



Calhoun: The NPS Institutional Archive

Faculty and Researcher Publications

Faculty and Researcher Publications

2014

Excise Taxes, Consumer Demand, Over-Shifting, and Tax Revenue

Dutkowsky, Donald H.

Public Budgeting & Finance / Fall 2014

<http://hdl.handle.net/10945/46138>



Calhoun is a project of the Dudley Knox Library at NPS, furthering the precepts and goals of open government and government transparency. All information contained herein has been approved for release by the NPS Public Affairs Officer.

Dudley Knox Library / Naval Postgraduate School
411 Dyer Road / 1 University Circle
Monterey, California USA 93943

<http://www.nps.edu/library>

Excise Taxes, Consumer Demand, Over-Shifting, and Tax Revenue

DONALD H. DUTKOWSKY AND RYAN S. SULLIVAN

This paper examines over-shifting in excise taxes, using the constant elasticity demand function under monopolistic competition. We apply the solution for price from this model to previous studies to obtain estimated price elasticities of demand. We also derive the excise tax, which maximizes tax revenue under this formulation, resulting in a revenue-maximizing tax-price ratio based upon the price elasticity. The model is applied to some previous experience regarding excise tax increases for alcoholic beverages and cigarettes. Our study offers structural insights behind empirical research that finds over-shifting. The model can also be used to help construct excise tax policy.

INTRODUCTION

Tax incidence continues to be an important issue for researchers and policymakers. In particular, federal, state, and local governments have increasingly used excise taxes to raise much-needed revenue as well as to deter the consumption of goods such as cigarettes (e.g., Center for Disease Control 2011) and alcohol. To this extent, governments have periodically levied increases in excise taxes on these and other goods, in some cases substantial.

As discussed in Sullivan and Dutkowsky (2012), estimates from Orzechowski and Walker (2010) state that from 2000 to 2010, the combined excise tax on cigarettes has risen over 150 percent in real dollars and that federal, state, and local government collect over \$32 billion in revenue per year from this source. Excise taxes on alcohol have been an important source of revenue as well. They generate over \$15 billion per year in revenue for federal, state, and local coffers (Tax Policy Center 2013). These taxes carry important implications for consumers, particularly in terms of how producers pass on these costs. And especially with the proliferation

Donald H. Dutkowsky is Professor of Economics in the Maxwell School of Citizenship, Syracuse University, Syracuse, NY 13244. He can be reached at dondutk@maxwell.syr.edu.

Ryan S. Sullivan is Assistant Professor of Economics in the Naval Postgraduate School, 205 Halligan Hall, Monterey, CA 93943. He can be reached at rssulliv@nps.edu.

of data in this area, a sizable body of empirical research has examined the effect of changes in the excise tax on prices for different goods.

In this regard, a number of studies have found empirical evidence of over-shifting, i.e. the price to consumers goes up by more than the amount of the excise tax increase. For cigarettes, the results of Barzel (1976), Johnson (1978), Harris (1987), Coats (1995), Keeler et al. (1996), Hanson and Sullivan (2009), and Sullivan and Dutkowsky (2012) all indicate over-shifting. Hanson and Sullivan (2009) find evidence of this behavior in examining the effect of an increase in Wisconsin cigarette taxes from \$0.77 to \$1.77 per pack, enacted January 1, 2008, on the prices charged by a set of individual retail stores. Sullivan and Dutkowsky (2012) also find over-shifting using panel data from two different samples, the Tax Bureau on Tobacco (TBT) and the American Chamber of Commerce Researchers Association (ACCRA). Harris (1987) has the highest estimates in this literature, showing price increases of roughly double the amount of the tax. Delipalla and O'Donnell's (2001) study with cross-country data points to over-shifting in cigarette taxes in some countries.

