A simulation model to predict the fiscal and public health impact of a change in cigarette excise taxes

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ABSTRACT

Objectives (1) To present a model that predicts changes in cigarette consumption and excise revenue in response to excise tax changes, and (2) to demonstrate that, if the industry has market power, increases in specific taxes have better tobacco control consequences than increases in ad valorem taxes.

Design All model parameters are user-determined. The model calculates likely changes in cigarette consumption, smoking prevalence and excise tax revenues due to an excise tax change. The model is applicable to countries that levy excise tax as specific or ad valorem taxes.

Results For a representative low-income or middle-income country a 20% excise tax increase decreases cigarette consumption and industry revenue by 5% and increases excise tax revenues by 14%, if there is no change in the net-of-tax price. If the excise tax is levied as a specific tax, the industry has an incentive to raise the net-of-tax price, enhancing the consumption-reducing impact of the tax increase. If the excise tax is levied as an ad valorem tax, the industry has no such incentive. The industry has an incentive to reduce the net-of-tax price in response to an ad valorem excise tax increase, undermining the public health and fiscal benefits of the tax increase.

Conclusions This paper presents a simple web-based tool that allows policy makers and tobacco control advocates to estimate the likely consumption, fiscal and mortality impacts of a change in the cigarette excise tax. If a country wishes to reduce cigarette consumption by increasing the excise tax, a specific tax structure is better than an ad valorem tax structure.

Over the past decades many countries have reduced tobacco consumption and increased excise tax revenues by increasing the excise tax on tobacco products. Despite nicotine's addictiveness, numerous studies have shown that people reduce their tobacco consumption when faced with higher prices.[1 2] Consumption decreases as a result of decreases in smoking prevalence (ie, people quitting or not starting smoking) and smoking intensity (ie, remaining smokers reducing their average consumption).[2]

Increasing the excise tax on tobacco acts as a double-edged sword; not only does it reduce tobacco consumption but, because tobacco is relatively price inelastic, it also increases government revenue. For a given percentage increase in the excise tax per cigarette, the percentage decrease in cigarette consumption is smaller, resulting in an overall increase in government revenue.

Whereas the rationale for increasing the excise tax in high-income countries is typically to reduce tobacco use, in low-income and middle-income countries the fiscal aspects often take priority. In low-income and middle-income countries governments typically raise insufficient revenue through direct taxes (eg, income and corporate tax) and are often more dependent on indirect taxation, of which excise tax is an important component.[3]

This paper presents an online model to help policy makers predict the likely fiscal and public health outcomes of a change in the tobacco excise tax. The model is a tool for policy makers, primarily in low-income and middle-income countries, where a paucity of data prevents them performing a comprehensive analysis of tobacco demand. The model requires few inputs, yet is programmed to provide a fairly comprehensive analysis of the aggregate impact of an excise tax change. For instance, the model predicts by what percentage cigarette consumption, smoking prevalence and excise tax revenue would change in response to a given percentage change in the excise tax. The online model has default values for all relevant parameters, but the user can calibrate these parameters to his/her country. All the outputs are presented as percentage changes, which imply that the user does not have to know the absolute values of the variables of interest at the outset (eg, cigarette consumption and the price level) for the model to function.

The model is available at http://www.commerce.uct.ac.za/TETSiM.

THE BASIC MODEL

The model estimates the quantitative impact of an excise tax change on a number of variables: cigarette prices, cigarette consumption, smoking prevalence, smoking intensity, excise tax revenue, industry revenue and smoking-related mortality.

The model requires, at the minimum, the following inputs from the user (unless the user accepts the model's default values shown in the next section): (1) excise tax burden at the outset (ie, the excise tax amount as a percentage of the retail price); (2) the general sales tax (or VAT) rate; (3) an estimate of the price elasticity of demand; (4) the percentage increase in the excise tax; and (5) the percentage increase in the net-of-tax price. To estimate the public health impact in more detail (eg, changes in smoking prevalence and smoking intensity, and the number of lives saved because of the intervention) the model is set up to require some additional inputs, not listed here.

