Chapter 4
Tax, price and aggregate demand for tobacco products

Introduction

Ever since the detrimental health impact of tobacco smoking was scientifically established in the 1950s and 1960s, the medical and public health community has called for interventions aimed at reducing smoking. This call was particularly strong in the United States, the United Kingdom, Canada, Australia and New Zealand, and these countries have implemented strong and effective tobacco control strategies. In the 1960s and 1970s, tobacco control strategy was driven primarily by the dissemination of information. In the 1980s and especially the 1990s the strategy became far more comprehensive, incorporating restrictions on public smoking, restrictions on advertising, legal challenges to the industry, and focused tax increases. Most other developed countries have subsequently implemented similar strategies, with the result that per-capita tobacco consumption in the developed world has been decreasing since the early 1980s (Gajalakshmi *et al*., 2000). Tobacco use in low- and middle-income countries has lagged tobacco use in high-income countries, although there has been a strong increase in tobacco use in the past half century. As a result, low- and middle-income countries have lagged developed countries in tobacco control, but since the early 1990s several developing countries, among them Bangladesh, Brazil, India, Poland, South Africa and Thailand, have implemented effective tobacco control strategies (De Beyer and Waverley Brigden, 2003).

Of the tobacco control interventions that are available, some (e.g. health warnings, restrictions on tar and nicotine content) have limited economic content, and as such, economists have little to say about these interventions. Other interventions (e.g. restrictions on smoking in hospitality establishments, advertising bans and restrictions of sales to minors) have definite economic consequences (for example, the alleged loss of revenue suffered by the hospitality industry after the imposition of clean indoor air legislation), but in the popular debate, the focus is usually on the non-economic aspects, such as freedom of choice and freedom of expression. The focus of this Handbook is not on these tobacco control interventions, thus they are not discussed further.

The primary theme of this book is that increases in the price of cigarettes are particularly effective in reducing the demand for cigarettes. This chapter provides a theoretical framework used in other chapters and reviews the literature that considers demand studies that are estimated with aggregate data. Aggregate data is constructed by, in principle, adding the relevant data of individuals for the relevant variables (such as consumption, income and advertising expenditure). Typically aggregate data are produced by government agencies. A common theme in all these studies is that cigarette prices are a crucial determinant of the demand for cigarettes. The price elasticity of demand is typically the metric of interest. The more price-elastic the demand, the more effective is a cigarette price increase in reducing cigarette consumption. The relevant policy variable is the excise tax; by increasing the excise tax, the government can raise the retail price of cigarettes. The policy implications of knowing the price elasticity of demand are: (1) it allows one to predict the likely decrease in consumption if the price of cigarettes were to increase by a certain percentage, and (2) it allows one to estimate the fiscal impact of a change in the excise tax on cigarettes.

The empirical literature on the demand for cigarettes is sizeable, and has several different focus points. In particular, in the past two decades there has been an explosion in the number of studies that are based on individual- or household-level data. These studies

are discussed in Chapters 5 and 6. The current chapter is limited to a review of studies based on aggregate data only. This literature grew rapidly before the 1990s, but has largely been eclipsed by studies based on micro-level data since then. In this chapter studies are categorized by geographical area: (1) the United States, (2) other developed countries and (3) developing countries. The rationale for this categorization is that studies from each of these geographic regions have tended to focus on different themes in the tobacco control literature.

The structure of the chapter is as follows. The theoretical framework underlying the demand for tobacco is considered in the first section. The following section provides a short overview of the econometric strategies that have been used to estimate the demand for tobacco using aggregate data. Next the relevant empirical literature is reviewed, focusing especially on price and income elasticities of demand. The chapter then concludes with a consideration of the issue of affordability and how this influences the demand for cigarettes.

Theoretical frameworks for the demand for tobacco

The negative relationship between the price of a product and the quantity demanded is a fundamental concept in economics. This relationship, the law of demand, applies not only for goods and services, but also to factors of production, in both micro and macro contexts. For example, within a microeconomic context, an increase in the price of a product decreases the quantity demanded of that product, if all other factors are held constant. Similarly, within a macroeconomic context, an appreciation of the currency (effectively making imported products more expensive) decreases aggregate imports.

The law of demand is derived from a constrained utility maximizing framework. Given consumers' preferences, which are presented by the utility function, the imposition of a budget constraint allows one to derive the demand function for a product, where the quantity demanded is a negative function of the price of that product. Empirically the interesting aspect is typically not whether the negative relationship between price and quantity demanded exists, but rather how responsive the quantity demanded is to changes in the price. This responsiveness is captured in the price elasticity of demand. The price elasticity of demand, which is a number without units, indicates by what percentage the quantity demanded changes in response to a 1% change in the price.

The relationship between cigarette price and consumption has opened up a lively methodological debate. One major source of contention is the theoretical modelling of addictive products, since the assumptions underlying the models employed have fundamentally different implications for the optimal tax level (Guhl and Hughes, 2006). Modelling tobacco consumption based on economic models of choice has undergone continuous evolution in response to expanding knowledge and insights into addictive behaviour. Initially the demand for tobacco was modelled with a contemporaneous specification. This means that current demand is specified as a function of current prices and current values of all other explanatory variables. Addictive behaviour was initially modelled through backward-looking "myopic" demand models, meaning that previous consumption (or the previous period's prices) influences current consumption. As an improvement on backward-looking demand models, forward-looking rational addiction models arose in the late 1980s. These were subsequently revised, at least on a theoretical level, by models of addictive behaviour that assumed that smokers were subject to time-inconsistent behaviour. This section describes this progression.

Underlying conventional demand models is the assumption that consumers are fully rational and sovereign in their decision-making. As such, they are the best judges of their own behaviour and on what goods and services to spend their money. Within this conventional framework tobacco is considered a good like any other good. A chosen behaviour is *a priori* assumed optimal because a person has rationally chosen it and the government has no reason, in the absence of market failures, to interfere with this revealed preference.

However, if a product is addictive, the assumption of consumer sovereignty applies no more. The addictiveness of the product "forces" a consumer to buy a product that she might not have bought had she not been addicted to it. Some early theorists have postulated that, given the addictive nature of nicotine, it was not conducive to standard economic analysis (Chaloupka, 1991). It also implies that the demand for tobacco products does not respond to changes in the price, and is thus perfectly price-inelastic (U.S. Department of Health and Human Services, 2000). If this view were true, it would imply that increases in the excise tax would be impotent as a measure to reduce tobacco consumption. However, as will be clear from this and other chapters in this book, this view does not have any empirical support.

Before the 1990s, empirical studies that investigated the determinants of demand for tobacco

were, in terms of their theoretical specification, not much different from studies that investigated the demand for other consumer products. Broadly speaking, tobacco consumption was specified as a function of the price of the tobacco product in question, an income variable, the prices of substitutes and complements, an advertising variable, and often some dummy variables aimed at capturing the impact of anti-tobacco measures. In some cases a lagged dependent variable was included in the regression equation to capture "habit persistence." Other than improving the statistical fit of the regression equation, it also allowed one to differentiate between short-run and long-run price elasticities of demand, as will be pointed out in the next section.

Empirical tobacco demand analyses in the past two decades have largely been underpinned by the rational addiction framework formally introduced by Gary Becker and Kevin Murphy in 1988. The model of rational addiction has become the standard approach to modelling the consumption of addictive goods. It has been applied to coffee (Olekalns and Bardsley, 1996), alcohol (Waters and Sloan, 1995; Grossman *et al*., 1998) and tobacco (Chaloupka, 1991; Becker *et al*., 1994). The essence of the rational addiction model is that people with stable preferences may rationally decide to engage in an addictive behaviour since this maximizes their lifetime utility (Becker and Murphy, 1988).

Becker and Murphy distinguish between myopic and rational addiction. A myopically addicted person's current consumption is determined by his/her past consumption. However, such a person does not consider the future in determining current consumption. As such, the future is discounted at an infinitely high rate.

A rationally addicted person's current consumption, on the other hand, is determined not only by past consumption (which in turn is determined by past prices), but also by future prices. For instance, if consumers of addictive goods predict that the price of the product will increase in future, that knowledge will cause his/her consumption in the current period to decrease.

Importantly, the full price of the product includes not only the monetary price of the product, but also the negative health effects and the legal sanctions associated with consumption. For example, the *full* price of drugs includes the fines, prison sentences and increased mortality associated with drug use, over and above the purchase price of the drugs. Similarly, for alcohol, the full price includes the increased risk of accidents, domestic violence and increased morbidity and mortality, while for tobacco, the full price includes social disapproval, increased morbidity and premature death, over and above the prices paid for these products. As an illustration, Becker and Murphy (1988) argue that the US Surgeon General's report published in January 1964 (U.S. Department of Health Education and Welfare, 1964) greatly increased the full price of tobacco smoking. Between 1964 and 1975 per-capita cigarette consumption in the US decreased by 34%. Becker and Murphy argue that this large decrease in consumption is consistent with rational (i.e. forward-looking) behaviour, and inconsistent with myopic behaviour. If smokers were myopic they would not respond to information about future consequences of their activities.

The rational addiction framework provides a theoretical model to describe three important concepts in the addiction literature, namely tolerance, reinforcement and withdrawal (Chaloupka, 1991). Tolerance implies that a given quantity of current consumption yields less additional satisfaction as the cumulative past consumption of the product increases. This implies that, to obtain the same amount of additional satisfaction, consumers would have to consume increasingly larger quantities of the product. Reinforcement means that current consumption of the product increases future consumption, and that past consumption increases current consumption. Stated differently, the more one consumes, the more one wants to consume. Withdrawal means that the smoker's total utility/satisfaction falls if cigarette consumption is reduced.

Furthermore, Becker and Murphy (1988) show that the rational addiction model can explain the observation that heavily addicted smokers often quit their consumption abruptly, i.e. "cold turkey." The explanation lies in the fact that if the addiction is strong, reinforcement in consumption is larger than had the addiction been weak. As the level of reinforcement increases, so does the degree of (adjacent) complementarity between current and future consumption. A person who wishes to reduce consumption slowly would be incurring a loss of utility over a long time period. On the other hand, by quitting abruptly, the consumer incurs a large immediate loss of utility, but this utility loss is smaller than the utility losses that would have been incurred had the quitting period been extended over a period of time.

Becker and Murphy (1988) point out some important interactions between time preference and addiction. First, people who discount the future more heavily are more likely to become addicted. Second, addicts with higher discount rates

will be relatively more responsive to changes in the price than those with lower discount rates. They tend to be more affected by short-term shocks, e.g. current cigarette price increases, than by long-term implications of smoking, e.g. detrimental health consequences in middle and old age. These two theoretical results explain why young and poor people are more likely to initiate smoking than older and richer people and typically have higher price elasticities of demand, as indicated in Chapters 6 and 7. Third, the long-run price elasticity of demand will be greater, in absolute terms, than the short-run price elasticity. Fourthly, the impact of an expected change in the price of the addictive good will be greater than the impact of an unanticipated price change.

The Becker-Murphy model has been empirically tested in a variety of contexts, using both aggregate data and cross-sectional data, and generally the studies find support for the hypothesis of rational addiction. These studies are discussed in later in this chapter and in Chapter 5. While studies differ in the econometric detail, the contribution of the Becker-Murphy approach lies in the fact that forward-looking behaviour is explicitly modelled into the demand equations.

However, the rational addiction framework has been severely criticized from some quarters. For many addiction researchers the concept of *rational* addiction is oxymoronic. Why would a person pursue an activity that he/she becomes addicted to? Becker and Murphy answer this question as follows. First, the model applies to a large range of human activities and endeavours. People become addicted to different things, some of which are not necessarily bad. For instance, Becker and Murphy point out that people can be addicted to "good" things like work, music, television, religion, other people, etc. Second, the model assumes that people recognize the addictive nature of the products they choose to consume, but they may still make them because the gains of consuming the product exceed the cost of future addiction. The model does not suggest that if an addict is rational, he/she is "happy." In fact, in real life addicts are often unhappy and depressed. Sometimes the addiction results from anxiety-raising and depressing events like death or divorce, which lowers their utility. Becker and Murphy (1988) argue that their model recognizes that people become addicted precisely because they are unhappy. However, they would be even unhappier if they were prevented from consuming the addictive goods.

The most criticized aspect of the rational addiction model is the assumption of perfect foresight (Chaloupka and Warner, 1999). The model assumes that people rationally decide that they will maximize their discounted lifetime utility by consuming an addictive product. According to Akerlof (Chaloupka *et al*., 2000a), the rational addiction model does not allow the possibility that people regret that they ever started smoking, given that they are assumed to be fully aware of the consequences of their consumption of a potentially addictive good when making these decisions. This is unrealistic, because surveys have shown that most smokers indicate that they want to quit and regret that they started smoking (Gruber and Köszegi, 2001). Similarly, numerous studies find that individuals do not have sufficient knowledge on which to base their consumption decisions (Guhl and Hughes, 2006). Chaloupka and Warner (1999), for example, observe that adolescents often underestimate the addictive nature of smoking.

Auld and Grootendorst (2002) attack the rational addiction model on a different level. While the rational addiction model has been successfully applied to several obviously addictive products (Grossman *et al*., 1998; Auld and Grootendorst, 2002), presumably the strength of the theory should lie in the fact that it would find that people are not addicted to things that clearly are not addictive. Auld and Grootendorst (2002) found that the standard methodology is generally biased in the direction of rational addiction. Using aggregate time series data, they found that milk, eggs and oranges were rationally addictive, and, specifically, that milk was more addictive than cigarettes. This result implied that the estimable rational addiction model tends to yield spurious evidence in favour of the rational addiction hypothesis when aggregate data are used.

The rational addiction framework assumes that consumers discount the future at an exponentially declining discount factor $d(t) = \delta t$, where $0 < \delta < 1$. The discount factor δ is often expressed as $1/(1+r)$, where r is a discount rate. Exponential discounting implies that consumers are time-consistent, i.e. have stable preferences. Any discounting is premised on the idea that people are impatient; they place a higher value on a unit of consumption today and demand compensation to defer consumption until tomorrow. In 2001 Gruber and Kozsegi added to both the theoretical and empirical debate by arguing that consumer preferences may not be stable over time. Preferences are time-inconsistent if a person, when asked on different occasions, displays different relative preferences. Camerer and Loewenstein (2002) explain hyperbolic discount

preferences, one mathematical form of time-inconsistent discounting, as follows:

> "Hyperbolic time discounting implies that people will make relatively far-sighted decisions when planning in advance—when all costs and benefits will occur in the future—but will make relatively short-sighted decisions when some costs or benefits are immediate. The systematic changes in decisions produced by hyperbolic time discounting create a time-inconsistency in intertemporal choice not present in the exponential model. An agent who discounts utilities exponentially would, if faced with the same choice and the same information, make the same decision prospectively as he would when the time for a decision actually arrives. In contrast, somebody with time-inconsistent hyperbolic discounting will wish prospectively that in the future he will take far-sighted actions; but when the future arrives he will behave against his earlier wishes, pursuing immediate gratification rather than long-run well-being."

If a person discounts the future at a hyperbolic rather than an exponential rate, time-inconsistent preferences are a likely outcome. Results from laboratory experiments and psychological research suggest that consumers are time-inconsistent and exhibit self-control problems (Gruber and Köszegi, 2002). Self-control problems are introduced into economic models through the idea of a competing internal self, where an individual's preferences change at different times with a view to improving the current self's welfare, sometimes at the expense of the future self's (O'Donoghue and Rabin, 2003). Most people exhibit present-biased preferences; they have a tendency to pursue immediate gratification in a way that they themselves may disapprove of in the long run. For instance, a smoker might indicate that he wishes to quit, but only in a year's time. In this scenario the future self makes the decision. However, if one were to ask him in a year's time whether he has quit smoking, the typical answer would be "no." Despite the commitment of a year earlier, the current self dominates the decision. The large time delay between exposure and disease makes smokers particularly prone to this phenomenon, since the health consequences of their current actions are only realized at a future date (Jha *et al*., 2000). This type of time-inconsistency, which describes smoking as an outcome of "multiple selves", strongly accords with common sense and conventional wisdom (O'Donoghue and Rabin, 2003). Many smokers want to quit smoking, but the immediate gratification from nicotine dominates the desire to quit. In this framework, cigarette consumption is more appropriately modelled based on the assumption that consumers are time-inconsistent. The existence of an "internality," arising from the psychological phenomenon of hyperbolic discounting and unstable preferences, supports an argument for a cigarette tax, not only on externality grounds, but on the grounds that smoking creates "internal" costs that markets fail to correct.

If consumers exhibit present-biased preferences (i.e. the time-inconsistent model), the assumptions of rational and time-consistent behaviour (i.e. the rational addiction model) may be seriously flawed. More importantly, the optimal tax rate prescribed by each model will differ significantly. Under the rational addiction hypothesis, tobacco consumption decisions are governed by the same rational decision-making process as any other good (Gruber and Mullainathan, 2002). Under this paradigm the optimal role for government is to correct for the "external costs" of smoking. Addiction *per se* does not constitute market failure, and the costs smokers impose on themselves are irrelevant for taxation unless they are rooted in misperceptions about the harmfulness of smoking (Guhl and Hughes, 2006). In comparison, the policy conclusion from the time-inconsistency approach is that "internality costs" should be accounted for in the same way as externality costs when setting government policy. Taxation may thus be theoretically justified even where no externalities are present (Gruber and Köszegi, 2001). As a result, time-inconsistency models generally prescribe an optimal tax level which is higher than that of the rational addiction model, since the internal costs often dwarf the external costs (Gruber and Köszegi, 2002).

The empirical strategy

Over the past decades there have been vast improvements in the techniques that are available for time series econometricians. Time series data are data that are published at regular intervals and that refer to well-defined time periods, e.g. years, quarters or months. Most of the studies discussed in this chapter consider the time series data for a particular country, and thus derive appropriate coefficients for that country. However, in a limited number of cases researchers have used a pooled set of time-series data. A pooled (or in some cases a panel) data set consists of the time series data of several countries (or regions).

Pooling data results in many more observations and more often yields statistically meaningful results. Early econometric studies that investigated the demand for tobacco and other commodities would be regarded as quite out-of-date by many applied time series econometricians today. However, since these studies were important then, and since many recent studies have not employed the most up-to-date techniques, it is worthwhile to discuss the methodology of such studies.

The typical starting point for estimating the price and income elasticities of demand is to specify a demand equation. According to standard demand theory, the quantity demanded of a product is a function of the price of the product, an income variable, the prices of substitutes and/or complements, advertising, and possibly some product specific factors. Within the context of tobacco demand studies, price and income are the most important and most commonly used variables. Earlier studies[1] often included an advertising variable in the regression equation (either advertising expenditure, some measure of the stock of advertising or some rudimentary count of the levels of advertising). Relatively few studies included the price of complementary and substitute goods in the regression equation. A notable exception is the seminal study by Chapman and Richardson (1990), who included the price of substitutes in their demand equations (leaf tobacco prices in the demand for cigarettes and cigarette prices in the demand for leaf tobacco). Similarly, Hsieh *et al.* (1999) included imported cigarette prices in the demand for local cigarettes and local cigarette prices in the demand for imported cigarettes.

The mathematical form of the regression equation is important. Many studies use a log-log specification, primarily because this results in a constant and easily derived elasticity estimate. The price elasticity is simply the coefficient on the (logged) price variable, and similarly the income elasticity can be read off as the coefficient on the (logged) income variable. It is important to note that this specification *assumes* a constant elasticity, over time or at different points on the demand curve. Of course such a specification would not allow one to determine whether there are changes in the price elasticity over time, whether the elasticity differs for various price levels, or whether the elasticity differs for different magnitudes of price changes.

Another standard mathematical form is a linear specification. The coefficients cannot be interpreted as elasticities, but with minor effort elasticity estimates can be calculated. Usually the elasticity is calculated at the mean quantity and price (or income, if one wishes to estimate the income elasticity).[2] The added advantage of the linear specification is that is allows one to estimate the elasticity at any point in time (Bardsley and Olekalns, 1999; Van Walbeek, 2002).