Some studies on tax incidence with cigarettes, though, do not find empirical evidence of over-shifting. Harding, Leibtag, and Lovenheim (2012), estimate tax shifting using Nielsen Homescan data of individual household purchases at the Universal Product Code level. They analyze the effect of a household living closer to lower-tax borders on tax shifting behavior and include a measure of consumer income in their estimations. The authors find evidence of under-shifting. DeCicca, Kenkel, and Liu (2013) investigate the effect of consumer price search on tax shifting using the Tobacco Use Supplements to the Current Population Survey. They find evidence of over-shifting based upon the full sample, but under-shifting for the subsamples of pack buyers, home-state carton buyers, and away-state carton buyers. Their results also indicate different pass-through responses in cigarette prices based upon consumer smoking habits and attitudes toward quitting.

Research has also found empirical evidence of over-shifting with alcohol. Barzel (1976) finds support for this behavior, based upon the price of distilled spirits in New York for 1971. Young and Bielinska-Kwapisz (2002) estimate the effect of changes in excise taxes on alcohol based upon quarterly ACCRA data from 1982 to 1997. Their results indicate over-shifting in beer, wine, and spirits. Kenkel (2005) investigates the effect of excise tax increases, all over 100 percent, levied by Alaska on January 1, 2003 for beer, wine and spirits. The author examines this behavior by calculating the "pass-through" rate as the change in retail price from individual establishments selling the beverage divided by the change in the excise tax. The results of Kenkel (2005) for a variety of specific name brands of alcoholic beverages, sold both on-premise and off-premise, almost uniformly point to over-shifting. He finds that the magnitude of over-shifting tends to be substantial, in some cases prices increasing by triple and even quadruple the amount of the excise tax change.

Partly as a result of the large number of empirical studies which show over-shifting, a literature has arisen that seeks to provide a theoretical basis for this phenomenon. This line of work has generally focused on models under imperfect competition, as standard tax incidence theory from perfect competition does not permit this behavior. To explain over-shifting, Barzel (1976) argues that tax increases induce multiple changes that affect prices, including the "quality

of the commodity and how it is transacted.” In their extensive survey, Fullerton and Metcalf (2002) put forth several different models of tax incidence, some of which allow for over-shifting, within imperfect competition. Young and Bielinska-Kwapisz (2002), Hanson and Sullivan (2009), and Sullivan and Dutkowsky (2012) also discuss possible reasons for this behavior. In the latter study, the authors derive a condition for when over-shifting will occur, based upon comparative statics results within a model of firm behavior under monopolistic competition.

This paper examines effects of the excise tax under monopolistic competition, given over-shifting. We work with a specification of consumer demand that has constant price elasticity. As described in Fullerton and Metcalf (2002), under certain conditions this model produces a closed-form solution for the firm’s price that implies over-shifting. We apply this model to previous empirical research in this area to obtain estimates of the price elasticity of demand.

Furthermore, we use the closed-form solutions for price and output to investigate the effectiveness of changes in the excise tax to generate tax revenue. We derive an operational condition for the ratio of the excise tax to the price of the good (including the excise tax) that maximizes tax revenue. This result is applied to some previous empirical research on price and excise taxes with over-shifting, by comparing actual mean tax-price ratios to the revenue-maximizing values indicated by our model. The comparisons enable us to obtain information on which goods are over-taxed, that is taxed beyond the revenue-maximizing level, or under-taxed, that is taxed below the revenue-maximizing value.

Overall, our study provides insights regarding possible structural behavior behind reduced-form models of excise tax pass-through that find over-shifting, including a number of previous studies. The framework also allows for formal investigation of tax revenue effects of excise tax changes for goods, which seem to exhibit over-shifting. This can serve as important information for governments to consider in determining whether to levy excise tax increases for such goods.

