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A welfare analysis of tobacco use

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Non-technical summary

This chapter examines the costs and benefits of smoking with the aim of asking whether, in economic terms, tobacco on net makes the world better or worse off. Given that the analysis is relatively complex and technical, we provide a summary for the reader interested in the key findings and an outline of the methods used.

Introduction. Like most consumer goods, cigarettes have both costs and benefits. The chief benefits are the satisfaction and enjoyment that smokers receive from smoking. There are also profits to producers. The chief costs are death and disability among smokers themselves. Other costs, which are much smaller, include health damage to non-smokers from passive smoking.

In conventional economics, consumers are assumed to weigh the personal costs and benefits of any purchase. It is assumed that, in buying something, a consumer has judged the personal benefits to outweigh the personal costs. Therefore, conventional cost-benefit analyses exclude consumers' own costs and analyze only the costs that their consumption choices impose on others. In the case of smoking, the costs to smokers themselves—including the premature loss of life and health—should thus theoretically be excluded, because they are assumed to have been taken into account. However, it is argued here that smokers cannot be assumed to have taken all their personal costs into account, given the nature of tobacco as a consumer good. Most smokers start young, become addicted, and then face significant adjustment costs when trying to stop their addiction. In high-income countries, most adult smokers say they regret starting. The aim of this paper is to analyze the costs and benefits of smoking in a way that goes beyond the traditional approach and accounts for these factors.

Benefits. By examining the relationship between the price of a good and the demand for it (demand-elasticity), economists can approximate, but not precisely measure, the benefits people assign to that good. This is called consumer surplus, defined as the amount that people are prepared to pay for a product over and above its price. (The more benefits people assign to the product, the less willing they are to give it up at higher prices.) Cigarettes are addictive, so, in this analysis, we take addiction into account by assessing the demand-elasticity for tobacco over a long period rather than a short one, because consumers of addictive products will take longer than consumers of non-addictive products to adjust their demand for the product in response to price changes.

For producers, economists can approximate the benefits by examining the relationship between the price of a good and the amount of it supplied (supply-elasticity). This is called

producer surplus, and is calculated by estimating how much money could be taken from producers without reducing the amount that they would supply. Using empirical data on price, expenditures on cigarettes, and demand- and supply-elasticities, we can calculate estimates of consumers' and producers' surpluses in dollar terms.

Costs. While it is relatively easy to estimate the benefits of cigarettes, estimating costs is much more difficult. We use the following approach. First and most importantly, we assume that people are willing to pay to avoid death and disability. Thus, a smoker who fully understands the risks of smoking would be considered to have taken the loss of life and health into account. But an uninformed smoker would be considered not to have taken the loss of life into account, and would be willing to pay something to buy it back. Second, we assign a monetary value to what each year of healthy life would be worth to smokers. We use a standard measure, the disability-adjusted life-year, or DALY. This unit expresses the sum of years lost due to premature mortality and years lived with disability adjusted for severity. One DALY is thus one lost year of healthy life. We use a base value of \$7750 per DALY, which is average global per capita gross domestic product (GDP) weighted for tobacco consumption. This, according to various studies, is a very conservative value of what people are actually willing to pay to live an extra year. Third, using projections of the number of DALYs that will be attributed worldwide due to tobacco, if current smoking patterns continue between 1990 and 2020, we can estimate the monetary value of the future costs of smoking-attributable DALYs. Fourth, we determine what proportion of today's smokers would need to be uninformed about their health risks for the total smoking-attributable DALY burden to have the same dollar value as the sum of the consumer and producer surpluses. In other words, we ask what proportion of smokers would have to be uninformed about their risks for the costs of smoking to rise as high as the benefits—the point at which smoking would be considered to have no social benefits. It should be noted that other smoking-attributable costs, including external costs, are not considered in this analysis. Finally, we subject these values to various sensitivity analyses.

Key results. Depending on different assumptions, the proportion of smokers worldwide who would have to be uninformed for there to be no social benefits from smoking ranges from 3% to 23%. This may also be considered in terms of individual smokers' risk perceptions. If a typical or average smoker under-estimates his or her own health costs of smoking by 3 to 23%, then the net benefits are zero. We also use this framework to examine the impact of higher taxes on cigarettes. The resulting higher prices lead to loss of satisfaction, as some smokers give up or reduce smoking in response to the higher prices. This loss of satisfaction has a dollar value. However, if only 3% of smokers are uninformed about the risks of smoking, then the avoided costs of ill health exceed the costs of lost satisfaction that would be associated with a price rise of 10% due to tax. This suggests that modest tax increases are likely to enhance global welfare.

Discussion. The framework presented here is illustrative. The actual numeric results depend on several assumptions and limited data. The analyses do suggest that any discussion of benefits of smoking to smokers or producers must take into account that people are willing to pay to avoid death and disability and that there are substantial information problems in using tobacco. Given the evidence that many smokers do underestimate their future health costs, our analyses raise questions as to the validity of traditional assessments of the benefits of smoking.

6.1 Introduction

For determining policy toward tobacco, an estimate of the net social benefit of tobacco consumption—that is, an estimate of both costs and benefits—is very useful. Such an estimate provides an answer to the question: Does the presence of tobacco, on net, make the world better off or worse off? With the data currently available, this question is difficult to answer directly, but this paper develops an alternative approach that indirectly addresses this question. Conventional economic analysis defines total benefits as the sum of the consumers' total willingness to pay for tobacco products, net of expenditures, and all economic profits generated by tobacco production. Net benefits are determined by subtracting the relevant social costs from total benefits. Usually, the relevant social costs are so-called external costs (the value of resources utilized in the production or consumption of tobacco that are not taken into account by consumers or producers because they are borne by others). For example, smokers may not take into account the impact of environmental tobacco smoke (ETS) on the health of non-smokers who are present when they smoke. However, there are other costs that smokers may fail to take into account because they are uninformed or only partially informed about them. These costs have been omitted from previous studies, but we argue that they should be considered. The costs arise from consumers' lack of information about the health risks of tobacco. Most smokers start young, become addicted, and then face significant adjustment costs when trying to stop their addiction. Rather than determining the size of costs arising from uninformed tobacco use directly, which would be difficult given available data, we determine instead the fraction of the smoking population that would need to be uninformed for the total net benefits of tobacco use to be zero. To illustrate our approach we calculate this threshold percentage of uninformed smokers using World Bank data. Depending on various assumptions, this threshold percentage of uninformed smokers ranges from 3% to about 23%. These initial estimates mean that if more than one-quarter of the world's smokers are uninformed about smoking risks, then the net benefits of smoking are negative. An alternative interpretation is that if the typical or average smoker under-estimates the cost of smoking by between 3% and 23%, then there are net social costs. The approach parallels the classical cost–benefit technique of determining an internal rate of return, that is, finding an interest rate that equates net benefits with zero.