In some studies the addictiveness of tobacco was modelled by including a lagged dependent variable in the regression equation. This is a standard econometric technique, based on the concept of "habit persistence" (Gujarati, 2003). If the product is addictive, it is intuitively obvious that past consumption determines current consumption. An econometric specification that includes a lagged dependent variable has the property that one can differentiate between short-run and long-run price elasticity. If ε_P is the short-run price elasticity and α is the coefficient on the lagged dependent variable ($0 < \alpha < 1$), then the long-run price elasticity is equal to $\varepsilon_P/(1-\alpha)$. The long-run elasticity is always greater (in absolute terms) than the short-run elasticity, suggesting that a current change in the price will have a greater impact on consumption in the long run than in the short run.

To test the rational addiction hypothesis, the focus is on future price or future consumption, explaining current consumption. Becker *et al.* (1994) tested their theoretical model using US state-level time series data. The forward-looking nature of the model made them include next-period consumption (i.e. C_t+_1) into the demand equation. If α_1 is the coefficient on C_t-_1 and α_2 is the coefficient on C_t+_1, then rational addiction would imply that α_2 is statistically significant. If only α_1 is significant, this would suggest that smokers are myopically addicted. Also, within this framework, the short-run elasticity is derived from the coefficient on P_t, while the long-run elasticity is equal to $\varepsilon_P/(1-\alpha_1-\alpha_2)$. If smokers are rationally addicted, one would find that the long-run price elasticity is greater than if smokers are myopically addicted.

In the econometric literature the potential problem of identification (i.e. distinguishing between supply and demand) has been an important issue. The price-quantity combination at any moment in time is an equilibrium point,

[1] Hamilton (1972), McGuinness and Cowling (1975), Fujii (1980), Witt and Pass (1981), Bishop and Yoo (1985), Leeflang and Reuijl (1985), Radfar (1985), Abernethy and Teel (1986), Baltagi and Levin (1986), Chetwynd *et al.* (1988), Kao and Tremblay (1988), Duffy (1991), Seldon and Boyd (1991), Tegene (1991), Wilcox and Vacker (1992), Valdés (1993), Duffy (1995), Tremblay and Tremblay (1995), and Cameron (1997).

[2] See Warner (1977), Warner (1981), Leeflang and Reuijl (1985), Warner (1989), Flewelling *et al.* (1992), Becker *et al.* (1994), Wilcox *et al.* (1994), Tremblay and Tremblay (1995), Van Walbeek (1996), Bardsley and Olekalns (1999) and Bask and Melkersson (2004) for examples of elasticities at the mean.

i.e. the intersection of the supply and the demand curve. Any change in the equilibrium position from one period to another is the result of a change in the demand or the supply curve, or both. To identify the demand curve a systems approach is recommended. If the system meets certain criteria, one can specify both the supply and the demand curves. Very few studies follow this approach, with notable exceptions being Bishop and Yoo (1985) and Tremblay and Tremblay (1995). Bishop and Yoo (1985) point out that a single equation demand model can provide consistent estimates if the supply curve is either perfectly elastic or perfectly inelastic. An assumption of a perfectly inelastic supply curve, given the storability of tobacco, is unrealistic. On the assumption that the supply curve is perfectly elastic, changes in the price will trace out a demand curve. Most studies assume that the demand curve is stable in price-quantity space and that movements in the curve are a result of changes in the other demand determinants. In the absence of data on costs and other supply determinants, and given that tobacco companies often have significant market power (which results in them not having identifiable supply curves), it is little wonder that so few studies attempt to estimate supply equations.

The dependent variable is almost always the quantity of cigarettes consumed, although some variations have been used. The quantity consumed is typically calculated in one of two ways. The first method is to obtain, or derive, the quantity consumed from the fiscal authorities. By dividing the total excise tax revenue by the average excise tax amount per cigarette, one can calculate the quantity of cigarettes consumed. This considers the consumption of legal cigarettes only; counterfeit and smuggled cigarettes are not considered. If the proportion of smuggled cigarettes remains constant over time, then the price elasticity estimates and other coefficients will not be affected. However, if the proportion of smuggled cigarettes increases in response to an increase in price, the legal sales of cigarettes will understate true cigarette consumption. To the extent that this may occur, the price elasticity estimate (in absolute terms) will be biased upwards. The second approach calculates cigarette consumption as cigarette production, plus imports, less exports. The method of data collection could also lead to biases. Local production may be underreported (because of illicit manufacturing, for example) or imports may be underreported (through large-scale or small-scale smuggling). If such underreporting were to increase in sympathy with increases in the real price of cigarettes, the absolute value of the price elasticity estimates would be biased upwards. Essentially, consumption cannot be directly observed, and what is termed as consumption is proxied by a measure that represents tax paid production or shipments. Furthermore, timing issues may affect the composition of the series since retailers or consumers might increase purchases in response to an anticipated price increase, thereby artificially increasing consumption now and reducing consumption in some future period. This becomes more of an issue in higher-frequency data.

Cigarette prices and income enter the models as independent variables and are presented in real terms by dividing the nominal variable (or index) by an appropriate deflator (usually the consumer price index). The conversion of nominal price and nominal income to real price and real income is critical, since the prices of almost all goods (both substitutes and complements) rise over time. The absolute change in nominal cigarette prices is not important; what is important is by how much cigarette prices change relative to the changes in the prices of all other goods. Models using only nominal values are also likely to provide spurious results, since all both price and income are likely to trend upward over time. Real income can be presented in aggregate or per-capita terms. Some studies regress aggregate consumption on aggregate income and the real price while other studies regress per capita consumption on per-capita income and a price variable (examples). Most studies use the adult population (aged 15 or 16 and older) as the appropriate population measure with which they obtain per-capita values, although this is not a strict rule.

Other variables that have been included in demand equations revolve around policy interventions (e.g. advertising restrictions, counter advertising, smoke free policies, age restrictions, etc). The most common way to account for policy interventions is by means of dummy variables. For example, the counter-advertising that was legislated through the Fairness Doctrine in the USA in the late 1960s and early 1970s is typically captured by a variable that had a value of one in the period 1968 to 1970, and zeroes in all other years (Hamilton, 1972; Kao & Tremblay, 1988).

The most tested interventions are advertising bans and restrictions. Initially the approach was to investigate the relationship between cigarette consumption and advertising expenditure (or other measures of advertising including stocks and counts), controlling for other demand determinants (Hamilton, 1972; Fujii, 1980; Bishop

& Yoo, 1985; Abernethy & Teel, 1986; Holak & Reddy, 1986; Kao & Tremblay, 1988; Wilcox & Vacker, 1992). The argument was that if a positive relationship between these two variables was found, a reduction in advertising expenditure would result in a reduction in tobacco consumption. This would be the empirical foundation for a ban on tobacco advertising. No consistently strong relationships were found. However, this finding was subsequently rationalised on the grounds that, since tobacco products were among the most advertised products in the world, and advertising expenditure is probably subject to decreasing returns, moderate changes in the advertising expenditure are unlikely to be picked up in substantial changes in cigarette consumption (Saffer and Chaloupka, 2000). Subsequent studies have tested the impact of advertising *bans*, rather than advertising *expenditure*, on consumption and have found that bans have typically resulted in significant declines in consumption (see the last section of this chapter for a more comprehensive discussion of this literature).

Since the early 1990s there have been significant advances in time series econometrics. This has been primarily in reaction to the long-known but largely suppressed fact that regression on non-stationary variables can easily result in statistically significant but economically meaningless relationships. Most economic variables are non-stationary, meaning that they tend to be subject to long-run upward or downward trends. To prevent such spurious relationships, cointegration techniques were developed. The technical details of cointegration are available in any standard econometric textbook (for example, Hamilton, 1994, Pindyck and Rubinfeld 1998, Enders, 2004). The first studies that used cointegration techniques used the Engle-Granger two-step procedure. Subsequently the Johansen procedure was developed, which is theoretically less restrictive than the Engle-Granger approach. In similar vein, econometric techniques that placed fewer restrictions on the data, like vector autoregression, were developed.

The uptake of the more advanced econometric techniques has been relatively slow in tobacco demand studies based on aggregate data. The primary reason seems to be a lack of data. Time series data are typically of annual, quarterly or monthly frequency, and even when the series are relatively long, the data demands of the new techniques are often such that the modern techniques are not applied. In developing countries this problem is more acute than in developed countries. In many instances the data are available only at an annual frequency, and consists of no more than 20 or 30 observations. The quality and accuracy of data in developing countries are likely to be inferior to that in developed countries. In cases where the data are limited or of dubious quality, state-of-the-art techniques will not always be possible. However, data limitations should not provide a licence for researchers to ignore modern developments in econometrics. At the very minimum, one should test for the time series properties of the data, and possibly perform the regression in first differences. The review of the literature suggests that many studies in the past two decades do not employ these econometric developments.

The proportion of tobacco demand studies that use aggregate data has been declining relative to studies that use microeconomic or household cross sectional data. Studies that use household data are discussed and reviewed in Chapters 5 and 6. Studies based on aggregate data have some significant drawbacks. The first is the relative paucity of data. Data sets in excess of 50 time series observations are scarce (Prest, 1949; Tegene, 1991, being important exceptions). In contrast, the number of observations in household surveys is limited only by the budget of the survey. Second, the questions one can answer with aggregate data are limited. One can estimate price and income elasticities, but one cannot, for example, estimate the impact of price or income changes on the consumption of different groups (by gender, race, income, education, etc.), or determine changes in smoking prevalence or smoking intensity. Household data sets are much richer than aggregate data sets, and are better suited to answering such questions. Third, data limitations may result in biased parameter estimates. A high degree of multicollinearity between the independent variables, a very common problem in time series data, results in large standard errors on the estimated coefficients. Regressions may also suffer from omitted variable bias. Some variables might be omitted because the data do not exist or because the inclusion of the data worsens the multicollinearity problem to the extent that the researchers decide to exclude variables that they regard as important. Similarly, autocorrelation in the residuals, a very common problem in time series data, results in inefficient coefficients. Having said this, studies based on household data are subject to similar and other estimation and data problems.

A more recent development has been the estimation of cross-

country (or, in the USA, cross-state) panel models, which are essentially cross sectional models based on the aggregated data of a country (or state). The first study in this genre was by Baltagi and Levin (1986), who exploited the fact that different US states had different excise tax regimes, and they could thus estimate price elasticity of demand, making appropriate adjustments for small-scale smuggling from low-tax to high-tax states. Models that are based on country data provide global estimates of price and income elasticities; in most cases these models control for price and income effects when testing the effectiveness of advertising bans and restrictions on a global level. Earlier models were elementary and did not use fixed effects to control for cross-country differences nor the addictive nature of cigarettes (Laugesen and Meads 1991; Stewart 1993). More recent additions to the literature have made significant improvements in methodology and estimation techniques. Saffer and Chaloupka (2000) applied country-specific fixed effects. Nelson (2003) tested the endogeneity of advertising bans, and Blecher (2008) extended the sample of countries to include a large number of developing countries.

Empirical literature

A survey of tobacco demand studies reveals that the focus of attention has changed several times in the past 60 years. In fact, several "waves" of empirical studies into the demand for tobacco can be identified.

In what could be termed the first wave, a small number of studies investigated the demand for tobacco in the 1940s to 1960s (Stone, 1945; Prest, 1949; Koutsoyiannis, 1963). These studies were part of a growing literature that aimed to investigate the demand for household goods. Price and income elasticities were estimated, but the public health implications of these estimates were not discussed, presumably because the health impact of smoking was not well publicized at that time.

The focus of tobacco-related empirical research changed significantly in the early 1970s. During the 1970s–1990s, which could be called a second wave, researchers began to draw policy conclusions from their results. The focus in this period shifted away from the estimation of price and income elasticities to the impact of advertising and health awareness on the demand for tobacco products. In estimating the impact of advertising and health awareness on cigarette demand, price and income were included as control variables in the regression equation, but these were often not the focus of the investigation. During this period the lines between "pro-industry" research and "pro-tobacco control" research were drawn, and the debate between these two camps was vigorous and often acrimonious.

The first two waves focused exclusively on developed countries, and the empirical results were based on time series data. The third wave had its origins in 1990, when price elasticity estimates were published for Papua New Guinea, the first developing country studied (Chapman and Richardson, 1990). During the 1990s the focus gradually shifted towards developing countries. This shift in research focus was in reaction to the large increase in smoking in the developing world, and the likely impact that this would have on mortality patterns in the 21st century (Jha and Chaloupka, 1999). The focus in most of the developing country studies was on the price elasticity of demand.

United States of America

In terms of methodological complexity, the USA-based studies are generally the most advanced, and have addressed issues that have not been addressed by researchers in other countries. Researchers in the US have several significant advantages over their colleagues in other countries. First, tobacco control is high on the authorities' agendas[3] and attracts large financial resources from government and private institutions. Consider the following examples. In 2000 the 11th World Conference on Tobacco or Health, held in Chicago, received a US$10 million sponsorship from two US health societies and a private foundation. This is more than ten times any previous World Conference.[4] In 2002 the Fogarty International Centre made US$18 million available for tobacco control research around the world. One of the requirements was that the research teams in other countries be linked to established research bodies in the US. Subsequently much larger amounts have been made available by US aid agencies, primarily for tobacco-related research in low-and middle-income countries. These studies are often anchored by US researchers. More than 40 working papers have been published by the prestigious National Bureau for Economic Research (NBER) on matters relating to the economics of tobacco control. There is a pool of researchers who specialize in

[3] This is generally true for most states and particularly true for states like California and New York State. However, the tobacco-growing states like Kentucky and the Carolinas do not have a strong tobacco control focus.

[4] The World Conference on Tobacco or Health is held every three years and is the premier meeting of tobacco control experts, researchers and lobbyists.

the economics of tobacco control research, unmatched in any other country. As an illustration, of the 39 authors that contributed to Tobacco Control in Developing Countries (Jha and Chaloupka, 2000), arguably the most comprehensive book on the economics of tobacco control to date, 19 were from academic and/or governmental institutions in the USA, while another eight were from the World Bank, World Health Organization or the International Monetary Fund. Of the remaining 12 authors, ten were from developed countries (especially the United Kingdom and Australia), and two were from developing countries.

Second, the existence of more than 50 states and territories, each with separate legislative, excise tax and retail pricing systems, often creates a research design environment that allows researchers to test phenomena that would have been virtually impossible to test otherwise. For example, changes in state-specific excise taxes were used to obtain quasi-experimental price elasticities of demand (Baltagi and Goel, 1987). Also, studies that employ individual-level data to determine price elasticities of demand for specific demographic groups can take advantage of the fact that there is a large degree of variation in individual states' tobacco excise tax regimes and other tobacco control interventions.[5]

Third, there are some very large survey data sets that specifically investigate smoking behaviour, especially among the young. Because these surveys are often repeated year after year, changes in smoking behaviour over time can be monitored. For example, several waves of the Monitoring the Future Surveys have been used to estimate the price elasticity of demand for cigarettes among secondary school pupils, and various demographic groups within this sample (e.g. Chaloupka and Grossman, 1996; Chaloupka and Pacula, 1998). These studies are discussed in detail in Chapters 5 and 6.

As indicated in the discussion of econometric strategies, the demand for cigarettes is typically specified as a function of price, income and some tobacco control interventions. For most US studies, the prime focus of the study is on the impact of cigarette prices on quantity consumed. However, some studies focused primarily on the effect of a non-price determinant of the demand for cigarettes (such as advertising, health publicity or other tobacco control interventions), and in such cases the price would enter the regression equation as a control variable. Table 4.1 is a comprehensive chronological summary of studies of cigarette demand in the US using aggregate data studies. The studies differed in many respects, including: (1) the frequency of data,[6] (2) the use of econometric or non-econometric estimation techniques,[7] (3) the use of single equation versus multiple equation regression techniques, and (4) the use of national or state-specific data.[8]

While the techniques for estimating the demand equations are similar enough to not list all the US studies in this chapter, some seminal articles, as well as those that are in some way unique, are briefly discussed here.

Warner (1977) estimated the impact of various health scares and other high-profile anti-smoking publicity campaigns on the demand for cigarettes. In his study he did not estimate the price elasticity of demand, but included the impact of price into the regression model by *assuming* that the demand curve was linear in price-quantity space and that the price elasticity of demand was the mean price and quantity for the period (1947–70) being studied. Imposing a price elasticity onto the regression equation, rather than allowing the data to estimate the price elasticity, was rationalised on the grounds that including price in the regression equation would result in unacceptable levels of multicollinearity. Based on this analysis, Warner concluded that the various anti-smoking campaigns resulted in a significant decrease in smoking. In fact, he suggests that per capita consumption of cigarettes would have been 20–30% higher in 1975 had it not been for the success of the anti-smoking campaign. What is interesting about this study is that changes in the excise tax on cigarettes were not presented as a particularly effective tobacco control instrument. The focus was on anti-tobacco publicity, and excise-induced changes in the retail price appear to have entered the analysis as somewhat of an afterthought.

[5] For example, see Chaloupka and Wechsler (1997), Chaloupka and Pacula (1998), Tauras and Chaloupka (1999), and Tauras *et al.*, (2001). These studies are dealt with separately in Chapters 5 and 6.

[6] Most studies made use of annual data. Flewelling *et al.* (1992), Wilcox and Vacker (1992), Duffy (1995) and Hu *et al.* (1995a) use quarterly data, while Keeler *et al.* (1993), Hu *et al.* (1994 and 1995b) and Gruber and Kőszegi (2001) use monthly data.

[7] Studies that have estimated price elasticities without using econometric techniques include Baltagi and Goel (1987) and Peterson *et al.* (1992). In these studies the researchers assessed the magnitude of changes in cigarette consumption following state-specific cigarette tax increases.

[8] Of all US states, California (closely followed by New York) has the most stringent tobacco control legislation. Published studies that have investigated the impact of tobacco control interventions on the demand for cigarettes in California include Flewelling *et al.* (1992), and Hu et al. (1994 and 1995b). Most US studies that investigate the demand for cigarettes focus on the country as a whole. Some studies take cognizance of differences in taxes between states and try to account for the small- and large-scale smuggling between low-tax and high-tax states (Baltagi and Levin, 1986, Baltagi and Goel, 1987 and Thursby and Thursby, 2000).