The model is based on a number of assumptions:

- The price elasticity of demand is assumed to be constant
- General sales tax (eg, value-added tax) is levied on the sum of the excise tax and the net-of-tax price

(ie, the amount of the retail price that is distributed between the cigarette manufacturers and the rest of the supply chain)
- The cigarette market is assumed to be fairly homogeneous, with limited variation in the price around the average. The model is not appropriate for countries where premium cigarettes sell at significantly higher prices than discount cigarettes, and where smokers are likely to move to the discount brands when faced with price increases
- While cigarette smuggling may exist at the outset, it is assumed that the increase in the excise tax does not increase cigarette smuggling
- The excise tax is levied either as a specific tax (ie, as a certain amount per unit) or as an ad valorem tax (ie, as a percentage of value). The model does not consider more complex taxation structures—for example, combinations of specific or ad valorem taxes, or taxes subject to weight, length or price thresholds
- The model does not assume that the government or the tobacco industry aims to optimise some quantity—for example, excise tax revenues or industry profits, respectively. Given an initial situation, it simply considers what will happen if the government changes the excise tax (and if the industry possibly changes the net-of-tax price in response). The model does not suggest that the outcome is optimal, in that it is the result of some maximisation or minimisation exercise.

The starting point of the model is that one can subdivide the retail price of cigarettes (P) into three components: the excise tax (ET), a general sales tax (typically value-added tax, denoted τ) and the remainder, called the net-of-tax price (NTP). The user enters the excise tax burden (ie, ET/P) and τ. On the assumption that τ is levied on the sum of the net-of-tax price and the excise tax—that is, $P=(NTP+ET)\times(1+\tau)$, and if P at the outset is set at an arbitrary value of 100, the net-of-tax price is calculated as follows:

$$\mathrm{NTP} = 100/(1 + \tau - ET) \quad (1)$$

Since all model outputs (eg, price, consumption, government revenue and industry revenue) are in percentage changes, the model does not require information about the absolute magnitudes of these values at the outset. Using an arbitrary base value for cigarette consumption (say 1000), the model calculates initial excise tax revenue (ie, $ET\times1000$) and industry revenue (ie, $NTP\times1000$). In the second step the user indicates by what percentage the government raises the excise tax, and by what percentage the industry changes the net-of-tax price (if they do). The model calculates the new retail price as follows:

$$P = [NTP(1 + \psi) + ET(1 + \lambda)](1 + \tau) \quad (2)$$

where ψ is the proportional change in the net-of-tax price and λ is the proportional change in the excise tax.

Cigarette consumption changes as a result of the price change, the magnitude depending on the price elasticity of demand. Since the price change is a discrete amount (rather than an infinitesimally small amount), it is appropriate to use the midpoint formula, rather than the point formula,[4] to calculate the new point of consumption. For minor changes in the price, the midpoint and the point formulas provide similar answers. However, for large price increases the point formula is inappropriate since it yields implausible answers. For example, if the price elasticity is −0.6 and the price increases by 200%, consumption would decrease by 120%, which is mathematically impossible. The midpoint formula would predict a more plausible decrease of 41.2%.

Once the new level of consumption has been calculated, the model calculates new levels of excise tax revenue and industry revenue, based on the new consumption figures. The model subsequently calculates percentage changes in the retail price, cigarette consumption, excise revenues and industry revenues. For most policy makers, these are likely to be the most important outputs of the model.

A decrease in total cigarette consumption can come about in two ways: a decreased number of smokers (ie, a decrease in smoking prevalence) or a decreased number of cigarettes smoked by smokers (ie, a decrease in smoking intensity). The model calculates the percentage change in smoking prevalence and smoking intensity if the magnitudes of the respective proportions are specified by the user. Furthermore, if the user enters the initial smoking prevalence percentage and the size of the adult population, the model calculates the absolute numbers of people who are expected to quit smoking and the number that will be saved from a premature tobacco-related death.

A comprehensive appendix of the mathematical structure of the model is available as part of the online model.

SOME SIMULATIONS FOR A TYPICAL LOW-INCOME OR MIDDLE-INCOME COUNTRY

Initially a set of outcomes is presented, based on default parameters. Subsequently the sensitivity of the outputs to different input parameters is investigated, by changing one parameter at a time, while holding the others constant. First a specific excise tax is considered and then the analysis is repeated for an ad valorem excise tax.