THE MODEL FRAMEWORK

Our model framework uses the constant elasticity demand model under monopolistic competition, as discussed in Fullerton and Metcalf (2002). This approach focuses on the behavior of the retail outlet that sells the good, such as the supermarket, smoke shop, liquor store, or convenience store, as opposed to the firm that produces the good in general. Monopolistic competition allows for product differentiation between a large number of individual stores, based upon characteristics such as consumer convenience or service. Another body of research on over-shifting puts forth theoretical models within oligopoly (see Fullerton and Metcalf 2002). In particular, Anderson, de Palma, and Kreider (2001) examine tax incidence under oligopoly with differentiated products. They demonstrate that within this framework over-shifting can take place, given summary conditions based upon demand curvatures. As an alternative to the model we work with, Fullerton and Metcalf (2002) also provide a Salop (1979) style model of tax incidence under monopolistic competition that emphasizes the distance between firms and concentration of firms as the distinguishing factor. They show that the Salop-based model, though, does not permit over-shifting.

Our model proceeds as follows. For the i th firm whose good has excise tax τ_i , with $i = 1, 2, 3, \dots, N$, consider the demand function $D(\cdot)$ given by:

$$Q_i = D(P_i, X_{D,i}) = f(X_{D,i})P_i^{-\beta}, \quad (1)$$

where Q is output, P is price, X_D is a vector of exogenous variables affecting demand, and $f(\cdot)$ denotes a positive-valued function. The elasticity parameter β has positive sign. This demand equation is convex in the price level, as $D_{PP} \equiv \partial^2 D / \partial P^2 = \beta(\beta + 1)f(X_{D,i})P_i^{-(\beta+2)}$. This property corresponds to the necessary condition for over-shifting under monopolistic competition discussed in Sullivan and Dutkowsky (2012).

As described by Fullerton and Metcalf (2002) and Young and Bielinska-Kwapisz (2002), under a cost function which is linear in output a closed-form solution exists for the firm's profit-maximizing price. To illustrate this result, we specify the firm's cost function $C(\cdot)$ as $C(Q_i, X_{C,i}) = g(X_{C,i})Q_i$, with X_C denoting a vector of exogenous variables affecting cost and $g(\cdot)$ a positive-valued function. Setting up the conventional profit maximization problem for the firm under monopolistic competition, substituting (1) and the above cost function into the profit maximization equation, performing the optimization, and solving the resulting first-order conditions yields the solution for the optimum price of the good, given by:¹

$$P_i = \frac{\beta}{(\beta - 1)}g(X_{C,i}) + \frac{\beta}{(\beta - 1)}\tau_i. \quad (2)$$

The price of the good charged by the i th firm (including the excise tax) is a function of the exogenous cost variables and is linearly related to the excise tax.

The above solution offers several results, which can be applied to the empirical literature on over-shifting. First, the exogenous demand variables X_D do not enter into the firm's price, most likely due to the linearity of the cost function with respect to output. Second, the usual assumption that higher excise taxes lead to increases in price requires the restriction that $\beta > 1$; the relationship holds only for price elastic goods.² Third, given that the good is price elastic, over-shifting necessarily takes place. Fourth, with the linear form of (2), the model can be used to infer structural properties of consumer demand from estimated models relating the price to the excise tax. For example, specifying the first term from this equation as $X_{C,i}\theta + \varepsilon_i$, with θ a parameter vector and ε_i a residual, and defining $\alpha = \beta/(\beta - 1)$, we can rewrite (2) as:

$$P_i = X_{C,i}\theta + \alpha\tau_i + \varepsilon_i. \quad (3)$$

1. We provide a detailed presentation of the optimization problem in Appendix A.

2. As stated previously, the price elasticity pertains to the good sold by the individual retail outlet. This is in contrast to estimates of price elasticity for the goods in general, which generally point to price inelastic behavior. For example, Chaloupka and Warner (2000) report estimated price elasticities for cigarettes of around 0.4.