Table 4.1. Studies employing aggregate data in the United States

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Hamilton (1972)	United States	-0.51	0.73	Advertising expenditures (positive although insignificant), health scares (negative and generally significant)	Myopic addiction log linear and linear OLS	Annual time series data from 1926 to 1970	
Warner (1977)	United States	-0.5	Not included	Time trend, health, dummies for health scares, Surgeon General's report and Fairness Doctrine	Myopic addiction	Annual time series data from 1947 to 1970	
Fujii (1980)	United States	**Short-run** *Log linear* -0.63 *Linear* -0.48 **Long-run** *Log linear* -0.92 *Linear* -0.71	**Short-run** *Log linear* 0.33 *Linear* 0.27 **Long-run** *Log linear* 0.50 *Linear* 0.33	Advertising expenditure (positive although not generally significant), time period dummies (negative but generally insignificant)	Log linear and linear myopic addiction OLS	Annual time series data from 1929 to 1973	
Warner (1981)	United States	-0.37	Positive and significant	Many dummies for various health scares and interventions, state law population measure	Static myopic addiction model OLS	Annual time series data from 1947 to 1978	
Bishop and Yoo (1985)	United States	Preferred value = -0.45; other specifications yield elasticities between -0.41 and -0.64	Preferred value = 0.92; other specifications yield elasticities from 0.86 to 1.10	Advertising expenditure, health scare dummy variable	Static system approach (equations for both supply and demand equations) using 2SLS and 3SLS	Annual time series data from 1954 to 1980	
Abernethy and Teel (1986)	United States	Negative and significant (unable to calculate elasticity since model is linear)	Not included in model	Print advertising (generally positive and significant), broadcast advertising (generally positive although insignificant), package warnings (negative although generally insignificant), broadcast counter advertising (negative	Linear OLS and log dependent variable OLS, myopic addiction	Annual time series data from 1949 to 1981	

Table 4.1. Studies employing aggregate data in the United States

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Abernethy and Teel (1986) (contd)				and significant), print advertising warning (negative although insignificant), broadcast advertising ban (insignificant)			
Baltagi and Levin (1986)	46 US States	**Short-run** -0.22 to -0.23	Insignificant	Price in neighbouring states (positive), advertising (positive although insignificant), Fairness Doctrine dummy (negative although generally insignificant)	Log linear myopic addiction OLS within, Hausman-Talyor, Zellner-Geisel Search Procedure	Pooled annual data from 1963 to 1980	Uses the price of cigarettes in neighbouring states to control for smuggling; finds that there may be spill over effects to neighbouring states where smuggling may be significant
Holak and Reddy (1986)	United States	**Wide variation and significance** *Before advertising ban* 0.07 to 0.50 (yes, positive) *After advertising ban* 0.70 (yes, positive) to -0.84	Income not controlled for	None	Log linear myopic addiction model (Maximum likelihood)	Annual time series 1950 to 1979	Industry and brand-level regressions
Baltagi and Goel (1987)	United States	-0.17 to -0.56 Downward trend in elasticities over time and an upward biased in states where small-scale smuggling exists	Not controlled for	Small-scale smuggling	Non-econometric quasi experimental computational approach	Annual time series data from 1956 to 1983	Attempts to understand how elasticities change over time and how small-scale smuggling impacts on elasticities
Kao and Tremblay (1988)	United States	**Static** -0.50 to -0.66 **Dynamic** *Short-run* -0.50 to -1.02 *Long-run* -0.44 to -1.77	**Static** 0.77 to 1.30 **Myopic** *Short-run* 0.74 to 1.48 *Long-run* 0.59 to 3.03	Advertising expenditure (positive), dummies for the 1964 health scare (negative), 1968 Fairness Doctrine (insignificant), 1971 broadcast ban (insignificant)	Log linear myopic addiction with an IV technique	Annual time series data from 1953 to 1980	Improving Bishop and Yoo
Seldon and Doroodian (1989)	United States	**Short-run** -0.4	**Short-run** 0.27	Health scare (negative), media policy (negative although	Non-linear myopic addiction 3SLS simultaneous demand system	Annual time series data from 1952 to 1984	

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Seldon and Doroodian (1989) (contd)				insignificant), advertising increase competition			
Warner (1989)	United States	-0.2	Significant and positive	Dummies for interventions	Linear myopic addiction OLS	Annual time series data from 1947 to 1987	
Seldon and Boyd (1991)	United States	**Short-run** -0.22 to -0.26. Long-run not significantly different from short-run	**Short-run** 0.14 to 0.25. Long-run not significantly different from short-run	Advertising (positive), policy dummies in 1964, 1968, 1971, 1979 (Negative)	Myopic addiction Maximum Likelihood	Annual time series data from 1953 to 1984	Uses a Cooley-Prescott model, interested in the instability of demand due to continuous government intervention
Tegene (1991)	United States	-0.29	0.53	Advertising	Log linear myopic addiction model with Kalman filter	Annual time series data from 1929 to 1986	Elasticities are found to decline over time
Flewelling *et al.* (1992)	California, United States	-0.25 to -0.35	Income not included	Seasonal and trend dummies and dummies to control for consumption spikes related to previous tax increases	Linear static OLS (including ridge regression)	Quarterly time series data from 1980 to 1990	
Peterson *et al.* (1992)	United States	Not a demand model. Tax increases were associated with a decline in consumption. Larger the increase, the larger the decline	Not in model	None	Analytical model	Annual time series data from 1955 to 1988	
Wilcox and Vacker (1992)	United States	Positive and insignificant	Positive and insignificant (nominal income)	Advertising, seasonality population, inflation, warnings and policies. Only price and income in final model	Linear stepwise regression	Quarterly time series data from 1961 to 1990	Nominal prices rather than real prices are used
Keeler *et al.* (1993)	California, United States	**Short-run** -0.3 to -0.5 **Long-run** -0.5 to -0.6	Insignificant	Regulation (negative), Arizona and Oregon tax increase dummies (positive)	Non-linear myopic, rational and constrained rational addiction models	Monthly time series data from 1980 to 1990	
Becker *et al.* (1994)	50+1 US States	**Short-run** -0.36 to -0.48 **Long-run** -0.73 to -0.85 (unable to estimate myopic addiction elasticities since the	Generally positive and significant (unable to estimate elasticies since the models were linear and the income elasticities were not	Index of incentive to smuggle, index of incentive for short distance export smuggling, index of incentive for short distance export	Linear myopic and rational addiction models, 2SLS and OLS with group and year fixed effects	Pooled annual data from 1955 to 1985	

Table 4.1. Studies employing aggregate data in the United States

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Becker *et al.* (1994) (contd)		models were linear)	specifically reported)	smuggling; all three generally negative and significant			
Hu *et al.* (1994)	California, United States	No elasticity estimated, examining the direct impact of a tax change instead	Not included in model	Time trend	Analytical time series model	Monthly time series data from January 1984 to December 1991	
Sung *et al.* (1994)	11 Western US states	**Short-run** -0.40 **Long-run** -0.48	Positive	Many demographic variables, regulation (negative), small-scale smuggling (positive)	Rational addiction panel linear	Pooled annual data from 1967 to 1990	
Thursby and Thursby (1994)	39 US states	-0.26	0.11	Canada-bordering states (negative although insignificant), Indian reservations (positive), military (negative although not significant), tax differentials (negative although not significant), membership of anti-smuggling organisations (positive), felony (negative), discount rate paid to wholesalers (negative), time dummies (negative)	Log linear static and myopic addiction models	Pooled annual data from 1972 to 1990	Model attempts to estimate the extent of smuggling
Hu *et al.* (1995a)	California, United States	No elasticity estimated, examing the direct impact of a tax change instead	Not included in model	Quarterly dummies, tax, media	Analytical time series model	Quarterly time series data from 1980 to 1993	
Tremblay and Tremblay (1995)	United States	-0.41 to -0.43	Positive and significant	Advertising expenditure, dummies for Surgeon General's report, Fairness Doctrine, time trend	Linear static 2SLS W2SLS	Annual time series data from 1955 to 1990	Includes supply side in the equation

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Keeler *et al.* (1996)	United States	Not a demand study. Shows that price competition can reduce impact of regulation. A 1 cent state tax increase increases prices by 1.11 cents	N/a	N/a	Analytical model	Pooled annual data from 1960 to 1990	
Baltagi *et al.* (2000)	46 US States	**Traditional models (OLS, GLS, etc)** *Short-run* -0.09 to -0.30 *Long-run* -1.79 to -2.98 **Instrumental models** *Short-run* -0.21 to -0.50 *Long-run* -0.68 to -1.37	**Traditional models (OLS, GLS, etc)** *Short-run* -0.03 to 0.10 *Long-run* -1.00 to 0.60 **Instrumental models** *Short-run* -0.02 to 0.19 *Long-run* -0.11 to 0.51	State-specific demographic variables including religion, education and race. Price in neighbouring states (substitutes)	Various dynamic panel estimators including OLS and GLS (with various effects), and 2SLS, EC2SLS and FD2SLS for dynamic.	Pooled annual data from 1963 to 1992	Tests whether homogenous estimators preferred to heterogeneous estimators
Gruber and Köszegi (2001)	United States	*Short-run* [-0.43 to -0.48]	Not reported	Unknown	Linear rational addiction model with group and year fixed effects	Annual time series data from 1973 to 1996	Values in [ ] calculated by the Working Group
Huang *et al.* (2004)	42 states and Washington DC, USA	*Short-run* -0.21 *Long-run* [-1.88] **Instrumental** *Short-run* -0.41 *Long-run* [-2.69]	*Short-run* 0.04 *Long-run* [3.73] **Instrumental** *Short-run* 0.06 *Long-run* [0.38]	Price in neighbouring states, time trends, proportion of population 65 and above	Log linear myopic addiction, OLS and 2SLS	Pooled annual data from 1961 to 2002	Long-run results calculated from the short-run results and the lagged dependent variable by the Working Group
Goel (2009)	United States	**Static** -0.86 to -0.92 **Dynamic** *Short-run* -0.04 to -0.11 *Long-run* [-2 to -3.7]	**Static** 0.05 to 0.08 **Dynamic** *Short-run* -0.01 to -0.03 *Long-run* [-0.3 to -1.5]	Advertising, master settlement agreement	Log linear dynamic OLS with fixed effects	Pooled annual data from 1975 to 2004	Long-run results calculated from the short-run results and the lagged dependent variable by the Working Group

Values in [ ] calculated by the Working Group using data reported in corresponding studies.
EC2SLS, 2-stage least squares procedure that assumes a one-way error-component model; FD2SLS, first-difference 2-stage least square estimator; GLS, generalized least squares estimates/estimator; OLS, ordinary least squares estimates/estimator; W2SLS, weighted least squares estimates/estimator; 2SLS, 2-stage least squares estimates/estimator; 3SLS, 3-stage least squares estimates/estimator

Fujii's (1980) study uses ridge regression to alleviate the problems associated with multicollinearity between the independent variables. While the focus of his analysis was still largely on the impact of the health scare introduced by the Surgeon General in 1964 and airing of anti-smoking commercials at the end of the 1960s, he found the effects of these interventions modest. However, he concluded that "taxation, however, could have more substantial effects. Estimates of the price elasticity of demand (about −0.45) indicate that a 10% increase in the price of cigarettes will lower consumption by 4.5%. This effect became more pronounced in the long run" (Fujii, 1980).

Baltagi and Levin (1986) estimated the demand for cigarettes in the USA, based on annual data for the period 1963–1980 for 46 states. What is interesting about this study is that it accounts for possible small-scale smuggling between states and cross-border shopping. Given differences in cigarette excise taxes and hence prices between states, one can expect a difference between sales and consumption in states (high-price states have greater consumption than sales, and vice versa in low-price states). If one does not account for the small-scale smuggling effect and cross-border sales, the price elasticity estimates would be biased away from zero. To account for small-scale smuggling and cross-border sales between high- or low-price states, they included the cigarette price in the lowest-price neighbouring state.

They found a neighbouring state price elasticity of 0.08, suggesting that if the price in the neighbouring state is 10% lower than the home state, the cigarette sales in the home state would be expected to decrease by 0.8%. The price elasticity accounting for the small-scale smuggling effect and cross border sales is estimated at about −0.2.

An innovation introduced by Seldon and Boyd (1991) was to test and adjust for instability in the demand function. Using annual data for the period 1953–1984 and using a technique developed by Cooley and Prescott (1976), they found that the demand for cigarettes was in fact quite unstable over this period. The instability of the demand function is attributed to government interventions (e.g. the 1964 Surgeon General's report, the 1965 Cigarette Labelling and Advertising Act and the anti-smoking commercials that started after 1968). By including appropriate dummy variables for these interventions and estimating the demand equations with a Maximum Likelihood technique derived from the Cooley-Prescott method, they found that the demand system stabilized, and that the inclusion of the dummy variables reduces the price elasticity estimate in absolute terms from −0.26 to −0.22.

The rational addiction framework of Becker and Murphy spawned a substantial literature that aimed to incorporate the principles of forward-looking behaviour into the empirical results. The rational addiction framework has been applied to both aggregate and individual-level data. Studies based on individual-level data, initiated by Chaloupka (1991), are covered in Chapter 6. The first studies to test the rational addiction hypothesis with aggregate data were by Keeler *et al*. (1993) and Becker *et al*. (1994).

Keeler *et al*. (1993) considered monthly data for California for the period 1980–1990. In specifying a demand equation, they regressed current consumption on, among others, future consumption. Given that the monthly data were too unstable to yield meaningful results, they were forced to use an unweighted moving average of the previous 12 months' consumption as a proxy for current consumption and an unweighted moving average of the next 12 months' consumption as a proxy for next period consumption. They found that the coefficient on future consumption is positive and significant, and thus supportive of the rational addiction hypothesis. However, they found that the price elasticities produced by the myopic and rational addiction frameworks, and by a framework which does not account for addictive behaviour, were remarkably consistent in the range of −0.47 to −0.58.

Becker *et al*. (1994) used a large aggregate data set of more than 1500 observations (50 states over 31 years) to investigate empirically whether cigarette smokers are "rational" in the way that rational addiction is defined. Overall, the results rejected the myopic model of addiction, and provided evidence that consumers do consider future prices in their current consumption decisions (Becker *et al*., 1994).

Despite the many differences in research methodology, there are several generalizations that follow from these studies. First, all empirical studies included the cigarette price as a determinant of cigarette consumption, and evidence for a strong negative relationship between these two variables is overwhelming. The price elasticity estimates generally varied between −0.15 and −0.90, but seem to be concentrated in the −0.20 to −0.60 range. This implies that the demand for cigarettes is relatively price-inelastic, but certainly not perfectly price-inelastic. From a tobacco control perspective this result provides the rationale for using excise tax increases as a tool

to reduce cigarette consumption. An increase in the excise tax increases the retail price of cigarettes, which in turn decreases cigarette consumption. Furthermore, since cigarettes are inelastic, the increase in price will be greater than the decrease in consumption. Therefore, total tax revenue is likely to rise when taxes rise since the tax increase more than compensates for the declining consumption.

Second, studies that investigated "health scares" and anti-smoking publicity which resulted from the Fairness Doctrine generally found that they reduced the demand for cigarettes (Hamilton, 1972; Baltagi and Levin, 1986; Kao and Tremblay, 1988). According to this Doctrine, companies advertising "controversial goods" (which, after the publication of the 1964 Surgeon General's report, included cigarettes) had to pay for advertisements that presented the alternative view. This resulted in substantial anti-tobacco advertising between 1967 and 1970. However, the relative magnitude of the publicity effect is unclear. Hamilton (1972), Warner (1977, 1981 and 1989), Kao and Tremblay (1988), found evidence of a sizeable long-term effect, while Fujii (1980) and Bishop and Yoo (1985) concluded that the impact was small and transitory. In more recent studies, anti-smoking publicity as a determinant of consumption seems to have received little attention in the empirical literature.

Third, there is no consensus on the impact of advertising expenditure on the demand for cigarettes. Several studies (Hamilton, 1972; Wilcox and Vacker, 1992; Duffy, 1995), found no significant relationship between advertising expenditure and cigarette consumption. Other studies found a positive relationship, but even when such a relationship was found, its impact on cigarette consumption was small (Fujii, 1980; Bishop and Yoo, 1985; Abernethy and Teel, 1986;[9] Holak and Reddy, 1986; Kao and Tremblay, 1988; Seldon and Doroodian, 1989; Seldon and Boyd, 1991).[10]

Saffer (2000) has proposed that advertising *per se* is an inappropriate measure and that, since many countries have experimented with advertising restrictions and bans, we can actually test the impact of policies (we review this literature in the last section of this chapter). He argues that the high level of aggregation of advertising expenditure data used in time series studies leaves little variation to correlate with consumption data. Generally, since the marginal product of advertising is very low (and possibly even zero) it is not likely that we would find any relationship between advertising expenditure and consumption. Chapman (1989) also criticized the use of these techniques, and in particular noted the inability of aggregate studies to examine all methods of promotion (including non-advertising and price-based promotion) used by the tobacco industry. Econometric analysis only examines the effects of advertising on aggregate data, while advertising also has an influence on smoking related cognition and beliefs.

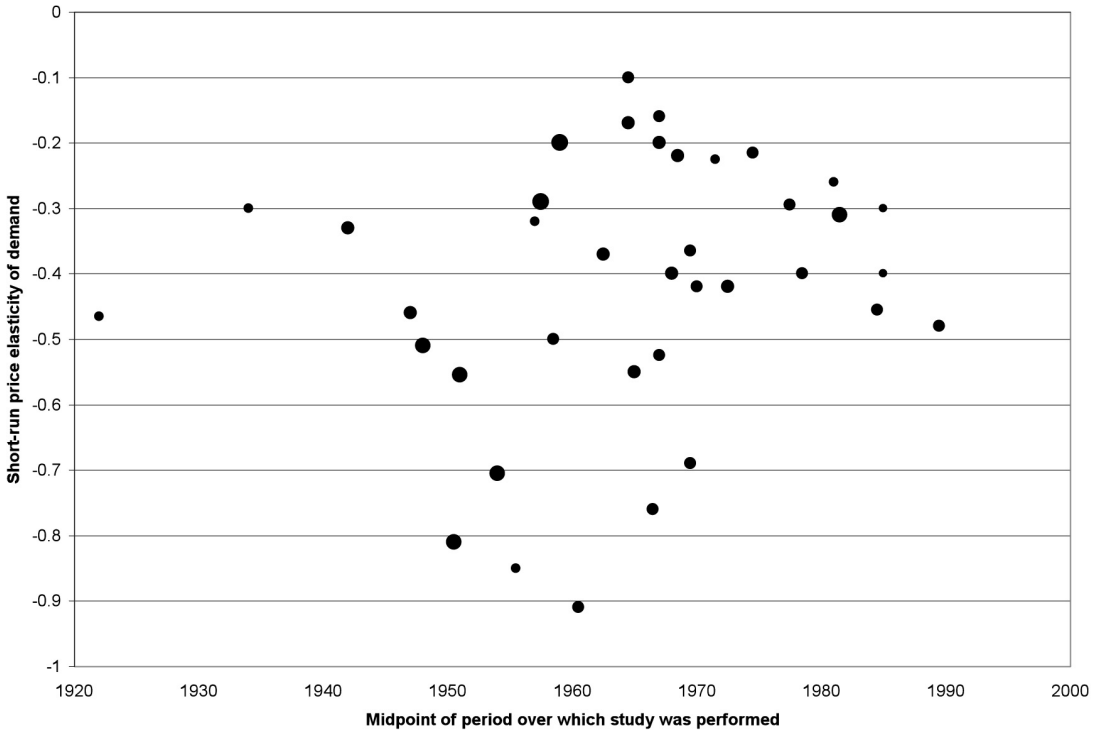
Fourthly, most studies incorporate an income variable in the demand equation as a control variable. There is no consensus on the value of the income elasticity of demand for cigarettes, other than that it lies between zero and one (Andrews and Franke, 1991). This suggests that cigarettes are a normal good, which is intuitively reasonable (income elasticity estimates are explicitly reviewed in this chapter). However, the policy impact of this result is not that one should advocate for lower income as a tobacco control measure, but that growth in income should be taken into account when considering tax policy. A separate literature that considers affordability (price and income simultaneously) has recently developed and is considered later in this chapter.

Baltagi and Goel (1987) and Tegene (1991) used estimation techniques that allowed the price elasticity to change over time and found that the demand for cigarettes in the USA became less elastic over time. Andrews and Franke (1991), using a meta-analysis of published studies came to a similar conclusion. Figure 4.1 shows a scatter plot of the estimated price elasticity of demand, against the midpoint of the period for which the study was performed. The studies included in this scatter plot have been taken primarily from Andrews and Franke (1991) and US Department of Health and Human Services (2000), supplemented by more recent research.[11] In Figure 4.1 the number of years of data used in each study is represented by the size of each dot. The smallest dots represent the smallest number of years of data, while the studies that use the largest number of years of data have the largest dots. The smallest number of years of data is 10 years while the largest is 58 years.

Figure 4.1 shows that the majority of estimates of price elasticity lie between −0.1 and −1.0, with most clustered between −0.2 and −0.6.

[9] Abernethy and Teel (1986) found a significant positive relationship for print advertising but not broadcast advertising.
[10] See Andrews and Franke (1991) for a more complete list.
[11] For studies listed in US Department of Health and Human Services (2000), the price elasticity estimates as published in USDHHS were used in Figure 4.1. For studies listed in Andrews and Franke (1991), an average price elasticity is calculated if more than one price elasticity estimate was published in any particular study. Long-run price elasticities are not shown.