Excise tax levied as a specific tax

The default assumptions are shown in the top half of column (1) in table 1. The initial excise tax burden (ie, ET/P) of 40% is informed by the median burden of 36% in low-income and middle-income countries and a global median of 45% (author's calculations, based on a recent WHO publication[5]). The price elasticity (ϵ_P) value of −0.6 is based the World Bank's estimate that ϵ_P in low-income and middle-income countries lies between −0.4 to −0.8.[6] The VAT rate of 15% is based on a recent KPMG study, which found the average VAT rate to be 19.5% in the EU, 17.7% in OECD countries, 14.2% in Latin America and 10.8% in the Asia Pacific region.[7] The assumption that 40% of the decrease in cigarette consumption is attributed to a decrease in smoking prevalence is informed by findings from South Africa[1] and some youth studies in the USA.[8 9 i] A change in the excise tax is assumed to be fully passed onto smokers. Initially the industry is assumed not to change the net-of-tax price in reaction to the tax change.

Using an arbitrary value of P of 100 at the outset, an initial excise tax burden (ET/P) of 40% and a VAT rate (τ) of 15%, the net-of-tax price (NTP) is 46.96, using equation (1). The total tax burden (ie, the excise tax and the VAT amount expressed as a percentage of the retail price) is 53.04%. A 20% increase in the

[i] There is currently no consensus in the literature (eg, the HNP Working Paper series published by the World Bank) on the relative magnitudes of the "participation elasticity" (which determines how smoking *prevalence* is affected by changes in the retail price) and the "conditional demand elasticity" (which determines how smoking *intensity* is affected by changes in the retail price). While the relative magnitudes of these two sub-elasticities influence the mortality impact of a change in cigarette taxes or prices, they have no fiscal or aggregate consumption impact.

Table 1 Inputs and output of the simulation model, given a 20% excise tax increase

	Specific tax								Ad valorem tax		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Inputs											
Initial excise tax burden*	*40*	20	65	40	40	40	40	40	*40*	40	40
Price elasticity of demand	*−0.6*	−0.6	−0.6	−0.3	−1.2	−0.6	−0.6	−0.6	*−0.6*	−0.6	−0.6
Percentage change in net-of-tax price	*0*	0	0	0	0	0	10	−5	*0*	10	−5
Percentage of decrease in consumption attributed to decrease in smoking prevalence	*40*	40	40	40	40	70	40	40	*40*	40	40
Outputs											
Initial total tax burden†	*53.04*	33.04	78.04	53.04	53.04	53.04	53.04	53.04	*53.04*	53.04	53.04
New total tax burden	*57.00*	35.99	80.90	57.00	57.00	57.00	54.93	58.11	*57.00*	57.00	57.00
Percentage change in											
Retail price	*9.20*	4.60	14.95	9.20	9.20	9.20	14.60	6.50	*9.20*	20.12	3.74
Cigarette consumption	*−5.14*	−2.66	−8.01	−2.60	−10.03	−5.14	−7.84	−3.71	*−5.14*	−10.14	−2.18
Smoking prevalence	*−2.11*	−1.08	−3.34	−1.06	−4.22	−3.69	−3.27	−1.51	*−2.11*	−4.39	−0.88
Smoking intensity	*−3.10*	−1.60	−4.83	−1.57	−6.06	−1.50	−4.73	−2.23	*−3.10*	−6.29	−1.31
Excise tax revenue	*13.83*	16.81	10.39	16.87	7.97	13.83	10.59	15.55	*13.83*	18.27	11.52
Industry revenue	*−5.14*	−2.66	−8.01	−2.60	−10.03	−5.14	1.37	−8.52	*−5.14*	−1.44	−7.07

*Excise tax as percentage of retail price.
†Excise plus VAT as percentage of retail price.

specific excise tax increases ET from 40 to 48, and P from 100 to 109.2, using equation (2). The retail price increases by 9.2%, which is less than the excise tax increase (20%). The total tax burden increases to 57% (=(109.2−46.96)/109.2). Based on a ϵ_P value of −0.6, cigarette consumption decreases by 5.1%, using the midpoint formula.[ii] Smoking prevalence (with −2.1%), smoking intensity (−3.1%) and industry revenue (−5.1%) all decrease; and excise tax revenue increases (+13.8%). The increase in the excise tax has obvious public health and fiscal benefits.

