40; 2.03) Effect of clean indoor air legislation: 2.36 cigarettes/day **States with average cigarette price per pack ≥ $3.17** No significant change in cigarette consumption (estimates not reported)	Prevalence: The association of price with smoking prevalence did not change with educational attainment, household income or race/ethnicity. No statistically significant interaction between cigarette price and clear indoor air coverage Consumption: No statistically significant interaction between price and educational attainment, household income or race/ethnicity was found
Other high-income countries						
Australia						
Cameron & Williams (2001) Australia	National Drug Strategy Household Surveys (NDSHS) for 1988, 1991, 1993 and 1995 Nationally representative surveys of the Australian population ≥14 yrs Analysis sample: n=9744 (≥20 yrs)	A probit model for cigarette use (smoking prevalence) Adjusted for age, sex, marital status, employment status, education, capital city, number of children legal sanctions against cannabis use in the state of residence, survey years, real price index of alcohol, real predicted price of a gram of head of marijuana, and interaction terms of pairs of real prices Real price index of cigarettes		**Overall** -0.436		Two probit equations for two other discrete choice dependent variables: (i) using cannabis and (ii) using alcohol were used Cannabis and cigarettes were found to be complements. Similarly, alcohol and cigarettes were complements

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Zhao & Harris (2004) Australia	Australian National Drug Strategy Household Surveys (NDSHS, 1995, 1998, 2001) N> 40 000 individuals (≥14 yrs) Nationally representative surveys of the Australian population ≥14 yrs	Multivariate probit for three discrete choice dependent variables: (i) using any tobacco products (smoking prevalence), (ii) using marijuana, and (iii) using alcohol Adjusted for survey years, age, sex, marital status, legal status of the state of residence, employment status, education, capital city, Aboriginal or Torres Strait Islander origin, home language, number of children, real household income, real price of marijuana, and real price index of alcohol Real price index of tobacco		**Overall** -0.863		A complementary relationship between alcohol and tobacco and the similar relationship between marijuana and tobacco were found in the participation decisions
Harris & Zaho (2007) Australia	Australian National Drug Strategy Household Survey (NDSHS, 1995, 1998, 2001) N>40 000 individuals (≥14 yrs) Nationally representative surveys of the Australian population ≥14 yrs n=28 813 individuals	A double-hurdle model. The two hurdles were: i) decision to participate; ii) level of consumption that also included zero consumption A zero-inflated ordered model combining a split probit model and an ordered probit model Four discrete variables (0, 1, 2, and 3) describing different levels of tobacco consumption Covariates: age, age squared, sex, marital status, education, region of residence, employment status, language spoken			**Marginal effect of tobacco price on zero consumption** +0.145 **Marginal effect of tobacco price on non-zero consumption by level of consumption** ***1st level (lowest)*** +0.005 ***2nd level*** -0.070 ***3rd level (highest)*** -0.081	**Marginal effect of personal income on non-participation** +0.027 **Marginal effect of personal income on non-participation zero consumption** -0.017 **Marginal effect of personal income on non-zero consumption** ***1st level (lowest)*** -0.003 ***2nd level*** -0.007 ***3rd level (highest)*** 0.000

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Harris & Zaho (2007) (contd) Australia		at home, real price index of alcohol, real price of marijuana, real personal annual before-tax income, and an indicator of females younger than 26 years Real prices and personal income were log-transformed				
Siahpush *et al.* (2009) Australia	Face-to-face population survey conducted in the 5 largest Australian capital cities (1991-2006) Sample size: 515,866 individuals (≥18 yrs)	Dependent variable: monthly smoking prevalence Poisson regression Adjusted for income, interaction between price and income category, education, age, sex and time trend Cigarette price: state-specific average real price of the two top-selling Australian brands (Peter Jackson and Winfield)		**By income group** ***Low*** -0.32 ***Medium*** -0.04 ***High*** -0.02		The results suggest that increasing the real prices of cigarettes is an effective tobacco control strategy to lower smoking prevalence and may provide a means of reducing social disparities in smoking
Canada						
Hamilton *et al.* (1997) Canada	Longitudinal (retrospective) Survey on Smoking in Canada (1994/1995) Follow up 4 times during one year 11 119 respondents (≥ 15 yrs) Telephone survey Population in the provinces with tobacco tax cut : 5 770 100; population in the provinces without tobacco tax cuts: 7 019 200	No multivariate regression analysis Simple descriptive analysis No computation of elasticities		Smoking prevalence in provinces where taxes were not cut declined more (from 29.0% to 24.9%) vs. smoking prevalence in provinces without taxes cut (from 31.0% to 28.3%)		Rates of starting cigarette smoking were higher (ranges: 0.9–1.7% vs. 0.7–1.2%) and smoking quit rates were lower (ranges: 2.5–10.3% vs. 5.7–10.7%) in the provinces where taxes had been cut than in those where taxes had not been cut
Stephens *et al.* (1997) Canada	Cross-sectional General Social Survey (GSS; 1991) n=11 652 households (individuals ≥ 15 yrs)	Logistic regression (current smoking status) Adjusted for age, sex, marital status, education, policy		OR of smoking vs. non-smoking (never and former together) Smoking prevalence associated with		No mention of adjustment for the analysis using the 1990 HPS data Smoking prevalence associated with infrequent

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Stephens *et al.* (1997) (contd) Canada	National representative of householders at a provincial level Health Promotion Survey (HPS; 1990) n=14 000 No details on interview procedure	variables (tobacco price, percent increase of price over 1 year and 10 years, percentage of population covered by no-smoking laws) Price of 200 cigarettes Percentage increase in the price over 1 year and 10 years		relatively low prices (OR=1.26; 95% CI 1.11-1.43) No association with price increase		smoking regulations (OR=1.21; 95% CI 1.08-1.36) [according to results from the analysis using the 1991 GSS data]
Gruber *et al.* (2003) Canada	Canadian Survey of Family Expenditure (FAMEX) 8 pooled household surveys (1982–1998) Analysis sample: 81 479 observations	Dependent variables: (1) total household spending on cigarettes, (2) any spending on cigarettes (prevalence) and (3) level of spending on cigarettes (intensity) Two kinds of models: 1) an OLS for total spending 2) a two-part model: (i) OLS for prevalence, and (ii) OLS for intensity Controlled for fixed effects for regions, years, region-specific linear time trends, and household characteristics (after-tax income, sex of the household head, and family size) Cigarette price was instrumented using the cigarette excise and sales tax rate	**Overall** -0.45 **By income quartile** ***1st*** -0.99 ***2nd*** -0.45 ***3rd*** -0.31 ***4th*** -0.36 **By expenditure quartile** ***1st*** -0.92 ***2nd*** -0.73 ***3rd*** -0.20 ***4th*** -0.37	Overall: -0.02	Overall: -0.41	When smuggling provinces and years were excluded from the models, the price estimates were similar. As the price elasticity of intensity was large, all of the response of consumption occurred through reductions in consumption Using legal sales data, overall price elasticity was 0.72, and declined to -0.47 when excluding smuggling provinces and years.
Gospodinov & Irvine (2009) Canada	Cross-sectional Health Canadian Tobacco Use Monitoring Survey (CTUMS) (2000-2005) Analysis sample: 90 850 (≥20 yrs)	Two-part model: 1) Probit; 2) OLS Adjusted for health warnings, year of interview, household size, sex, education, age, sex, profession, language and region Price: retail price of a pack of cigarettes	**Overall** -0.299 **By education** *< High school* -0.299 ***High school*** -0.333 ***College*** -0.300			Another computational method based on the median instead of average of the partial effects evaluated at all observations provided similar elasticities

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Italy						
Aristei & Pieroni (2009) Italy	Cross-sectional The 2000 Italian survey on Health status and use of health services (HSHS) Analysis sample: N=47 777 ever smokers (current and former) Men: n=31 912 Women: n=15 865	Box-Cox double-hurdle model: 1) smoking prevalence; 2) smoking intensity Adjusted for age, education, sex, marital status, social and occupation status, health status, smoking habit, BMI, chronic illness, physical activity, children, and number of earners and other smokers in the household Price: weighted average price of national per pack prices (including excise taxes) of both domestic and imported cigarettes			**Overall** -0.24 **By sex** ***Men*** -0.13 ***Women*** -0.65	Definition of age and education: Age = age in years Education = years of formal education Reported results were obtained from the IV Box-Cox double hurdle models in which peer effects were treated as endogenous variables The presence of smokers (peer measures) significantly increased the probability of remaining a smoker and smoking intensity
Republic of Korea						
Chung *et al.* (2007) Republic of Korea	Telephone interview survey Analysis sample: 3000 males (≥20 yrs)	Two-part model: 1) logistic regression (smoking prevalence); 2) OLS (smoking intensity) Adjusted for age, education, religion, occupation, family income, marital status, children, area of residence, lifestyle habits, BMI, health status, health perception, age at starting smoking, and parental and friend's smoking No experienced smoker is excluded	**Overall** -0.66	**Overall** -0.02	**Overall** -0.64	Three logistic regressions and four OLS models were run with different number of covariates included The inclusion of other behavioural risk factors substantially reduced the price elasticity of prevalence but had no effect on the price elasticity of intensity
Spain						
García & Labeaga (1996) Spain	Spanish Households Budget Surveys (EPF) 1980–1981 n=23 669 households	A double-hurdle model Covariates: total real expenditure, occupation,			**Price elasticities** ***Base*** -0.24	Elasticities of total expenditure: Base: +0.03 Lowest education: +0.01 Highest education: +0.12

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
García & Labeaga (1996) (contd) Spain		employment status, education, size of the town of residence, age and age squared, and household size Price: retail price index (base year=1976)			***Lowest education*** -0.52 ***Highest education*** +0.07 Unemployed -0.31 The head aged < 25 years old: 0.70	Unemployed: +0.09 Head of household aged <25 years old: +0.18 Base: a household having four members, the head was a non-manual worked age 50 who had secondary education and lived in an Andulusian town of 50 000–500 000 inhabitants For comparison estimation results, a Tobit model was also estimated
Jiménez-Martín *et al.* (1998) Spain	Spanish Continuous Family Expenditure Surveys (ECPF) 1985–1995 Individual data that were used to construct population averages for smoking prevalence and intensity per household were from 38 quarterly cross-sections of the ECPF for 1985(1)–1994(2) Two samples of cohort data were formed based on (*) the date of birth of the head of the household (sample 1) and both on (*) and on his/her education level (sample 2). Both samples contained 456 cell means total	A double-hurdle model: (i) probability of smoking (participation rate), and (ii) intensity (budget share on tobacco per smoking household) Adjusted for education, employment status, rural/urban area, number of dependents in the household, an indicator describing the anti-tobacco legislative measures, and quarterly dummies Tobacco expenditure: weekly expenditures on any kind of tobacco grossed up to the quarter Reported results here were obtained from the static pooled within-groups models (WG static models) and from the dynamic pooled within-groups models accounting for cohort fixed effects (WG dynamic models)		**Probability of smoking** ***WG static model*** *Sample 1* -0.16 *Sample 2* -0.14 ***WG dynamic model*** *SR elasticity* Sample 1 -0.13 Sample 2: -0.11 *LR elasticity* Sample 1 -0.20 Sample 2 -0.16	**Intensity** ***WG static model*** *Sample 1* -0.47 *Sample 2* -0.40 ***WG dynamic model*** *SR elasticity* Sample 1 -0.21 Sample 2 -0.22 *LR elasticity* Sample 1: -0.56 Sample 2: -0.50	The Almost Ideal Demand System was applied. A lagged smoking/consumption was used as an independent variable in the dynamic model Elasticity estimates obtained from the static OLS models using pooled data: Prevalence Sample 1: -0.28 Sample 2: -0.72 Intensity Both samples: -0.54 Price elasticities obtained from the models using aggregate individual data and the heterogenous models (cohort by cohort estimated) varied much and were not reported here

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Labeaga (1999) Spain	The Spanish Permanent Survey of Consumption (EPC) Unbalance panel of households n=34 413 households	A double-hurdle rational addiction model with heterogeneity A two-step structural model using a generalized method of moments (GMM) within-groups estimator Covariates: sex, occupation, employment status and education of the head, number of members over 16 yrs, household composition, age and age squared of the head and the spouse, region of residence, and housing tenure dummy variables. Lags and leads of real prices and income appeared in several models. Income was also considered as endogenous in some models	Price: real price of tobacco (price of tobacco was deflated by means of a weighted average of prices of nine goods)	**Model where total expenditure was endogenous** ***Short-run price elasticities*** *Overall* -0.27 *Ever smoker* -0.17 ***Long-run price elasticities*** *Overall* -0.36 *Ever smoker* -0.23	**Model where total expenditure was endogenous** ***Short-run price elasticities*** *By education* No studies: -0.30 <High school: -0.28 University: -0.21 *By age (in years)* < 25: -0.26 ≥ 60: -0.34 *By income decile* D1 poorest: -0.50 D10 richest: -0.17 Manual workers: -0.267 ***Long-run price elasticities*** *By education* No studies: -0.40 <High school: -0.37 University: -0.28 *By age in years* < 25: -0.34 ≥ 60: -0.50 *By income decile* D1 poorest: -0.67 D10 richest: -0.23 Manual workers: -0.36	**Model where total expenditure was strictly exogenous** ***Short-run price elasticities*** *Overall* -0.27 *Ever smoker* 0.17 *By education* No studies: -0.30 <High school: -0.28 University: -0.21 *By age in years* < 25: -0.26 ≥ 60: -0.34 *By income decile* D1 poorest: -0.50 D10 richest: -0.17 Manual workers: -0.267 ***Long-run price elasticities*** *Overall* -0.36 *Ever smoker* -0.23 *By education* No studies: -0.40 <High school: -0.37 University: -0.28 *By age in years* < 25: -0.34 ≥ 60: -0.50 *By income decile* D1 poorest: -0.67 D10 richest: -0.23 Manual workers: -0.36
United Kingdom						
Jones (1989) United Kingdom	Household survey data 1954–1986 consisted of the annual series published by the Tobacco Advisory Council 1954–1974 and the bi-annual data from the General Household Survey (GHS) 1972–1986 The data were used to derive the proportion of	A double-hurdle approach A seemingly unrelated regression for (i) participation rate and (ii) budget share of cigarettes (intensity) Covariates in the two equations: price of cigarettes and total consumers' expenditure per capita at constant	**Price elasticity of per capital demand at 1986 values** -0.562	**Elasticity of participation rate at 1986 values** -0.192	**Elasticity of intensity at 1986 values** -0.370	Equation of budget share was similar to the Almost Ideal Demand System model