The analysis also underscores an important direction for future research. To assess and understand the impact of tobacco consumption, we need to have a better understanding of how well-informed individuals are about the addiction and the health consequences of tobacco consumption. There is already significant evidence indicating that many smokers initially under-estimate the addictive potential and health consequences of tobacco (see Chapter 8).

We also examine the incremental benefits and costs associated with a 10% increase in the retail price of cigarettes. The social cost of raising cigarette prices is the net reduction in consumer welfare and producer profits, the so-called deadweight loss. The social benefits of higher cigarette price arise from reductions in either external or uninformed costs. We find that the deadweight loss is an order of magnitude smaller than the

decline in tobacco-related death and disability. Accordingly, a price rise of 10% will generate net positive benefits if more than 3% of smokers are uninformed.

The paper is organized as follows. First, the theoretical underpinnings of measuring consumer benefits are briefly reviewed. We then present our estimates of net consumer benefits, i.e. consumer surplus. We then turn to producer benefits, i.e. producer surplus. Next we discuss costs and, in particular, explain the distinction between external and internal costs. We then present our estimates of the threshold percentage of smokers who would need to be uninformed about the health risks of smoking for the social benefits to be zero. Following this is a discussion of the incremental benefits and costs of a 10% increase in the price of tobacco. The paper closes with discussion of some implications and suggestions for further research.

6.2 The benefits of tobacco consumption

6.2.1 Introduction

The benefits of tobacco consumption flow from two sources. First, there are the profits earned by producers. While these are non-trivial amounts, of the order of US\$40 billion to \$50 billion per year, they are dwarfed by the primary source of benefits: the satisfaction derived by the consumers of tobacco products. Our results are sensitive to elasticity of demand, a concept discussed below, but our best guess is that annual consumer surplus (also considered below) is about \$236 billion (measured in 1990 prices). In this section, consumer surplus is discussed first, followed by a discussion of producer surplus.

6.2.2 Consumer surplus

For any standard economic commodity, there are two distinct, equally legitimate ways to measure the benefits to consumers. The first approach considers willingness to accept payment. One can ask, what is the total amount of compensation required by consumers so that they are just willing to give up tobacco products? Here, we are considering the cash amount that makes a consumer indifferent between consuming the product and not consuming the product. This benefit measure is referred to as compensating variation. In the case of tobacco products, this is equivalent to determining the size of the bribe or payment required to induce smokers to quit.

The second approach is based on willingness to pay. In particular, one measures benefits by determining the maximum amount consumers are willing to pay to prevent the loss of tobacco products. In this approach, we are asking how much a consumer would be willing to pay to continue smoking. This measure of consumer benefit is called equivalent variation. Both approaches are equally sound, but give different answers. In particular, willingness to accept payment is always larger than the willingness to pay.¹ For reasonable preferences, these two measures tend to move together: a large compensating variation implies a large equivalent variation. For cigarettes, however, the gap between equivalent variation and compensating variation may be

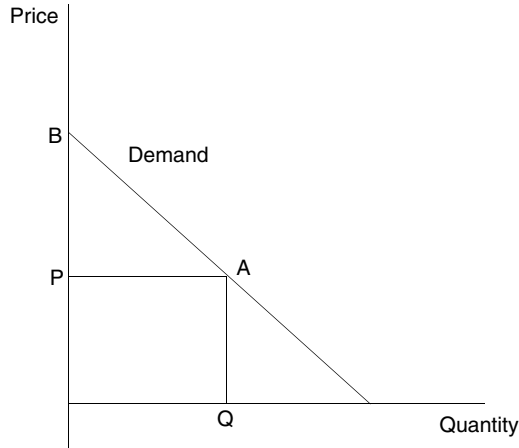


Fig. 6.1 Demand curve with consumer surplus PBA.

quite large; an addicted smoker may require infinite compensation to quit, yet his willingness to pay, since it is bounded by the smoker's income, may be finite. The two measures do assume different entitlements. In measuring compensating variation, one is implicitly assuming that individuals have the right to smoke and that one must pay people not to smoke. In contrast, equivalent variation, it has been argued, implicitly assumes that smokers do not possess the right to smoke and therefore must purchase this right.

When there is insufficient data available, it is standard to approximate benefits by considering consumer surplus.² The justification for such an approximation in the case of a non-addictive good is provided by Willig (1976), though the applicability of the Willig results for addictive goods remains an open research area. The standard interpretation of consumer surplus is that it gives net willingness to pay for a given amount of the commodity, that is, total willingness to pay minus what is actually spent. For a given price, consumer surplus is geometrically the area under the demand curve up to the amount consumed at the specified price minus the total amount paid for tobacco; this is shown as area of the triangle PBA in Fig. 6.1.

Consumer surplus is estimated as follows. The long-run demand curve is assumed to be linear, that is:

$$P = a - bQ. \quad (6.1)$$

¹ A statement and proof of this well-known result can be found in Hausman (1981).

² The framework we have outlined for determining consumer benefits is very general and can be applied to a variety of consumer goods. Many have argued, however, that the demand for tobacco is distinctive and special because tobacco is an addictive substance. A natural question to ask is what willingness to pay and willingness to accept payment mean for a good that is addictive. For economists, the analytical definition of an addictive good is that it is a good for which current consumption depends on past consumption, as well as on current price and other factors. Since past consumption depends on past prices, this implies that for

With a linear demand curve, if the current price is P and current consumption is Q and the price elasticity in absolute value at P and Q is e , then annual consumer surplus, CS , is:

$$CS = PQ/2e. \quad (6.2)$$

Price elasticity, e , measures the sensitivity of quantity demanded to changes in price; formally it is the percentage change in quantity demanded for a 1% increase in price. This consumer surplus formula indicates that consumer surplus varies inversely with the price elasticity.³ When the price elasticity is infinite, consumer surplus is zero and when the price elasticity is less than 0.5 in absolute value, consumer surplus exceeds total expenditures. This formula is very useful when data are limited, since consumer surplus can be calculated with only two variables: expenditures and price elasticity. Put differently, by assuming linear demand curves, there is sufficient structure to estimate consumer surplus with very limited data.