Columns (2) and (3) consider the impact of a relatively low (20%) and high (65%) initial excise tax burden on the output variables. For a sample of 120 countries, ranked from the lowest to the highest excise tax burden, these percentages represent the 17th and the 92nd percentiles, respectively.[5] For a given increase in the excise tax, a low initial excise tax burden (20% vs 40%) has a smaller impact on the retail price (4.6% vs 9.2%) and consumption (−2.7% vs −5.1%), than had the initial excise tax burden been higher (40%).[iii] However, a low initial tax burden results in a larger percentage increase in government excise revenue (16.8% vs 13.8%). A 20% increase in the excise tax, when the initial tax burden is high (65%) results in a larger increase in the retail price (15.0% vs 9.2%), a larger decrease in consumption (−8.0% vs −5.1%), and a smaller increase in excise revenue (10.4% vs 13.8%).

Two values are used to illustrate the impact of price elasticity differences on consumption and excise revenue. If demand is highly inelastic (ϵ_P=−0.3, column (4)), a 20% excise tax increase decreases consumption by a smaller percentage (−2.6% vs −5.1%), but increases excise tax revenues by a greater percentage (16.9% vs 13.8%) than in the default scenario. In contrast, if the demand is relatively price elastic (ϵ_P=−1.2, column (5)), a 20% excise tax increase decreases consumption by a greater percentage (−10.0% vs −5.1%) and increases excise tax revenues by a smaller percentage (8.0% vs 13.8%).[iv]

The value of ϵ_P influences the relative size of the public health and fiscal benefits of an excise tax increase. For a given excise tax change, the public health benefit is greater and the fiscal benefit is smaller if the demand is more price elastic; the fiscal benefit is greater and the public health benefit is smaller if the demand is less elastic. However, this is only a *relative* trade-off; both public health and fiscal causes are served in an absolute sense if the excise tax is increased.

Column (5) indicates that, even if the price elasticity is in the elastic region of the demand curve, an increase in the excise tax increases excise tax revenue. Standard economic theory posits that demand elasticity increases with the price.[4] Cash-strapped ministries of finance may worry that, if initial consumption is close to the point of unit elasticity, a further tax increase may push the price into the inelastic region of the demand curve and result in a decrease in tax revenue.[v] This analysis indicates that such fears are unfounded. Only if the demand is unrealistically price elastic ($|\epsilon_P|$=1.8, given the other default parameters) will an increase in the excise tax per cigarette decrease tax revenue.

In column (6) 70% (rather than 40% in the default scenario) of the decrease in cigarette consumption is attributed to a decrease in smoking prevalence. This parameter change does not change the fiscal and overall consumption scenarios. Smoking prevalence would decrease by a greater percentage (−3.7% vs −2.1%) and smoking intensity by a smaller percentage (−1.5% vs −3.1%) than in the default scenario. Since smoking-related mortality is more closely associated with smoking prevalence than smoking intensity, a larger decrease in smoking prevalence is a better public health outcome. [10]

The analysis so far assumed that the tobacco industry does not change the net-of-tax price in response to an excise tax

[ii] Using the point formula, the decrease in consumption would be −0.6×9.2=5.5%, but as indicated earlier, the point formula gives implausible results if the price changes are large, which makes the midpoint formula preferable. The midpoint formula is also used to determine the impact of the price change on smoking prevalence.
[iii] In this section, unless stated otherwise, all comparative (ie, second-mentioned) values shown in parentheses refer to the percentage changes in the default scenario (ie, column (1)).
[iv] Reviewing the literature, Van Walbeek[1] found that less than 10% of all published $|\epsilon_P|$ estimates were greater than one. Where they were, they usually applied to sub-populations, rather than the whole population. These sub-populations were typically youths in the USA and low-skilled and/or low-income groups in other countries.
[v] This belief is probably derived from the fact that an increase in the *price* will increase *total expenditure* (by consumers) only if the price elasticity is less than one. However, since the excise tax is always a fraction of the retail price, an increase in the excise tax increases the retail price by a lower percentage.

change. The increase in the excise tax is fully passed on to consumers; no more and no less. In such an environment industry revenues fall by the same percentage as consumption; see the last row of columns (1) through (6).