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Jones (1989) (contd) United Kingdom	cigarette smokers in the adult population aged over 16 years old	prices, and dummies capturing both permanent effects of three health events and returning trends of the health scares				
Low- and middle-income countries						
Bulgaria						
Sayginsoy *et al*. (2002) Bulgaria	The study is based on a 1995 household survey and encompasses 2259 households	Control variables: Income, Average age of household members, highest education of a household member, alcohol consumption, ratio of adult males in household	**Overall** -0.80 **Low- and lower-middle- income earners** -1.33 **Upper-middle- income earners** -1.02 **High-income earners** -0.52			HNP study
China						
Mao & Jiang, (1997) China	Random cluster sampling in Sichuan Province (1995) N=2431 subjects (≥15 yrs), including 1412 men and 921 women.	Two-part model for cigarette use: 1) logit (smoking prevalence); and 2) OLS (smoking intensity)	**Overall** -0.69			
Mao *et al.* (2003) China	National Smoking Consumption Survey (1998) N=24 641 adults (≥20 yrs), including 12 854 men and 11 786 women	Two-part model and two-stage least square method Adjusted for gender, race, education, occupation, income, age, price, area, perception of risk, knowledge, propaganda of tobacco control Price: expenditure of tobacco/consumption of tobacco (packages)	**Overall** -0.513 **By sex** ***Men*** -0.45 ***Women*** -0.69 **By income group** ***Poverty*** -1.906 ***Low-income*** -0.774 ***High-income*** -0.507			Poverty group: <200 RMB household income per month; Low-income group: <500 RMB household income per month; High-income group: >500 RMB household income per month;

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Lance *et al.* (2004) China	China Health & Nutrition Survey (1989–1993 waves) Cross-sectional (from follow-up studies) N=8557 men (≥13 yrs)	Two-part model for cigarette use: 1) logit (smoking prevalence); and 2) OLS (smoking intensity) Adjusted for wealth, age, education, household size, community, price deflator and survey year Price: cigarette price of local market where participants resided		**Overall** -0.019 **With fixed effects (province and urbanicity)** -0.045 **With fixed effects (community-level)** -0.034	**Overall** -0.063 **With fixed effects (province and urbanicity)** -0.056 **With fixed effects (community-level)** +0.027	Included in the same study with the Russian analysis above
Lee *et al.* (2004) China (Taiwan)	Two random samples of smokers: 1488 in 2000–2001 and 1014 in 2002–2003 (17–69 yrs) Annual face-to-face interview Analysis sample: 2502 current smokers (4 surveys)	(1) OLS for smoking intensity by smoker group Current smokers were categorized by age, sex, education, monthly income, and amount of cigarettes smoked. Price and income were mutually adjusted. No additional covariates were added into the model New tax scheme in 2002 (2) OLS for smoking intensity by time period Adjusted for sex, age, education, monthly income, and smoking degree Cigarette price: average retail price of the top three most consumed cigarettes			**Overall** ***By survey year*** *2000*: -0.31 *2001*: -0.37 *2002*: -0.53 *2003*: -0.31 **Period 2001–2002** ***Overall*** -0.34 ***By sex*** *Men*: -0.31 *Women*: -0.12 **Period 2002–2003** ***Overall*** -0.41 ***By sex*** *Men*: -0.39 *Women*: -0.14	In 2002, after Taiwan, China had enacted the new tax scheme, there was an increase in cigarette price elasticity Higher elasticity for men, for lower-income men, and for smokers of light cigarettes. No specific pattern in strata of age and education Income elasticity provided negligible estimates (ranging from 0.00 to +0.03)
Tsai *et al.* (2005) China (Taiwan)	Two-year follow-up cohort (face-to-face survey); 2001 and 2002 surveys Analysis sample: n=501 male smokers (≥18 yrs)	Logistic regressions (for behavioural change (i) reduction of smoking, and (ii) brand switching). Odds ratios were obtained Adjusted for demographic factors, individual income, smoking behaviour,		For reduced smoking with respect to increased retailed cigarette price by 1 NT$: OR = 1.03		For brand smoking with respect to higher retail cigarette price: OR = 1.07 Overall, 17.4% switched brand, 18.8% reduced smoking, 8.4% both types of behavioural changes The study also used independent linear regressions and the Zeller's seemingly

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Tsai *et al*. (2005) (contd) China (Taiwan)		living area, expense on smoking, addiction level, advertisement, and favourite cigarette brand Change in smoking behaviour before (2001) and after the introduction of a new cigarette tax scheme (year 2002)				unrelated regression for modelling changes of smoking behaviour
Bishop *et al.* (2007) China	1995 Chinese Household Income Project (10 provinces) Urban adult males Province and county: N=4051 County only: N=1963	A two-part model: (i) a probit model (smoking prevalence); (ii) a linear regression model Explanatory variables: income, education, age, marital status, number of children in the household, and mean price Price = household expenditures on cigarettes/total number of packs used by a household	**Province and county** -0.463 **County only** -0.511	**Province and county** -0.213 **County only** -0.209	**Province and county** -0.250 **County only** -0.303	The estimated price elasticity of demand obtained from an estimated Tobit model was 1.5. This was not considered, as the fat tail of the smoking distribution violated the normality assumption of Tobit.
Mao *et al.* (2007) China	National Smoking Prevalence Survey (NSPS; 2002) Face-to-face interview. A national representative sample N=16 056 (≥16 yrs)	A two-part model for cigarette use: 1) logit (smoking prevalence); and 2) OLS (smoking intensity) Adjusted for sex, age, education, family income, residence area and smoking initiation age Cigarette price: average market price (computed as the average of the self-reported prices among smokers) assigned to the participants by their residence location	**Overall** -0.154 **By income group** ***Poor*** -0.589 ***Low*** -0.234 ***Middle*** -0.018 ***High*** +0.257	**Overall** -0.064 **By income group** ***Poor*** -0.478 ***Low*** -0.199 ***Middle*** +0.093 ***High*** +0.340	**Overall** -0.090 **By income group** ***Poor*** -0.111 ***Low*** -0.035 ***Middle*** -0.111 ***High*** -0.083	

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Chang & Chiang (2009) China (Taiwan)	Cross-sectional National Survey on Knowledge, Attitude and Practice of Health Promotion (2002–2003) Face-to-face interview Representative sample Analysis sample: 13 030 men (≥18 yrs)	OLS models (smoking intensity) with a double log specification for: i) depressive smokers ii) non-depressive smokers iii) all smokers Adjusted for age, education, income, marital status, and urbanization Cigarette price = ratio of cigarette expenses to the number of cigarettes smoked (per day)			**All male smokers** -0.40 **Depressive male smokers** -0.82 **Non-depressive male smokers** -0.41	The sample was limited to men because of low prevalence of smoking among women
Estonia						
Taal *et al.* (2004) Estonia	Monthly household data from the Household Income and Expenditure Study, 1992 to 1999	Myopic addiction model A log-linear model for smoking intensity (average monthly cigarette consumption) Explanatory variables: Average real income per household member, real tobacco product price index, quarterly dummies, time trend, lagged consumption	**Price elasticity** -0.34			HNP study
Egypt						
Nassar (2003) Egypt	The study considered the 1995–6 and 1999–2000 household expenditure surveys.	Control variables: Income quartile (poorer households have higher price elasticity), education Expenditure elasticities were calculated by expenditure groups, educational level, work status and urban/rural area	**National average price elasticity for "tobacco", not only cigarettes** -0.40 **Urban households** -0.41 **Rural households** -0.39			HNP study
India						
John (2008) India	Cross-sectional survey (1999–2000) N=120 309 households Household with zero	OLS regression Price of each tobacco product: average unit values (self-reported			**Rural (own elasticities)** ***Bidis*** -0.91	Own- and cross-price elasticities considered A demand system model Spatial variation in prices of

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
John (2008) (contd) India	consumption of tobacco (37% from rural and 60% from urban) were excluded from the analyses Unit of analysis: household	expenditure divided by quantity)			***Cigarettes*** -0.41 ***Leaf tobacco*** -0.87 **Urban (own elasticities)** ***Bidis*** -0.87 ***Cigarettes*** -0.179 ***Leaf tobacco*** -0.877 When symmetry restrictions were imposed (for the unique substitution complementary patterns), own price elasticity estimates: **Rural** ***Bidis*** -0.92 ***Cigarettes*** -0.34 ***Leaf tobacco*** -0.87 **Urban** ***Bidis*** -0.86 ***Cigarettes*** -0.20 ***Leaf tobacco*** -0.87	tobacco products were used to estimate own- and cross-price elasticities See also Table 5.3
Indonesia						
Adioetomo *et al.* (2005) Indonesia	Study using the 1999 National Socio-Economic Survey (Susenas), collected by the Central Bureau of Statistics.	Control variables: Cigarette price in rupiah per pack of 16 cigarettes (expenditure on cigarettes divided by the quantity of cigarettes consumed), per capita household income per day in rupiah, dummy for urban/rural location, dummies for education, profession, age and sex	**Overall price elasticity** -0.61 **By income groups (lowest to highest)** ***Q1***: -0.67 ***Q2***: -0.33 ***Q3***: -0.31			HNP study

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Mexico						
Jiménez-Ruiz *et al.* (2008) Mexico	Cross sectional (7 surveys) National Household Income and Expenditure Survey (1994–2005) N=109 089 households (individuals aged ≥15 yrs) Nationally representative samples Unit of analysis: household	Two-part model for cigarette use: 1) probit (smoking prevalence); 2) log-log OLS (smoking intensity) Adjusted for household income, education, sex, age of the household head, alcohol intake, number of adults in the household, and year of interview Price: ratio of total expenditure on cigarettes per week to the number of cigarettes smoked. Average price paid by each household	**Overall** -0.52	**Overall** -0.06	**Overall** -0.45	**Income elasticity** ***Overall*** +0.49 ***For prevalence*** +0.25 ***For smoking intensity*** +0.24
Myanmar						
Kyaing (2003) Myanmar	The survey was performed in 2001 and includes 9847 households	The price elasticity of demand was estimated using the two-step procedure described in Onder (2002). Control variables: Income, price, age, education and literacy, gender, marital status and urban/rural residence The study considered the household expenditure on cigarettes, cheroots and *phet kyan* (tobacco covered with *thenatphet* leaves).	**Total price elasticity** -1.62	Price elasticity of smoking participation: -1.28 average, but varies from –1.09 for poorest quintile to -1.41 for middle quintile	Conditional price elasticity of demand: -0.34 average, but varies from –0.42 for poorest quintile to –0.24 for richest quintile	HNP study In Myanmar tobacco is consumed primarily in the form of cheroots
Kyaing *et al.* (2005) Myanmar	Household survey undertaken for the study among low-income groups in two peri-urban communities and four townships. The data was collected among tobacco users	A log-log OLS model was used for the estimation Control variables: Income, addiction, gender, marital status, education and occupation			**Conditional price elasticity for all tobacco products** -0.11 **Conditional price elasticity for cheroots** -0.36	HNP study

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Kyaing *et al.* (2005) (contd) Myanmar	only (2414 tobacco users interviewed)				**Conditional price elasticity for cigarettes** -0.25	
Nepal						
Karki *et al.* (2003) Nepal	For this study 1400 households (about 4000 people) were interviewed.	Based on the cross-sectional study a two-step procedure, similar to that of Onder (2002) was applied to determine the price elasticity of smoking participation and the conditional price elasticity of demand. In this comprehensive study price elasticities were estimated to determine the likely impact of price and tax increases on consumption and government revenue. Control variables: Income, age, gender, literacy, education level, occupation, urban/rural, number of years that the person has smoked	**Total price elasticity (average)** -0.88 Total price elasticity among youth (aged 15-24) was much higher than the average (-1.88)	**Price elasticity of smoking participation** -0.46	**Conditional price elasticity of demand** -0.42	HNP study
Poland						
Gardes & Starzec (2004) Poland	Polish Consumption Panel database (1987–1990) 3630 households	Three different models: 1) Tobit 2) Probit (long-run elasticity) 3) Frisch direct method. Adjustment for location, education dummies, logarithmic equivalence scale, log age, proportion of children, quarter dummies	**Average elasticity from the 3 models** ***Short-run*** -0.4 ***Long-run*** -0.7			