The principle shortcoming of linear demand curves is that they may not accurately portray behavior when tobacco prices are very high. Of course, we have no direct observations about the behavior of demand when prices are extremely high. However, for a linear demand curve, the price intercept is given by:

$$a = P(1 + 1/e), \quad (6.3)$$

where a is the price at which the demand for tobacco products is zero. This formula implies that if the price of cigarettes is \$2.00 and the observed elasticity at \$2.00 is -0.8 , then at a price of \$4.50, the long-run demand for tobacco products would be zero. The fact that this is not a very plausible conclusion can be taken as evidence that the assumption of linear demand curves may, for this reason, lead to an under-estimation of total consumer surplus. However, as outlined below, there are also reasons to believe that linear demand curves over-estimate total consumer surplus.

In implementing this formula, we take into account the fact that the retail price of cigarettes and the quantity of cigarettes consumed vary across regions. It is also likely that the price elasticity will vary from region to region, since per capita incomes vary considerably across regions. To compute total world annual consumer benefits over n regions, we have:

$$CS_{\text{world}} = 1/2[p_1q_1/e_1 + p_2q_2/e_2 + \dots + p_nq_n/e_n]. \quad (6.4)$$

an addictive good, current consumption levels are determined by past and current prices. For 'rational' addicts, future prices are also an important determinant of current consumption (see Chapter 5). In our analysis, we compare long-run steady-states so that prices and the long-run use of tobacco remain constant over time. Thus, when we talk about willingness to pay, we mean how much an individual is willing to pay to maintain smoking with the long-run price of tobacco at its current level. The compensating variation measure of benefits, when the long-run price is fixed at p , is the amount required to ensure that utility remains constant if the long-run price is raised arbitrarily high.

³ With a linear demand curve, the elasticity increases as the price rises, i.e. the elasticity varies along the demand curve. If the consumer surplus is computed at a different P and Q , then the elasticity has to be re-computed for that particular price and quantity combination.

This approach to consumer surplus takes into account the addictive nature of tobacco products in the following way. Economic theories of addiction indicate that for an addictive good, the elasticity of demand is greater in the long-run than in the short-run. Hence, for an addictive good, the long-run consumer surplus is smaller than the short-run consumer surplus. In determining the elasticity of demand, we distinguish two regions: the high-income countries, known as the established market economies (EME); and the rest of the world (Non-EME). For the established market economies, based on a large literature from high-income countries, we use a long-run price elasticity of -0.8 (see Chapter 10). For the rest of the world, we use a long-run price elasticity of -1.2 , based on the higher short-run elasticities in these countries and the finding from high-income countries that long-run demand is more elastic than short-run demand (see Chapter 10).⁴ The price of a pack of cigarettes in 1990 employed for EME countries is \$1.80. For India and China, the prices employed are \$0.40 and \$0.20, respectively. Finally, for the rest of the world, price is set at \$0.60 per pack. These estimated prices are based on data from the World Bank's tobacco database.

The level of expenditures for each World Bank region is given in Table 6.1. The annual consumer surplus for each region is given in column three of Table 6.2. The average annual per capita consumer surplus implied by our parameter values is \$108. One can think of this amount as approximately the average amount that would have to be paid to induce each smoker to quit for one year; this amount is bounded above by approximately \$3600.⁵ This is, of course, a global average and will vary from region to region, as well as varying from one individual to the next.

To convert this annual stream of consumer surplus into a discounted present value, annual consumer surplus is divided by the social discount rate, that is:

$$\text{Discounted Present Value of Consumer Surplus} = \text{CS}/r. \quad (6.5)$$

Here we are assuming that the annual stream of consumer surplus, denoted by CS, extends indefinitely; that is, the implicit time period over which we are discounting is infinite. Using a value of 0.03 for the social discount rate, the discounted sum of future consumer surplus is \$4.2 trillion.⁶ Table 6.2 presents the annual and discounted present value of consumer surplus for a range of price elasticities. The table indicates that our results are sensitive to assumptions about the price elasticity of demand. For example, if the demand elasticities in EME and non-EME countries are -0.2 and -0.4 , respectively, our estimates rise by a factor of 3.7. Geometrically this arises because, as demand becomes more inelastic, the demand curve becomes steeper and the area under the demand curve increases. The underlying economics is straightforward: more inelastic demand indicates that consumers are willing to continue purchasing the product at higher prices, indicating a greater willingness to pay. Because expenditures are high in the EME, the price elasticity assumed for this region is of particular importance.

⁴ This estimate for price elasticity is also consistent with estimates for US teenagers, who can be regarded as a lower income group relative to the remainder of the US population.

⁵ Here we assume that an individual is paid in one lump sum an amount equal to the present discounted value of an annual flow \$108 in perpetuity with an interest rate of 3%. If the interest rate is 5%, this is equal to \$2160.

⁶ Trillion is here defined as 1000 billion.

Table 6.1 Expenditures on tobacco

1990 Expenditures (Billions of 1990 US\$)	
Established market economies	148.2
Formally socialist economies	11.6
India	14.9
China	15.8
Other Asia and islands	15.3
Sub-Saharan Africa	3.7
Latin America and Caribbean	10.2
Middle Eastern Crescent	8.7

Table 6.2 The consumer surplus of tobacco use

EME price elasticity	Non-EME price elasticity	Annual consumer surplus (Billions\$)	Discounted consumer surplus (Billions\$)
0.2	0.4	471	15692
0.4	0.8	236	7846
0.6	1.0	156	5453
0.8	1.2	119	4201
1.0	1.4	97	3425
1.2	1.6	82	2894

All prices are in 1990 US\$.

The choice of a discount rate also affects our estimates of total discounted consumer benefits. The traditional range for the social rate of discount is between 3% and 6%. The fact that discounted benefits become arbitrarily large when the discount rate falls close to zero is an artifact of assuming an infinite horizon. With an infinite horizon, as the discount rate drops toward zero, the discounted value of benefits becomes unbounded. If we used a fixed horizon, say 30 years, then benefits have a finite upper bound, even as the discount rate approaches zero. The problem with using such a fixed horizon is, however, that this implicitly assumes that the flow of benefits beyond the horizon is zero, which is a problematic assumption.⁷

⁷ A shortcoming of the approach, as outlined, is that it does not account for economic growth or population growth, which will shift out the demand curve and lead to higher estimates of consumer surplus. It is straightforward to amend our framework, however, to account for growth. A simple way to account for economic growth is to assume that real expenditures are growing at fixed annual rate, say g . This means that the discounted consumer surplus will be given by approximately:

$$\text{Discounted Present Value of Consumer Surplus} = \text{CS}/(r-g).$$

For example, if real expenditures are growing at 2% annually, the discount rate is 3%, and the annual consumer surplus in 1990 equal to \$119 billion, then the discounted present value of consumer surplus will be \$11.9 trillion. This calculation assumes that the elasticities remain constant; if they fall over time then discounted consumer surplus will be higher.