Figure 4.1. Price elasticity estimates for the USA, based on time series studies

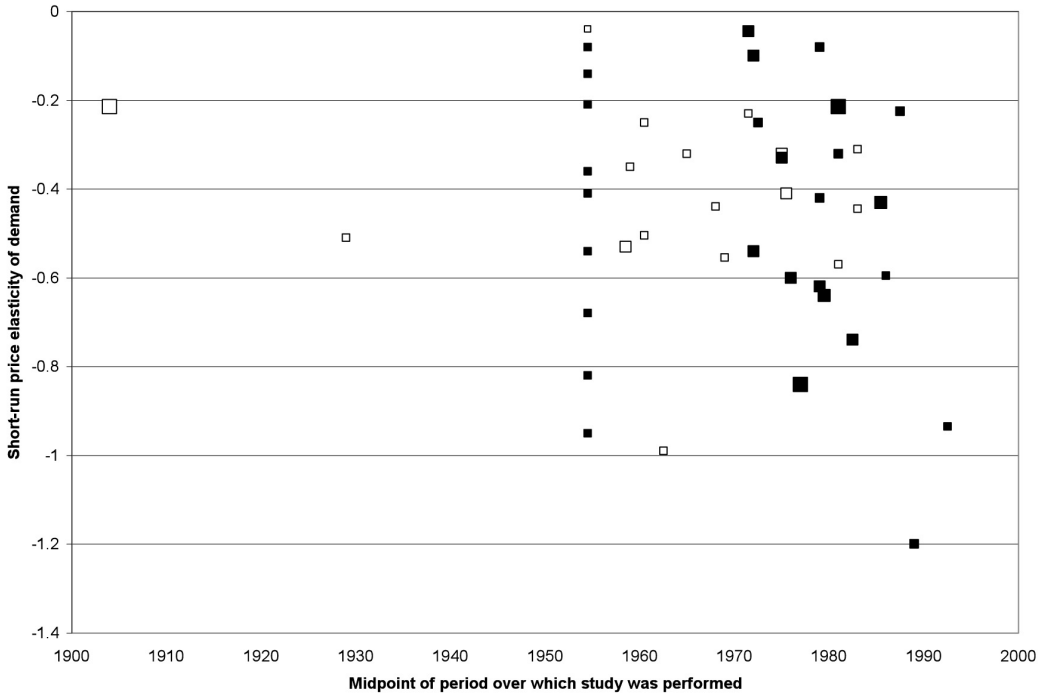


Sources: The studies referred to in the figure can be found in Table 4.1. The table only includes short-run elasticities. The years refer to the middle year under investigation in those studies, hence the most recent study (Goel, 2009) includes data from 1975 to 2004 and is thus listed in 1989/90.

The small number of studies which fall outside of this cluster have no systematic methodological, data or estimation technique differences from those within the cluster. On the basis of these studies there is no strong evidence that the demand for cigarettes has become less elastic over time. More recent studies suggest that the range of estimated price elasticities has narrowed somewhat since the 1970s, with reduced variability, between −0.20 and −0.50. Of course this raises the question of why this may be the case. Several reasons can be put forward. First, estimation techniques (and possibly data quality) may have improved over time. For example, including variables in the demand equation that are positively related to price will tend to reduce the coefficient on price (and thus reduce the absolute value of the price elasticity). However, while this is a theoretical possibility, the list of control variables in demand equations based on aggregate data has not changed much over time, and thus more complete and more comprehensive specification of the demand equation is not a likely reason for the perceived reduction in the price elasticity over time. However, more recent studies have given explicit recognition of illicit cigarettes (i.e. smuggled, etc.) and their impact on the price elasticity estimates (Baltagi and Levin, 1986, Baltagi and Goel, 1987, Becker *et al*., 1994, Sung *et al*., 1994, Thursby and Thursby, 2000, Baltagi *et al*., 2000, Huang *et al*., 2004). If the illicit trade in cigarettes is not controlled for, this results in price elasticity estimates that are biased away from zero. Accounting for illicit cigarettes reduces the bias and hence the absolute value of the price elasticity estimates.

Second, as the general level of income has increased over the past 50 years, cigarettes have generally become more affordable (despite the fact that their real price has increased over this time period). Thus the proportion of income required to purchase a packet of cigarettes has decreased over this long time period. However, this is not true for the past two decades, which have seen very rapid increases in the price of cigarettes. Economic theory indicates that the price elasticity (in absolute terms) decreases as the product takes up a smaller proportion of a

Figure 4.2. Price elasticity estimates for the United Kingdom and other high-income countries, based on time series studies. White squares are United Kingdom studies and solid black squares are from other high-income countries.



Sources: Figure calculated by the Working Group.
The studies referred to in the figure can be found in Table 4.2. The table only includes short-run elasticities. Estimates for several countries come from a single study by Koutsoyiannis (1963) and result in a grouping on the midpoint 1954/1955. The years refer to the middle year under investigation; hence the most recent study (Pierani and Tiezzi, 2009) includes data from 1960 to 2002 and is thus listed in 1981.

person's or household's total income and becomes more affordable.

Other high-income countries

Table 4.2 is a comprehensive chronological summary of 39 published cigarette demand studies in developed countries other than the US. The list is dominated by studies based on the United Kingdom (16), followed by that of New Zealand (four). As it turns out, these two countries, together with Australia, Canada and the USA, have been at the forefront of tobacco control policy.

Figure 4.2 depicts all of the elasticity estimates from Table 4.2. The large number of estimates from the United Kingdom are depicted by the white squares and studies from other high-income countries by the solid black squares. Again, the larger squares represent longer time periods under consideration, the smallest being 9 years and the largest being 68 years. The price elasticity estimates range between zero (i.e. not significant) and −1.2, with most studies clustered between −0.2 and −0.6. With two exceptions, all estimates in the United Kingdom lie between −0.2 and −0.6. There is greater variation in other high-income countries, although this might be expected since the countries vary significantly with respect to many factors (i.e. price, income and tobacco control measures). Even though the methodologies, types of data and estimation techniques differ widely between studies, the results do not differ widely, especially in the United Kingdom. Whereas there is very limited evidence that the absolute value of the price elasticity of demand may be decreasing in the USA, there is no such evidence for other developed countries. It is part of the conventional wisdom that the average price elasticity of demand for tobacco is around −0.4 in developed countries (Jha and Chaloupka, 1999; Chaloupka *et al*., 2000b; U.S. Department of Health and Human Service, 2000).

Several of the studies in this group of countries are notable. Stone (1945), Prest (1949) and Koutsoyiannis (1963) were the first to estimate demand in any country. Townsend (1987) was unique in that it estimated different elasticities for different social classes in the United Kingdom.

Table 4.2. Studies employing aggregate data in other high-income countries

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Stone (1945)	United Kingdom and United States	**UK** between –0.49 and –0.53 **UK** 0.24	**UK** 0.07 (not significant) **US** 0.33	Time trend (positive), UK dummy for coupon trading (1928–33) (positive)	Static log linear OLS	Annual time series data from 1920 to 1938	First known study to attempt to estimate elasticities
Prest (1949)	United Kingdom	Between –0.12 and –0.31, depending on specification	0.17	Time trend (positive), post-World War I dummy variable (positive)	Static levels and first differences log linear model	Annual time series data from 1870 to 1938 with 1915 to 1919 excluded	
Koutsoyiannis (1963)	14 high-income countries (single country equations)	**US** -0.94 **UK** -0.04 (insig.) **France** -0.54 **Italy** -0.82 **The Netherlands** -0.08 (insig.) **Belgium** -0.68 **Sweden** -0.41 **Norway** Not shown (insig.) **Finland** -0.41 **Austria** -0.95 **Greece** Not shown (insig.) **Ireland** -0.15 (insig.) **Canada** -0.21 (insig.) **Australia** -0.36	**US** 0.34 (insig.) **UK** 0.07 (insig.) **France** 0.83 **Italy** 0.48 (insig.) **The Netherlands** 0.10 (insig.) **Belgium** Not shown **Sweden** 0.26 (insig.) **Norway** 0.18 **Finland** 0.13 (insig.) **Austria** 0.11 **Greece** 0.07 (insig.) **Ireland** 0.56 (insig.) **Canada** 0.09 (insig.) **Australia** 0.43 (insig.)	Population size (positive), prices of all other goods and services (negative for Greece, not included for other countries), Time trend (generally positive)	Static log linear OLS	Annual time series data from 1950 to 1959	Single equation for each country
Sumner (1971)	United Kingdom	**For annual data** between –0.13 and –0.57, depending on specification **For quarterly data** between –0.60 and –0.83, depending on specification	Positive	Health publicity dummy and trend variables (negative)		Annual and quarterly time series data from 1951 to 1967	Investigated the impact of the 1962 Royal College of Physicians report on cigarette consumption

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Atkinson and Skegg (1973)	United Kingdom	**All adults** between –0.1 and –0.4 depending on specification *Males* statistically insignificant *Females* -0.35	Positive	Health publicity dummy and trend variables (generally negative)		Annual time series data from 1951 to 1970	
Russell (1973)	United Kingdom	-0.50 to –0.66	Not explicitly included, a price-income ratio is included (affordablility elasticity) -0.44 to -0.58	Royal College of Physicians Reports (1962 and 1971) (negative)	Rather than using regression analysis, the results are based on correlations and graphical representations of the data	Annual time series data from 1946 to 1971	Males only
Peto (1974)	United Kingdom	*For males* -0.37 to –0.64 Females not investigated	0.14 to 0.49 (generally insignificant)	Health publicity dummy and trend variables (generally negative)	Seemingly a log linear OLS	Annual time series data from 1951 to 1970	Used to try to address the conflicting results regarding price elasticity between Atkinson and Skegg (1973) and Russell (1973)
McGuinness and Cowling (1975)	United Kingdom	**Short run** -0.99 **Long run** -1.05	**Short run** 0.31 **Long run** 0.33	«Stock» od advertising expenditure (positive)	Log linear model addition (Koyck)	Quarterly time series data from 1957 (Q2) to 1968 (Q4)	
Metra Consulting Group Ltd (1979)	United Kingdom	**Short-term** -0.34 to –0.54 **Long-term** -0.42 to –0.54	Unknown	Unknown	Unknown	Quarterly time series data from 1958 to 1978	The study was based on and aimed to refute McGuinness and Cowling's (1975) finding of a positive relationship between advertising and cigarette consumption. Using data supplied by the tobacco industry, the study found no significant relationship between advertising and cigarette consumption. Quoted in High (1999)

Table 4.2. Studies employing aggregate data in other high-income countries

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Witt and Pass (1981)	United Kingdom	-0.3	Income (positive)	Advertising expenditure (positive), "Health scare" dummy variables (negative)		Annual time series data from 1955 to 1975	Investigated whether the reports by the Royal College of Physicians (1962 and 1971) and the US Surgeon General (1964) had an impact on cigarette consumption
Leeflang and Reuijl (1985)	West Germany	Excluded from analysis because "coefficient of variation is extremely low"	[0.50 to 0.60] (insignificant)	Household consumption (proxy for income) (positive), Sales quantities of substitutes to cigarettes (generally negative), Advertising expenditure (positive)	Linear OLS myopic addiction	Annual, quarterly and monthly time series data from 1961 to 1975	The Working Group calculated the elasticities in [ ] at the mean
Radfar (1985)	United Kingdom	-0.23	0.12	"Stock" of advertising expenditure (positive), health publicity (interaction dummy variables with advertising variables)	Myopic addiction log linear OLS	Quarterly time series data from 1965 (Q3) to 1980 (Q4)	Replicates McGuinness and Cowling's (1975) study
Johnson (1986)	Australia	-0.10 at the means of the sample data	Positive	Advertising expenditure (insignificant), ban on electronic media advertising dummy variables (insignificant)		Annual data from 1961/62 to 1982/83	
Worgotter and Kunze (1986)	Austria	-0.54	Positive	Total private consumption (proxy for income) (positive), "Stop smoking" dummy variable for 1974 (negative)		Annual time series data from 1955 to 1983	
Stavrinos (1987)	Greece	**Linear** *Short-run* -0.01 *Long-run* -0.57 **Log linear** *Short-run* -0.08 *Long-run* -0.15	**Linear** *Short-run* 0.12 *Long-run* 0.70 **Log linear** *Short-run* 0.18 *Long-run* 0.33	Health promotion programme dummy variable (negative)	Myopic addiction linear and log linear OLS	Annual time series data from 1961 to 1982	Uses nominal data

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Townsend (1987)	United Kingdom	Between +0.15 (male professionals) and –1.26 (for unskilled male workers), all insignificant	Between 2.6 (male professionals) and 0.2 (for unskilled male workers), all insignificant	Trend (generally negative, but insignificant), Health publicity dummy variables (varying, but generally negative)	Static log linear OLS	Annual time series data from 1961 to 1977	Investigates differential elasticities amongst demographic groups (five social classes); more educated and well-off people have lower price elasticity of demand, but respond faster to health information than less-educated and poorer people
Chetwynd *et al.* (1988)	New Zealand	Between –0.13 and –0.73 (but insignificant)	Between –0.26 and 0.64 (but insignificant), only significant estimates are between 0.50 and 0.64	Advertising expenditure (positive), consumption in previous period (positive)	Myopic addiction, log linear OLS	Quarterly and annual time series data from 1973 to 1985	
Harrison *et al.* (1989)	New Zealand	**Short-run** -0.08 **Long-run** [-0.14] (but both elasticity estimates are statistically insignificant)	**Short-run** 0.50 **Long-run** [0.78] The Working Group calculated the long-run estimates in [ ] from the short-run estimate and the lagged dependent variable	Lagged consumption, Seasonal dummy variables	Log linear OLS		An extension of Chetwynd *et al.* (1988) and addresses Jackson and Ekelund's (1989) criticism that the original paper suffers from a number of econometric modelling drawbacks. Using some standard econometric tests, Harrison *et al.* show that "the original model and conclusions appear to be very robust"
Harrison and Chetwynd (1990)	New Zealand	-0.32	Positive	Advertising expenditure (positive), Anti-smoking advertising (negative)		Quarterly time series data from 1973 (Q1) to 1989 (Q2)	
Duffy (1991)	United Kingdom	-0.32	0.89	Advertising expenditure (not significant)	Demand system model	Quarterly time series data from 1963 (Q1) to 1987 (Q3)	Demand system includes alcoholic drinks and cigarettes

Table 4.2. Studies employing aggregate data in other high-income countries

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Andrews and Franke (1991)	Meta analysis of studies performed in the United Kingdom, United States, and six other countries	**Weighted mean elasticity for all 198 regression equations** -0.36 **Weighted mean elasticity for all 41 studies** -0.47	**Weighted mean elasticity for all 190 regression equations** 0.36 **Weighted mean elasticity for all 36 studies** 0.40	Other relationships: Advertising expenditure (positive)	Meta-analysis		Meta-analysis of 48 studies
Valdés (1993)	Spain	**Short-run** -0.60 **Long-run** -0.69	**Short-run** 0.17 **Long-run** 0.20	Advertising expenditure (positive), dummy variables for legislative interventions (generally negative)	Myopic log linear OLS	Annual time series data from 1964 to 1988	
Simester and Brodie (1994)	Meta-analysis of studies performed in United Kingdom, United States, New Zealand and West Germany	**Average price elasticity** -0.54 **Median price elasticity** -0.48	Positive	Advertising (positive)	Meta-analysis		Meta-analysis of 29 published studies
Townsend *et al*. (1994)	United Kingdom	**For males (overall)** -0.47 **For females (overall)** -0.61 Elasticity was inversely related to social class. Young adult males are not price-responsive, but young adult females are	Generally no significant income effect, generally positive amongst men with the exception of older men (50+)	Health publicity (negative)	Static log linear OLS, single equation for each group	Annual time series data from 1972 to 1990	Assesses elasticitties for different demographic groups
Duffy (1995)	United Kingdom	-0.35 to -0.47	0.96 to 1.01	Advertising (insignificant)	Almost Ideal Demand System (AIDS), static and dynamic	Quarterly time series data from 1963 (Q1) to 1992 (Q1)	System includes beer, spirits, wine and all other commodities
Cameron (1997)	Greece	Negative and insignificant price elasticity	Income (positive and significant in myopic addiction model, positive and insignificant in rational addiction model)	Television advertising dummy (positive but insignificant), Anti smoking campaign dummy (generally negative and significant)	Linear and log linear myopic and rational addiction OLS	Annual time series data from 1970	No end date reported

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Hondroyiannis and Papapetrou (1997)	Greece	**Short-run** -0.33 **Long-run** -0.60	**Short-run** 0.35 **Long-run** 0.54		Dynamic Error Correction Model	Annual time series data from 1960 to 1990	
Lanoie and Leclair (1998)	Canada	**Legal consumption** *Short-run* [-0.34] *Long-run* [-0.61] **Total consumption** *Short-run* [-0.11] *Long-run* [-0.28]	**Legal consumption** *Short-run* [0.24] *Long-run* [0.44] **Total consumption** *Short-run* [0.14] *Long-run* [0.36]	Regulation and time trend	Myopic linear GLS with fixed effects	Pooled annual data from 1980 to 1995	Looks at smuggling and its impact on elasticities. Values in [ ] calculated by the Working Group
Bardsley and Olekalns (1999)	Australia	**Short-run** Between [-0.2 and –0.3] for period 1963 to early 1980s, but increases rapidly to [–1.2] between 1982 and 1996 **Long-run** Between [-0.5 and –0.6] for period 1963 to early 1980s, but increases rapidly to [–3.0] between 1982 and 1996	**Short-run** Between [0.2 and 0.4] for period 1963 to early 1980s, but increases rapidly to [0.7] between 1982 and 1996 **Long-run** Between [0.4 and 0.8] for period 1963 to early 1980s, but increases rapidly to [1.5] between 1982 and 1996	Age structure of population (older population ==> more cigarette consumption), Advertising (positive, but small), Health warnings (negative, but small), Ban on smoking in public places (negative, but small)	Linear rational addiction model, GMM	Annual time series data from 1962/63 to1995/96	Investigates how elasticity estimates have changed over time. Elasticity values in [ ] computed at the mean by the Working Group
Mindell and Whynes (2000)	Netherlands	-0.45 to -1.03	1.2	Unemployment and health promotion expenditure	Log linear static OLS	Annual time series data from 1970 to 1995	Looks specifically at substitution between manufactured and hand-rolled
Reinhardt and Giles (2001)	Canada	**Short-run** -0.62 **Long-run** -0.23	**Short-run** 0.19 **Long-run** no estimated	Includes dummy variables for structural breaks	Log linear OLS Myopic model	Quarterly times series data from 1968:1 to 1990:2	
Yorozu and Zhou (2002)	Japan	-0.64 to -1.23	-0.20 to 0.38	Anti smoking budget, time trend	Static linear OLS and WLS	Data from two time periods: 1990 and 1995	Study looks at regional cross sections at two points in time
Gallus *et al.* (2003)	Italy	-0.43	0.10		Static log linear model	Annual time series data from 1970 to 2001	
Gruber, Sen and Stabile (2003)	Canada	-0.72 but -0.47 excluding smuggling, provinces and years	Positive	Unemployment	Two way fixed effects linear model	Annual time series data from 1981 to 1991	

Table 4.2. Studies employing aggregate data in other high-income countries

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Bask and Melkersson (2004)	Sweden	**Long-run** *Separate models* -0.81 (-3.63 when two lags and leads included) *Joint models (alcohol and cigarettes together)* -0.65 to -1.03	Not included in model	Price of alcohol (negative)	Rational addiction linear OLS, SUR and GMM. First differences.	Annual time series data from 1955 to 1999	
Escario and Molina (2004)	Spain	**Virginia tobacco** -0.80 **Black tobacco** -0.48 **Cigars** -0.93	**Expenditure elasticities** *Virginia tobacco* 0.37 *Black tobacco* 0.67 *Cigars* 0.70		Almost Ideal Demand System	Annual time series data 1964 to 1995	Elasticities have fallen over time in absolute terms
Duffy (2006)	United Kingdom	**Static** -0.41 to -0.48 Myopic Short-run -0.16 to -0.46 Long-run -0.45 to -0.49 Rational Short-run -0.01 to -0.13 Long-run -0.26 to -0.41	Static 0.28 to 0.31 Myopic Short-run 0.08 to 0.28 Long-run 0.20 to 0.29 Rational Short-run 0.05 to 0.06 Long-run 0.11 to 0.16	Advertising expenditure	Static, myopic and rational models, linear, elasticity at the mean. Demand system.	Quarterly time series data from 1962, 2nd quarter to 2002, 3rd quarter	
Pierani and Tiezzi (2009)	Italy	**Short-run** [-0.09 to -.0.34] **Long-run** [-0.31 to -1.07]	**Short-run** [-0.09 to -.034] **Long-run** [0.19 to 1.56]	Price of complement (i.e. alcohol or tobacco) in single equation model	Rational addiction first difference GMM (independent and systems equations)	Annual time series data between 1960 and 2002	Studies the relationship between alcohol and cigarette consumption. Elasticity values in [ ] computed at the mean by the Working Group

For quarterly data, corresponding quarter specified in parenthesis.
In this table, short-run & long-run estimates can also be designated as SR and LR respectively.
Values in [ ] calculated by the Working Group using data reported in corresponding studies.
(insig.) refers to non statistically significant estimates
GLS, generalized least squares estimates/estimator; GMM, generalized methods of moments estimator; OLS, ordinary least squares estimates/estimator; SUR, seemingly unrelated system of equations; WLS, weighted least squares estimates/estimator

This is unusual in aggregate data studies and usually only found in cross-sectional studies. Unsurprisingly, the results showed that unskilled male workers were more responsive to price changes than were male professionals. Townsend *et al*. (1994), in another United Kingdom study again estimated elasticities for different socioeconomic and age groups using aggregate data. They found that females are more sensitive to price changes than were males, and that elasticities are inversely related to social class. Young adult males were not found to be price-responsive but young adult females were (see Chapters 5 and 6, which consider cross-sectional studies with similar themes). Chetwynd *et al*. (1988) began a series of important studies in New Zealand. The study was concerned with examining the relationship between print advertising and consumption but estimated price elasticities ranging between −0.13 and −0.73 as a control in the model. Harrison *et al*. (1989) was an extension to address the methodological concerns raised, and improved the paper by using a myopic addiction model estimating a smaller price elasticity of −0.08. Harrison and Chetwynd (1990) made further improvements using quarterly data instead of annual data, and estimated a price elasticity of −0.32.