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Russia						
Ogloblin & Brock (2003) Russia	Cross-sectional The Russia Longitudinal Monitoring Survey (RLMS); two waves of data collected in1996 and 1998–1999 N=4718 households (individuals ≥18 yrs) Analysis sample: Men: N=6015 Women: N=8457	Probit models for men and women Computation of price elasticity of smoking prevalence by using the resulting marginal effects Adjustment for age, age2, community type, marital status, education, occupation, real income, alcohol drinking and BMI Price: geometric average of 4 real prices: lowest price of domestic cigarettes, highest price of domestic cigarettes, lowest price of imported cigarettes and highest price of imported cigarettes		**Overall** ***Men*** -0.085 ***Women*** -0.628 **For 1996** ***Men*** -0.046 ***Women*** -0.430 **For 1998** ***Men*** -0.120 ***Women*** -0.919		Income elasticity overall: Men: -0.007 Women: +0.047
Lance *et al.* (2004) Russia	Russian Longitudinal Monitoring Survey (1996, 1998, 2000) N=10 638 men (>13 yrs)	Two-part model: 1) logit (smoking prevalence); and 2) OLS (smoking intensity) Adjusted for wealth, age, education, household size, community, price deflator and survey round Price: cigarette price of local market where participants resided		**Overall** -0.106 **With fixed effects (province x urbanicity)** -0.101 **With fixed effects (community-level)** -0. 050	**Overall** -0.026 **With fixed effects (province x urbanicity)** -0.026 **With fixed effects (community-level)** 0.000	Included in the same study with the Chinese analysis below
South Africa						
Berg & Kaempfer (2001) South Africa	Living Standard Measures Survey (LSMS), 1993 Study population: 1131 black households and 998 white households	Censored maximum likelihood (ML) and censored least absolute deviation (LAD) estimation techniques Adjusted for prices of various food items, number of adults and children, and income	**By ethnicity** ***Black*** -0.80 ***White*** -1.79		**By ethnicity** ***Black*** +0.34 ***White*** +0.09	

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Van Walbeek (2002) South Africa	Income and expenditure surveys (IES) of 1990, 1995 and 2000 Analysis unit: household Analysis sample: 1990: N=14 332 1995: N=16 903 Only households that lived in urban areas and had (positive) expenditure for cigarettes were analyzed	Cigarette demand (intensity) was determined by the real price of cigarettes and real income Price elasticity for each income quartile was estimated as the net change in cigarette consumption divided by the change in the real price of cigarettes The tax burden with respect to income, i.e. the ratio of household's total annual expenditure on cigarettes to household income, was estimated in the first place Price: retail price each year			**Price elasticity of smoking intensity for the period 1990–1995** ***By income quartile Q*** *Q1 lowest:* 1.39 *Q2*: 1.13 *Q3*: 1.08 *Q4 highest:* 0.81	**Income elasticity** ***By year and income quartile Q*** *1990* Q1 lowest: +0.27 Q2: +0.48 Q3: +0.40 Q4 highest: +0.08 *1995* Q1 lowest: +0.52 Q2: +0.41 Q3: +0.54 Q4 highest: +0.24 Cigarette price increases did not fall disproportionately heavily on the poor during 1990–1995
Sri Lanka						
Arunatilake & Opatha (2003) Sri Lanka	Survey data of about 7500 households.	Control variables: Income, occupation, education, male ratio (males smoke more)	**Overall price elasticity** -0.53 **By expenditure quintile** ***Q1 (poorest)*** -0.64 ***Q2*** -0.55 ***Q3*** -0.60 ***Q4*** -0.68 ***Q5*** -0.29			HNP study The aim of the study was to determine the impact of price increases on smoking prevalence and smoking intensity of different expenditure quintiles. The price elasticity of smoking participation was generally small and insignificant (and sometimes even positive), but the conditional elasticities are as expected
Thailand						
Sarntisart (2003) Thailand	A sub-sample of 11 968 households that bought cigarettes from 24 747 households surveyed in the 2000 household	Using a linear expenditure system (LES) approach, the study estimated price, cross-price and income	Average price elasticity: -0.39; price elasticity varies between –1.00 for poorest urban households and –0.04			HNP study Demand for cigarettes among rural households is generally less elastic than among urban households.

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Sarntisart (2003) (contd) Thailand	socioeconomic survey	elasticities of 12 different categories of household goods and services Control variables: Expenditure on cigarettes and other tobacco products, household income, prices of 12 consumer goods, age, education, dummy: urban/rural	for richest urban households			
Turkey						
Onder (2002) Turkey	This part of the study considered the 26 166 households covered in the 1994 Household Expenditure Survey	Using a two-step model, the determinants of smoking participation were estimated first, using a logit model. In the second step, the conditional price elasticity of demand was estimated for those households that decide to smoke. The results were used to determine the impact of a change in the tax rate on cigarette consumption, government tax revenue and the regressivity of the tax. Control variables: Income, education, age, geographic region.	**Total price elasticity** -0.41	Price elasticity of smoking participation: -0.03 average, but varies from –0.32 for second poorest quintile to 0.15 for richest quintile	Conditional price elasticity of demand: -0.39 average, but varies from –0.58 for second poorest quintile to –0.30 for richest quintile	HNP study
Bilgic *et al.* (2009) Turkey	National household expenditure survey (2003) n=22 208 households Families with teenagers: 7844 Families without teenagers: 14 364	A zero-inflated negative binomial model: 1) logit (for non-smoking prevalence); 2) parent negative binomial (for number of cigarette packs purchased per week)	Covariates in the equations: age, sex and education of the head of the household, household income, households' socioeconomic characteristics, age groups, special health insurance status, number of members having regular medication, share of		**Price elasticities of smoking intensity** ***Family with teenagers*** -0.264 ***Family without teenagers*** -0.221	**Income elasticities of smoking intensity** ***Family with teenagers*** +0.075 ***Family without teenagers*** +0.058

Table 5.1. Summary of studies on the effects of cigarette price on adults' demand for tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Bilgic *et al.* (2009) (contd) Turkey			health care expenditure, alcohol intake, number of smokers in the family, and regional variables Price: price of cigarette pack in Turkish Liras in 2003			
Ukraine						
Krasovsky *et al.* (2002) Ukraine	The study used data from a survey of individuals (both smokers and non-smokers) conducted in all regions of Ukraine (2700 individuals)	A two-part model: 1) probit (smoking prevalence); 2) OLS (smoking intensity) Control variables: For smoking prevalence: age, sex, education, marital status, urban/rural region, smoking status of a close relative or a friend, and income For smoking intensity: age, sex, price, household income, strength of addiction (assuming that on average heavily addicted smokers smoke more), region (assuming that smoking patterns may differ across regions of Ukraine), and dummy reflecting whether a smoker has under-age children		**Price elasticity of smoking prevalence** ***Overall*** -0.47 ***By income group*** *High income* -1.1 *Low-income* -0.27	**Price elasticity of smoking intensity** ***By income group and age in years*** *High income* 14–17: -0.52 18–28: -0.24 28+: -0.15 *Middle income* 14–17: -0.7 18–28: -0.42 28+: -0.33 *Low income* 14–17: -0.65 18–28: -0.37 28+: -0.28	HNP study
Viet Nam						
Van Kinh *et al.* (2006) Viet Nam	Household-level cross-sectional data from Viet Nam Living Standards Survey (VLSS; 1997–1998) N=6000 households with 28 518 individuals (≥15 yrs)	Two-part model: 1) Linear probability model (smoking prevalence); 2) OLS (smoking intensity) Adjusted for price of pipe tobacco, annual per capita	**VINATABA price** ***Overall*** -1.41 ***By income*** *Two low quintiles* -1.77 *Two high quintiles* -1.17	**VINATABA price** ***Overall*** -0.94 ***By income*** *Two low quintiles* -1.16 *Two high quintiles* -0.75	**VINATABA price** ***Overall*** -0.47 ***By income*** *Two low quintiles* -0.61 *Two high quintiles* -0.42	The coefficients of the 555 brand price resulting from the linear probability model were not statistically significant at the 10% level, and the estimated price elasticities of smoking prevalence were not provided

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Total price elasticity of demand	Price elasticity of smoking prevalence	Price elasticity of smoking intensity	Comment
Van Kinh *et al.* (2006) (contd) Viet Nam		income, individual characteristics (sex, age, education, work experience, occupation), household characteristics (household size, and sex, age, education, occupation of the household head), and geographic and commune characteristics Price: price of cigarettes at the commune level (price of VINATABA brand, price of 555 brand, and average price of the two brands)			**555 price** ***Overall*** -0.54 ***By income*** *Two low quintiles* -0.57 *Two high quintiles* -0.37 **Communal average price:** ***Overall*** -0.50 ***By income*** *Two low quintiles* -0.85 *Two high quintiles* -0..35 **Average price elasticity** ***Overall*** -0.50 ***By income*** *Two low quintiles* -0.59 *Two high quintiles* -0.40	

NHANES: National Health and Nutrition Examination Survey; CPS: Current Population Survey; NHIS: National Health Interview Survey; BRFSS: Behavioural Risk Factor Surveillance System; COMMIT: Community Intervention Trial for Smoking Cessation; HNP: Health, Nutrition and Population

He used alternative specifications of the rational addiction model and estimated these models for the full sample, the sample of those who ever smoked, and the sample of current smokers. For these three samples, he obtained overall long-run price elasticities of cigarette demand in the range from −0.27 to −0.36, −0.35 to −0.48, and −0.30 to −0.89, respectively (Chaloupka, 1991). Consistent with the predictions of the rational addiction model that individuals with a greater preference for present would respond more to price, Chaloupka found that smoking among less-educated persons was influenced more by price than was smoking among more educated persons. In contrast to the predictions of the rational addiction model and to Lewit and Coate's (1982) finding that younger populations were more sensitive to price than were older populations, Chaloupka (1991) found that young adults (17–24 years) were less responsive to price than middle-aged adults (25–64 years). Chaloupka (1990) used similar models for men and women and found that cigarette demand was significantly more responsive to price among men than among women. Finally, Chaloupka (1992) estimated additional specifications of these models that included explanatory variables to control for the presence of various state-level restrictions on smoking in public places. Estimated price elasticities obtained from these models were comparable to those described above. This result suggests that there were no significant omitted variables biases in the price elasticity estimates when the smoking restrictions were excluded from the models.

At about the same time, Wasserman and his colleagues (1991) pooled seven waves of the National Health Interview Survey conducted between 1970 and 1985 to examine how the price elasticity of adult cigarette demand was changing over time. Using two alternative models (a two-part model that looked separately at prevalence and intensity, and a generalized linear model that looked at the overall impact), Wasserman and colleagues (1991) found that cigarette demand was becoming increasingly responsive to price over time, going from virtually insensitive to price in the early/mid-1970s to a predicated overall elasticity of −0.26 to −0.28 by 1985–88. Consistent with Lewit and Coate (1982), Wasserman and colleagues (1991) found that price had a greater impact on smoking prevalence (elasticity of −0.17 in 1985) than on smoking intensity (elasticity of −0.09 in 1985).

Hu and his colleagues (1995) were the first to estimate the price elasticity of adult cigarette demand using state-specific individual-level survey data. They pooled the 1985 through 1991 waves of the California Behavioural Risk Factor Surveillance System survey. They used two-part models of cigarette demand that controlled for other health behaviours, in addition to the typical controls included in prior studies. Their estimates for California were consistent with those obtained from previous studies for the USA, with an overall price elasticity of −0.46. Price had a somewhat greater impact on smoking prevalence than on intensity.

In a series of papers using different waves of the Tobacco Use Supplement to the Current Population Survey, Ohsfeldt and his colleagues (1994, 1997, 1999) were the first to estimate the impact of smokeless tobacco taxes on smokeless tobacco use in the USA. Because of the very low prevalence of smokeless tobacco use among women in the USA, Ohsfeldt and colleagues (1994, 1997, 1999) focused their analyses on men. Given the lack of data on smokeless tobacco prices, they employed state-level taxes on smokeless tobacco products (typically *ad valorem* taxes applied at the wholesale level) as their proxy for price, using the resulting estimates and information on the share of price accounted for by tax to produce price elasticity estimates for snuff and chewing tobacco. They found consistent evidence that higher smokeless tobacco taxes were associated with reduced prevalence of any smokeless tobacco use among men, with prevalence elasticities in the range from −0.15 to −0.55.

In the most comprehensive analyses to that point, Farrelly and Bray (Centers for Disease Control and Prevention, 1998) and Farrelly and his colleagues (2001) pooled multiple waves of the National Health Interview Survey conducted between 1976 and 1993 to estimate cigarette demand for US adults, as well as for multiple subpopulations defined by gender, race/ethnicity, income and age. They used two-part models that controlled for a variety of individual characteristics and for region. They obtained overall price elasticities of adult cigarette demand in the range from −0.25 to −0.28, with similar elasticities estimated for smoking prevalence (−0.13 to −0.15) and smoking intensity (−0.10 to −0.15). Consistent with Lewit and Coate (1982), they found that cigarette demand became more inelastic with age and that smoking was more responsive to price among men than among women. They also found relatively greater sensitivity to price of cigarette use among minority populations (Hispanics and blacks) than among the majority population (whites) and among those in lower-income households compared to those in higher-income households.

Several studies of US adult cigarette demand have been published over the past decade. These more recent studies have taken advantage of the numerous and often large local, state and federal cigarette tax increases, increases in prices due to the pass-through of costs from settlements of legal challenges against the tobacco industry (most notably the 1998 Master Settlement Agreement that led to an immediate 45-cent increase in prices), and other factors that have contributed to increasing price variation over time. At the same time, many of the more recent studies have pooled numerous survey waves, with estimation samples exceeding one million respondents in some (e.g. Sloan & Trogdon, 2004; Franks *et al.*, 2007; Stehr, 2007; Farrelly & Engelen, 2008; Franz, 2008). The use of multiple survey waves over a period where taxes and prices have changed considerably in many states has allowed researchers to better control for a variety of other tobacco control policies[2] and underlying sentiment towards tobacco. Nevertheless, the findings from these more recent studies are remarkably similar to those from the earlier studies. They consistently suggest that higher cigarette taxes and prices lead to reductions in the prevalence and intensity of smoking among US adults. A few of these more recent studies are described briefly below.