Table 6.3 Per capita consumer surplus

	Per capita annual consumer surplus (1990 US\$)
Established market economies	173
Formerly socialist economies	22
India	12
China	9
Other Asia and islands	17
Sub-Saharan Africa	7
Latin America and Caribbean	17
Middle Eastern Crescent	15

Table 6.3 shows per capita annual consumer surplus by region (the total population, non-smokers and smokers, is included here). The most striking aspect of this table is the large disparity between per capita consumer surplus in established market economies (so-called EME countries) and per capita consumer surplus in the other regions: annual per capita consumer surpluses for the EME and non-EME regions differ by more than a factor of 10. The per capita annual consumer surplus in the EME countries is \$173, while for the other regions the average annual per capita consumer surplus is \$16.50. This reflects the higher expenditures for smokers in the EME; expenditures for EME countries are roughly 10 times as great as those of non-EME countries. This implies that, on a per capita basis, consumers in the EME currently receive a disproportionate share of the benefits from the consumption of tobacco products. After the established market economies, the formerly socialist economies have, at \$22 per person per year, the second highest per capita annual consumer surplus. This reflects the high per capita consumption of cigarettes in these countries (including the Czech Republic and Poland, which have the highest per capita consumption levels in the world). Sub-Saharan Africa, China, and India have relatively lower per capita annual consumer surplus, primarily reflecting lower cigarette prices.

The measurement and interpretation of consumer surplus is complicated by two confounding factors.⁸ The first is the addictive nature of cigarettes. Suppose that initially a consumer is not addicted and is deciding whether or not to try cigarettes. An individual may be uncertain about how she or he will respond to cigarettes. In particular, before trying cigarettes, the individual may not know his or her own addictive potential and how much he or she will like smoking. Depending on what type of person an individual is, there are a number of possible outcomes that arise when the individual experiments with cigarettes. For instance, one possible outcome is that cigarettes will be highly addictive for the individual but the individual may not, on net, like smoking. Here, experimentation would lead to addiction but the individual will regret his or

⁸ While we do not present a complete model of addiction, we discuss some relevant issues employing the framework of Orphanides and Zervos (1995) closely; see Chapter 5 for a more extensive discussion of economic models of addiction.

her decision to experiment with cigarettes. A second possibility is that an individual becomes addicted, but likes cigarettes, so that the individual becomes a 'happy addict' and does not regret the decision to try cigarettes. There is also a possibility that the individual will not like cigarettes and will not become addicted and will stop smoking. Thus consumers must make a decision about whether to try cigarettes under uncertainty, since they do not know which of these outcomes is most likely to apply to them personally. The individual has a subjective probability distribution over types and on the basis of this distribution, makes a consumption decision that maximizes expected utility subject to a budget constraint. For example, some individuals may believe that the probability of regretting the decision to try cigarettes is very high; that is, they believe that it is very likely that they will become addicted and not like cigarettes. Such individuals will accordingly decide not to experiment.

There is evidence that many individuals who try cigarettes consistently underestimate the addictive potential of cigarettes and over-estimate the benefits from cigarette smoking. On the assumption that the evidence is correct, the smoking population consists in part of individuals who are addicted but regret their decision to start smoking. A recent survey indicates that from 75% to 85% of current smokers in the United States would quit if they could, and regret their decision to start smoking. The 1994 Surgeon General's Report indicates that only 15% of teenagers smoking less than a pack a day think that they will be still smoking in 5 years. In fact, 5 years later, 42% of such teenagers are smoking at least one cigarette per day. Thus there is ample evidence that individuals under-estimate their propensity for addiction and over-estimate the utility that they will receive from smoking, leading to a high percentage of individuals expressing regret over the decision to begin smoking. For these individuals, the willingness to pay for cigarettes arises from the need to avoid the cost of ending their addiction to cigarettes, that is, the physical and psychological costs of withdrawing from cigarette use. Accordingly, addicted individuals who regret their decision to try cigarettes may have a positive willingness to pay for painless tobacco cessation. This suggests that one can argue that, for these individuals, the willingness to pay for cigarettes should be regarded as part of the cost of smoking and not a net economic benefit. Attempting to systematically take this into account in estimating consumer surplus would involve novel and somewhat speculative adjustments, and so is not pursued further. Nonetheless, this discussion strongly indicates that the consumer surplus estimates provided below should be regarded as upper bounds on the true consumer surplus.

The second caveat to keep in mind is that consumers may not be fully informed about all the adverse effects of tobacco consumption. In particular, to the extent that consumers lack complete information about the adverse health effects of tobacco consumption, consumer surplus is overstated.⁹ This can be seen as follows by noting that the individual demand curve takes into account perceived health costs in the following way. Associated with varying levels of consumption are the consumer's perceived

⁹ Of course, some individuals may overestimate the dangers of smoking (see Viscusi 1992); to the extent that these individuals do not smoke, they will receive no benefit from cigarette consumption and consumer surplus will be unaffected.

marginal benefits; the marginal benefit is measured as the incremental willingness to pay for an additional unit of consumption, given the current amount consumed. The consumer's consumption level is determined by comparing marginal benefits with marginal costs. Marginal costs consist of two components: market and non-market costs. The market marginal cost is just the market price of an additional unit of the product. The second component of marginal cost is the expected non-market marginal costs of tobacco consumption. These include the expected adverse health consequences of smoking, the increased probability of fire, as well as the cost of time involved in consumption. The consumer's consumption level is determined by comparing marginal benefits and marginal costs from tobacco consumption to those for consumption of other goods and services. Note that if marginal costs are sufficiently high or marginal benefits sufficiently low, the consumption level will be zero.