Duffy (1991) estimated cigarette demand using aggregate data by employing a demand system in the United Kingdom. The Almost Ideal Demand System (AIDS) yielded estimates of own price and cross price elasticities for cigarettes as well as alcoholic drinks (beer, wine and spirits). Duffy found that cigarettes and alcoholic drinks exhibited no significantly complementary behaviour. Duffy (1995) conducted another AIDS model including cigarettes, beer, wine, spirits and all other commodities. This time Duffy used a dynamic specification of demand although he did not report the cross price elasticities. Escario and Molina (2004) employed a dynamic AIDS in Spain.

However, they did not include alcohol, rather including three different types of tobacco products, Virginia tobacco, black tobacco and cigars. They found that the price elasticities, in absolute terms, fell over time between 1964 and 1995. Price elasticities for all tobacco products considered were negative, and Virginia tobacco and cigars were more price sensitive than black tobacco. Virginia and black tobacco were found to be substitutes in consumption, as were black tobacco and cigars, although Virginia tobacco and cigars were complements in consumption.

Although using a far simpler methodology, Mindell and Whynes (2000) also estimated product substitution although between manufactured cigarettes and hand-rolled cigarettes in the Netherlands. Although cross-price elasticities were negative, this was explained by the collinearity between the prices for manufactured and hand rolled cigarettes. However, they found that when the price of hand-rolled cigarettes increased by a greater proportion than the price of manufactured cigarettes, the decline in manufactured cigarette consumption was accompanied by a decline in hand-rolled cigarette consumption.

Hondroyiannis and Papapetrou (1997) is one of several Greek studies. It is one of the more thorough time series studies in that it estimates a dynamic specification of demand and employs an Error Correction Model to deal with the time series issues in the data. The use of advanced time series techniques is relatively rare in this literature, and this was the first studies to do so in this context. It found a short-run price elasticity of −0.33 and a long-run elasticity of −0.60. Other Greek studies found short-run price elasticities of −0.01 and −0.08 (Stavrinos, 1987) while Koutsoyiannis (1963) and Cameron (1997) found price to be insignificant.

Lanoie and Leclair (1998) is a Canadian study that aimed to deal with the problem of cigarette smuggling using annual time series data from 10 Canadian provinces from 1980 to 1995. During this time period the volume of smuggled cigarettes in Canada grew rapidly. The existence of a large illegal market is likely to result in overstated price elasticities (in absolute terms). Lanoie and Leclair estimated two models, one with legal cigarette consumption as the dependent variable and the second using an estimation of total cigarette consumption by adding estimates of the volume of illegal cigarettes to the volume of legal cigarettes. The elasticities using only the legal consumption were found to be significantly greater in absolute terms (both the short-run and long-run, −0.34 versus −0.11 and −0.61 versus −0.28 respectively) than the model using the total consumption. Gruber *et al*. (2003) also tackled the issue of the impact of smuggling on elasticities in Canada, and found that elasticities are larger, in absolute terms, when including provinces and years in which smuggling was known to be present (−0.72 versus −0.47).

Bardsley and Olekalns (1999) estimated a rational addiction model in Australia, and while they found support for rational addiction between 1963 and 1996, their interesting innovation was how they specified the model in linear terms to investigate how elasticities changed over time. They found that both short- and long-

run elasticities in absolute terms grew significantly over time, meaning that consumption became more responsive to changes in price. The short-run elasticity ranged between −0.2 and −0.3 between 1963 and the early 1980s, but increased rapidly to −1.2 between 1982 and 1996. The long-run elasticity ranged between −0.5 and −0.6 in the first period, and increased rapidly to −3.0 in the later period. Escario and Molina (2004), however, reported that elasticities have, in absolute terms, fallen over time in Spain.

Studies in high-income countries have found similar results to those in the USA. The variation in countries considered results in some variation in results, although the general range is similar.

Low- and middle-income countries

As pointed out in the introduction to this chapter, tobacco use is shifting from the developed to the developing world. Before 1990 the economics of tobacco control in developing countries received practically no attention from either policymakers or academic researchers. The fall of communism and rapid globalization created opportunities for multinational cigarette companies to diversify their markets into a rapidly growing developing world, particularly in eastern Europe and Asia. The USA used the threat of trade sanctions to prise open the markets in Thailand, Japan, the Republic of Korea and Taiwan, China to foreign cigarettes (Chaloupka and Laixuthai, 1996). Developing countries did not have effective tobacco control policies in place, and presumably many developing countries did not see the need for measures that were imposed in rich industrialised countries but that were deemed unnecessary in developing countries. Against this background an empirical literature on the demand for tobacco in developing countries developed.

A chronological summary of studies that investigated the demand for tobacco is provided in Table 4.3. The first attempt was by Chapman and Richardson (1990), who used annual time series data to estimate the response in tobacco demand to a change in tobacco excise taxes. They used cigarette excise taxes as a proxy for cigarette prices, because the latter were unavailable. They found that the "excise tax elasticity" was about −0.7 for cigarettes and −0.5 for other forms of tobacco. Subsequent studies, also based on time series data, estimated price elasticity estimates for Argentina (Gonzáles-Rozada, 2006), Bangladesh (Ali *et al*., 2003), Bolivia (Alcaraz, 2006), Brazil (Da Costa e Silva, 1998, Iglesias, 2006), Chile (Debrott Sanchez, 2006), China (Hu and Mao, 2002, Yuanliang & Zongyi, 2005), Taiwan, China (Hsieh *et al*., 1999, Lee, 2007, Lee and Chen, 2008), Egypt (Hanafy *et al*., 2011), Estonia (Taal *et al*., 2004), Indonesia (Djutaharta *et al*., 2005), Malaysia (Ross and Al-Sadat, 2007), Morocco (Aloui, 2003), Poland (Florkowski and McNamara, 1992), South Africa (Reekie, 1994, Van Walbeek, 1996, Economics of Tobacco Control in South Africa Project (ETCSA),1998, Boshoff, 2008), Republic of Korea (Wilcox *et al*., 1994, Kim and Seldon, 2004), Turkey (Tansel, 1993, Onder, 2002, Yurekli *et al*., 2010), Ukraine (Peng and Ross, 2009), Uruguay (Ramos, 2006) and Zimbabwe (Economics of Tobacco Control in South Africa Project 1998). Guindon *et al*. (2003) performed a multi-country study in Bangladesh, Indonesia, Maldives, Myanmar Nepal, Sri Lanka and Thailand.

The fact that cigarette demand in developing countries is more elastic than in developed countries was predicted by Warner (1990), on the grounds that cigarettes are generally less affordable in developing countries, given their much lower per-capita income levels (confirmed by Blecher and van Walbeek, 2004 and 2009). Warner (1990) argued that, like the lower social classes in the United Kingdom and teenagers in the USA, tobacco users in developing countries have relatively lower incomes, and consequently price increases for goods in their budgets impinge more significantly on their ability to purchase other goods and services (Warner, 1990).

Since the mid-1990s, tobacco control research in developing countries has received substantial financial and institutional support from organizations including Research for International Tobacco Control, the Tobacco-Free Initiative of the World Health Organization and the World Bank. More recently, support has come from the Bloomberg Initiative to Reduce Tobacco Use via the Campaign for Tobacco Free Kids and the International Union Against Tuberculosis and Lung Disease as well as the Bill and Melinda Gates Foundation. These organizations realized that there was a need for country-specific analytic work with a strong policy focus (De Beyer & Waverley Brigden, 2003). As is to be expected, policymakers in developing countries were unwilling to impose tobacco control policies in their countries solely on the grounds that they were successful in developed countries. They wanted research that took cognisance of the uniqueness of their countries.

The research performed under the auspices of these organizations attempted to address such policymakers' concerns. Countries that were investigated in this research drive and that used aggregate data in the analysis included

Table 4.3. Studies employing aggregate data in low- and middle-income countries

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Chapman and Richardson (1990)	Papua New Guinea	-0.50 for non-cigarette tobacco -0.71 for cigarettes (Important: these are "excise elasticities": see Comments)	1.37 for non-cigarette tobacco 0.86 for cigarettes	Price of substitutes (positive), Trend (negative)	Log linear static OLS	Annual time series from 1973 to 1986	First study conducted in a low-and-middle-income country. Excise tax data, rather than price data, were used because of data unavailability; as a result the price elasticities are larger than the "excise elasticities" estimated in the study
Florkowski and McNamara (1992)	Poland	-0.11	0.43	Price of substitutes, urban/rural population, trend for addiction	Linear static SUR system	Annual time series data from 1959 to 1985	System included vodka, wine and beer
Tansel (1993)	Turkey	**Short-run** -0.21 **Long-run** -0.37	**Short-run** 0.41 **Long-run** 0.71	Anti-smoking campaign dummy variable (negative), health warning dummy variable (negative)	Myopic addiction model	Annual time series data from 1960 to 1988	The first study to look at the time series effects in a developing country
Reekie (1994)	South Africa	-0.88	0.59	Advertising expenditures (insignificant)	Log linear static OLS	Annual time series data from 1970 to 1989	The demand equation was used to estimate the size of the consumer surplus
Wilcox *et al*. (1994)	Republic of Korea	Significantly negative (but elasticity estimate not shown)	Significantly positive (but elasticity estimate not shown)	Advertising expenditure (generally insignificant), population (insignificant), health warnings (insignificant)	Linear static stepwise OLS	Monthly time series data from July 1988 to April 1992	Regressions on aggregate and brand-level data
Van Walbeek (1996)	South Africa	**Short-run** –0.32 and –0.99 **Long-run** –0.53 and –1.52	**Short-run** 0.48 to 0.58	Time trend	Linear dynamic OLS	Annual time series data from 1960 to 1990	
Da Costa e Silva (1998)	Brazil	**Short-run** between –0.11 and –0.35 **Long-run** between –0.48 and –0.80	**Short-run** between 0.23 and 0.31 **Long-run** between 0.76 and 0.80	Unknown	Rational addiction	Annual time series data from 1983 to 1994	Lack of explanation precludes evaluation and unable to replicate

Table 4.3. Studies employing aggregate data in low- and middle-income countries

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Economics of Tobacco Control in South Africa Project (1998)	South Africa	**Short-run** between –0.57 and –0.59 **Long-run** -0.69	**Positive** *Long-run income elasticity* 1.70	Advertising expenditure (positive)	Myopic addiction Error Correction Model and long-run cointegrating VAR	Annual time series data from 1970 to 1994	Model included a supply side equation
	Zimbabwe	**Short-run** -0.52 **Long-run** -0.85	**Positive** *Long-run income elasticity* 1.67		Rational addiction OLS	Annual time series data from 1970 to 1996	
Hsieh *et al.* (1999)	Taiwan, China	Between –0.6 and –0.7, depending on specification	Positive	Market share of low tar cigarettes, female labour force participation rate, market share of imported cigarettes		Annual time series data from 1966 to 1995	Quoted in Chaloupka *et al.* (2000b)
		Between -0.56 and -0.73 for local brands; Between -1.08 and -1.28 for imported brands	Between 0.22 and 0.26, but centring on 0.22 for local brands; around 1.42 for imported brands.	Dependent variable = per capita (adult, 15+) consumption; Independent variables: Real price, subdivided into local and imported brands; market share of low-tar brands as proxy for health awareness; dummy variable (1991-1995 = 1) to account for warning labels; market share of imported cigarettes; female labour force participation rate	Dynamic OLS, 2SLS and SUR	Annual times series data from 1966 to 1995	Domestic and imported cigarettes are considered substitutes
Hu and Mao (2002)	China	**Short-run** -0.35 **Long-run** -0.66	Positive	Time trend	Dynamic semi log	Annual time series data from 1980 to 1997	
Onder (2002)	Turkey	**Static** *OLS* -0.31 to -0.41 *GLS* -0.19 to -0.28 **Dynamic** -0.09 to -0.12	**Static** *OLS* 0.27 to 0.29 *GLS* 0.23 to 0.25 **Dynamic** 0.10 to 0.17	Regulation index (not significant), Trend (not significant), Price of substitute cigarettes (varying)	Log linear static OLS and GLS	Annual time series data from 1960 to 2000	

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Ali *et al.* (2003)	Bangladesh	-0.27 (but not statistically significant)	0.62	None	Log linear static OLS	Annual time series data from 1983 to 1999	
Aloui (2003)	Morocco	**Short-run** between –0.51 and –0.73 **Long-run** between –1.36 and –1.54	**Short-run** between 0.32 and 0.56 **Long-run** between 0.87 and 1.04	Dummy variable to indicate tobacco control legislation (insignificant)	Myopic addiction linear and log linear OLS	Annual times series data from 1965 to 2000	
Guindon *et al.* (2003)	Bangladesh, Indonesia, Nepal, Sri Lanka, Thailand, Maldives and Myanmar	**Elasticities based on conventional demand specification** between –0.60 and –0.90 **Elasticities based on myopic addictive model** *Short-run* between –0.10 and –0.65 *Long-run* between –0.80 and –1.40	**Elasticities based on conventional demand specification** between 0.28 and 0.99 **Elasticities based on myopic addiction model** *Short-run* between 0.04 and 1.03 *Long-run* between 0.28 and 1.72	Appropriate dummy variables to account for political crises	Various techniques: OLS, GLS and 2SLS, controling for time-specific and period-specific effects	Annual time series data from 1970 to 2000	
Kim and Seldon (2004)	Republic of Korea	**Short-run** -0.28 **Long-run** -0.35	Insignificant	Health warnings	Myopic addiction log linear OLS	Annual time series data from 1960 to 1997	
Taal *et al.* (2004)	Estonia	**Short-run** -0.32 to -0.34	**Short-run** 0.09 to 0.18 (not significant)	Quarterly dummies, time trend	Myopic addiction model Log linear OLS	Monthly time series data from 1992 to 1999 and annual time series data from 1993 to 2000	
Djutaharta *et al.* (2005)	Indonesia	**Annual data** -0.35 on preferred model; for other specifications elasticity varies from -0.33 to -0.47 **Monthly data** -0.32 on preferred model; for other specifications elasticity varies from -0.32 to -0.43	**Annual data** 0.47 on preferred model; for other specifications elasticity varies from 0.14 to 0.51 **Monthly data** no specification yielded significant results	Economic crisis dummy (1997-2001 = 1); trend; health warning dummy (1991-2001 = 1); for monthly analysis similar variables were used	Log linear static OLS	Monthly time series data from January 1996 to June 2001 and annual time series data from 1971 to 2001	Tested for endogeneity of price

Table 4.3. Studies employing aggregate data in low- and middle-income countries

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Yuanliang and Zongyi (2005)	China	-0.84	0.90	Education, regional dummies (fixed effects) average propensity to consume	Static OLS with fixed effects	Pooled annual data from 1997 to 2002	Cross-sections are provincial and spatial municipalities
Alcaraz (2006)	Bolivia	[-0.78 to -2.18]	[0.56 to 0.71]	Some dummies	Static, dynamic and rational addiction models. Some IV techniques	Annual time series data from 1988 to 2002	Elasticity values in [ ] computed at the mean by the Working Group
Debrott Sanchez (2006)	Chile	**Short-term** -0.22 **Long-term** -0.45	**Short-term** 0.11 **Long-term** 0.22	Trend variable, seasonal dummy variable and a dummy reflecting tobacco and health information campaigns	Myopic addiction model	Quarterly time series data from 1993 (Q1) to 2003 (Q4)	
Iglesias (2006)	Brazil	**Short-run** -0.25 **Long-run** -0.42	0.05 to 0.36	Trend variable, smoking restriction index, seasonal dummy	Log linear OLS estimation. Dynamic myopic addiction	Quarterly time series data from 1991 to 2003	Tests endogeneity of price
Gonzáles-Rozada (2006)	Argentina	-0.23 to -0.27	0.45 to 0.49	Some dummies	Log linear dynamic model. Cointegrating VAR	Monthly time series data from Jan 1996 to June 2004	
Ramos (2006)	Uruguay	**Short-term** -0.34 to -0.49 **Long-term** -0.39 to -0.55	**Short-term** 0.51 to 0.65 **Long-term** 0.59 to 0.73	Real bilateral exchange rate with Argentina, Brazil and Paraguay	Log linear myopic addiction model using IV, SURE, 2SLS, 3SLS	Quarterly time series data from 1991 to 2003	
Lee (2007)	Taiwan, China	-0.66		Expenditure, substitutes (alcohol and betel nuts)	Log linear SUR demand system	Annual time series data from 1972 to 2002	
Ross and Al-Sadat (2007)	Malaysia	**Short-run** -0.08 **Long-run** -0.54 to -0.76	**Short-run** 0.03 **Long-run** 1.40 to 1.5	Tobacco control policies (negative and significant)	Dynamic log linear ECM	Annual time series data from 1990 to 2004	
Boshoff (2008)	South Africa	Short-run elasticities not estimated **Long-run** -0.16 to -0.66	**Long-run** 0.37 to 0.73	Market share of light cigarettes, smoking restrictions dummy	Dynamic VAR	Annual times series data from 1996–2006	
Lee and Chen (2008)	Taiwan, China	-0.49 to 0.81		Expenditure, substitutes (imported, domestic cigs and cigars), smoking risk information	Log linear SUR demand system	Annual time series data from 1987 to 2000	

Study	Country	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Peng and Ross (2009)	Ukraine	Insignificant	0.30	Advertising	Static log linear GLS-AR process	Monthly time series data from January 1997 to May 2006	
Yurekli *et al.* (2010)	Turkey	-0.33 to -0.44	0.56	Economic crisis, time trend	Log linear static GLS	Annual time series data from 1960 to 2006	
Hanafy *et al.* (2011)	Egypt	-0.47	1.60	Dummy for Fatwa prohibiting smoking	Log linear static OLS	Annual time series data from 1990 to 2006	

For quarterly data, corresponding quarter specified in parenthesis.Values in [ ] calculated by the Working Group using data reported in corresponding studies.
ECM, error correction models estimates; GLS, generalized least squares estimates/estimator; GLS-AR, generalized least squares - auto regression process; IV, instrumental-variable estimation/estimator; OLS, ordinary least squares estimates; SUR, seemingly unrelated system of equations; SURE, Spanish acronym for SUR; VAR, vector autoregression; 2SLS, 2-stage least squares estimates; 3SLS, 3-stage least squares estimates/estimator

Turkey, Morocco, China, Egypt and Bangladesh.[12]

Some studies in low- and middle-income countries are of specific interest. South Africa has contributed the largest number of studies to the literature (Reekie, 1994, Van Walbeek, 1996, Economics of Tobacco Control in South Africa Project (ETCSA), 1998, Boshoff, 2008), and most are noteworthy. Reekie's (1994) uniqueness lies in the attempt to use the demand estimation to calculate the consumer's surplus. He estimated the price elasticity and based on this, together with some fairly strong assumptions about the shape of the demand function, was able to derive a value for the consumer surplus. Van Walbeek (1996) used a demand model to calculate the revenue-maximizing excise tax rate of a cigarette-specific Laffer curve. Finding the price elasticity to range between −0.32 and −0.99 (depending on the data source), he suggested that the government maximize its tax revenue by raising the excise tax so that it occupied 46% of the retail price. Boshoff's (2008) study is the most methodologically sound of any study in a low- or middle-income country, applying a dynamic specification of demand and estimating this specification using a cointegrating Vector Autoregressive (VAR) model (one of the most advanced time series techniques available). However, this technique only yields a long-run rather than the conventional short-run price elasticity, ranging between −0.16 and −0.66. Although many studies in low-and-middle-income countries now employ dynamic specifications, few consider the time series properties of the data and apply appropriate techniques to account for these properties.