Sloan and Trogdon (2004) assessed the impact on smoking prevalence among different age groups of the large price increases in the US in the late 1990s that followed the settlement of state lawsuits with tobacco companies, using data from the 1990 through 2002 Behavioural Risk Factor Surveillance System. Consistent with the early estimates of Lewit and Coate (1982), they found that higher cigarette prices significantly reduced smoking prevalence among all age groups. Interestingly, however, the oldest group they examined (65 years and older) was as price-responsive as the youngest group (18–20 years), with estimated prevalence price elasticities of −0.25 and −0.26, respectively. The prevalence elasticity values for the age groups in between were less than half of those values reported in the oldest and the youngest groups.

Over the past two decades, smoking prevalence among those who smoked less than daily increased considerably, with almost one in five smokers smoking less than daily in 2006–07. Tauras (2004) was the first to assess the impact of price on the decision to smoke daily versus less than daily, using data from the 1991, 1993 and 1994 US National Health Interview Surveys. Tauras (2004) found that higher prices increase the likelihood that a smoker will smoke less than daily in addition to reducing smoking prevalence and average cigarette consumption. His price elasticity estimate of some day smoking conditional on current smoking is 0.86, while his estimates for smoke-free air policies were generally small and statistically insignificant. These findings suggest that much of the observed increase in prevalence of less than daily smoking resulted from the impact of tax and price increases rather than from the impact of other tobacco control policies on smoking.

Stehr (2007) focused on gender differences in the price sensitivity of US cigarette demand. As described above, most previous studies found that cigarette smoking among men was somewhat more sensitive to price than was cigarette smoking among women. Stehr (2007) argues, however, that this is due to an omitted variables bias resulting from a negative correlation between gender differences in smoking prevalence and cigarette taxes. Using data from the 1985 through 2000 Behavioural Risk Factor Surveillance System, Stehr (2007) developed gender-specific two-part models that include gender-specific state fixed effects to account for this correlation. He found that smoking among women was significantly more responsive to price than was smoking among men. For women, his estimated prevalence and total price elasticities were −0.40 and −0.51, and for men the corresponding estimates were −0.16 and −0.26.

DeCicca and McLeod (2008) similarly used multiple waves of the Behavioural Risk Factor Surveillance System data from 2000–2005 to examine differences in price elasticity among a variety of US population subgroups. Consistent with Sloan and Trogdon (2004), they found that smoking among older adults was more responsive to price than previously thought, suggesting that higher taxes and prices increase the likelihood of smoking cessation at all ages. Among other subgroups in older adults, they found that higher taxes have their greatest impact on smoking among those in poor health, among those on lower incomes (explored more fully in Chapter 7), and among those with fewer years of education.

Summary

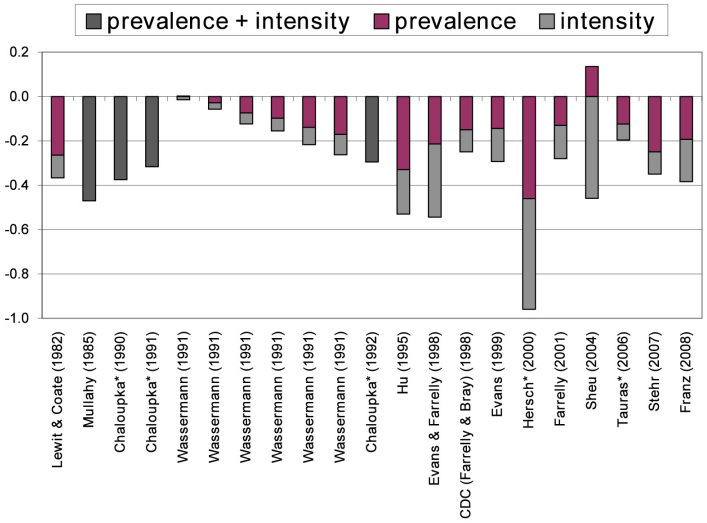
Over the past three decades, numerous studies of adult cigarette demand based on individual-level survey data have been produced in the USA (see 26 studies in Table

[2] Most notably smoke-free air policies targeting various venues, such as workplaces, bars and restaurants, and funding for comprehensive tobacco control programmes.

5.1). Over time, the econometric methods used in these studies have become more sophisticated, and the amount of data used to for analysis has increased exponentially. As with the estimates from the aggregate demand analyses for the USA reviewed in Chapter 4, these studies consistently find that higher cigarette taxes and prices reduce cigarette consumption, with most overall price elasticity estimates in the range from −0.2 to −0.5 (Chapter 4). As shown in Figure 5.1, studies that examine both smoking prevalence and intensity generally find that the effects of price on consumption are about evenly split between the effect of price on smoking prevalence and the effect of price on intensity of smoking among those who smoke. More recent studies also find evidence that higher prices increase the likelihood that smokers will smoke less than daily.

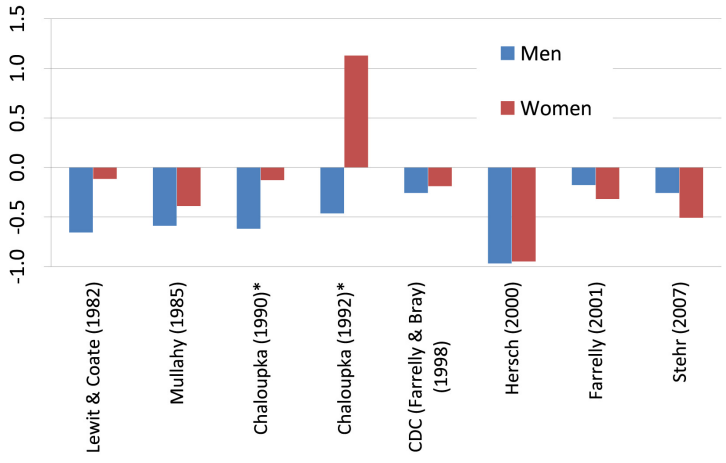
In general, earlier US studies that have examined gender differences in price elasticity found that smoking is more sensitive to price among men than among women. However, studies conducted on more recent data obtained at a more advanced stage of the tobacco epidemic (Lopez *et al.*, 1994), and consequently displaying a narrower gap between men and women on smoking prevalence and consumption, failed to find differences in elasticities (Figure 5.2). Moreover, Stehr's (2007) more recent study provides a compelling explanation for why earlier estimates were likely to be biased, along with estimates that smoking among women is roughly twice as responsive to price as is smoking among men once potential bias due to the omitted variables is accounted for. The current evidence suggests no major differences between sexes according to responsiveness to changes in cigarette prices.

Figure 5.1. Price elasticity for total cigarette consumption (prevalence and intensity) from 16 studies conducted in the USA



* elasticities estimated as the mean value between the upper and the lower limits of a range of estimates and/or as the mean value between men and women's estimates

Figure 5.2. Gender-specific price elasticities for total cigarette consumption (prevalence and intensity) from 8 studies conducted in the USA



* elasticities estimated as the mean value between the upper and the lower limits of a range of estimates

Similarly, most US studies that have considered differences in the price elasticity of cigarette by age find that smoking among younger age groups is more price-sensitive (described more fully in Chapter 6). However, price elasticity of demand generally becomes monotonically more inelastic among older age groups. Sloan and Trogdon (2004) find that this is not the case among those over 65, perhaps due to the more constrained resources for retirees on fixed incomes.

Other high-income countries

There have been several studies that examine the effects of price on consumption of cigarettes and other tobacco products in other high-income countries (see Table 5.1). These have been many fewer than the number of studies conducted in the USA due to the fact that there is limited within-country variability in tobacco product taxes and prices in most of those countries. Many of these studies use data taken from household consumption expenditures surveys. Information on spending and consumption is used to derive price measures for use in empirical analyses. Such price measures are likely to be endogenous because they at least in part reflect tobacco use behaviours (e.g. heavier consumers purchase cheaper brands), leading to biased estimates of price elasticity. Others take advantage of survey data on smoking and other tobacco use, comparable to those price measures used in the US studies, linked with market-level measures of prices based on respondents' place of residence.

Four studies have examined cigarette demand in Canada. Differences in Canadian provincial cigarette excise taxes provide significant cross-sectional variation in prices, while substantial increases and reductions in taxes provide considerable intertemporal variation. Stephens and colleagues (1997) used data from two cross-sectional surveys of Canadian adults, the 1990 Health Promotion Survey and the 1991 General Social Survey, to study the impact of cross-sectional variability in prices and changes in prices over time on adult smoking prevalence. They found that smoking prevalence was higher for respondents residing in provinces where cigarette prices were lower.

Hamilton and colleagues (1997) conducted a similar comparison across provinces, focusing on the significant reductions in taxes that were made in some provinces in early 1994. They used cohort data from the Survey on Smoking in Canada collected over four waves in 1994 and 1995, with the baseline survey collecting data on smoking status on 1 January 1994, before the tax cuts. To assess the impact of the tax cuts on smoking prevalence, they compared changes in smoking prevalence in provinces where taxes were cut with smoking prevalence in other provinces (in provinces where taxes were not cut). Hamilton and colleagues (1997) found that smoking prevalence fell in all Canadian provinces between January 1994 and February 1995, which was attributed to the implementation of various tobacco control efforts throughout Canada. However, smoking prevalence was reduced more in the provinces that did not cut taxes than in the provinces that cut taxes (a 4.1 percentage point reduction versus a 2.7 percentage point reduction).

More recently, Gruber and colleagues (2003) conducted a more rigorous, econometric analysis of cigarette demand. They used data from all eight waves of the Canadian Survey of Family Expenditure conducted between 1982 and 1998, with tax rates matched to the survey databased on respondents' region and acknowledging the need to take into account the presence of significant smuggling of tobacco products. They used two different sets of data, household-level expenditures on smoking from all households and another sample that excluded provinces and years where cigarette smuggling was thought to be a significant problem. For both samples, they obtained an overall price elasticity of cigarette demand of −0.45, which is quite consistent with the estimates described above for the USA. These results suggest that the availability of smuggled cigarettes had little impact on price elasticity in Canada. Additionally, they found that nearly all of the effect of price is on household cigarette consumption, with little impact on smoking prevalence. Furthermore, smoking was more responsive to price among the lowest-income households than among higher-income households (see more detail in Chapter 7).

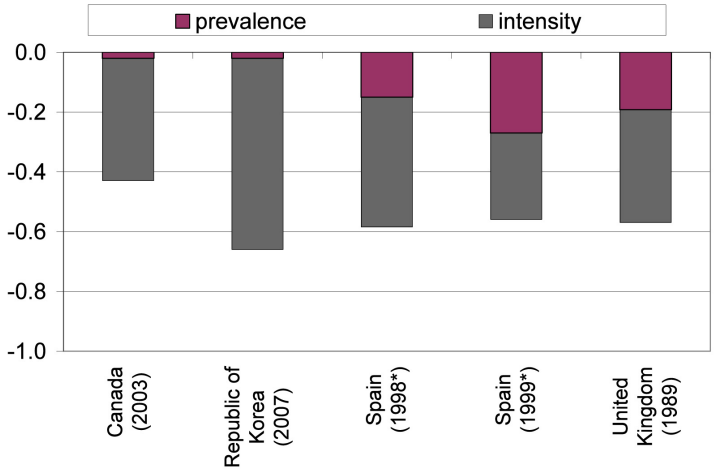
Most recently, Gospodinov and Irvine (2009) explored cigarette demand among Canadian adults, using data from the Canadian Tobacco Use Monitoring surveys conducted from 2000 through 2005 and applying two-part models. Consistent with Gruber and colleagues (2003), Gospodinov and Irvine (2009) found little impact of price on smoking prevalence in Canada, but did find that higher prices significantly reduce cigarette consumption, with an estimated price elasticity of intensity in the range from −0.28 to −0.30. However, they found little difference in price elasticity estimates of demand for socioeconomic groups defined by educational attainment (Gruber *et al.*, 2003).

Similarly, Australian researchers have taken advantage of differences

in cigarette prices across states to assess the impact of price on smoking among adults (see Table 5.1). For example, Cameron and Williams (2001) used data from multiple waves of the National Drug Strategy Household Surveys conducted in the late 1980s and 1990s that were matched with state-level price data. They obtained a price elasticity of smoking prevalence of −0.436. More recently, Zhao and Harris (2004) used the 1995, 1998 and 2001 waves of the same surveys, finding an even greater impact of tobacco product prices on prevalence of tobacco use (prevalence elasticity of −0.863) as well as a significant negative impact of price on the level of tobacco consumption. Most recently, Wakefield and colleagues (2008) used monthly data on smoking prevalence collected in the five largest Australian cities between June 1995 and December 2006 to examine the impact of changes in cigarette prices relative to income (a measure of affordability, as described in the previous chapter) on smoking prevalence during this period. Their finding implies that relatively small changes in affordability would reduce prevalence.

There are relatively few other studies from high-income countries that use individual-level or household-level data to investigate the impact of taxes and prices on adult tobacco use (one from Italy, 1 from the Republic of Korea, three from Spain and one from the United Kingdom). These studies identified by the search strategy described above are summarized in Table 5.1 and in Figure 5.3.

Figure 5.3. Price elasticity for total cigarette consumption (prevalence and intensity) from five studies conducted in high-income countries other than the USA



* elasticities estimated as the mean value between the upper and the lower limits of a range of estimates

Summary

Overall, 14 studies on adult cigarette demand using individual or household level survey data exist for high-income countries other than the USA. These studies are generally consistent with those from the USA in concluding that higher tobacco product taxes and prices lead to reduced smoking among adults. While estimates of price elasticity from these studies are more variable than those from studies based on US data, they do indicate that tobacco use in high-income countries is inelastic with respect to price, and that price influences both the prevalence and intensity of tobacco use. However, in contrast with evidence from the USA, in other high-income countries the effect of price changes on smoking intensity appears to be stronger than that on smoking prevalence (Table 5.3).