The demand curve in Fig. 6.1 is equal to the marginal benefits minus the perceived non-market marginal costs; that is, the marginal costs associated with adverse health consequences. The consumer's consumption level is determined by equating this net marginal benefit curve with the price of the commodity. The area shown as consumer surplus is the area under the net marginal benefit curve minus expenditures, and measures the net benefits to cigarette consumption. These are defined as the total benefits minus total health costs and total expenditures. If the perceived marginal costs due to adverse health effects rise, the net demand curve shown in Fig. 6.1 shifts in toward the origin. This inward shift means that consumer surplus is smaller. If the perceived marginal costs are lower than the 'true' marginal costs—that is, the consumer is under-informed about the true health consequences of smoking—then the demand curve will be shifted out and consumer surplus will be overstated. Thus, misinformed consumers will result in consumer surplus estimates that are too high. For the United States, Ippolito *et al.* (1979) estimate that the release of the Surgeon General's 1964 report on the health consequences of smoking led, over time, to a decline in annual tobacco consumption of around 30%, suggesting that the lack of consumer information would have led to excessive estimates of consumer surplus in the 1950s. This is another reason why the estimates of consumer surplus reported above should be regarded as upper bounds on true consumer surplus.

6.2.3 Producer surplus

Net economic benefits to tobacco producers and cigarette manufacturers depend on the alternative products that can be grown or manufactured with the assets currently used for tobacco products. Producer surplus is the payment that producers receive in excess of their opportunity cost. Producer surplus is also equivalent to economic rent, which is the amount that a payment exceeds the minimum amount necessary to ensure that the goods are supplied at the specified quantity. Thus, if a star basketball player receives a salary of \$1 million but would be willing to play for only \$50 000, then \$950 000 of his \$1-million-dollar salary is said to be economic rent. This connection between economic rent and producer surplus is made clear in the following alternative definition of producer surplus: producer surplus is the amount that can be taken from producers without diminishing the amount supplied.

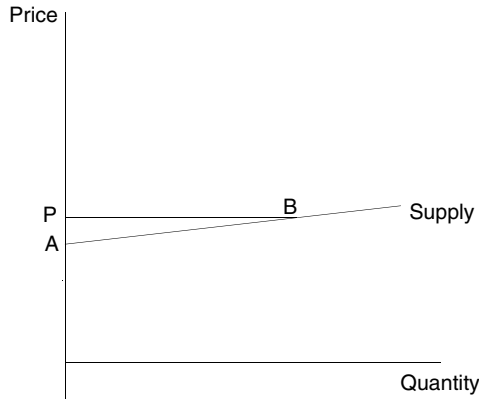


Fig. 6.2 Elastic supply curve with producer surplus PAB.

As a measure of economic profits, producer surplus is simply revenue minus opportunity costs.¹⁰ Geometrically, producer surplus is the area between price P and the supply curve; that is, the area above the supply curve and below the price line. Producer surplus arises from the production of tobacco leaf and from the manufacture of cigarettes. As a first approximation we assume that production of tobacco leaf occurs under competitive conditions. For the manufacture of cigarettes, this assumption is less tenable and we modify our approach to take into account the market power of cigarette manufacturers.

With a standard supply curve diagram, the connection between producer surplus and ease with which assets can be redeployed in the production of alternative products is easy to see. For example, if it is easy for tobacco growers to produce a lucrative alternative product, then small changes in price will lead to big changes in output. As the price for the product declines, producers will quickly shift assets into the production of the lucrative alternative product. In this case, the supply of tobacco will be relatively elastic as indicated in the Fig. 6.2. Total producer surplus will, all else being equal, be relatively small (shown in Fig. 6.2 as PAB). On the other hand, if there are no alternative products, producers will not be able to readily redeploy assets in the event of price decline. The supply curve, in this case, will be relatively inelastic. Here, producer surplus will be relatively large.

In general, producer surplus is given by the area between price and the supply curve; accordingly, given a supply curve, generating producer surplus is a matter of computing the appropriate integral. Modeling leaf production of tobacco as a competitive industry is, of course, only a first approximation to a much more complicated reality. We assume that supply curves are iso-elastic (this is the same assumption as Barnum (1993)), that is:

¹⁰ In general, the area underneath the supply curve is total variable cost. If firms are infinitesimal, i.e. efficient scale is small relative to total market demand, then one can show that the area under the supply curve is exactly total costs. For monopolies and oligopolies, supply curves may not be well-defined; for these cases the best approach is to compute profits directly.

Table 6.4 The producer surplus of tobacco

Supply elasticity	Annual producer surplus	Discounted producer surplus (1990 US\$ (millions))
0.1	51.2	1570
0.2	49.2	1503
0.3	47.5	1448
0.4	46.1	1400
0.5	44.8	1358
0.6	43.7	1321
0.7	42.8	1289
0.8	41.9	1260
0.9	41.1	1234
1.0	40.5	1212

$$Q_s = Ap^\eta, \quad (6.6)$$

where η is the supply-elasticity. For this supply curve, producer surplus, PS, is given by:

$$PS = PQ/(1 + \eta). \quad (6.7)$$

In this particular case, we only need the supply-elasticity, output, and the market price to determine producer surplus. This is the annual producer surplus. To convert this flow into a stock, we compute the present discounted value of the flow of producer surplus as follows:

$$\text{Discounted Present Value of Producer Surplus} = PS/r, \quad (6.8)$$

where r is the social discount rate.

We estimated agricultural supply functions from the World Bank data using country and year fixed-effects models. Our estimated supply elasticities were relatively low (0.2); the literature gives estimates that range from 0.4 to 0.8. We attribute these low-elasticity estimates to two factors. First, we are estimating short-run elasticities and, second, there is some measurement error in the price data. Measurement error tends to bias estimates downwards. Our base case assumes that the supply-elasticity is 0.6, which is consistent with estimates of supply elasticities for agricultural goods.¹¹ Accordingly, we find the annual producer surplus associated with the agricultural production of tobacco leaf to be about \$16 billion in 1990 (Table 6.4). To account for cigarette manufacturer profits, we assume that profits average \$0.10 per pack; this implies profits of about \$27 billion per year.¹² Accordingly, total producer benefits are \$43 billion per year. With a social discount rate of 3%, the discounted value of future producer surplus

¹¹ Estimates used in World Bank commodity price projections (World Bank 1991) suggest a supply-elasticity of 0.6; Dean (1966) estimates a supply-elasticity of 0.5 for tobacco farmers in Malawi. Johnson (1984) finds a supply-elasticity of 1.0 for US farmers.

¹² In the late 1990s, the estimated profit on a \$3.50 package of Marlboro cigarettes was \$0.28, a profit rate of 8% (Newman 1999). If we apply this rate to world production, total world profits are about \$16.9 billion, lower than our \$27 billion estimate.

Table 6.5 Per capita producer surplus

	Per capita producer surplus (1990 US\$)
Established market economies	197.7
Formerly socialist economies	7.6
India	2.7
China	17.5
Other Asia and islands	12.7
Sub-Saharan Africa	25.6
Latin America and Caribbean	11.3
Middle Eastern Crescent	8.4

Supply elasticity = 0.6.

is about \$1321 billion. The per capita producer surplus is shown for each region in Table 6.5.