In most countries the cigarette-manufacturing industry is highly concentrated, and individual firms have significant control over the net-of-tax price.

In column (7) the tobacco industry increases the net-of-tax price by 10%, coincident with a 20% excise tax increase. The retail price increases by a greater percentage than had only the excise tax been increased (14.6% vs 9.2%). Not surprisingly, cigarette consumption (−7.8% vs −5.1%), smoking prevalence (−3.3% vs −2.1%) and smoking intensity (−4.7% vs −3.1%) decrease by a greater percentage than in the default scenario. Excise revenues increase by a smaller percentage (10.6% vs 13.8%). However, despite the substantial decrease in cigarette consumption, industry revenues have increased (by +1.4% vs −5.1%)!

The industry has been able to increase its own revenue at the expense of consumers *and* government. Given that $|\epsilon_P|$ is less than 1, an industry-sponsored additional increase in the retail price increases total expenditure on cigarettes, and reduces government's additional excise tax revenue from 13.8% to 10.6%. Increased industry revenue, coupled with decreased total costs (because fewer cigarettes are produced) enhances the tobacco industry's absolute and per-unit-of-sales profitability.[vi]

Becker and colleagues[11] argue that, given the addictiveness of nicotine, it is rational for the cigarette industry to keep prices below the profit maximising level in the short term, since this strategy will increase the number of consumers. However, if cigarette smoking is in decline this principle no longer applies and the best strategy is to increase the net-of-tax price in order to extract as much consumer surplus as possible in the long term.[12] Industry documents from the USA reveal that the cigarette industry, and in particular Philip Morris, increased the real retail price of cigarettes by more than the increase in the federal tax in the early 1980s.[13] Similarly, an analysis of price and tax data in South Africa reveals that a significant proportion of the increase in the real retail price since 1994 was due to increases in the net-of-tax price, rather than to excise tax increases.[14]

As an example of how the industry uses increases in the excise tax as a smoke-screen to hide net-of-tax price increases, on 14 April 2005 the Jamaican government raised the special consumption tax (SCT, ie, an excise tax) on cigarettes by a nominal 49%, primarily to raise more government revenue. The tax increase was well-publicised in the local media. The next day Carreras, the BAT-affiliated Jamaican cigarette monopoly, published an advertisement that said, "as a result of the increase in the tax on cigarettes", the recommended retail price would increase from $J180 to $J220 per pack.[15] A more thorough investigation reveals that, given the complexity of the SCT formula, the tax increased by no more than $J7 per pack.[vii] At least $J33 of the retail price increase was captured by the industry, while smokers were led to believe that the price of cigarettes had increased to generate revenues for their cash-strapped government.[16]

While this is a rational and profitable industry response to an excise tax increase, the pricing strategy is not sustainable in the long term. The industry's client base shrinks at a faster rate than if only the excise tax were increased. More importantly, high net-of-tax prices attract competitors, and the added competition automatically subdues net-of-tax prices. Between 1994 and 2000 the South African government raised the real excise tax by 180%. In the same period the industry (a near-monopoly) increased the real net-of-tax price by nearly 60%, resulting in a 20% increase in real industry revenue, despite a 25% decrease in consumption.[14] The high net-of-tax price attracted numerous foreign tobacco firms to South Africa in the early 2000s, despite the unwelcoming legislative environment. Between 2000 and 2008 the real excise tax increased by another 56%, but the real net-of-tax price increased by a modest 12%.[17]

Column (8) considers the impact of a 5% reduction in the net-of-tax price in response to a 20% increase in the excise tax. Even though the industry mitigates the decrease in consumption somewhat (−3.7% vs −5.1%), it comes at the cost of a significantly larger reduction in its revenues (−8.5% vs −5.1%). Also, by decreasing the net-of-tax price, the industry increases government revenue (15.6% vs 13.8%) at the industry's expense. The upshot of this analysis is that, unless there are very strong competitive pressures (eg, a highly competitive market or a price war between oligopolists), it is not in the industry's interests to reduce their prices when faced with an increase in a specific excise tax.