Low- and Middle-Income Countries

Prior to the publication of the World Bank's *Curbing the Epidemic* report (Jha and Chaloupka, 1999), there were almost no survey-based studies on the impact of tax and price on tobacco use in low- and middle-income countries. Since then, however, a rapidly growing body of evidence has emerged from studies that use individual-level and/or household-level data collected in low- and middle-income countries, with studies available for countries in all regions. Much of this research has been produced with support from the World Bank, the World Health Organization, and other international organizations; publications are available in the *Economics of Tobacco Control* Discussion Paper series produced by the Health, Nutrition and Population Family (HNP) of the World Bank's Human Development Network. A smaller number of these studies have been published in peer-reviewed journals.

As with the demand studies based on aggregate data from low- and middle-income countries described in the previous chapter, there is also considerable variation in

the quality of the data and methods used in these studies (Chapter 4). Many studies employ household-level consumption expenditure data that often reflects all tobacco consumption, making it difficult to disentangle the effects of prices on use of different tobacco products, on use by different members of the household, and on prevalence and intensity of use. In many of these countries, there is considerable variability not only in the taxes on and prices of different tobacco products, but also in the taxes and prices of different brands for the same product. This situation creates significant endogeneity problems for measures of price that are derived from self-reported prices or from self-reported information on the consumption expenditures and consumption quantities. This typical endogeneity almost certainly results in biased price elasticity estimates when it is not accounted for in the estimation. Many of the studies described below address this problem by trying to assess the endogeneity of self-reported price using a Hausman or other test. However, these efforts are often hampered by appropriate instrument variables for price being unavailable in the survey data. Others address this by using a measure of average prices that is derived from the self-report data and averaged over respondents in the same location and/or based on other factors (e.g. income). Still others apply two-stage least squares models to first predict price (based on taxes, location, income, and other factors), then use the predicted price in the demand models. Where secondary sources for prices are available, other potential problems arise. For example, given the extensive variability in availability and prices of various tobacco products/brands and the limited within-country variation both in taxes and in prices for a particular product/brand, matching price data from other sources to the survey data can introduce its own measurement errors that can bias price elasticity estimates towards zero. Due to these potential problems, much care and caution must be taken when assessing the findings from these studies.

Given the variety of research available, the discussion below will briefly summarize the evidence by region, highlighting seminal studies and those that are most methodologically sound. Table 5.1 contains a more comprehensive listing of the studies identified by the search strategy described above.

Asia. Several studies have examined the impact of tax and price on tobacco use in various Asian countries, including China, India, Viet Nam, Thailand, Indonesia, Myanmar and Nepal. Mao and Jiang (1997) were the first to estimate the price elasticity of cigarette demand using individual-level data for a low- or middle-income country, using cross-sectional survey data for adults in the Sichuan province that were augmented with price data collected from retailers selling cigarettes in the survey respondents' locations. They used a two-part model of cigarette demand, producing elasticity estimates of −0.89 for smoking prevalence and −0.18 for smoking intensity. In follow-up studies using nationally representative data for China, they found that cigarette demand in China was becoming increasingly inelastic, with a price elasticity of −0.06 for smoking prevalence and that of −0.09 for cigarette consumption among smokers (Mao *et al*., 2007). These recent estimates were based on data from the National Smoking Prevalence Survey conducted in 2002, with the cigarette price measure based on the average of prices self-reported by respondents who resided in the same geographic region (Mao *et al*., 2007).

Others have produced similar estimates for the price elasticity of Chinese cigarette demand. Bishop and colleagues (2007) used data on adult urban males in ten provinces taken from the 1995 Chinese Household Income Project. Prices that were assigned to individuals were based on the average self-reported prices for respondents from the same province (which allows for more observations to be used in computing price) or county (which reduces the number of observations used to estimate price, but adds to the variability in the resulting price measure). They estimate two-part models using each of the alternative measures of price. Interestingly, the estimated elasticities with the two price measures are relatively similar, with prevalence elasticities around −0.21 and intensity elasticities in the range from −0.25 to −0.30. In contrast, Lance and colleagues (2004), using data from multiple waves of the China Health and Nutrition Surveys that were supplemented with locally collected prices from markets in the communities where respondents lived, concluded that cigarette demand in China was much less elastic. Their prevalence elasticities ranged from −0.02 to −0.04 and intensity elasticities from 0.03 to −0.06. However, as Bishop and colleagues (2007) note, the price measure employed by Lance *et al.* (2004) ignores the fact that many smokers buy cigarettes from nearby wholesalers rather than from local markets, introducing measurement error that can bias price elasticities towards zero.

At least four studies from Taiwan, China have examined the impact of

taxes and prices on tobacco use. They generally take advantage of large price changes that followed the large tax increases implemented in 2002. For example, Lee and Colleagues (2004) used survey data collected by the Taiwan, China National Health Research Institutes between 2000 and 2003 that were augmented with monthly data on average prices of leading brands to estimate the price elasticity of cigarette consumption among current smokers before and after the tax increase for a variety of population subgroups. Overall, their estimated price elasticities range from −0.31 to −0.53, with the greatest price elasticity in the year following the tax increase. In a follow-up study using survey data collected by phone in 2004, Lee (2008) used information from responses to a question about a hypothetical price increase and obtained a price elasticity of cigarette consumption of −0.29. This was consistent with that obtained from survey databased on actual experiences with tax and price increases. Related studies by Tsai and colleagues (2003, 2005) concluded that the 2002 tax increases altered other aspects of smoking behaviour in Taiwan, China, including brand choice and likelihood of purchasing smuggled cigarettes.

In general, and consistent with the estimates from studies based on aggregate data described in the previous chapter, it appears that cigarette demand in China has become less sensitive to price over the past two decades. One likely explanation for these increasingly inelastic price estimates for cigarette demand in China is the trend towards increased affordability of cigarettes in the country, as real household disposable incomes have increased much more rapidly than real cigarette prices. This trend is consistently described by the significant, positive income elasticities generally obtained in these studies.

John (2008) conducted the only survey-based study that produces estimates of price elasticity of adult tobacco use in India. Using data from the 55th round of the National Sample Survey Organization survey, a household expenditure survey conducted from July 1999 through June 2000, he examined the effect of price on demand for cigarettes, bidis and leaf tobacco separately for urban and rural populations. Using an empirical approach developed by Deaton (1988), he constructed unit values by dividing the self-reported individual household consumption expenditure to consumption quantity. The unit values reflect the averages for individual households in the same geographic areas and account for variations in the quality of the tobacco products consumed (John, 2008). Since this analysis was limited to households that consumed tobacco products, the price elasticity estimates reflect the impact of price on consumption by households that use these products, thus understating the full impact of price on tobacco demand in India. John's (2008) analysis produced significantly negative own-price elasticities of demand for each of the three tobacco products considered, with less inelastic estimates for bidis (ranging from −0.86 to −0.92 according to rural/urban area) and leaf tobacco (−0.87 to −0.88) and a relatively inelastic estimates for cigarettes (ranging from −0.18 to −0.34). John attributes the differences in the price elasticity estimates to the differences in income among those households who consume cigarettes and those who consume other products, with cigarettes generally consumed by higher-income households, while bidis and leaf tobacco are typically consumed by low-income households. For bidis and leaf tobacco, little difference in price elasticities is found among urban and rural households. For cigarettes, consumption decisions made by rural households are significantly influenced by cigarette prices, but the same is not true for consumption decisions made by urban households (John, 2008).

Several demand studies published in the *Economics of Tobacco Control* HNP Discussion Paper series are based on household expenditure or other survey data for various other Asian countries. These studies produce a range of estimates, generally confirming that higher taxes and prices will lead to reductions in tobacco use. Kyaing (2003) and Kyaing and his colleagues (2005), for example, used two expenditure surveys to estimate price elasticity of adult tobacco use in Myanmar. Kyaing (2003) uses a two-part model to examine the impact of price on the use of cigarettes, cheroots, and phet kyan which, together, account for nearly all of tobacco use in Myanmar. This study uses a price measure that is derived from self-reported expenditures and consumption quantities, treating this price variable as exogenous after having conducted a Hausman test for endogeneity of price. The estimated price elasticities are substantial—a prevalence elasticity of −1.28 and an intensity elasticity of −0.34. In addition, he finds that price elasticity of demand (in absolute values) falls with age, although demand remains elastic even among the oldest age groups, and that price elasticity rises and then falls with income. In the subsequent study (Kyaing *et al.*, 2005), separately examining the effect of price on consumption of cigarettes and cheroots among low-income consuming households, only tobacco-consuming households

were considered in the analysis. The price variables that were derived from self-reported prices were determined to be endogenous in some specifications and exogenous in others, based on Hausman tests. When the price variable was endogenous, a two-stage least squares model was estimated using taxes as instruments for price. The resulting estimated intensity elasticities were −0.25 for cigarettes and −0.36 for cheroots.

Karki and colleagues (2003) used Nepalese household consumption expenditure data to estimate the price elasticity of combined cigarette and bidi demand after having concluded that price can be treated as exogenous based on a Hausman test. They obtained an overall price elasticity of −0.88, with the impact of price on combined demand about evenly divided between its impact on prevalence (−0.46) and use in consuming households (−0.42). Adioetomo and colleagues (2005) used data from the 1999 National Socioeconomic Survey to analyse cigarette demand in Indonesia. To account for the potential endogeneity of price, they conducted a two-stage least squares model, finding little impact of price on smoking prevalence, while estimating that the overall price elasticity of consumption among smokers is −0.61, with demand less inelastic among those smokers on lower incomes. Arunatilake and Opatha (2003) performed a similar analysis, using household consumption expenditure and consumption quantities taken from the 1999–2000 Sri Lanka Integrated Survey database. They also find that smoking prevalence is unaffected by price, that higher prices reduce consumption in smoking households (intensity elasticity of −0.60), and that demand in lower-income households is most responsive to price. Sarntisart (2003) takes a somewhat different approach, applying a linear expenditure system model to data from the 2000 Thailand Household Socioeconomic Survey that were augmented with local price data on many goods and services collected as part of the survey. He obtains an overall price elasticity of −0.39, with demand increasingly inelastic among higher-income households and relatively less inelastic among urban households.

Europe. Several studies of the impact of taxes and prices on adult tobacco use based on individual or household survey data have been conducted for a few former Soviet Republics (the Russian Federation, Ukraine, and Estonia) and other central and eastern European countries (Bulgaria and Poland). In general, these studies find that higher taxes and prices reduce tobacco use, with widely varying estimates of price elasticity across countries.

Two peer-reviewed studies used data from the Russian Longitudinal Monitoring Survey, a nationally representative household survey that collects data on household members' tobacco use and includes a community module that collects information on retail prices for the highest and lowest domestic and imported cigarette brands (Ogloblin and Brock, 2003; Lance *et al.*, 2004). Ogloblin and Brock (2003) used data from the 1996 and 1998–99 waves of the survey to investigate the impact of price on smoking prevalence among men and women. They concluded that smoking prevalence among men was relatively unresponsive to price (elasticity of −0.085), while smoking prevalence among women was significantly affected by price (elasticity of −0.63). In addition, they found that smoking prevalence was becoming less inelastic over time, as cigarette prices nearly doubled between the two waves of the survey they analysed. In their subsequent analysis, Lance and colleagues (2004) added the 2000 wave of the survey to assess the impact of price on both prevalence and intensity among men. They similarly found little impact of price on prevalence (prevalence elasticities ranging from −0.05 to −0.1) and almost no impact of price on consumption among male smokers (intensity elasticities ranging from 0 to −0.03). Ogloblin and Brock (2003) attributed the low intensity elasticities obtained for male smokers to the fact that they mostly consume low-quality, very inexpensive cigarettes (in contrast, many female smokers use the higher-price, higher-quality cigarette brands).

Krasovsky and his colleagues (2002) used data on over 2700 individuals they surveyed throughout Ukraine to explore differences in the price elasticity of cigarette demand by age and income. Their measure of price was based on a self-reported price in response to a survey question that asked respondent smokers "What is the price for a pack of the cigarettes you usually smoke?" This measure of price is likely to be endogenous, reflecting a variety of factors including brand choice, quantity purchased and location of purchase. That is, heavier consumers will likely choose less-expensive brands, buy in greater quantities, and obtain these products from lower-priced locations. Their overall intensity elasticity was −0.4, while their other price elasticity estimates indicated that younger or lower-income Ukrainian smokers were generally more responsive to price.

Taal and colleagues (2004) used monthly household survey data on cigarette consumption and household

composition from 1992 through 1999 to construct a measure of average adult cigarette consumption for use in their estimation of the price elasticity of cigarette demand in Estonia. The price was the real tobacco product price index reported by the Statistical Office of Estonia. Using ordinary least squares methods applied to a myopic addiction model, they obtained an overall price elasticity of cigarette demand of −0.34.

Sayginsoy and colleagues (2002) used data from the 1995 Living Standards Measurement Survey for Bulgaria, a nationally representative household expenditures survey, to estimate the impact of price on cigarette demand in Bulgaria. To estimate price elasticities, they used a multistep process. First, prices were derived from self-reported expenditures and consumption quantities for smoking households. Second, for non-smoking households, the average of the derived prices from smoking households in the same income quintile was used. Finally, price was modelled as a function of taxes and cigarette characteristics. Using a two-stage least squares model, they estimated an overall price elasticity of cigarette demand of −0.80, with price elasticity in absolute value being greatest among lower-income households and becoming more inelastic as household income rises.

Gardes and Starzec (2004) applied a variety of methods to estimate the price elasticity of cigarette demand in Poland. They used data from the 1987 through 1990 Polish Consumption Panel database—a database that contains information on household consumption expenditures and price indices for various goods including tobacco products. Specifically, they estimated an Almost Ideal Demand System (cited and explained in Gardes and Starzec, 2004) using the consumption expenditure data, a Rotterdam system using a Frisch scheme, and a rational addiction model (Becker and Murphy, 1988). The alternative approaches produced comparable elasticity estimates, with a short-run price elasticity of overall cigarette demand of −0.4 and a long-run elasticity of −0.7.