Hsieh *et al.'s* (1999) Taiwan, China study was also novel in that it estimated separate price and income elasticities for domestic and imported cigarettes. They found that consumers of imported cigarettes were more price responsive than consumers of domestic cigarettes.

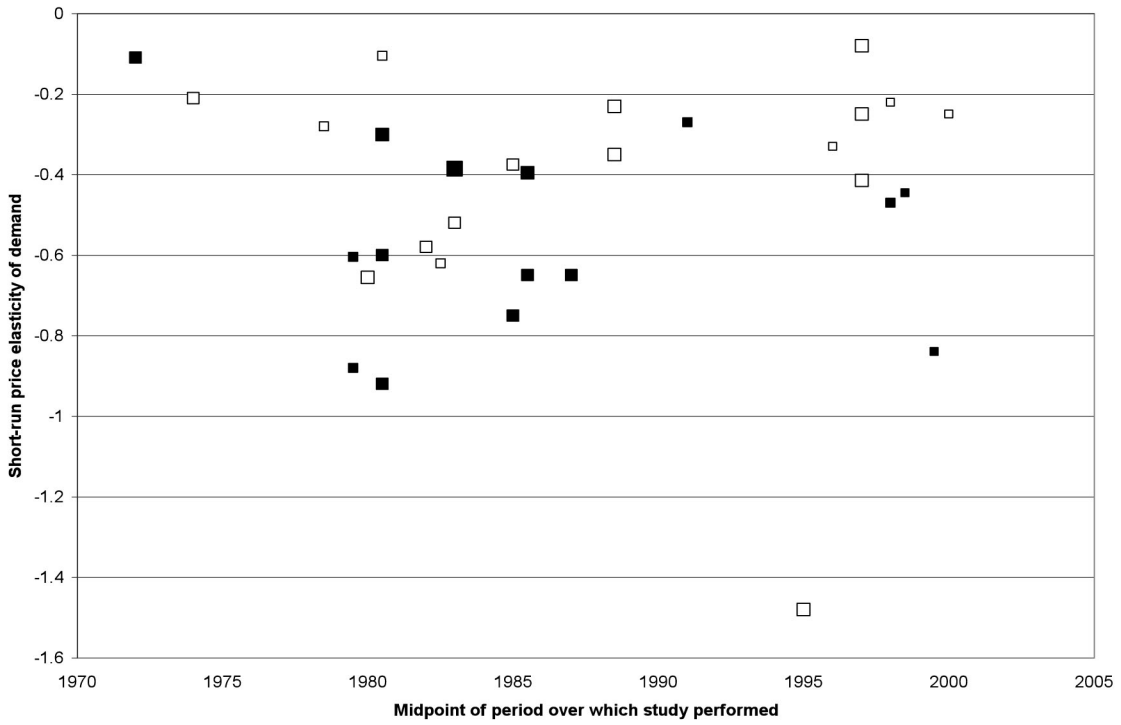
This should be expected since imported cigarettes are more expensive than domestic cigarettes. The estimated price elasticities for imported cigarettes ranged between −1.08 and −1.28, while the price elasticities for domestic cigarettes ranged between −0.56 and −0.73. Domestic and imported cigarettes were also found to be substitutes in consumption.

Two recent studies in Taiwan, China employed a systems approach to understand the substitutive behaviour between cigarettes, alcohol and betel nuts (Lee, 2007) and between imported cigarettes, domestic cigarettes and cigars (Lee and Chen, 2008). Lee (2007) found both alcohol and betel nuts to be complements in consumption to cigarettes. Lee and Chen (2008) found that imported and domestic cigarettes are substitutes, as expected. Imported cigarettes and cigars were also found to be substitutes in consumption, while domestic cigarettes and cigars were found to be complements in consumption.

The primary aim of most of these studies was to estimate the price elasticity of demand. The elasticity estimates varied significantly from one country to another, but as was the case with the earlier studies on the demand for tobacco in developing countries, they practically all found a relatively inelastic demand for cigarettes.

[12] These studies were, respectively, by Onder (2002) and Yurekli *et al.* (2010), Aloui (2003), Hu and Mao (2002), Hanafy *et al.* (2011) and Ali *et al.* (2003).

Figure 4.3. Price elasticity estimates for low- and middle-income countries, based on time series studies. White squares are dynamic studies and solid black squares are static studies.



Sources: Figure generated by the Working Group.
Note: The studies referred to in the figure can be found in Table 4.3. The table only includes short-run elasticities. The years refer to the middle year under investigation, hence the two most recent studies (Hanafy et al., 2011, and Yurekli *et al*., 2010) include data from 1990 to 2006 and 1960 to 2006 respectively and thus they are listed in 1998 and 1993 respectively.

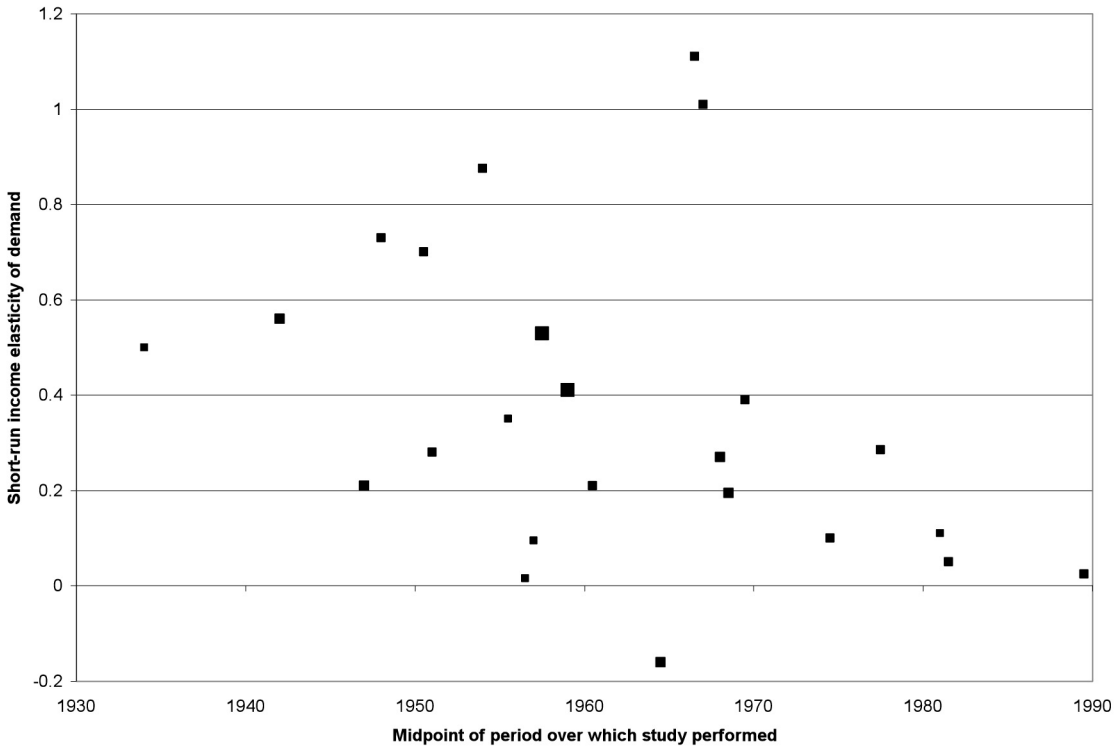
Figure 4.3 graphs all price elasticity studies in developing countries. It separates those studies which assume static specifications of demand (i.e. which do not control for the addictiveness of tobacco), represented by the solid black squares from those which assume dynamic specifications of demand (i.e. which control for the addictiveness of tobacco), represented by the white squares. Again, the larger data points represent a longer period under consideration in the study. The shortest time period is 5 years and the longest 46 years. When looking at only the static estimates, we find that the price elasticity of demand varies over a wide range between −0.2 and −1.0. However, when including only the dynamic estimates we find a narrower range of estimates between −0.1 and −0.7 (there is one outlier which is ignored). First, it is important to again confirm that all estimates indicate that tobacco is price-inelastic. Second, the range of elasticities differs somewhat between the static and dynamic specifications, with dynamic specifications resulting in a tighter range than static specifications.

Income elasticities

Most studies discussed have estimated income elasticities (the responsiveness of consumption as a result of a change in income). While this is generally not the intention of the studies, it is methodologically important to control for changes in income over time. Almost all of these studies find that tobacco is a normal good in that income has a positive impact on consumption, although this impact is not always statistically significant. The three figures below indicate the income elasticities estimated in the studies considered in the previous section and their evolution over time, Figure 4.4 for those studies in the USA, Figure 4.5 for other high-income countries and Figure 4.6 for low- and middle-income countries.

Almost all studies in the United States find that the income elasticity is positive and thus cigarettes are a normal good. Prior to 1970 the range of estimates was fairly wide (between 0 and 1.2) but has narrowed significantly since. Only

Figure 4.4. Income elasticity estimates for the USA, based on time series studies



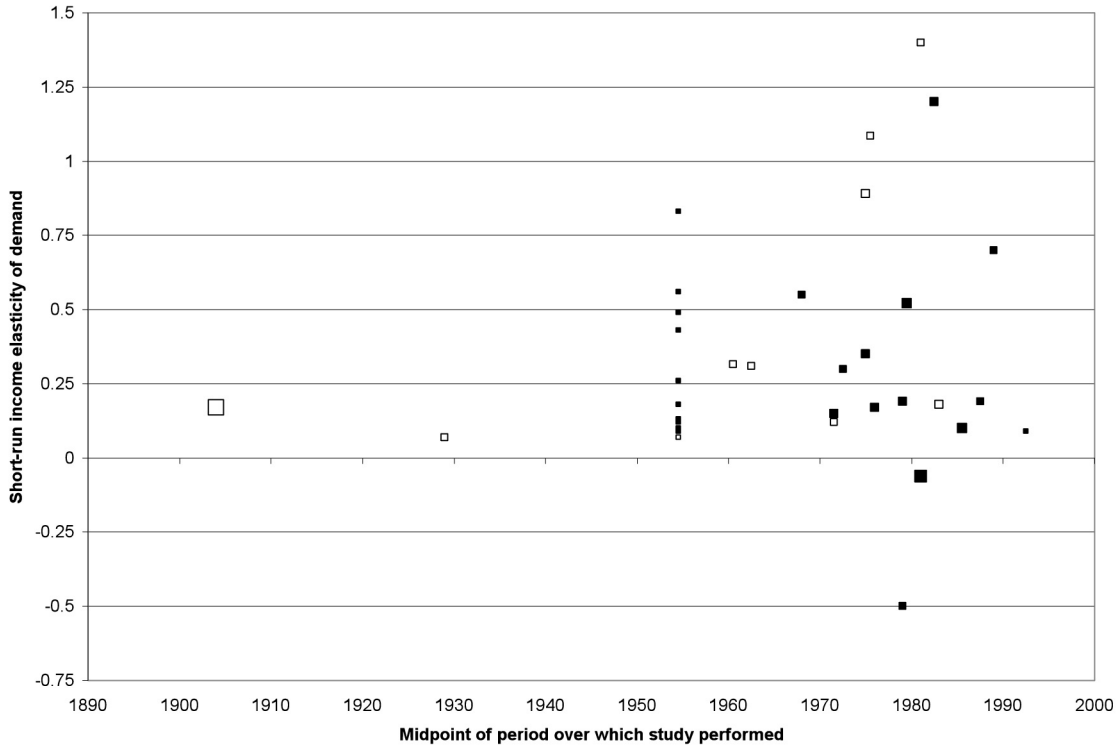
Sources: Figure calculated by the Working Group. The studies referred to in the figure can be found in Table 4.1. The table only includes short-run elasticities. The years refer to the middle year under investigation, hence the most recent study (Goel, 2009) includes data from 1975 to 2004 and is thus listed in 1989/90.

four studies found, in some but not all specifications, that the income elasticity is negative (Schmalensee, 1972, Porter, 1986, Baltagi *et al.*, 2000, Goel, 2009). Only one study (Porter, 1986) finds that the income elasticity is negative in all specifications. Figure 4.4 provides some evidence that income elasticities in the USA have fallen over time, indicating that consumption has become less sensitive to changes in income. This is not an unexpected result since higher incomes are associated with higher education, and higher education in itself is associated with lower consumption (presumably through a better understanding of the health consequences of smoking) (Kenkel and Chen, 2000).

From Figure 4.5 one can see that, for the most part, tobacco is a normal good in other developed countries. The figure separates the estimates for the United Kingdom (white squares) and other developed countries (solid black squares), and shows that all estimates in the United Kingdom are positive. In other developed countries negative estimates are found in two countries: New Zealand (Chetwynd *et al.*, 1988, Harrison *et al.*, 1989) and Italy (Pierani and Tiezzi, 2009). It is not possible to generalize the trends in elasiticites over time in developed countries although one may say with a fair degree of confidence that tobacco is a normal good in developed countries and that income elasticities tend to lie between 0 and 1.

All estimates of the income elasticity of demand in developing countries are positive, indicating that tobacco is a normal good (see Figure 4.6). Since developing countries are poorer and in an earlier stage of the tobacco epidemic (Lopez *et al.*, 1994), one would expect increases in income to be associated with greater tobacco consumption. When one considers estimates that employed a static specification of demand (i.e. not accounting for the addiction of tobacco, indicated by solid black squares) we find a broad range of results between 0.2 and 1.0 and two higher outliers. However, when one considers only dynamic specifications (i.e. accounting for addiction through a myopic or rational addiction model – white squares) we

Figure 4.5. Income elasticity estimates for other high-income countries, based on time series studies. White squares are United Kingdom studies and solid black squares are other high-income countries.



Sources: The studies referred to in the figure can be found in Table 4.2. The table only includes short-run elasticities. Estimates for several countries come from a single study by Koutsoyiannis (1963) and result in a grouping on the midpoint 1954/1955. The years refer to the middle year under investigation, hence the most recent study (Pierani and Tiezzi, 2009) includes data from 1960 to 2002 and is thus listed in 1981.

find estimates between 0 and 0.6. However, since many developing countries are growing rapidly, large increases in tobacco consumption are likely to occur in a relatively short period of time. For example, annual GDP growth of 8% may result in an annual increase in tobacco consumption of 4.8% (assuming an income elasticity of 0.6). Given the impact of compounding, this could result in a doubling of consumption in 15 years.

Affordability

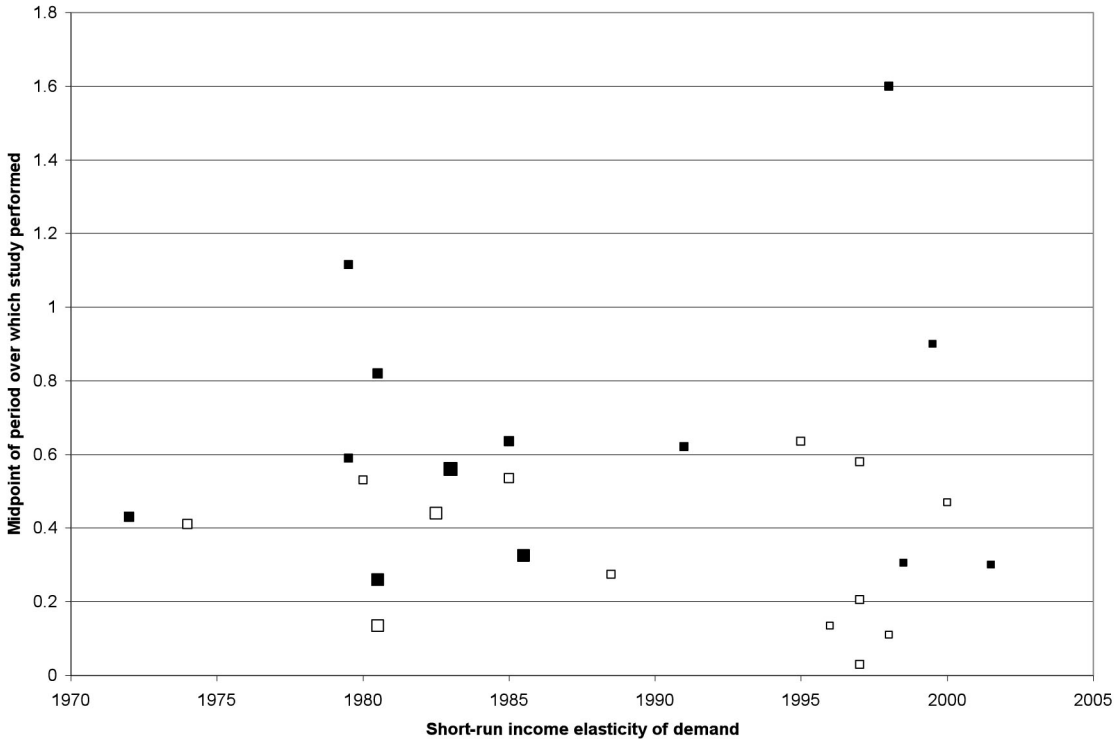
The studies reviewed typically do not focus on the impact of changes in income on the demand for cigarettes. Most studies include income in the demand specification as a control variable. Even if one knew by how much cigarette consumption changes in response to a change in income, few people would argue against economic growth on the grounds that it would increase the demand for cigarettes.

In recent decades some countries, mainly in Asia, have achieved rapid economic growth rates. In China, India, Indonesia, Viet Nam and Bangladesh, real per-capita gross domestic product (GDP) has grown at annual rates of 6% or more (Blecher and van Walbeek, 2009). The literature shows that as incomes rise, so does the consumption of tobacco products.

Affordability considers the simultaneous effect of income and cigarette price, whereas conventional studies consider the effect of price and income in isolation. One can investigate the level of affordability (in a cross-sectional context) or inter-temporal changes in affordability. Affordability refers to the quantity of resources (not exclusively monetary) required to purchase tobacco products.

A limited number of published studies have explicitly investigated the affordability of cigarettes (Scollo, 1996; Lal and Scollo, 2002; Guindon *et al*., 2002; Blecher and van Walbeek, 2004,2009; Kan, 2007). Guindon *et al*. (2002) and Kan (2007) define affordability as the time worked to purchase a pack of cigarettes. Guindon *et al*. (2002) found that cigarettes became less

Figure 4.6. Income elasticity estimates for low- and middle-income countries, based on time series studies. White squares are dynamic studies and solid black squares are static studies.