One way to interpret this figure is that it is the minimum lump payment necessary to induce tobacco growers and manufacturers to voluntarily quit their activities and use their assets in other, non-tobacco activities. Sensitivity analysis indicates that when the supply-elasticity is 0.1, annual agricultural producer surplus is \$26 billion, and when the elasticity is twice our base-case value, i.e. 1.2, it is about \$12 billion. The discounted sum of producer surplus ranges from \$1570 billion, when the elasticity is 0.1, to \$1172 billion, when the elasticity is 1.2. While not particularly sensitive to assumptions about the supply-elasticity, the total discounted producer surplus does vary significantly with the social discount rate.

6.3 Cost of tobacco consumption

6.3.1 Internal and external costs

The central issue in calculating the social costs of tobacco consumption is determining which costs are already accounted for in consumer and producer decisions and which costs are not taken into account. Costs that are already accounted for should not be explicitly subtracted in the analysis, since this would lead to double counting. Costs that are not counted in consumer or supplier decisions, however, need to be explicitly taken into account by the analysis. In determining what costs should be taken into account, the following taxonomy is useful. Internal costs are costs that are taken into account and are typically borne by the smoker. The reason why these costs are not subtracted from measured benefits in determining the net social benefit or loss from smoking has been explained in our discussion of consumer surplus. External costs are costs that are not taken into account by the decision-maker because they do not affect the decision-maker; as such, they must be imposed on others in order to be external costs. External costs need to be counted explicitly as part of the social costs. Finally, if individuals choose to smoke but are not fully informed about the consequences of their

decision, some costs may not be fully reflected in demand and supply curves. If individuals are completely uninformed about the adverse consequences of tobacco consumption, then the costs associated with premature death and higher morbidity may be explicitly subtracted as an additional uncounted cost. We refer to this category of uncounted costs as uninformed costs.

The following simple matrix summarizes the discussion. The rows indicate whether the decision-maker is uninformed or informed, while the columns are labeled internal and external costs. ‘Uninformed’ implies that the decision-maker is not aware of the relevant cost and does not take the cost into account in his decision-making. ‘Informed’ means that the individual is aware of the cost, and takes the cost into account in making a decision. If a cost is uncounted, then that cost needs to be explicitly accounted for in our analysis; if the cost is counted, it has already been taken into account by the decision-maker and is accordingly reflected in consumer or producer surplus. Informed, internal costs are taken into account by consumers and are already measured by standard consumer surplus. As the matrix indicates, there are three other possible configurations that give rise to costs that are uncounted in conventional measures of consumer and producer surplus.¹³ These costs should be subtracted from consumer and producer surplus to determine the net social costs of tobacco consumption. In our analysis, we assume away all external costs and focus on uncounted internal costs.

	Internal cost	External cost
Informed decision-maker	Counted cost	Uncounted cost
Uninformed decision-maker	Uncounted cost	Uncounted cost

6.4 The social cost of smoking

If the total discounted stream of benefits from tobacco consumption is B and the total discounted stream of uncounted costs of tobacco consumption, external and uninformed cost, is C , then $B-C$ is the net discounted flow of social benefits from tobacco consumption. This represents the net amount that society would be better off, from the initial point of time measured into the indefinite future when tobacco products are present. If this sum is negative, then society is on net worse off with tobacco products than without them. It is, of course, conceptually and empirically difficult to measure all uncounted costs. To address the difficulties of distinguishing counted and uncounted costs directly, we propose the following alternative procedure that focuses on the uncounted costs arising from a lack of consumer information. It is standard to measure the aggregate health impact of tobacco use in units called DALYs. DALY is an acronym for disability-adjusted life-year; DALYs capture in a

¹³ External costs generated by an informed individual may become internalized if his utility function is interdependent, i.e. the individual cares about his impact on others.

single time-based unit, years lost due to premature mortality and years lived with disability, adjusted for severity. One DALY is thus one lost year of healthy life. Estimates for DALYs attributable to smoking were provided by WHO (1996, 1999). DALYS caused by smoking refer only to disease among smokers and exclude the effects of smoking on non-smokers. They are derived from the smoking-impact ratio model (SIR) (Peto *et al.* 1994; see Chapter 2, for a more detailed discussion). DALY projections from 1990 to 2030 are also provided by WHO (1996; Lopez, personal communication).

Uncounted costs result when consumers make uninformed or under-informed decisions to consume tobacco products. Here, we regard uninformed consumers as assuming that the expected DALY cost of smoking is zero, when in fact such costs are positive. We compute the percentage of the population that must be uninformed so that the net social benefits are zero. Thus if a fraction α of the smoking population is uninformed and the value of one DALY(D) is L, then there is a total uninformed cost of:

$$\sum_{t=0}^{\infty} \alpha L D_t / (1+r)^t, \quad (6.9)$$

that needs to be subtracted from total benefits to determine net benefits. We then consider:

$$B - \sum_{t=0}^{\infty} \alpha L D_t / (1+r)^t = 0. \quad (6.10)$$

This equation gives the level of uninformed costs resulting in a net social benefit of zero.¹⁴ Note that this calculation assumes all other uncounted costs are zero. The solution of this equation, α^* , is given by:

$$\alpha^* = B / \left(\sum_{t=0}^{\infty} L D_t / (1+r)^t \right). \quad (6.11)$$

This fraction can be interpreted as the percentage of the smoking population that must be uninformed so that net benefits are zero. If the fraction uninformed exceeds α^* , then the total uncounted cost will be larger than the above sum, and the net social benefit will be negative.

6.5 Empirical findings

Our base case is as follows. We assume a supply-elasticity of 0.6 and demand-elasticity for EME countries of -0.8 , and a demand-elasticity of -1.2 for non-EME countries. The discount rate is set at 3%. We compute the threshold level of uninformed individuals for our base case and find that it is 23%. Thus, if more than a quarter of the population is consuming tobacco products without fully realizing the addiction and

¹⁴ Note that though the interpretation is different, this is algebraically equivalent to assuming that the uncounted costs associated with each DALY, L^* , are equal to α^*L , so that net benefits of smoking equal zero. To see this, merely substitute $\alpha^*L = L^*$ into the summation given in eqn 6.10.