Onder (2002) applied a two-part model to examine whether price affects smoking prevalence among households and intensity among smoking households, using 1994 expenditure survey data for Turkey. Using two-stage least squares methods to account for the endogeneity of the price measure that is derived from the self-report data on consumption expenses and consumption quantities, Onder (2002) obtained an overall price elasticity of −0.41, but finds little impact of price on households' smoking prevalence (elasticity of −0.03). In general, she found that overall demand is less inelastic among lower-income households.

Africa. Few price elasticity estimates based on survey data exist for African countries. To date, such studies have been conducted in South Africa (Berg and Kaempfer, 2001; Van Walbeek, 2002 and 2005) and Egypt (Nassar, 2003).

Berg and Kaempfer (2001) used the 1991 Living Standards Measurement Survey to estimate the price elasticity of cigarette demand for black and white households in South Africa. Prices appear to be derived from the self-reported expenditures and consumption quantities, while the potential endogeneity of price does not appear to be addressed in the estimation. Using censored maximum likelihood and censored least absolute deviations methods Berg and Kaempfer (2001) found that cigarette consumption was more than twice as responsive to price among whites (total price elasticity of −1.79) than among blacks (total price elasticity of −0.80). When limiting the analysis to only consuming households, however, they found little impact of price on consumption for either group. This finding suggests that the impact of higher prices in reducing smoking in South Africa is limited to reducing prevalence. However, the estimates they obtained may be biased due to the likely endogeneity of price in their models.

Van Walbeek (2002) considered smoking prevalence and the percentage of total income spent on cigarettes by income quartile for two periods, 1990 and 1995. The data were obtained from Income and Expenditure Surveys that are used to determine the weightings of the CPI (consumer price index) basket. Van Walbeek (2002) considered the expenditure patterns of approximately 15 000 urban households. In a subsequent study, he expanded the period to include the year 2000. He found that the percentage of households that bought cigarettes decreased from 49% in 1990 to 30% in 2000 (Van Walbeek, 2005). This was a period in which the real price of cigarettes increased by more than 100%. He found that the percentage of households in the poorest income quartile that bought cigarettes decreased from 46% to 22% while among the richest income quartile that percentage decreased from 43% to 34%. He concludes that the poor are significantly more price sensitive than the rich in consuming cigarettes.

Nassar (2003) estimated the price elasticity of tobacco use in Egypt, using data from 1995–96 and 1999–2000 household expenditure surveys. In addition to overall price elasticity estimates, she produced similar

estimates for a variety of population subgroups based on urban/rural location, income and education, using average unit values that were derived from the self-reported price data. She estimated an overall price elasticity of −0.40 for tobacco use in Egyptian households, finding little difference in price elasticity for urban and rural households (elasticities of −0.41 and −0.39, respectively), while generally finding that tobacco use is less price inelastic among lower-income, less-educated households than higher-income, more educated households.

The Americas. For low- or middle-income counties in the Americas, only one study on the effects of price on adult tobacco use based on survey data was identified. Jiménez-Ruiz and colleagues (2008) examined cigarette demand in Mexico, using data from multiple waves of the National Household Expenditure Survey conducted from 1994 through 2005 and applying two-part models for demand. To account for the potential endogeneity of price, they used average prices derived from self-reported information on consumption expenditures and consumption quantities, stratified by household location (state and rural/non-rural) and income quintile. Jiménez-Ruiz and colleagues (2008) found little impact of price on households' smoking prevalence (elasticity of −0.06), with a much greater impact on consumption in smoking households (elasticity of −0.45).

Summary

Over the past decade, at least 28 studies have used individual or household survey data to assess the impact of prices on adult tobacco use in low- and middle-income countries. Given the limited geographic differences in prices and the considerable variability in the availability and prices of different tobacco products and brands in these countries, as well as the reliance on self-reported information on expenditures or/and prices in many of these studies, researchers conducting these demand analyses have faced several challenges in estimating price elasticities. As a result, they have applied a variety of different approaches in their modelling, overcoming to the extent possible the potential measurement errors and endogeneity biases they faced.

Despite these challenges and the problems that are likely to remain in many of the studies, this growing body of research consistently demonstrates that higher taxes and prices lead to reductions in tobacco use. There are considerable differences across countries in terms of the estimated price elasticities. Some studies indicate that price has limited impact on prevalence of tobacco use, while significantly reducing tobacco consumption among users. Others find price to have large effects on prevalence but more limited impact on amount used, and still others discover that both prevalence and intensity of tobacco use are reduced by higher tobacco prices. While the point estimates vary considerably, they generally imply that adult demand for tobacco products in low- and middle-income countries is at least as sensitive to price, and often more sensitive to price, than it is in high-income countries. Studies that produce price elasticity estimates that are less elastic tend to come from countries where cigarettes are very inexpensive or affordability has increased significantly over time (most notably recent studies for China and the Russian Federation).

Systematic review of the scientific literature: Impact of price on adult cessation

A growing number of studies consider the impact of higher tobacco taxes and prices on cessation of tobacco use among adults. Given the variety of available data and the extensive cross-sectional and intertemporal variation in taxes and prices, much of the work on cessation also uses data from the USA. A few studies use data from other high-income countries, such as Canada, the United Kingdom, France and Spain. Only one study to date uses data from a low- or middle-income country, Viet Nam. These studies are summarized in Table 5.2 and are described below (see Chapter 6 for studies that focus on cessation among young people).

Most of these studies use one of three basic designs: analysis of cross-sectional data with retrospective information on when an individual quit; analysis of cross-sectional data with information on recent quit attempts or interests in quitting; or analysis of longitudinal data with information on tobacco use behaviours over time. Two potential problems arise in the analysis of retrospective data on cessation: first, there may be measurement error in the cessation measure due to imperfect recall of the age at which an individual quits; second, there may be measurement error in prices that were matched to the survey data, given the problems with the timing of quitting as well as the possibility that a survey respondent has moved since quitting. In general, these problems will be less significant than when using retrospective data on initiation, as described more fully in the next chapter, given that quitting will be much more recent than initiation.

Table 5.2. Summary of studies on the effect of cigarette price on smoking cessation

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Endpoint – (definition of price)	Main results (elasticity)	Sub-populations (which subpopulations are considered)	Comment
USA						
Douglas (1998) USA	Longitudinal analysis (retrospective) from reconstructed tobacco histories from the 1987 cross-sectional survey (NHIS) N=22 080 Analysis sample: 8754 (≥25yrs)	An ordered aprobit split-sample duration model Taken into account lagged duration dependence and time-varying covariates With and without a state-level regulation	Weighted average real prices per pack (including taxes) for each state from 1954 to 1991	**Price elasticity** -1.05 -0.98 (after being controlled for regulation)	**Price elasticity** 1.31 (for future price) 1.07 (after being controlled for regulation)	"Quitting hazard" increases substantially with future cigarette price; a result that is robust across alternative specifications
Franz (2008) USA	Cross-sectional (8 surveys from BRFSS (1993–2000) Analysis sample: N=1 000 013 (≥18 yrs)	Two models were considered: i) A simple OLS ii) A two-part model: 1) OLS; 2)OLS Adjusted for sex, health status, age, race, education, marital status, income, region and year effects Price: state-level average real price of a pack of cigarettes	Dependent variable: quitting decision	**Overall** +0.375	**By age (in years)** ***18–29*** +0.493 ***30–39*** +0.424 ***40–64*** +0.398 ***≥65*** +0.202	
Ross *et al.* (2011) USA and Canada	Longitudinal data (three waves of International Tobacco Control Policy Evaluation Survey (ITC) 2002, 2003 and 2004) Cohorts were based on the national representative samples of adult smokers annually interviewed in the three waves (N=4352 at wave 1) Study sample: N=5304–5973 depending on models Longitudinal sample: ca. N=2000	(1) OLS for change in cessation stage over time (2) Generalized Estimating Equations (GEE) models for smoking cessation Different OLS and GEE models were considered according to the number of covariates included in the models. The first, simplest model only included demographic and socioeconomic variables. The second model further adjusted for knowledge of the health risk of smoking. The third model furthermore accounted for nicotine addiction	Cessation stage of an individual (collapsed into three stages) Price: (i) Change in self reported price (ii) Change in external price (iii) Change in tax	Coefficient estimates from the OLS models Overall: 0.0009 to 0.0015 Coefficient estimates from the GEE models Overall: 0.0007 and 0.0044		Cigarette prices increased the likelihood of actual quitting Only the coefficient estimates of the external price obtained from the GEE models were statistically significant The results lends support to that higher cigarette prices can be used to increase cessation and to motivate smokers to quit

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Endpoint – (definition of price)	Main results (elasticity)	Sub-populations (which subpopulations are considered)	Comment
Other high-income countries						
Canada						
Hamilton *et al.* (1997) Canada	Longitudinal (retrospective) Survey on Smoking in Canada (1994) Follow-up one year 11 119 respondents (≥15 yrs) Telephone survey	No multivariate regression analysis Simple descriptive analysis	No computation of elasticities	Higher cessation rates (10.7% vs. 10.3%) in provinces where taxes were not cut vs. provinces without taxes cut		Quit rate by different time of interview in provinces: With tax cut: +2.5 to +10.3 Without tax cut: +5.7 to +10.7 Changes in taxes across years not analyzed
France						
Peretti-Watel (2004) France	Life-course perspective of retrospective data extracted from the 1999 cross-sectional survey French Health Barometer (FHB) (A telephone survey representative of the French population 12–75 yrs) n=13 685	Time hazard model of smoking cessation: logistic regression Adjusted for time-constant variables (gender, education and age of smoking initiation), and for time-varying variables (age, age2, parenthood, and price) Cessation was assessed separately for men and women aged 21–50	Odds ratio (OR) of cessation given an increase in price by 1%	**For subsample of individuals aged 21–50, by sex** ***Men*** OR=1.007 ***Women*** OR=1.009	**Full sample** ***Cessation by age range*** *Age 20 or younger* OR=1.005 *Age 21–30:* OR=1.017 *Age older than 30* OR=1.011	Risk estimates were statistically significant for both subsamples (p<0.001)
Spain						
López Nicolás (2002) Spain	Longitudinal analysis (retrospective) from reconstructed tobacco histories from cross-sectional surveys National Health Interview Surveys (ENSE) 1993, 1995 and 1995 Face-to-face interview Analysis sample (≥16 yrs): Starting: Men: N=7092 Women: N=9913 Quitting: Men: N=2305 Women: N=1817	A log-logistic split population model with the Weibull distribution Adjusted for education, dummies for tobacco policies, time trend and birth cohort	Real price of 20 cigarettes	**Elasticity of quitting with respect to the price of black tobacco** ***By sex*** *Men* -1.32 *Women* -1.50		Different price series for black cigarettes and blond cigarettes, and a weighted average of both were used Different model specifications were also tested **Elasticity of starting** ***Men*** +0.07 ***Women*** +0.08

Table 5.2. Summary of studies on the effect of cigarette price on smoking cessation

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Endpoint – (definition of price)	Main results (elasticity)	Sub-populations (which subpopulations are considered)	Comment
United Kingdom						
Forster & Jones (2001) United Kingdom	Cross-sectional survey (1984) British Health and Lifestyle Survey (HALS) Sample of adults (≥18 yrs) representative of the population living in households in England, Scotland and Wales N=9003 Retrospective smoking data by using individuals' self-reporting information Analysis sample: N=9003	Split-population log-logistic probit duration model for smoking initiation Generalized gamma and Weibull models for smoking quitting Adjusted for social class, education, ethnicity, parental smoking, and a time trend	Tobacco tax: proxy for the real price of cigarettes Tax elasticity of quitting smoking	**Full sample** -0.41 to -0.69	**By sex** Men -0.41 to -0.63 Women -0.41 to -0.69	**Tax elasticities of starting smoking** ***By sex*** *Men* +0.16 *Women* +0.08
Low- and middle-income countries						
Viet Nam						
Laxminarayan & Deolalikar (2004) Viet Nam	Viet Nam Living Standards Survey, waves 1992/93 and 1997/98 6110 males (≥16 years) Two forms of tobacco: cigarettes and rustic tobacco	Three multinomial logit regressions for change of tobacco use status from 1993 to 1998 for three samples: 1) all smokers in 1993 2) all cigarette smokers in 1993 3) all rustic tobacco users Explanatory variables: real per capita expenditure in 1993, age in 1993, education, price of cigarettes in 1993, price of rustic tobacco in 1993; changes between 1993 and 1998 in real per capita expenditure, in price of cigarettes and in price of rustic tobacco Price data: collected from separate, commune-level surveys. Tobacco prices for year 1997/98 were imputed from household rustic tobacco expenditures and price of tobacco sold obtained from households producing tobacco		Given a change in price of cigarettes, price elasticities of decisions to quit cigarette smoking: -0.242 Given a change in price of rustic tobacco, price elasticities of decisions to quit rustic tobacco: +0.735		Cigarette smokers appear to be more price-sensitive than rustic tobacco users

BRFSS, behavioral risk factor surveillance system; NHIS, national health interview survey; OLS, ordinary least squares

Similarly, the analysis of cross-sectional data with information on recent quit attempts or interest in quitting will be useful in understanding how tax and price increases motivate cessation, but will be of limited utility in understanding their impact on successful, long-term cessation. Multiple waves of longitudinal data are most useful for addressing this, but few such data are available to researchers.

Given the available data, the most commonly employed design has been the use of retrospective information on smoking behaviour and cessation constructed from cross-sectional survey data. Douglas (1998) was the first to use this approach, constructing smoking histories from the retrospective data collected in the 1987 US National Health Interview Survey, with historical cigarette prices matched to the survey on the basis of each respondent's current state of residence. Using ordered probit, split-sample duration methods, Douglas (1998) modelled cessation using the rational addiction framework. He found that higher prices significantly increased the probability of cessation, with the duration of smoking approximately unitarily elastic (e.g. a 10% increase in prices would reduce the duration of smoking by 10%). In addition, he found that the probability of quitting rose with the duration of smoking, consistent with the predictions of the rational addiction model.