Sources: Figure calculated by the Working Group. The studies referred to in the figure can be found in Table 4.3. The table only includes short-run elasticities. The years refer to the middle year under investigation, hence the two most recent studies (Hanafy *et al.*, 2011, and Yurekli *et al.*, 2010) include data from 1990–2006 and 1960–2006 respectively; thus they are listed in 1998 and 1993 respectively.

affordable in most countries studied (both high-income and low- and middle-income countries) between 1990 and 2000. Kan, focusing on cities rather than countries, and on lower-income occupations, came to a similar result.

Blecher and van Walbeek (2004) considered a larger sample of countries, most of which were low- and middle-income countries. They defined affordability in terms of per-capita gross domestic product (GDP), and found that cigarettes were generally more affordable in high-income countries relative to low- and middle-income countries. They found that during the 1990s cigarettes became less affordable in high-income countries and more affordable in low- and middle-income countries. Furthermore, they found that cigarette affordability is inversely related to consumption, and that the affordability elasticity of demand is about −0.5. This is similar to the consensus price elasticity estimates in the previous sections. In a subsequent study, they updated their earlier study and found that cigarettes have become more affordable in low- and middle-income countries at an increasingly rapid rate since 2000. In almost all countries where cigarettes became less affordable, the real price increased; in most countries where cigarettes became more affordable, real price decreased.

The implication of international comparisons is that cigarette prices should not only be viewed in monetary terms but also in terms of their affordability. Fast-growing countries face greater tobacco control challenges, since rising incomes increase the affordability of cigarettes. The fact that cigarettes have become increasingly affordable in most low-income and middle-income countries is a major tobacco control failure.

A more recent paper by Blecher (2010) uses the concept of affordability to asses the risks of aggressive economic growth on tobacco consumption. Using the case study of South Africa he proposes that cigarette taxation be linked to changes in affordability rather than simply targeting the price or excise tax incidence (the percentage of the retail price that is taken up by excise). He also points out that simply maintaining affordability will

result in increases in consumption and that cigarettes must become less affordable to maintain or reduce consumption. Furthermore, this is especially important when taking cognisance that tobacco consumption is more responsive to increases in income in low- and middle-income countries relative to high-income countries.

Other recent applications of affordability include the tax reports commissioned by the Bloomberg Initiative to Reduce Tobacco Use (see for example Hu *et al*., 2008 or Guindon *et al*., 2010), the WHO MPOWER package (World Health Organization, 2008) and the Tobacco Atlas (Shafey *et al*., 2009).

Cross-country studies

Some studies have not focused on an individual country but rather on a group of countries. countries (Table 4.4). Such pooled or cross-country studies have generally, although not exclusively (Gallus *et al*., 2006), been used to consider the impact of advertising bans on tobacco consumption. Gallus *et al*. (2006) provides a cross-sectional view of demand in Europe (including 52 countries), finding price to be inelastic with estimates ranging from −0.46 to −0.74 with higher absolute elasticities in the non-European Union countries (−0.8 versus −0.4). This falls in line with the generalizations of the results in individual country studies. Even though the study uses aggregate data, the interpretation of the elasticity is not strictly comparable with the time series studies. Income is excluded from the analysis rather controlling for purchasing power parity in the price, and the model is estimated using a static specification. Furthermore, annual data are from different years.

The first cross-country study to analyse the impact of advertising restrictions was by Laugesen and Meads (1991), who investigated the impact of advertising restrictions on cigarette consumption in 22 OECD countries (all developed countries). They found that adverting restrictions significantly reduced tobacco consumption, and that the impact of these restrictions became more pronounced after 1970. Furthermore, they found cigarettes to be price-inelastic, and a global price elasticity of −0.20 and income elasticity of 0.28, in line with the single country studies in developed countries. In response, Stewart (1993) performed a similar study to that of Laugesen and Meads (1991) and found that advertising bans did not have a significant impact on cigarette consumption. A global price elasticity of demand of −0.31 was estimated (again in line with single-country studies in high-income countries) while income was excluded from the specification.

Economists have noted that partial advertising bans are relatively ineffective in reducing tobacco consumption, while comprehensive bans seem to be much more effective (Jha and Chaloupka, 1999). Using data from 22 OECD countries, Saffer and Chaloupka (2000) found that the imposition of comprehensive advertising bans would reduce cigarette consumption while partial advertising bans did not have a significant impact. A global price elasticity of demand was estimated to lie between −0.41 and −0.55, with income having a positive impact on consumption.

Nelson (2003) used a cross-country model to test whether advertising bans are endogenously determined with consumption. Nelson indicates that the most comprehensive advertising bans only came into being once large-scale decreases in consumption had occurred. To test this hypothesis, he estimated a two-stage model treating advertising restrictions endogenously. Nelson found the price elasticity to range between −0.26 and −0.44 and the income elasticity to range between 0.09 and 0.28. However, he did not find advertising restrictions to be significant although the consistent negative coefficients decreased over time, indicating that advertising restrictions have become less important in determining consumption over time. Nelson was unable to reject the null hypothesis that advertising bans and restrictions were exogenous.

Blecher (2008) advanced the literature further by including 30 developing countries in addition to 21 developed countries in the cross-section of countries. Blecher followed the Saffer and Chaloupka (2000) model of analysing both limited and comprehensive advertising bans, finding that advertising bans reduce consumption and specifically that comprehensive bans are more effective than limited bans. Furthermore, Blecher found the price elasticity of demand to range between −0.09 and −0.13 and income elasticities between 0.07 and 0.21. The absolute magnitudes of the elasticities were significantly smaller in the Blecher study compared to the other studies.

All of these studies estimated a global elasticity rather than individual country elasticities. This may be appropriate in high-income countries but when low-and-middle-income countries are included this may not be appropriate due to larger inter-country differences in low- and middle-income countries. The use of a model that does not impose homogeneity and a global elasticity might result in estimates that fall within the expected range.

Table 4.4. Cross-country studies employing aggregate data

Study	Countries	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Laugesen and Meads (1991)	22 OECD countries	-0.20	0.28	Advertising restrictions score (negative), Female labour participation rate (negative), Manufactured cigarettes as fraction of total tobacco consumption (positive)	Static pooled log linear GLS	Pooled annual data from 1960 to 1986	The advertising restriction score is problematic as well as the pooling of the data with no fixed effects. Thoroughly critiqued by Stewart (1992 and 1993), High (1999), Saffer & Chaloupka (2000), Blecher (2008).
Stewart (1993)	22 OECD countries	**All countries** -0.31 for middle year, but was decreasing (in absolute terms) over time **Individual countries** *Austria* (-0.34) *Australia* (insig.) *Belgium* (-0.61) *Canada* (-0.37) *Denmark* (-0.29) *Finland* (-0.45) *France* (-0.23) *Greece* (-0.35) *Iceland* (-0.32) *Ireland* (-0.30) *Italy* (-0.39) *Japan* (-0.18)	Not included	Advertising ban (insignificant), Quadratic trend (varied for different countries)	Static pooled non-linear OLS	Pooled annual data from 1964 to 1990	In response to Laugesen and Meads (1991). Thoroughly critiqued by Saffer & Chaloupka (2000), and by Blecher (2008). The advertising restrictions are accounted for poorly and the method is unreplicable. Was paid by the industry and did not disclose funding

Table 4.4. Cross-country studies employing aggregate data

Study	Countries	Estimated price elasticity	Estimated income elasticity	Control variables	Estimation method	Data	Comments
Stewart (1993) (contd)		*Netherlands* (-0.69) *New Zealand* (-0.25) *Norway* (-0.49) *Portugal* (insig.) *Spain* (-0.16) *Sweden* (-0.45) *Switzerland* (-0.83) **UK** (-0.55) *US* (-0.29) *West Germany* (-0.54)					
Saffer and Chaloupka (2000)	22 OECD countries	-0.41 to 0.55	Positive (significant in some specifications)	Advertising bans (negative), unemployment rate, percent of filter cigarettes, time fixed effects	Static log linear static fixed effects panel OLS	Pooled annual data from 1970 to 1992	Categorizes advertising bans as weak, limited or comprehensive
Nelson (2003)	20 OECD countries	-0.26 to -0.44	0.09 to 0.28	Advertising bans, warnings, unemployment rate, percent filtered cigarettes	Static log linear fixed effects panel OLS	Pooled annual data from 1970 to 1995	Tested endogeneity of advertising bans
Gallus *et al.* (2006)	52 European countries	-0.40 to -1.00 (higher in non-EU member countries)	Not included	Male to female smoking prevalence ratio (generally insignificant)	Static log linear pooled OLS	Cross sectional data for 2000 or nearest year	Income is excluded from the model in order to calculate a GDP-PPP adjusted price (essentially a measure of affordability)
Blecher (2008)	51 countries	-0.09 to -0.13	0.07 to 0.21	Advertising bans (negative)	Static log linear fixed effects panel OLS	Pooled annual data from 1990 to 2003	Includes 30 low- and middle-income countries

GLS, generalized least square estimates; OLS, ordinary least square estimates

Country differences include differing demographics, availability of substitutes and different tobacco products, tax structures and affordability.

The cross country literature is at a relatively early stage; thus most of the studies have varied significantly in methodology. Laugesen and Meads (1991) and Stewart (1993) employed pooled models including both cross-sections and time series. Saffer and Chaloupka (2000), Nelson (2003) and Blecher (2008) employed panel models by including country and/or time period fixed effects. Methodologically, the simple pooled models are not appropriate since they do not control for the vast differences between countries. The panel models do, but also make assumptions regarding homogeneity. Baltagi *et al*. (2000) tested this homogeneity assumption in a panel model using US states, finding that homogenous estimators are preferred to heterogeneous estimators. However, US states are more similar than different countries. Cross-country differences may not be significant in the studies that only include OECD countries, but this is likely to pose a far more significant problem in studies that include both developing and developed countries, or those that include only developing countries. Furthermore, all the cross-country models assume static specifications of demand, most likely as a result of the difficulties of estimating dynamic panel models where an instrumental variable technique is required.

Advertising bans comprises more than just bans on advertising, but other types of marketing including sponsorships. Measures of advertising bans do not capture price-based marketing measures including price discounts, price promotions, multiple pack purchases, etc. The global price and income elasticity estimates fall into the same ranges as those in individual country studies in high-income countries, although not in low-and-middle-income countries, likely the result of methodological and estimation issues rather than fundamental differences.

References

Abernethy AM, Teel JE (1986). Advertising regulation's effect upon demand for cigarettes. *J Advert,* 15:51–55.

Alcaraz VO (2006). Economia del Control del Tobaco en los paises del Mercosur y Estados Asociados: Bolivia. Washington, Organizacion Panamericana de la Salud.

Ali Z, Rahman A, Rahman T (2003). Appetite for nicotine: an economic analysis of tobacco control in Bangladesh. HNP Discussion Paper Series, Economics of Tobacco Control Paper No.16. Washington DC, The World Bank.

Aloui O (2003). Analysis of the economics of tobacco in Morocco. HNP Discussion Paper Series, Economics of Tobacco Control Paper No.7. Washington DC, The World Bank.

Andrews RL, Franke GR (1991). The determinants of cigarette consumption: a meta-analysis. *J Public Policy Mark,* 10:81–100.

Atkinson AB, Skegg JL (1973). Anti-smoking publicity and the demand for tobacco in the UK. *Manchester Sch Econ Soc Stud,* 41:282.

Auld MC, Grootendorst P (2002). An empirical analysis of milk addiction. Working paper 2001–17. University of Calgary, Department of Economics.

Baltagi B, Levin D (1986). Estimating dynamic demand for cigarettes using panel data: the effects of bootlegging, taxation and advertising reconsidered. *Rev Econ Stat,* 68:148–155 doi:10.2307/1924938.

Baltagi BH, Goel RK (1987). Quasi-experimental price elasticities of cigarette demand and the bootlegging effect. *Am J Agric Econ,* 69:750–754 doi:10.2307/1242184.

Baltagi BH, Griffin JM, Xiong W (2000). To pool or not to pool: homogenous versus hetergeneous estimators applied to cigarette demand. *Rev Econ Stat,* 82:117–126 doi:10.1162/003465300558551.

Bardsley P, Olekalns M (1999). Cigarette and tobacco consumption: have anti-smoking policies made a difference? *Econ Rec,* 75:225–240 doi:10.1111/j.1475-4932.1999.tb02452.x.

Bask M, Melkersson M (2004). Rationally addicted to drinking and smoking? *Appl Econ,* 36:373–381 doi:10.1080/0003684041000167 4295.

Becker GS, Grossman M, Murphy KM (1994). An empirical analysis of cigarette addiction. *Am Econ Rev,* 84:396–418.

Becker GS, Murphy KM (1988). A theory of rational addiction. *J Polit Econ,* 96:675–700 doi:10.1086/261558.

Bishop JA, Yoo JH (1985). "Healh scare", excise taxes and advertising ban in the cigarette demand and supply. *South Econ J,* 52:402–411 doi:10.2307/1059626.

Blecher E (2008). The impact of tobacco advertising bans on consumption in developing countries. *J Health Econ,* 27:930–942.doi:10.1016/j.jhealeco.2008.02.010 PMID:18440661

Blecher EH (2010). Targeting the affordability of cigarettes: a new benchmark for taxation policy in low-income and-middle-income countries. *Tob Control,* 19:325–330.doi:10.1136/tc.2009.030155 PMID:20530141

Blecher EH, van Walbeek CP (2004). An international analysis of cigarette affordability. *Tob Control,* 13:339–346.doi:10.1136/tc.2003.006726 PMID:15564616

Blecher EH, van Walbeek CP (2009). Cigarette affordability trends: an update and some methodological comments. *Tob Control,* 18:167–175.doi:10.1136/tc.2008.026682 PMID:19179369

Boshoff WH (2008). Cigarette demand in South Africa over 1996–2006: the role of price, income and health awareness. *S Afr J Econ,* 76:1–16.

Camerer C, Loewenstein G (2002). Behavioural Economics: Past, Present and Future. Division of Humanities and Social Sciences, Caltech, Pasadena; Department of Social and Decision Sciences, Carnegie-Melton University, Pittsburgh

Cameron S (1997). Are Greek smokers rational addicts? *Appl Econ Lett,* 4:401–402 doi:10.1080/135048597355122.

Chaloupka FJ (1991). Rational addictive behavior and cigarette smoking. *J Polit Econ,* 99:722–742 doi:10.1086/261776.

Chaloupka FJ, Grossman M (1996). Price, tobacco control policies and youth smoking. NBER Working Paper Series. Working Paper #5740. Cambridge, MA, National Bureau of Economic Research.

Chaloupka FJ, Hu TW, Warner KE *et al.* (2000b). Taxation of tobacco products. In: Jha P, Chaloupka F, eds., *Tobacco control in developing countries*. Oxford, U.K., Oxford University Press: 237–272.

Chaloupka FJ, Laixuthai A (1996). US trade policy and cigarette smoking in Asia. NBER Working Paper Series. Working Paper#5543. Cambridge, MA, National Bureau of Economic Research.

Chaloupka FJ, Pacula RL (1998). An examination of gender and race differences in youth smoking responsiveness to price and tobacco control policies. NBER Working Paper Series. Working Paper#6541. Cambridge, MA, National Bureau of Economic Research.

Chaloupka FJ, Tauras JA, Grossman M (2000a). The economics of addiction. In: Jha P, Chaloupka F, eds., *Tobacco control in developing countries.* Oxford, U.K., Oxford University Press.

Chaloupka FJ, Warner KE (1999). The Economics of Smoking. In: Culyer AJ, Newhouse JP, eds., *Handbook of Health Economics Volume 1B.* Oxford, UK, Elsevier: 1539–1627.

Chaloupka FJ, Wechsler H (1997). Price, tobacco control policies and smoking among young adults. *J Health Econ,* 16:359–373. doi:10.1016/S0167-6296(96)00530-9 PMID:10169306

Chapman S (1989). The limitations of econometric analysis in cigarette advertising studies. *Br J Addict,* 84:1267–1274.doi:10.1111/j.1360-0443.1989.tb00723.x PMID:2513013

Chapman S, Richardson J (1990). Tobacco excise and declining tobacco consumption: the case of Papua New Guinea. *Am J Public Health,* 80:537–540.doi:10.2105/AJPH.80.5.537 PMID:2327528

Chetwynd J, Coope P, Brodie RJ, Wells E (1988). Impact of cigarette advertising on aggregate demand for cigarettes in New Zealand. *Br J Addict,* 83:409–414.doi:10.1111/j.1360-0443.1988.tb00487.x PMID:3155345

Cooley TF, Prescott EC (1976). Estimation in the presence of stochastic parameter variation. *Econometrica*, 44:167–184 doi:10.2307/1911 389.

Da Costa e Silva VL (1998). The Brazilian cigarette industry: prospects for consumtion reduction. In: *The economics of tobacco control: towards an optimal policy mix.* Cape Town, Applied Fiscal Research Centre, University of Cape Town.

De Beyer J, Waverley Brigden L (2003). Tobacco control policy: strategies, successes and setbacks. Washington and Ottawa, World Bank and Research for International Tobacco Control.

Debrott Sanchez D (2006). Economia del control del tobaco en los paises del Mercosur y Estados Asociados: Chile. Washington DC, Organizacion Panamericana de la Salud.

Djutaharta T, Viriya-Surya H, Haidy N *et al.* (2005). Aggregate analaysis of the impact of cigarette tax rate increases on tobacco consumption and government revenue: the case of Indonesia. HNP Discussion Paper Series, Economics of Tobacco Control Paper No.25. Washington DC, The World Bank..

Duffy M (1991). Advertising and the consumption of tobacco and alcohol drink: a system-wide analysis. *Scott J Polit Econ,* 38:369–385 doi:10.1111/j.1467-9485.1991.tb00325.x.

Duffy M (1995). Advertising in demand systems for alcoholic drinks and tobacco: a comparative study. *J Policy Model,* 17:557–577 doi:10.1016/0161-8938(95)00020-8.

Duffy M (2006). Tobacco consumption and policy in the United Kingdom. *Appl Econ,* 38:1235–1257 doi:10.1080/00036840500392599.

Economics of Tobacco Control in South Africa Project (1998). The economics of tobacco control in South Africa. Report submitted to the International tobacco Initiative. Cape Town, Applied Fiscal Research Centre, School of Economics, University of Cape Town.

Enders W (2004). *Applied econometric time series.* John Wiley and Sons, Inc.

Escario J, Molina J (2004). Modeling the optimal fiscal policy on tobacco consumption. *J Policy Model,* 26:81–93 doi:10.1016/j.jpolmod.2003.11.003.

Flewelling RL, Kenney E, Elder JP *et al.* (1992). First-year impact of the 1989 California cigarette tax increase on cigarette consumption. *Am J Public Health,* 82:867–869. doi:10.2105/AJPH.82.6.867 PMID:1585966

Florkowski WJ, McNamara KT (1992). Policy Implications of Alcohol and Tobacco Demand in Poland+. *J Policy Model,* 14:93–98 doi:10.1016/0161-8938(92)90025-8.

Fujii ET (1980). The demand for cigarettes: further empirical evidence and its implications for public policy. *Appl Econ,* 12:479–489 doi:10.1080/00036848000000008.

Gajalakshmi CK, Jha P, Randon K *et al.* (2000). Global patterns of smoking and smoking-attributable mortality. In: Jha P, Chaloupka F, eds., *Tobacco control in developing countries.* Oxford, U.K., Oxford University Press: 11–39.

Gallus S, Fernandez E, Townsend J *et al.* (2003). Price and consumption of tobacco in Italy over the last three decades. *Eur J Cancer Prev,* 12:333–337.doi:10.1097/00008469-200308000-00015 PMID:12883388

Gallus S, Schiaffino A, La Vecchia C *et al.* (2006). Price and cigarette consumption in Europe. *Tob Control,* 15:114–119.doi:10.1136/tc.2005.012468 PMID:16565459

Goel RK (2009). Cigarette prices and illicit drug use: is there a connection? *Appl Econ,* 41:1071–1076 doi:10.1080/00036840601019141.