With a sample of data including excise taxes that vary across time, states, or localities, this specification conforms directly to linear reduced-form models utilized in empirical research examining tax incidence, with possible choices for $X_{C,i}$ consisting of individual firm or state effects, time effects, or cost variables. Given estimates of the tax effect α , we can obtain the corresponding estimated price elasticity of demand as:

$$\hat{\beta} = \frac{\hat{\alpha}}{\hat{\alpha} - 1}. \quad (4)$$

A reasonable approximation to the standard error of the estimated price elasticity can also be found, using the standard error of $\hat{\alpha}$ and a first-order Taylor series approximation of (4) around the reduced-form estimate.

Table 1 reports estimated price elasticities and standard errors (where available), based upon some previous research that has found over-shifting in examining tax incidence under excise taxes (details regarding sources of the information from previous studies in our tables are available from the authors upon request). Using the estimates of the tax effect ($\partial P/\partial \tau$) taken from these studies, we compute the corresponding estimated price elasticity. The results uniformly indicate large estimated price elasticities of demand for cigarettes sold by individual retail outlets, since the estimated tax effects are close to unity. On the other hand, the higher estimated tax effects for alcohol from this literature point to smaller estimated price elasticity coefficients. Estimated price elasticities in this case range from 1.313 (red wine in Kenkel 2005) to 5.167 (wine in Young and Bielinska-Kwapisz 2002). Standard errors of the price elasticities are generally larger for estimated tax effects close to unity. For cases in which the standard t -test calls for rejecting the null hypothesis $H_0: \alpha = 1$ versus the alternative hypothesis $H_1: \alpha > 1$ at some reasonable level of significance, indicating over-shifting, the corresponding test on the price elasticity tends to reject the null hypothesis $H_0: \beta = 1$ versus $H_1: \beta > 1$.

The model also produces a closed-form solution for the i th firm's output under over-shifting. Substituting (2) into (1) for price yields:

$$Q_i = f(X_{D,i}) \left[\frac{\beta}{(\beta - 1)} g(X_{C,i}) + \frac{\beta}{(\beta - 1)} \tau_i \right]^{-\beta}. \quad (5)$$

Unlike price, output depends upon exogenous demand variables. The effect of the excise tax on optimum price from (2), $\beta/(\beta - 1)$, appears in this solution. As discussed previously, given that the elasticity parameter β has positive sign, a positive effect of the excise tax on price—and ultimately over-shifting—requires the additional assumption that the good is price elastic that is $\beta > 1$. With this assumption along with a positive-valued demand function $f(\cdot)$ and cost function $g(\cdot)$, it follows that $\partial Q_i/\partial \tau_i < 0$ for all nonnegative values of the excise tax.

A REVENUE-MAXIMIZING EXCISE TAX

Looking at the market as a whole, we now apply our model to the question of the revenue-maximizing excise tax for an individual good. The criterion consists of simply maximizing the total tax revenue collected by government(s). This framework offers a different perspective from

TABLE 1
Selected Estimated Price Elasticities of Demand Based Upon Previous Studies
(Standard Errors Appear in Parentheses)

Study	Tax effect	Price elasticity
Cigarettes		
Barzel (1976)	1.065 (0.011)	16.384 (2.604)
Johnson (1978)	1.101 (0.013)	10.901 (1.274)
Coats (1995)	1.021 (0.028)	48.619 (63.49)
Keeler et al. (1996)	1.110 (0.184)	10.091 (15.21)
Hanson and Sullivan (2009)		
Name brand	1.128 (0.009)	8.843 (0.554)
Generic	1.176 (0.025)	6.672 (0.804)
Sullivan and Dutkowsky (2012)		
TBT: premium	1.097 (0.033)	11.309 (3.507)
TBT: generic	1.098 (0.032)	11.204 (3.332)
ACCRA: state taxes	1.136 (0.032)	8.353 (1.730)
ACCRA: state and local taxes	1.104 (0.026)	10.615 (2.404)
Beer		
Young and Bielinska-Kwapisz (2002)	1.710 (0.356)	2.408 (0.706)
Kenkel (2005)		
Budweiser: on-premise	2.290	1.775
Budweiser: off-premise	2.140	1.877
Wine		
Young and Bielinska-Kwapisz (2002)	1.240 (0.099)	5.167 (1.719)
Kenkel (2005)		
White on-premise	3.270	1.441
Red: on-premise	4.190	1.313
Spirits		
Barzel (1976)	1.310 (0.040)	4.226 (0.416)
Young and Bielinska-Kwapisz (2002)	1.640 (0.497)	2.563 (1.213)
Kenkel (2005)		
Jack Daniels: on-premise	3.740	1.365
Jack Daniels: off-premise	1.960	2.042