Forster and Jones (2001) applied a similar approach to estimating the impact of cigarette tax on smoking cessation in the United Kingdom, using retrospective information from the 1984 British Health and Lifestyle Survey. They studied men and women separately, obtaining tax elasticities for the number of years of smoking before quitting of −0.60 for men and −0.46 for women in their baseline models. A variety of sensitivity analyses produce similar elasticity ranges: −0.41 to −0.63 for men and −0.41 to −0.69 for women. Similar methods were employed by López Nicolás (2002) for Spain and by Peretti-Watel (2004) for France. Both studies similarly concluded that higher cigarette prices increased the probability of cessation.

Franz (2008) applied a related approach to look at the impact of cigarette prices on quitting in the past year, using cross-sectional data for the USA from the 1993 through 2000 Behavioural Risk Factor Surveillance System surveys. He found that cigarette prices were positively associated with this measure of cessation, with an estimated elasticity of cessation of 0.375 (the higher the price, the higher the probability of having quit the previous year). In addition, the elasticity estimate of cessation fell with increasing age, although it remained statistically significant (the elasticity estimate for the youngest group was more than twice that of the oldest group; Franz, 2008).

Two studies have employed longitudinal data taken from the International Tobacco Control (ITC) Policy Evaluation Project's nationally representative surveys of adult smokers to examine the impact of tax and price on cessation related outcomes. Hyland and colleagues (2006) used the first (late 2002) and second (mid-2003) waves of the US, United Kingdom, Canadian, and Australian ITC surveys to look at the effects of cigarette purchase behaviours in wave one on the likelihood of making a quit attempt and the likelihood of having quit by wave two. They found that smokers who purchased cigarettes from a low or untaxed source (e.g. from duty-free shops, online vendors and various other sources) were less likely to have made a quit attempt or to quit successfully between waves than those who did not purchase from these sources. This finding suggests that the availability of opportunities for tax avoidance and evasion reduces cessation.

More recently, Ross and colleagues (2011) used the first three waves of the US and Canadian ITC surveys to further explore the role of price and related factors on cessation outcomes. Using a five-level "stages of change" measure of quit intentions (pre-contemplation, contemplation, preparation, action and maintenance), they found that smokers living in areas with higher taxes and higher prices were significantly more interested in quitting. Similarly, they found some evidence that increases in prices resulted in increased motivation to quit and higher prices increased the likelihood of successful quitting. In contrast to Hyland and colleagues (2006), they found that the availability of cheaper cigarettes did not deter cessation, although smokers would respond more aggressively in their cessation efforts if lower priced cigarettes were not as readily available.

In the only cessation study conducted in a low- or middle-income country, Laxminarayan and Deolalikar (2004) used data for the subset of households participating in both the 1992–93 and 1997–98 waves of the Viet Nam Living Standards Survey[3]. They considered two forms of tobacco—cigarettes and rustic tobacco—and used price data collected from separate, commune-level surveys,

[3] Laxminarayan and Deolalikar (2004) also assess initiation with these data, as discussed in Chapter 6.

with rustic tobacco prices in the latter wave imputed because only cigarette prices were collected at that wave. They found little evidence that higher cigarette prices lead to cessation of cigarette smoking or that higher prices of rustic tobacco increase the probability of quitting among rustic tobacco users. Their findings indicated the occurrence of product substitution in response to increases in price; in this particular instance, smokers switching from manufactured cigarettes to the use of rustic tobacco. However, this finding may be the result of several factors. The sample sizes used in their models are relatively small. Correlations in price changes over time may reduce the precision of their estimates. The use of imputed rustic tobacco prices for one of the two waves included in the analysis can also bring about measurement errors to the estimates.

Summary

Studies on the impact of tobacco product taxes and prices on cessation are relatively scarce. The majority of these rely on retrospective data on smoking histories collected in cross-sectional surveys that are subject to various sources of measurement errors. Nevertheless, the findings from the small but growing body of research from high-income countries are consistent with the findings described above for the impact of price on smoking prevalence. Specifically, these studies consistently find that higher cigarette prices are associated with increased motivation to quit and with successful cessation. The only study from a low- or middle-income country, using Vietnamese data, does not reach similar conclusions, which may be accounted for by data limitations.

Systematic review of the scientific literature: Impact of relative prices on substitution among tobacco product by adult tobacco users

Even fewer studies have used survey data to examine the effects of changes in the price of one tobacco product relative to other tobacco products on substitution between these products by adult tobacco users. This is likely due to the very low prevalence of non-cigarette tobacco product use in many countries, to the lack of detailed data on use of multiple tobacco products in the same survey, and to the correlations that exist between taxes and prices for various tobacco products which make it difficult to empirically sort out the differential impact of each on use. Most of the studies that have examined the impact of changes in relative prices on substitution have been discussed above where findings regarding the effects of own-price on use were reviewed. This section briefly reviews the limited existing evidence on cross-price effects, with Table 5.3 providing a summary of the relevant studies.

Most of the evidence on cross-price effects also comes from the USA, with Ohsfeldt and colleagues responsible for most of those studies (Ohsfeldt and Boyle, 1994; Ohsfeldt *et al.*, 1997; Ohsfeldt *et al.*; 1999). In their various papers, Ohsfeldt and colleagues used data from different waves of the Tobacco Use Supplement to the Current Population Survey augmented with data on state-level cigarette and smokeless tobacco taxes. As described above, they consistently obtained negative own-tax effects, with higher cigarette taxes associated with reduced cigarette use and higher smokeless tobacco product taxes associated with reduced use of snuff and chewing tobacco. In their demand models for cigarettes and smokeless tobacco use, they included state-level taxes on both cigarettes and smokeless products to examine cross-price effects on tobacco use. While the point estimates vary from study to study, they find consistent evidence that higher cigarette taxes encourage some substitution to smokeless tobacco products, with positive cross-tax elasticities for smokeless tobacco use with respect to cigarette taxes. In contrast, they find little evidence in the opposite direction: estimates for smokeless tobacco taxes were generally insignificant in models of cigarette smoking.

Delnevo and colleagues (2004) find similar evidence of substitution between cigarettes and cigars based on data from the 2001 and 2002 New Jersey Adult Tobacco Use Surveys. Their analysis takes advantage of a significant increase in the New Jersey cigarette excise tax (from $0.80 per pack to $1.50 per pack) between the two waves of the survey, while the tax on other tobacco products in New Jersey was unchanged. They found that the prevalence of cigar use increased significantly from 2001 to 2002 among current cigarette smokers, and even more so among those who had recently quit smoking cigarettes. Delnevo and colleagues (2004) concluded that the changes in cigar smoking were the result of some cigarette smokers who had switched to cigar use following the significant increase in the relative price of cigarettes in New Jersey.

To date, only three survey-based studies of cross-price effects for adult tobacco use exist for low- and middle-income countries. In addition to estimating the own-price effects for cigarettes, bidis and leaf tobacco, John's (2008) analysis of tobacco demand in India estimated cross-price effects.

Table 5.3. Summary of studies on the effect of cigarette price on substitution among tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Endpoint	Main results	Sub-populations	Comment
USA						
Ohsfeldt & Boyle (1994) USA	Cross-sectional CPS (1985) n=100 000 in file Analysis sample: only men (≥16 yrs) (N not reported)	Multivariate regression (snuff use, chewing tobacco use, and any smokeless tobacco use) Adjusted for per capita income, education, state population characteristics (residence, race, religious denomination, and divorce rate), men aged 16–17, and existing state tobacco regulation	Prevalence of use of smokeless tobacco Price of smokeless tobacco products: border-adjusted state smokeless tobacco average excise tax	**Cross-(tax) elasticities of demand for smokeless with respect to the cigarette tax** ***Snuff use*** +0.3 and +0.62 ***Chewing tobacco use*** +0.49 and +0.39 ***Any smokeless tobacco use*** +0.44 and +0.41		Ranges of elasticity estimates were obtained according to two models See also Table 5.1 for price elasticities of demand for smokeless tobacco use
Ohsfeldt *et al.* (1997) USA	Cross-sectional CPS (1985) n=100 000 in file Analysis sample: only men (≥16 yrs) (N not reported)	Multivariate Logit regression (for (i) cigarette use, (ii) snuff use, (iii) chewing tobacco use, and (iv) any smokeless tobacco use) Adjusted for total real family income, age, marital status, race, ethnicity, employment status, education, and occupation, metropolitan, religion, and tobacco control policy	Prevalence Price of smokeless tobacco products: border-adjusted state average smokeless tobacco excise tax	Cross-tax-elasticities of demand (prevalence) for smokeless tobacco with respect to the cigarette tax	**Cross-tax-elasticities of demand (prevalence) for smokeless tobacco with respect to the cigarette tax** ***By age (in years)*** *Snuff use* >15: +0.13 16–24: +0.71 ≥25: +0.04 *Chewing tobacco use* >15: +0.09 16–24: +0.19 ≥25: +0.08 *Any smokeless tobacco use* >15: +0.10 16–24: +0.23 ≥25: +0.09	See also Table 5.1 for price elasticities of demand for smokeless tobacco use
Ohsfeldt *et al.* (1999) USA	Cross sectional (pooled surveys) CPS (1992–1993) Analysis sample: 165 653 males either white or black (≥16 yrs) Nationally representative samples	Multivariate regression Adjusted for price (tax) of snuff, index of smoking regulation, family income, age, occupation and education, ethnicity (black/white), marital status, per capital income, poverty, unemployment rate and religion	Prevalence Price: real federal excise tax rate	**Overall cross-tax elasticity of demand for** ***Cigarette use*** +0.001 (given a 1-percent change in snuff tax rate) ***Snuff use*** +0.98 (given a 1-percent change in cigarette tax rate)	**Cross-tax elasticity of demand for** ***Cigarettes (given a 1-percent change in snuff tax rate)*** *By age (in years)* 16–24: +0.002 25–44: +0.001 ≥45: -0.002 ***Snuff (given a 1-percent change in***	Tobacco models were estimated with the cigarette tax and smoking regulation variables treated as exogenous and endogenous variables Higher cigarette tax rates are associated with greater snuff use, but higher snuff tax rates

Table 5.3. Summary of studies on the effect of cigarette price on substitution among tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Endpoint	Main results	Sub-populations	Comment
Ohsfeldt *et al.* (1999) (contd) USA					***cigarette tax rate)*** *By age (in years)* 16–24: +1.15 25–44: +0.04 ≥45: +0.54	are not associated with greater cigarette use
Delnevo *et al.* (2004) USA	Cross-sectional New Jersey Adult Tobacco Survey (NJATS) (2001–2002) RDD Analysis sample: N=7934 (≥18 yrs) 2001 data: N=3090 2002 data: N=4004	A logistic regression for (i) ever cigar use and (ii) current cigar use Adjusted for sex, race, age, education, and cigarette smoking status No price elasticities nor association of consumption (OR) with price are reported	Comparison between the odds of being an ever and current cigar user before (2001) and after (2002) a new cigarette excise tax	The odds of being an ever and current cigar smoker substantially increased among recent cigarette quitters after the new tax were taken into account	**The adjusted odd ratio for current cigar use of other tobacco products** ***Men*** *2001* +13.7 *2002* +6.2 ***By smoking history*** *Former smoker* 2001: +1.40 2002: +2.68 *Recent quitter* 2001: +0.52 2002: +4.73 *Current smoker* 2001: +2.82 2002: +4.51	Substitution of cigarettes by cigars after increases in excise tax for cigarettes were controlled for (and reducing that for cigars)
Low- and middle-income countries						
China						
Tsai *et al.* (2005) China (Taiwan)	Two-year follow-up cohort (face-to-face survey) Analysis sample: N=501 male smokers (≥16 yrs)	Logistic regressions (for behavioural change (i) reduction of smoking, and (ii) brand switching). Odds ratios were obtained Adjusted for demographic factors, individual income, smoking behaviour, living area, expense on smoking, addiction level, advertisement, and favourite cigarette brand	Change in smoking behaviour before (year 2001) and after the introduction of a new cigarette tax scheme (year 2002)	OR for reduced smoking with respect to increased retailed cigarette price by 1 NT$=1.03 OR for switching brand with respect to increased retailed cigarette price by 1 NT$=1.07		Overall, 17.4% switched brand, 18.8% reduced smoking, 8.4% both

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Endpoint	Main results	Sub-populations	Comment
India						
John (2008) India	Cross-sectional survey (1999–2000) N=120 309 households Household with zero consumption of tobacco (37% from rural and 60% from urban) were excluded from the analyses Unit of analysis: household	OLS regression Price of each tobacco product: average unit values (self-reported expenditure divided by quantity)	Substitution among tobacco products	**Cross-elasticities (consumption)** ***Rural*** *Demand for cigarettes given a 1% change in the price of* Bidis: -0.24 Leaf tobacco: +0.010 *Demand for bidis given a 1% change in the price of* Cigarettes: -0.117 Leaf tobacco: -0.010 *Demand for leaf tobacco given a 1% change in the price of* Cigarettes: +0.15 Bidis: -0.067 ***Urban*** *Demand for cigarettes given a 1% change in the price of* Bidis: -0.122 Leaf tobacco: +0.002 *Demand for bidis given a 1% change in the price of* Cigarettes: +0.011 Leaf tobacco: +0.011 *Demand for leaf tobacco given a 1% change in the price of* Cigarettes: -0.221 Bidis: +0.252		A demand system model Spatial variation in prices of tobacco products were used to estimate own and cross-price elasticities. When symmetry restrictions were imposed, price elasticity estimates did not considerably change Authors concluded that there are no substitution effects due to price change Cross-price elasticities reported here were symmetric-constrained estimates See also Table 5.1
South Africa						
Van Walbeek (2005) South Africa	Income and Expenditure surveys (IES), 1990, 1995 and 2000 Analysis unit: household Analysis sample: 1990: N=14 332 (urban households) 1995: N=16 903 (urban and rural households) 2000: N=26 263 (urban and rural households)		Two research questions: (1) the relative importance of tobacco in South African households' expenditure patterns; and (2) changes in the regressivity of cigarette taxes between 1990 and 2000	**Percentages of urban households spending money on tobacco products in 1990, 1995 and 2000 by income quintile (lowest to highest)** **Q1**: 46; 42; 22 **Q2**: 54; 46; 31 **Q3**: 51; 45; 34 **Q4**: 43; 44; 34 Between 1990 and 2000 the percentage of		The poor are significantly more price sensitive than the rich in consuming cigarettes. The decrease in aggregate cigarette consumption was driven largely by poorer households quitting (or not starting) cigarette smoking