Excise tax levied ad valorem

Whereas a specific excise tax is levied as an amount per quantity of cigarettes, an ad valorem excise tax is levied as a percentage of value. Columns (9) to (11) of table 1 illustrate the impact of a 20% increase in the ad valorem excise rate on the variables of interest.[viii] If the industry does not change the net-of-tax price in response to an increase in the excise tax, as shown in column (9), it is immaterial whether the tax is levied as a specific tax or ad valorem, since the numbers in column (9) are identical to those in column (1).

This section aims to show that, if the tax is levied ad valorem, the incentive to raise the net-of-tax price in response to an increase in the excise tax is much lower than if the tax had been levied specifically. In fact, the industry has a much stronger incentive to reduce the net-of-tax price in response to an ad valorem excise tax increase.

In column (10) the tobacco industry increases the net-of-tax price by 10%, coincident with a 20% increase in the ad valorem excise tax. An increase in the net-of-tax price automatically ratchets up the absolute amount of excise tax per cigarette (by 32%, not shown in table 1), which amplifies the retail price increase (20.1% vs 9.2%). As a result, consumption decreases more sharply (−10.1% vs −5.1%). In comparison, if the excise tax had been levied specifically, a 10% net-of-tax price increase in response to a 20% tax increase would reduce consumption by 7.8%. The fiscal benefit of an increase in the net-of-tax price in response to the 20% ad valorem tax increase is also enhanced (18.3% vs 13.8% increase in tax revenue).

While this is an extremely positive fiscal and public health outcome, it is unlikely to materialise. Even though the tobacco industry will improve its short-term financial position marginally (change in revenue of −1.4% vs −5.1%), the long-term

[vi] Without knowledge of the industry's cost structure (and thus profit margins), one cannot calculate by how much industry profits will increase.

[vii] The SCT on cigarettes is levied as a specific tax, but if the "base price" (essentially an ex-works price) is greater than a threshold value, the additional value is taxed at a much higher ad valorem rate. In 2005 the Jamaican government increased the specific tax component by 49%, but also raised the threshold where the ad valorem component became effective. In effect, the higher *specific* SCT component replaced the *ad valorem* SCT component, with the result that the SCT increased only marginally.

[viii] Note that this is a 20% and not a 20 percentage point increase in the excise rate. Given the information in column (9), the initial excise tax rate is 40/(100−13.04−40)=85.2% on the net-of-tax price. The new excise tax rate is 85.2×(1+(20/100))=102.2% on the net-of-tax price, *not* 85.2+20=105.2%.

Table 2 Model simulation growth rates versus actual growth rates, South Africa, 1994–2004

	1994 Value (1)	2004 Value (2)	Actual percentage change (3)	Predicted percentage change (4)
Retail price (Rand per pack, constant 2000 prices)	4.26	8.98	110.8	113.1
Consumption (millions of packs)	1769	1202	−32.1	−29.0
Per capita consumption (packs/adult)	69.6	38.5	−44.7	−42.3
Excise tax revenue (R million, constant 2000 prices)	1605	3927	144.7	163.2
Industry revenue (R million, constant 2000 prices)	5011	5541	10.6	15.6
Smoking prevalence (percentage)	31.0	23.5	−24.2	−24.4

cost—an additional 5 percentage points decrease in consumption (−10.1% vs −5.1%)—is probably too high for this to be considered a feasible strategy. This strategy greatly enhances the public health and fiscal benefits of an excise tax increase, at the industry's expense, which is not in the industry's financial interests.