Gonzáles-Rozada M (2006). Economia del control del tobaco en los paises del Mercosur y Estados Asociados: Argentina: 1996–2004. Washington DC, Organizacion Panamericana de la Salud.

Grossman M, Chaloupka FJ, Sirtalan I (1998). An empirical analaysis of alcohol addiction: results from the monitoring the future panels. *Econ Inq,* 36:39–48 doi:10.1111/j.1465-7295.1998.tb01694.x.

Gruber J, Köszegi B (2001). Is addiction "rational"? Theory and evidence. *Q J Econ,* 116:1261–1303 doi:10.1162/003355301753265570.

Gruber J, Köszegi B (2002). A theory of government regulation of addictive bads: optimal tax levels and tax incidence for cigarette excise taxation. NBER Working Paper Series. Working Paper #8777. Cambridge, MA, National Bureau of Economic Research.

Gruber J, Mullainathan S (2002). Do cigarettes make smokers happier? NBER Working Paper Series. Working Paper #8872 Cambridge, MA, National Bureau of Economic Research.

Gruber J, Sen A, Stabile M (2003). Estimating price elasticities when there is smuggling: the sensitivity of smoking to price in Canada. *J Health Econ,* 22:821–842.doi:10.1016/S0167-6296(03)00058-4 PMID:12946461

Guhl N, Hughes D (2006). Cigarette smoking and Market Faikure: a determination of the economically efficient cigarette tax rate.

Guindon GE, Nguyen TTH, Hoang VK *et al.* (2010). *Tobacco Taxation in Vietnam.* Paris: International Union Against Tuberculosis and Lung Disease.

Guindon GE, Perucic A-M, Boisclair D (2003). Higher tobacco prices and taxes in South-East Asia: an effective tool to reduce tobacco use, save lives and generate revenue. HNP Discussion Paper Series, Economics of Tobacco Control Paper No.11. Washington DC, The World Bank..

Guindon GE, Tobin S, Yach D (2002). Trends and affordability of cigarette prices: ample room for tax increases and related health gains. *Tob Control,* 11:35–43.doi:10.1136/tc.11.1.35 PMID:11891366

Gujarati DN (2003). *Basic Econometrics.* New York, McGraw-Hill.

Hamilton JD (1994). *Time series analysis.* Princeton, Princeton Univeristy Press.

Hamilton JL (1972). The demand for cigarettes: advertising, the health scare, and the cigarette adverising ban. *Rev Econ Stat,* 54:401–411 doi:10.2307/1924567.

Hanafy K, Saleh ASE, Elmallah MEBE *et al.* (2011). The *Economics of Tobacco Taxation in Egypt.* Paris: International Union Against Tuberculosis and Lung Disease.

Harrison R, Chetwynd J (1990). Determinants of aggregate demand for cigarettes in New Zealand. Report No. Discussion Paper 9002. Canterbury, New Zealand, Department of Economics, University of Canterbury.

Harrison R, Chetwynd J, Brodie RJ (1989). The influence of advertising on tobacco consumption: a reply to Jackson and Ekelund. *Br J Addict,* 84:1251–1254 doi:10.1111/j.1360-0443.1989.tb00720.x.

High H (1999). Does advertising increase smoking? *Economics, free speech and advertising bans.* London: The Institute of Economic Affairs.

Holak SL, Reddy SK (1986). Effects of a television and radio advertising ban: a study of the cigarette industry. *J Mark,* 50:219–227 doi:10.2307/1251297.

Hondroyiannis G, Papapetrou E (1997). Cigarette consumption in Greece: empirical evidence from cointegration analysis. *Appl Econ Lett,* 4:571–574 doi:10.1080/135048597355050.

Hsieh CR, Hu TW, Lin CFJ (1999). Demand for cigarettes in Taiwan: domestic versus imported cigarettes. *Contemp Econ Policy,* 17:223–234 doi:10.1111/j.1465-7287.1999.tb00677.x.

Hu T, Keeler TE, Sung HY, Barnett PG (1995b). The impact of California anti-smoking legislation on cigarette sales, consumption and prices. *Tob Control,* 4 suppl.1;S34–S38.

Hu T, Mao Z (2002). Economics analysis of tobacco and options for tobacco control. HNP Discussion Paper Series, Economics of Tobacco Control Paper No.3. Washington DC, The World Bank.

Hu T, Sung HY, Keeler TE (1995a). The state antismoking campaign and the industry response: the effects of adverising on cigarette consumption in California. *AEA Papers and Proceedings,* 85:85–90.

Hu TW, Bai J, Keeler TE *et al.* (1994). The impact of California Proposition 99, a major anti-smoking law, on cigarette consumption. *J Public Health Policy,* 15:26–36. doi:10.2307/3342605 PMID:8027359

Hu TW, Mao Z, Shi J *et al.* (2008). Tobacco Taxation and Its Potential Impact in China. Paris, International Union Against Tuberculosis and Lung Disease.

Huang BN, Yang CW, Hwang MJ (2004). New evidence on demand for cigarettes: a panel data approach. *International Journal of Applied Economics,* 1:97.

Iglesias R (2006). Economia del control del tobaco en los paises del Mercosur y Estados Asociados: Brasil. Washington DC, Organizacion Panamericana de la Salud.

Jackson JD, Ekelund RB Jr (1989). The influence of advertising on tobacco consumption: some problems with Chetwynd *et al.*'s analysis. *Br J Addict,* 84:1247–1250, discussion 1251–1254.doi:10.1111/j.1360-0443.1989.tb00719.x PMID:2519560

Jha P, Chaloupka FJ (1999). *Curbing the epidemic. Governments and the Economics of Tobacco Control.* Washington D.C., World Bank.

Jha P, Chaloupka FJ (2000). *Tobacco control in developing countries.* New York, Oxford University Press on behalf of WHO and the World Bank.

Jha P, Musgrave P, Chaloupka FJ *et al.* (2000). Chapter 7: the economic rationale for intervention in the tobacco market. In: Jha P, Chaloupka FJ, eds., *Tobacco control in developing countries.* New York, Oxford University Press on behalf of WHO and the World Bank.

Johnson LW (1986). Advertising expenditure and aggregate demand for cigarettes in Australia. *Int J Advert,* 5:45–58.

Kan MY (2007). Investigating cigarette affordability in 60 cities using the cigarette price-daily income ratio. *Tob Control,* 16:429–432.doi:10.1136/tc.2007.020487 PMID:18048622

Kao K, Tremblay VJ (1988). Cigarette health scare, excise taxes, and advertising ban [comment]. *South Econ J,* 54:770–776 doi:10.2307/1059019.

Keeler TE, Hu TW, Barnett PG *et al.* (1996). Do cigarette producers price-discriminate by state? An empirical analysis of local cigarette pricing and taxation. *J Health Econ,* 15:499–512.doi:10.1016/S0167-6296(96)00498-5 PMID:10164041

Keeler TE, Hu TW, Barnett PG, Manning WG (1993). Taxation, regulation, and addiction: a demand function for cigarettes based on time-series evidence. *J Health Econ,* 12:1–18.doi:10.1016/0167-6296(93)90037-F PMID:10126486

Kenkel D, Chen L (2000). Consumer information and tobacco use. In: Jha P, Chaloupka FJ, eds., *Tobacco control in developing countries.* Washington, World Bank.

Kim S, Seldon BJ (2004). the demand for cigarettes in the Republic of Korea and implucations for government policy to lower cigarette consumption. *Contemp Econ Policy,* 22:299–308 doi:10.1093/cep/byh021.

Koutsoyiannis AP (1963). Demand functions for tobacco. *Manchester Sch Econ Soc Stud,* 31:1–19 doi:10.1111/j.1467-9957.1963.tb01009.x.

Lal A, Scollo M (2002). Big Mac index of cigarette affordability. *Tob Control,* 11:280–282.doi:10.1136/tc.11.3.280-b PMID:12198286

Lanoie P, Leclair P (1998). Taxation or regulation: looking for a good anti-smoking policy. *Econ Lett,* 58:85–89 doi:10.1016/S0165-1765(97)00258-9.

Laugesen M, Meads C (1991). Tobacco advertising restrictions, price, income and tobacco consumption in OECD countries, 1960–1986. *Br J Addict,* 86:1343–1354. doi:10.1111/j.1360-0443.1991.tb01710.x PMID:1751850

Lee JM (2007). The synergistic effect of cigarette taxes on the consumption of cigarettes, alcohol and betel nuts. *BMC Public Health,* 7:121.doi:10.1186/1471-2458-7-121 PMID:17592627

Lee JM, Chen HF (2008). The effects of price and smoking risk information on the demand for tobacco in Taiwan: an empirical study. *Appl Econ,* 40:1757–1767 doi:10.1080/00036840600905142.

Leeflang P, Reuijl J (1985). Advertising and insutry sales: an empirical study of the West German cigarette market. *J Mark,* 49:92–98 doi:10.2307/1251435.

Lopez AD, Collishaw NE, Piha TA (1994). A descriptive model of the cigarette epidemic in developed countries. *Tob Control*, 3:242–247 doi:10.1136/tc.3.3.242.

McGuinness T, Cowling K (1975). Advertising and the aggregate demand for cigarettes. *Eur Econ Rev,* 6:311–328 doi:10.1016/0014-2921(75)90015-X.

Metra Consulting Group Ltd (1979). The relationship between total cigarette advertising and total consumption in the United Kingdom. London.

Mindell J, Whynes D (2000). Cigarette consumption in The Netherlands 1970-1995: does tax policy encourage the use of hand-rolling tobacco? *Eur J Public Health,* 10:214–219 doi:10.1093/eurpub/10.3.214.

Nelson JP (2003). Cigarette demand, structural change, and advertising bans: international evidence, 1970–1995. *Contributions to Economic Analysis and Policy,* 2:1–27.

O'Donoghue T, Rabin M (2003). Studying optimal paternalism, illustrated by a model of sin taxes. *Am Econ Rev,* 93:186–191 doi:10.1257/000282803321947029.

Olekalns N, Bardsley P (1996). Rational addiction to caffeine: an analysis of coffee consumption. *J Polit Econ,* 104:1100–1104 doi:10.1086/262054.

Onder Z (2002). The economics of tobacco in Turkey: new evidence and demand estimates. HNP Discussion Paper Series, Economics of Tobacco Control Paper No.2. Washington DC, The World Bank.

Peng L, Ross H (2009). The impact of cigarette taxes and advertising on the demand for cigarettes in Ukraine. *Cent Eur J Public Health,* 17:93–98. PMID:19662827

Peterson DE, Zeger SL, Remington PL, Anderson HA (1992). The effect of state cigarette tax increases on cigarette sales, 1955 to 1988. *Am J Public Health,* 82:94–96. doi:10.2105/AJPH.82.1.94 PMID:1536343

Peto J (1974). Price and consumption of cigarettes: a case for intervention? *Br J Prev Soc Med,* 28:241–245. PMID:4455342

Pierani P, Tiezzi P (2009). Addiction and interaction between alcohol and tobacco consumption. *Empir Econ,* 37:1–23 doi:10.1007/s00181-008-0220-3.

Pindyck RS, Rubinfeld DL (1998). *Econometric models and economic forecasts, 4th Edition.* McGraw-Hill Book Companies Inc, Singapore.

Porter R (1986). The impact of government policy on the US cigarette industry. In: Ippolito P, Scheffman D, eds., Empirical approaches to consumer protection economics. US Government Printing Office: 447–484.

Prest AR (1949). Some experiments in demand analysis. *Rev Econ Stat,* 31:33–49 doi:10.2307/1927192.

Radfar M (1985). The effect of advertising on total consumption of cigarettes in the UK: A comment. *Eur Econ Rev,* 29:225–231 doi:10.1016/0014-2921(85)90053-4.

Ramos A (2006). Economia del control del tobaco en los paises del Mercosur y Estados Asociados: Uruguay. Washington DC, Organizacion Panamericana de la Salud.

Reekie WD (1994). Consumers' surplus and the demand for cigarettes. *Managerial and Decision Economics,* 15:223–234 doi:10.1002/mde.4090150304.

Reinhardt FS, Giles DE (2001). Are cigarette bans really good economic policy? *Appl Econ,* 33:1365–1368 doi:10.1080/00036840010007489.

Ross H, Al-Sadat NA (2007). Demand analysis of tobacco consumption in Malaysia. *Nicotine Tob Res,* 9:1163–1169.doi:10.1080/14622200701648433 PMID:17978990

Russell MA (1973). Changes in cigarette price and consumption by men in Britain, 1946–71: a preliminary analysis. *Br J Prev Soc Med,* 27:1–7. PMID:4717796

Saffer H (2000). Chapter 9: Tobacco advertising and promotion. In: Jha P, Chaloupka FJ, eds., *Tobacco control in developing countries.* New York, Oxford University Press on behalf of WHO and the World Bank.

Saffer H, Chaloupka F (2000). The effect of tobacco advertising bans on tobacco consumption. *J Health Econ,* 19:1117–1137. doi:10.1016/S0167-6296(00)00054-0 PMID:11186847

Schmalensee R (1972). *The economics of advertising.* Amsterdam, North-Holland.

Scollo M (1996). The Big Mac index of cigarette affordability. *Tob Control,* 5:69.doi:10.1136/tc.5.1.69a PMID:8795863

Seldon BJ, Boyd RG (1991). The stability of cigarette demand. *Appl Econ,* 23:319–326 doi:10.1080/00036849100000139.

Seldon BJ, Doroodian K (1989). A simultaneous model of cigarette advertising: effects on demand and industry response to public policy. *Rev Econ Stat,* 71:673–677 doi:10.2307/1928110.

Shafey O, Ericksen M, Ross H *et al.* (2009). *The Tobacco Atlas. Third Edition.* Atlanta, Georgia, American Cancer Society.

Simester D, Brodie R (1994). The effects of advertising on brand and industry demand for tobacco: a meta-analysis of econometric research. *New Zealand Journal of Business,* 16:21–37.

Stavrinos VG (1987). The effects of an anti-smoking campaign on cigarette consumption: empirical evidence from Greece. *Appl Econ,* 19:323–329 doi:10.1080/00036848700000004.

Stewart MJ (1992). Tobacco consumption and advertising restrictions: a critique of Laugesen and Meads (1991). *Int J Advert,* 11:97–118.

Stewart MJ (1993). The effect on tobacco consumption of advertising bans in OECD countries. *Int J Advert,* 12:155–180.

Stone R (1945). The analysis of the market demand. *JR Stat Soc,* 108:286–346 doi:10.2307/2981291.

Sumner MT (1971). The demand for tobacco in the UK. *Manchester Sch Econ Soc Stud,* 39:23–36 doi:10.1111/j.1467-9957.1971.tb00365.x.

Sung HY, Hu T, Keeler TE (1994). Cigarette taxation and demand: an empirical model. *Contemp Econ Policy,* 12:91–100 doi:10.1111/j.1465-7287.1994.tb00437.x.

Taal A, Kiivet R, Hu TW (2004). The economics of tobacco in Estonia. HNP Discussion Paper Series, Economics of Tobacco Control Paper No.9. Washington DC, The World Bank.

Tansel A (1993). Cigarette demand, health scares and education in Turkey. *Appl Econ,* 25:521–529 doi:10.1080/00036849300000060.

Tauras JA, Chaloupka FJ (1999). Price, clean indoor air laws and cigarette smoking: evidence from longitudinal data for young adults. NBER Working Paper Series. Working Paper #6937. Cambridge, MA, National Bureau of Economic Research.

Tauras JA, O'Malley PM, Johnston LD (2001). Effects of price and access laws teenage smoking intiation: a national longitudinal analysis. Research Paper Series Number 2. University of Illinois, Chicago, impacTEEN, YES! (Youth, Education and Society).

Tegene A (1991). Kalman filter and the demand for cigarettes. *Appl Econ,* 25:521–529.

Thursby JG, Thursby MC (1994). Interstate cigarette bootlegging; extent, revenue losses, and effects of federal intervention. NBER Working Paper Series. Working Paper #4763. Cambridge, MA, National Bureau of Economic Research.

Thursby JG, Thursby MC (2000). Interstate cigarette bootlegging; extent, revenue losses, and effects of federal intervention. *Natl Tax J,* 53:59–77.

Townsend J (1987). Cigarette tax, economic welfare and social class patterns of smoking. *Appl Econ,* 19:355–365 doi:10.1080/00036848700000007.

Townsend J, Roderick P, Cooper J (1994). Cigarette smoking by socioeconomic group, sex, and age: effects of price, income, and health publicity. *BMJ,* 309:923–927. PMID:7950662

Tremblay CH, Tremblay VJ (1995). The impact of cigarette advertising on consumer surplus, profit, and social welfare. *Contemp Econ Policy,* 13:113–124 doi:10.1111/j.1465-7287.1995.tb00718.x.

U.S. Department of Health Education and Welfare (USDHEW) (1964). Smoking and health: report of the advisory committee to the surgeon general of the public health service. Washington DC, US Department of health, Education, and Welfare, Public Health Service.

U.S. Department of Health and Human Services (USDHHS) (2000). Reducing Tobacco Use. A Report of the Surgeon General. Atlanta,GA, U.S. Dept. of Health and Human Services, Center for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

Valdés B (1993). Cigarette consumption in Spain: empirical evidence and implications for public health policy. *Appl Econ,* 25:149–156 doi:10.1080/00036849300000019.

Van Walbeek CP (1996). Excise taxes on tobacco: how much scope does the government have? *S Afr J Econ,* 64:21–42.

Van Walbeek CP (2002). Economics of Tobacco Control Project (Phase II), 2002. The economics of tobacco control in South Africa. Applied Fiscal Research Centre. ISBN 0–7992–2174–0. Written by CP van Walbeek (145 pp).

Warner KE (1977). The effects of the anti-smoking campaign on cigarette consumption. *Am J Public Health,* 67:645–650.doi:10.2105/AJPH.67.7.645 PMID:879393

Warner KE (1981). Cigarette smoking in the 1970's: the impact of the antismoking campaign on consumption. *Science,* 211:729–731. doi:10.1126/science.7455711 PMID:7455711

Warner KE (1989). Effects of the antismoking campaign: an update. *Am J Public Health,* 79:144–151.doi:10.2105/AJPH.79.2.144 PMID:2913831

Warner KE (1990). Tobacco taxation as health policy in the Third World. *Am J Public Health,* 80:529–531.doi:10.2105/AJPH.80.5.529 PMID:2327526

Waters TM, Sloan FA (1995). Why do people drink? tests of the rational addiction model. *Appl Econ,* 27:727–736 doi:10.1080/00036849500000062.

Wilcox WB, Tharp M, Yang K (1994). Cigarette advertising and consumption in South Korea. *Int J Advert,* 13:333–346.

Wilcox WB, Vacker B (1992). Cigarette advertising and consumption in the United States, 1961–1990. *Int J Advert,* 11:269–278.

Witt SF, Pass CL (1981). The effects of health warnings and advertising on the demand for cigarettes. *Scott J Polit Econ,* 28:86–91 doi:10.1111/j.1467-9485.1981.tb00076.x.

Worgotter WG, Kunze M (1986). Cigarette prices and cigarette consumption in Austria 1955–83. *N Y State J Med,* 3:478–479.

World Health Organization (2008). WHO report on the global tobacco epidemic 2008: the MPOWER package. Geneva, World Health Organization.

Yorozu I, Zhou Y (2002). The demand for cigarettes in Japan: impact of information dissemination on cigarette consumption. *Contemp Econ Policy,* 20:72–82 doi:10.1093/cep/20.1.72.

Yuanliang B, Zongyi Z (2005). Aggregate cigarette demand and regional differences in China. *Appl Econ,* 37:2523–2528 doi:10.1080/00036840500358640.

Yurekli A, Onder Z, Erk N *et al.* (2010). The economics of tobacco taxation: challenges and opportunities for a tobacco free Turkey. Paris, International Union Against Tuberculosis and Lung Disease.