Table 5.3. Summary of studies on the effect of cigarette price on substitution among tobacco products

Publication (author, yr, country)	Methods (time period, study design and sample size)	Model	Endpoint	Main results	Sub-populations	Comment
Van Walbeek (2005) (contd) South Africa				households consuming tobacco decreased by 14, 19, 16, and 8 percentage points for income quintiles Q1 to Q4.		
Viet Nam						
Laxminarayan & Deolalikar (2004) Viet Nam	Viet Nam Living Standards Survey, waves 1992/93 and 1997/98 6110 males (≥ 16 years) Two forms of tobacco: cigarettes and rustic tobacco	Three multinomial logit regressions for change of tobacco use status from 1993 to 1998 for three samples: 1) all smokers in 1993 2) all cigarette smokers in 1993 3) all rustic tobacco users Explanatory variables: real per capita expenditure in 1993, age in 1993, education, price of cigarettes in 1993, price of rustic tobacco in 1993; changes between 1993 and 1998 in real per capita expenditure, in price of cigarettes and in price of rustic tobacco Price data: collected from separate, commune- level surveys. Tobacco prices for year 1997/98 were imputed from household rustic tobacco expenditures and price of tobacco sold obtained from households producing tobacco		**Given a change in price of cigarettes, price elasticities of decisions to** ***(1) initiate into*** *cigarettes*: -1.175 *rustic tobacco:* +1.375 ***(2) switching from*** *cigarettes to rustic tobacco* +1.395 *rustic tobacco to cigarettes* +0.004 **(3) quitting** *cigarettes* -0.242 *rustic tobacco* +0.243 **Given a change in price of rustic tobacco, price elasticities of decisions to** ***(1) initiate into*** *cigarettes*: 0.477 *rustic tobacco*: 1.558 ***(2) switching from*** *cigarettes to rustic tobacco* -3.240 *rustic tobacco to cigarettes* -1.601 ***(3) quitting*** *cigarettes*: -1.411 *rustic tobacco*: +0.735		Although higher cigarette prices discourage initiation of cigarette smoking, they may encourage the use of rustic tobacco

CPS, current population survey; OLS, ordinary least squares; RDD, random digit dialing

In contrast to the evidence from high-income countries, John (2008) found no evidence that changes in the relative prices of tobacco products would result in substitution from higher-priced to lower-priced tobacco products. Instead, most of his cross-price elasticity estimates were negative, although few of them were statistically significant, suggesting complementarity among these tobacco products in India.

In contrast, Laxminarayan and Deolalikar (2004) found some evidence of substitution between cigarettes and rustic tobacco use in their analysis of adult tobacco use in Viet Nam. Specifically, they found that higher cigarette prices resulted in some substitution from cigarette use to rustic tobacco use, but found little impact of higher rustic tobacco price on cigarette use. Similarly, in his analysis of South African tobacco prices and tobacco use, Van Walbeek (2005) found evidence of substitution in response to relative price changes, at least in some populations. Specifically, he found strong evidence that the poor were switching to pipe and other tobacco (presumably to make roll-your-own (RYO) cigarettes) much more often than the rich as the price of cigarettes went up relative to these products. In 1990, the poorest quarter of the population spent about 5% of their tobacco purchases on pipe and other tobacco; in 2000, this had increased to 18%. Among the second-poorest quarter of the population, there was also an increase in the relative consumption share of pipe and other tobacco (from 2.4% to 7.1% of total tobacco expenditure). However, among the richer half of the population, the consumption share of pipe and other tobacco remained unchanged over this period.

Summary

The limited survey-based research on cross-price effects in adult tobacco use suggests that, at least in high-income countries, tobacco products are generally substitutes for one another. An increase in the price of one product relative to the price of another product will lead some users of products whose relative prices increase to switch to products whose relative prices fall. The even scarcer research on this issue from low- and middle-income countries suggests that cultural differences may be important in reducing cross-price effects.

Systematic review of the scientific literature: Attitudes, perceptions and behaviours towards increases of cigarette prices

Tables 5.4 and 5.5 summarize findings on attitudes and perceptions towards increases of cigarette prices and willingness of smokers to quit in response to increments of cigarette prices, respectively. In these tables, papers are sorted by country (USA, other high-income countries, and low- and medium-income countries) and year of publication.

Attitudes and perceptions towards increasing of cigarette prices

Table 5.4 gives a summary tabulation of studies providing evidence on the attitudes and perceptions of adults towards increasing cigarette prices. Studies were available from the USA (Torabi *et al.*, 1994; King *et al.*, 2003; Hamilton *et al.*, 2005; Shelley *et al.*, 2007), Taiwan, China (Tsai *et al.*, 2003), Italy (Gallus *et al.*, 2005; Gallus *et al.*, 2006), Germany (Hanewinkel & Isensee, 2008), and New Zealand (Wilson *et al.*, 2010). These studies were based on samples ranging between 800 and 27 000 subjects that in most cases were representative of the corresponding target (state or national) populations.

The key messages are that a substantial proportion (i.e. generally between a third and a half) of the population would support tax increases, and that such a support becomes appreciably greater (i.e. 60–80% or more) whenever such tax increases are devoted to measures for tobacco control. A study from New York City (Shelley *et al.*, 2007), based on focus groups and qualitative information on economically disadvantaged population's smoking and purchasing responses to increases on tobacco taxes, reported that a substantial tax rise (e.g. US$5) increased intention to quit but also increased smuggling.

In several studies, the support for increased taxation was greater in nonsmokers and in smokers who were more educated, elderly or less young. However, a study that concerned African Americans' attitudes did not consider a rise in taxation unfair for African Americans (King *et al.*, 2003). At each level of education, responders agreeing with a tax increase represented the most numerous group. A study from Germany (Hanewinkel & Isensee, 2008) also showed growing support for increasing taxation over the most recent calendar periods (35% in 2002 to 42% in 2005).

Willingness of smokers to quit according to increases in cigarette prices

Table 5.5 gives summary findings from studies on the willingness of smokers to quit according to increases in cigarette prices and taxation.

Table 5.4. Summary of studies providing data on the attitudes and perceptions of adults towards increasing cigarette prices

Reference, year, country	Methods	Main results	Comments
USA			
Torabi *et al.* (1994) Indiana, USA	Random sample of 800 adults	About 85% in favour of tax rise for health education and tobacco research	Representative state sample
King *et al.* (2003) USA	1000 African American adults from 10 districts	47% of the sample supported increase in taxation. Positive relation with education	Rise in taxation not considered unfair for African Americans
Hamilton *et al.* (2005) Massachusetts, USA	14 000 adults from 351 Massachusetts towns	Over 80% of support for tax increase if used for tobacco control only, 74% for health or tobacco control, 31% for any government purpose	Greater support by non smokers, more educated, less young individuals and women
Shelley *et al.* (2007) New York City, USA	104 subjects in 14 focus groups	The US$5 price increase in New York City increased interest in quitting, but also smuggling	Qualitative data
Other high-income countries			
Germany			
Hanewinkel & Isensee (2008) Germany	Ten representative samples of the general population, 27 608 persons aged ≥14	Greater support to tax increase over time, from 35% in 2002 to 42% in 2005. General support among elderly, more educated subjects	The amount of price increase did not affect this support
Italy			
Gallus *et al.* (2005) Italy	3114 Italians aged ≥15	54% of the sample confident that an increase of price is effective. 21% of smokers stated there they would reduce, and 10% stop smoking following an 1€ increase in price	Representative sample of the Italian population
Gallus *et al.* (2006) Italy	3050 Italians aged ≥15 interviewed in 2006	36% of ever smokers reported that a tax increase would have a high (10.5%) or intermediate (25.4%) impact on cigarette consumption in the young	Representative sample of the Italian population
Gallus *et al.* (2008) Italy	Adults ≥15 years, interviewed in 2006–07 partly overlapping with Gallus *et al.* 2006	25% of 1456 smokers strongly in favour, and 37% moderately favour of an increased of 10 € cents devoted to supporting another association 39% of smokers indicate that a minimum price of 5 € per pack, would decrease smoking	Greater support in middle-aged moderate smokers
New Zealand			
Wilson *et al.* (2010) New Zealand	1376 smokers	59% would support a tax increase if the revenue if used to promote healthy lifestyle and quitting	Greater support for smokers with intention to quit

Reference, year, country	Methods	Main results	Comments
Low- and middle-income countries			
China			
Tsai *et al.* (2003) China (Taiwan)	National sample. Face-to-face interviews of 3279 adults aged 18 to 64 years in 2000	Lower support towards cigarette tax increase among current (OR=0.34) and former smokers, and among lower social classes	Survey conducted before the introduction of a national tax
South Africa			
Martin *et al.* (1992; 1993)	Household survey representative of the South African population Sample size: 2006 adults	56% of adults believed that taxes on tobacco products should be increased. Supporters for tax increases were more frequently whites (60%) and Asians (62%), females (58%), subjects aged ≥ 45 years (59%) and more educated subjects (63%). Greater support was evident in non smokers (59%) and particularly ex-smokers (70%) compared with current smokers (45%)	

Table 5.5. Summary of studies providing data on the willingness of smokers to quit according to increases of cigarette prices

Reference, year, country	Methods	Main results	Comments
USA			
Biener *et al.* (1998)	Ad hoc survey (1993-1994) 1783 adult smokers 216 teenager smokers Telephone survey Representative sample of Massachusetts	Changes in smoking behaviour in front of an hypothetical increase in price: Low income associated to cut cost (switch to cheaper tax or reduce number of cigarettes; OR=3.30; 95% CI 1.79–6.36) and consider quitting (OR=1.98; 95% CI 1.17–3.34) vs. no response Heavy smoking associated to cut cost (OR=2.08; 95% CI 1.10–3.93) vs. no response Teenagers: Low income associated to cut cost (OR=7.64; 95% CI 1.37–42.56) vs. no response and cut cost (OR=13.26; 95% CI 1.93–91.57) vs. consider quitting	Survey after increase of 25¢ and prior to a statewide tobacco control programme Estimates adjusted for age, sex, income, and amount smoked
Other high-income countries			
Republic of Korea			
Chung *et al.* (2007)	3000 men aged ≥20 Telephone interview	Overall price elasticity -0.66	Key impact on amount of cigarette smoked (-0.64), but very limited on smoking cessation (-0.02)
Chung *et al.* (2008)	702 subjects	Mean of the willingness to quit for an increase in price of about 40%	Greater willingness with larger increases
Low- and middle- income countries			
China			
Lee (2008) (Taiwan)	483 questionnaires from a population survey	Elasticity -0.29 for a 44% increase in price	Greater elasticity for women, low income smokers, moderately addicted and smokers who purchase low-price cigarettes

Studies were available from the USA (Biener *et al.*, 1998), the Republic of Korea (Chung *et al.*, 2007, 2008) and Taiwan, China (Lee, 2008) and based on samples from 500 to 3000 subjects.

A study conducted in the USA on 1783 adult smokers analysed changes in smoking behaviour in front of a hypothetical increase of price. Lower-income smokers were significantly more likely to cut smoking costs (by switching to cheaper brands or smoking less cigarettes) or seriously consider quitting than to not adjusting their smoking behaviour in the face of a tax increase ("no response") as compared to higher-income smokers (Biener *et al.*, 1998). Heavy smoking was significantly and positively associated with the probability of cutting costs (OR = 2.08; 95% CI: 1.10–3.93) compared to no response.

Overall summary

A large and growing number of studies have used individual-level or household-level survey data to assess the impact of tobacco product taxes and prices on use of tobacco products among adults. Studies have used survey data to examine the differential impact of tax and price on tobacco use among population subgroups defined by gender, age, socioeconomic status and/or other characteristics, as well as to assess the separate effects of price on different aspects of tobacco use, such as prevalence, frequency, intensity, initiation, uptake and cessation. The relatively large literature from the USA and other high-income countries shows that adult smoking prevalence and intensity are negatively related to cigarette taxes and prices, with most total elasticity estimates falling in the range from −0.2 to −0.6. While the quality of data and methods varies more, estimates obtained in studies from several low- and middle-income countries generally confirm that various aspects of adult tobacco use are responsive to price, with higher prices reducing both prevalence and intensity of use. Several studies from high-income countries have examined adult smoking cessation, generally finding that higher taxes and higher prices reduce the duration of smoking, raise interest in quitting, boost quit attempts and increase the number of smokers who successfully quit smoking. Finally, a few US studies found similar effects of tax and price on the use of other tobacco products, such as smokeless tobacco and cigars, and produced some evidence of substitution among tobacco products in response to changes in the relative prices of these products. In contrast, no clear patterns emerge from the small number of studies from countries other than the US that consider substitution among tobacco products in response to changes in the relative prices of these products.

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