Table 6.6 The percentage of smokers who would need to be uninformed of the health risks for social benefits of smoking to be zero

Discount rate	EME price elasticity	Non-EME price elasticity	Fraction of the population uninformed (DALY= US\$7750)	Fraction of the population uninformed (DALY = US\$15 500)
0.01	0.2	0.4	0.59	0.25
0.01	0.4	0.8	0.32	0.16
0.01	0.8	1.2	0.20	0.10
0.01	1.0	1.6	0.17	0.09
0.03	0.2	0.4	0.70	0.35
0.03	0.4	0.8	0.38	0.19
0.03	0.8	1.2	0.23	0.12
0.03	1.0	1.6	0.19	0.10
0.05	0.2	0.4	0.79	0.39
0.05	0.4	0.8	0.43	0.21
0.05	0.8	1.2	0.26	0.13
0.05	1.0	1.6	0.22	0.11
0.07	0.2	0.4	0.86	0.43
0.07	0.4	0.8	0.47	0.23
0.07	0.8	1.2	0.29	0.14
0.07	1.0	1.6	0.24	0.12

health consequences (i.e. is not cognizant of the full DALY cost of tobacco use), then we conclude that there are net social costs. In reaching these estimates, we assume that the value of one DALY is US\$7750, which is the global average per capita gross domestic product (GDP) weighted for tobacco consumption. This assumption is extremely conservative,¹⁵ for instance, if the value of one DALY is doubled, the threshold level of uninformed individuals falls to 13%. Sensitivity analyses indicate that our results depend fairly heavily on our assumption regarding price elasticity, particularly our choice of the price elasticity for the EME countries (see Table 6.6). This arises because tobacco consumption in the EME countries is high, relative to the rest of the world, which means that consumer surplus in the EME countries dominates the expression for benefits, B . On the other hand, our conclusions are not very sensitive to the choice of the social discount rate; this is because the social discount rate enters both the numerator and the denominator of the expression that determines α .

¹⁵ This is an extremely conservative choice in the following sense. In a survey of 23 studies using US data (Viscusi 1993) the average value of a life is \$5.8 million (typically derived from labor-market data), while the average income in these studies is \$22 600. Assuming that one life translates into 40 healthy life-years (allowing for age weighting and discounting), this implies that the value of a DALY is about \$320 000. Accordingly, the ratio of a DALY to income for the United States is about 14.3. If we assume that the value of a DALY is 14.3 times per capita GNP, the threshold percentage who would have to be uninformed for the net benefits of tobacco to be zero is 3%.

6.6 Incremental analysis

We also consider the welfare effects of a 10% increase in the price of cigarettes arising from a tax increase. This exercise is relevant for two reasons. First, tobacco tax increases are a widely discussed policy option, so it is useful to measure its welfare effects in the context of our framework. Second, an incremental analysis of this type does not involve extrapolation into situations that have not been observed. In particular, the global analysis of the previous section may make untenable assumptions about the behavior of demand when prices are extremely high. An incremental analysis of the type proposed here makes much more modest extrapolations about the behavior of demand.

We suppose that the 10% increase in the price of tobacco arises because of the imposition of a tax. This means that there is a reduction in the quantity of tobacco products produced and consumed. There are also significant money transfers from tobacco consumers and producers to governments. Transfers are not included in the assessment of costs and benefits because, while they represent a cost to consumers, they also generate an equal sized benefit to taxpayers and the beneficiaries of government programs financed by the tax revenues. Accordingly, transfers net out to zero. Losses to consumers and producers, however, exceed the amount collected in tax revenue and this extra burden is referred to as a deadweight loss. Deadweight losses are the net social costs generated by the taxation of tobacco products. We first calculate the deadweight loss that arises from the reduction in consumer demand, denoted as DWL_C . DWL_C can be expressed as a function of the elasticity parameter ϵ as follows:

$$DWL_C = 1/2 PQ\epsilon(\Delta P/P)^2. \quad (6.12)$$

The most salient feature of this formula is that the percentage change in price is squared. This implies that the deadweight loss will be an order of magnitude smaller than the drop in DALYs that is roughly proportional to the percentage change of price.

The next step is the computation of the deadweight loss of producer surplus for tobacco producers, denoted as DWL_P . This is the net reduction in producer profits; that is, the decline in producer profits minus transfers to the government sector. The formula for this computation is:

$$DWL_P = PQ/(1 + \eta) - P_1Q_1/(1 + \eta) - Q_1(P - P_1), \quad (6.13)$$

where P and Q are the original price and quantity, and P_1 and Q_1 are the new price and quantity that arise after the 10% increase in cigarette prices is put into place. P_1 and Q_1 are computed as follows. A 10% increase in the price of cigarettes leads to a lower quantity of cigarettes sold, based on the shape of the demand curve for cigarettes. We assume that the reduction in tobacco leaf is proportional to the reduction in cigarettes, so that if cigarette consumption falls by $\Delta Q/Q\%$, then tobacco leaf production also falls by $\Delta Q/Q\%$. Given the equation for the supply curve $Q = AP^\eta$, the market price that corresponds to reduced level of production can be computed.

The final set of calculations concerns DALYs. We estimated the relationship between consumption and mortality at the country level based on cigarette smoking in 1970 and lung cancer in 1990 (see Chapter 2, Figure 2.4) as follows:

$$Y = 0.0248X + 5.5, \quad (6.14)$$

where Y equals lung cancer deaths per 100 000 at ages 35–69, and X is total cigarette consumption. For every lung cancer death there are approximately 36 DALYs (Murray and Lopez 1996). Based on these figures, we estimated the percentage decline in DALYs that results from a 10% increase in cigarette prices, using the above estimates of price elasticity. In particular, we took original DALYs in the year 2020, and assumed that they would fall by the percentage amount predicted by eqn 6.14. When properly discounted, this produces an 8% decline in discounted DALYs.

The results are summarized in Table 6.7. For our base case of a demand-elasticity of -0.8 for the EME countries and -1.2 for the non-EME countries, and a supply-elasticity of 0.6 , the discounted deadweight loss is US\$44 billion. We compute a break-even percentage of uninformed smokers for a range of demand and supply elasticities. For our base case, the break-even percentage of uninformed smokers is 2.2%. The most striking feature of Table 6.7 is that the numbers are an order of magnitude lower than the numbers for the global analysis, i.e. the figures presented in Table 6.6. This is basically because the deadweight losses are, as pointed out earlier, an order of magnitude smaller than the change in producer and consumer surplus. (Most of the change in producer and consumer surplus results from the transfer of funds from the private to public sector, assuming that the 10% increase is the result of a tax increase.) On the other hand, the reduction in DALYs is on the same order of magnitude as the change in price and hence much bigger.