In column (11) the industry decreases the net-of-tax price by 5% in response to a 20% increase in the ad valorem tax rate. This industry strategy undermines both the public health (−2.2% vs −5.1% change in consumption) and fiscal objectives (11.5% vs 13.8% increase in excise revenue) of the tax increase. This pricing strategy imposes a modest cost on the tobacco industry in terms of their revenue (−7.1% vs −5.1%). However, an industry interested in its long-term survival is likely to accept this modest short-term loss.

DISCUSSION

This paper presents a simple model that examines the likely outcomes of a change in cigarette excise taxes. The online application can be calibrated to approximate the cigarette tax structure in many low-income and middle-income countries. It will hopefully empower tobacco control advocates in their discussions with policy makers, in particular officials of the ministries of finance. Tobacco control advocates would be able to provide numerical estimates of the impact of a change in the excise tax, rather than talking in vague and general terms. Where there is uncertainty about the magnitude of certain parameters, the model allows the user to perform sensitivity analyses.

The online model also has a module that considers the impact of sustained increases in the excise tax and/or the net-of-tax price on the outcome variables for a 10-year period, using the same mathematical model as the one-off model presented in this paper, but taking cognizance of the fact that cigarette consumption increases as average income increases. In order to test the model's predictive ability, the outputs of the 10-year model are compared to South Africa's actual experiences between 1994 and 2004, a period marked by sharp increases in both the excise tax and the net-of-tax price. The price and income elasticity estimates of −0.8 and 0.9, respectively, are derived from a comprehensive time-series econometric study.[1] The realised average annual growth rates for relevant inputs for South Africa are the following: excise tax (in real terms, levied as a specific tax): 14%; real net-of-tax price: 5%; real income (approximated by GDP): 3%; and population: 2.1%. The VAT rate remained unchanged at 14%.

Comparing columns (3) and (4) in table 2 indicates that the model predicts the actual changes in the variables of interest quite well. Actual cigarette consumption decreased somewhat more rapidly than predicted, probably reflecting the fact that tobacco control legislation (banning tobacco advertising and introducing smoke-free indoor areas in 2001) has reduced cigarette consumption by a greater proportion than is explained by changes in the price alone. As a result, the actual increase in excise tax revenue and industry revenue is slightly less than predicted. Despite these minor deviations, the model seems to be adequate in predicting the underlying trends in the important variables. A similar accuracy test is more difficult for the short-term model, given stochastic variation, but since the short-term and long-term models have the same mathematical structure, one can infer that the short-term predictions should be of a similar quality as the long-term predictions.

A number of simulations were presented in this paper. While the quantitative conclusions depend on the parameter values, one can make a number of general conclusions for a wide range of parameter values. First, for all price elasticity values, an increase in the excise tax decreases cigarette consumption, smoking prevalence, smoking intensity and smoking-related mortality. The more elastic the demand for cigarettes, the greater the effect will be. Second, for a wide range of price elasticities, covering all realistic (and even some unrealistic) values, an increase in the excise tax will increase a government's excise revenue. Third, by increasing the net-of-tax price, the tobacco industry can reduce cigarette consumption by a greater percentage than had only the excise tax increased. As long as the tax structure creates the appropriate incentives for the tobacco industry to raise the net-of-tax price on cigarettes, the industry can be an unlikely ally in reducing tobacco consumption.

The structure of the excise tax plays a critical part in this regard. If the tax is levied specifically, an excise tax increase typically creates an incentive for the industry to increase the net-of-tax price, enhancing the tobacco control impact. If the excise tax is levied ad valorem, there is very little incentive for the industry to increase the net-of-tax price; it is more likely that the industry reduces the net-of-tax price. This strategy would impose a comparatively minor cost on the industry itself, but it would greatly undermine the public health and fiscal benefits of an excise tax increase.

The relative benefits and drawbacks of specific and ad valorem taxes have been discussed at length[3] and this paper does not wish to add to this literature, other than illustrating one important point: from the perspective of reducing tobacco consumption, a specific tax is more appropriate than an ad valorem tax. Also, increases in specific taxes have, given the incentive structures facing the industry, more predictable consequences than increases in an ad valorem tax. It is quite conceivable that, if the tax is levied ad valorem, the industry responds in a way that undermines the increase in the excise tax. This is not likely to happen if the tax is levied specifically.

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