Table 6.7 Incremental cost–benefit analysis

Supply elasticity	EME price elasticity	Non-EME price elasticity	Deadweight loss (Billions \$)	Breakeven % uninformed (DALY = US\$7750)
0.3	0.2	0.4	26.1	1.3
0.3	0.4	0.8	36.4	1.8
0.3	0.8	1.2	51.6	2.5
0.3	1.0	1.6	61.9	3.0
0.6	0.2	0.4	18.6	0.9
0.6	0.4	0.8	28.9	1.4
0.6	0.8	1.2	44.1	2.2
0.6	1.0	1.6	54.4	2.7
1.2	0.2	0.4	14.6	0.7
1.2	0.4	0.8	24.9	1.2
1.2	0.8	1.2	40.1	2.0
1.2	1.0	1.6	50.4	2.5

Discount rate = 0.03.

6.7 Comparison with earlier analyses

Barnum (1993, 1994) estimated the costs and benefits of smoking, using a different methodology, and reached somewhat different conclusions. His approach is designed to answer the question: What are the net benefits of additional investments in tobacco production capability? Accordingly, Barnum takes an incremental approach; also his treatment of the costs of cigarette consumption is very different than the approach we have taken. Barnum assumes that there is a one-time increase in tobacco production of 1000 metric tonnes that results in a one-time net increase in output of 500 metric tonnes. The incremental producer and consumer surplus occurs for just the initial year; Barnum does not consider a discounted stream of consumer and producer surplus. Barnum then assumes that this increase in production is consumed in the initial year. As a result of this one-time increase in consumption, there are subsequent rises in the death and morbidity rates. The incremental cost of additional deaths, in the Barnum analysis, is \$3.1 million. The incremental cost due to disability and morbidity is \$3.4 million. Barnum also considers the direct cost of added morbidity, at \$2.3 million. The net change in consumer and producer surplus is 1.7 million. Adding the Barnum figures together, we reach a total of \$7.2 million costs per 1000 metric tonnes. Assuming that this marginal rate is also the average rate, this implies a total annual cost of \$46.8 billion per year ($6500 \times \7.2 million). If we assume that this cost occurs each year, i.e. costs are constant over time, the total discounted costs are \$1.6 trillion. The Barnum estimate is for a one-time increase in tobacco production of 1000 metric tonnes. If this were sustained indefinitely, then the marginal increase in present discounted value of net benefits would be $-7.2/0.03$ or $-\$240$ million. In contrast, we determine total consumer and producer surplus, rather than marginal quantities. We also highlight the proportion of the smoking population that must be uninformed for net benefits to equal zero and thereby stress the uncounted costs that arise from smokers' lack of information about the health risks. Thus our analysis takes into account explicitly the distinction between internal and uncounted social costs. In determining these quantities we use total DALYs attributable to tobacco consumption, rather than the marginal DALYs utilized by Barnum in his work.

6.8 Conclusion

The approach we have outlined here provides a framework for assessing the economic impact of tobacco consumption. It also suggests important areas for future work. This study suggests that better estimates of demand and supply functions, along with estimates of regional demand and supply elasticities, are needed. We would also like to have a better understanding of how various government interventions affect demand and supply. Finally we need to have better measures of the degree to which consumers are informed about the health consequences of tobacco consumption. Our approach is different from Barnum's and has some novel features. Instead of considering an incremental change in tobacco production and then determining the marginal consumer and producer surplus and the incremental costs, we consider total consumer surplus and total producer surplus. We then consider the percentage of the smoking

population that needs to be completely uninformed so that net social benefits to tobacco consumption are equal to zero. To illustrate our approach we provide calculations and find that, for our base case, this number is 23%. Thus we conclude that if individual smokers underestimate the cost of smoking by more than 23%, the net social benefit will also be negative. Given what we know about the levels of consumer information on the health risks of tobacco, these figures are consistent with the notion that, on net, consumption of tobacco products leads to a net decline in economic welfare.

We also consider the effect on social welfare of an incremental increase of 10% in the retail price of cigarettes. Here the results are very striking: if only a very small percentage of the population is uninformed, 2.2%, then increasing tobacco prices by relatively modest amounts raises economic welfare. Again, given what we know about levels of consumer information on tobacco health risks, this result is consistent with arguments in favor of moderate increases in tobacco taxes.

References

- Barnum, H. (1993). *The Economic Costs and Benefits of Investing in Tobacco*. Unpublished manuscript, Human Development Department, The World Bank.
- Barnum, H. (1994). The economic burden of the global trade in tobacco. *Tobacco Control*, **3**(4), 358–61.
- Dean, E. (1966). *The Supply Responses of African Farmers: Theory and Measurement in Malawi*, Amsterdam, North Holland.
- Hausman, J. (1981). Exact consumer surplus and deadweight loss. *American Economic Review*, **71**, 662–76.
- Ippolito, R. A., Murphy, R. D., and Sant, D. (1979). *Staff Report on Consumer Responses to Cigarette Health Information*. Washington DC: Federal Trade Commission.
- Johnson, P. R. (1984). *The Economics of the Tobacco Industry*, New York, Praeger.
- Murray, C. J. L. and Lopez A. D. (ed) (1996). *The Global Burden of Disease*. Cambridge, MA: Harvard University Press, 1996.
- Newman, A. (1999). The economics of cigarettes: smoke on for the tax man. *New York Times*, February 28.
- Orphanides, A. and Zervos, D. Rational Addiction with Learning and Regret, *Journal of Political Economy*, **103**, 739–58.
- Peto, R., Lopez, A. D., Boreham, J., Thun, M., and Heath, C. Jr. (1994). *Mortality from smoking in developed countries, 1950–2000*. Oxford, Oxford University Press.
- Viscusi, W. K. (1992). *Smoking: Making the Risky Decision*, New York, Oxford University Press.
- Viscusi, W. K. (1993). The value of risks to life and health. *Journal of Economic Literature*, **31**, 1912–46.
- Willig, R. (1976). Consumer surplus without apology. *American Economic Review*, **66**(4), 589–97.
- World Bank (1991). *Price Prospects for Major Primary Commodities, 1990–2005*, Washington, D.C., World Bank.
- World Health Organization (1996). Investing in Health Research and Development, report of the Ad Hoc Committee on Health Research Relating to Future Intervention Options (Document TDR/Gen/96.1). Geneva, World Health Organization.
- World Health Organization (1999). *World Health Report: Making a Difference*. Geneva, World Health Organization.