Note: Tax effects refer to the estimated coefficients of the effect of a change in the excise tax on the retail price. Estimated price elasticities of demand are computed using equation (4). We compute standard errors based upon a first-order Taylor series approximation of (4) around the estimated tax effects.

the standard Pigouvian treatment of optimal taxation as done by a number of previous studies, including Gruber and Koszegi (2002) and DeCicca, Kenkel, and Liu (2010) with cigarettes and Pogue and Sgontz (1989) and Kenkel (1996) for alcoholic beverages. Pigouvian models tend to find high optimal taxes, although DeCicca, Kenkel, and Liu (2010) find that incorporating tax avoidance lowers the optimal tax. Our model assumes that governments levy excise taxes on cigarettes and alcoholic beverages just to obtain tax revenue, even though consumption of these

goods could lead to negative externalities. In so doing, it offers an alternative that avoids thorny modeling issues associated with using taxes to address negative externalities.

Revenue collection has arguably played an important if not primary role in excise taxation, especially for state and local governments. Levying and hiking excise taxes have been a key source of obtaining much-needed revenue, especially in times of budget tightness. This has particularly been the case when governments have been hampered from imposing or changing other types of taxes, due to difficulties in passing new legislation or existing institutional restrictions.³

We now work with the model based upon tax revenue maximization. Suppose that the set of governments (federal, state, and local) wish to impose a uniform excise tax τ on the good across firms. They seek the total excise tax which maximizes total tax revenue collected from sales of the good as denoted by TaxR, where $\text{TaxR} = \tau Q$ and $Q = Q_1 + Q_2 + Q_3 + \dots + Q_N$. Multiplying the solution for the i th firm's output from (5) by the tax and summing across the N firms results in the objective function:

$$\text{TaxR} = \tau \left\{ \sum_{i=1}^N f(X_{D,i}) \left[\frac{\beta}{(\beta-1)} g(X_{C,i}) + \frac{\beta}{(\beta-1)} \tau \right]^{-\beta} \right\}. \quad (6)$$

The government(s) then chooses the excise tax in order to maximize (6). Performing the optimization with respect to τ and substituting the solutions for price and output from (2) and (5), the resulting first-order condition can be expressed as:

$$-\tau \frac{\beta^2}{(\beta-1)} \sum_{i=1}^N \frac{Q_i}{P_i} + \sum_{i=1}^N Q_i = 0. \quad (7)$$

In turn, some rearrangement of (7) yields:

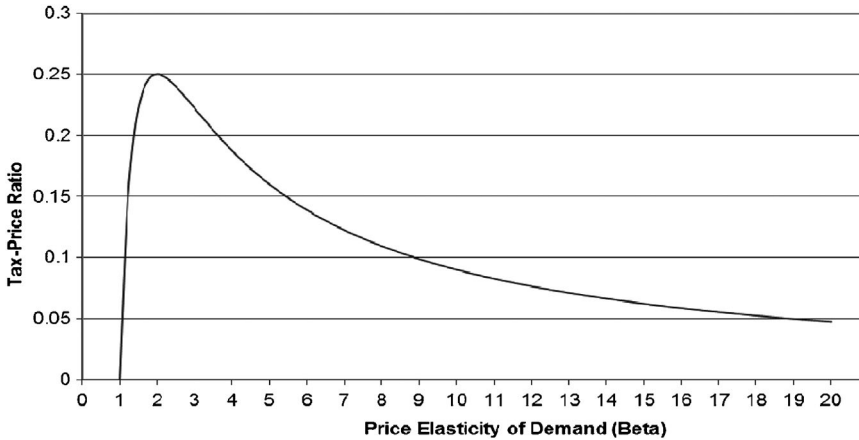
$$\tau = \left[\frac{\sum_{i=1}^N Q_i}{\sum_{i=1}^N (Q_i/P_i)} \right] \frac{(\beta-1)}{\beta^2}. \quad (8)$$

Note that the above equation does not represent a solution for the revenue-maximizing tax, as the τ variable appears in the price and output terms for each firm. Nevertheless, it puts forth an explicit condition for the revenue-maximizing tax, given store-level data on prices and output along with an estimate of the price elasticity described in the previous section.

In practical terms, though, store-level output data are difficult to obtain. So for operational purposes, we approximate (8) by assuming the same marginal cost across firms so that $g(X_{C,i}) = g(X_C)$, for $i = 1, 2, 3, \dots, N$. Given a uniform excise tax, from (2), this assumption implies that

3. For example, California enacted proposition 13 in 1978, which constrains property tax increases on homes of existing owners to 1 percent, unless in special circumstances.

FIGURE 1
The Revenue-Maximizing Tax-Price Ratio



Note: The revenue-maximizing tax-price ratio from (9), for various price elasticities of demand (β).

$P_i = P$, for $i = 1, 2, 3, \dots, N$. As implied by (5), heterogeneity in output can still occur due to different demand characteristics.

Substituting this restriction into (8), the condition simplifies to:

$$\frac{\tau}{P} = \frac{(\beta - 1)}{\beta^2} \tag{9}$$

We can obtain a closed-form solution for the revenue-maximizing tax from this equation, as substituting for the price from (2) into (9) and rearranging gives us $\tau = g(X_C)/(\beta - 1)$. That being said, a practical application comes from (9) as it stands. Subject to the approximation it provides a tax-price ratio that maximizes tax revenue, given the average price and estimated price elasticity of the good.

Figure 1 shows a graph of the revenue-maximizing tax-price ratio from (9) for a range of price elasticities. The function rises sharply as β moves from one to two, reaching a maximum of 0.250 at $\beta = 2$. This indicates that for a good with price elasticity of 2, the government(s) should tax to the amount where the ratio of the total excise tax to the price (including the tax) equals 0.250. For values of β greater than 2, the function exhibits a gradual decline but stays above 0. Even at $\beta = 20$, the revenue-maximizing tax-price ratio equals roughly 0.050.

Operationally we can compute revenue-maximizing tax-price ratios by substituting estimated price elasticities of demand, such as those that appear in Table 1, into (9). Given this information along with the existing excise tax and price of the good, the actual tax-price ratio can be compared to the revenue-maximizing value. In this way, it can be determined whether the good is under-taxed that is the actual tax-price ratio lies below the revenue-maximizing value, or if it is over-taxed that is the actual tax-price ratio exceeds the revenue-maximizing value. For

under-taxed goods, government(s) can increase the excise tax and gain additional revenue.⁴ Over-taxed goods generate less than the maximum tax revenue because the tax-price ratio is greater than the revenue-maximizing value. Based upon results from some previous studies, we apply the model to alcoholic beverages and cigarettes.

Alcoholic Beverages

Table 2 reports revenue-maximizing tax-price ratios and mean tax-price ratios for alcoholic beverages, based upon the previous findings of Young and Bielinska-Kwapisz (2002) and Kenkel (2005). The estimated price elasticities, the second column of results, come from the estimated tax effects as described in the previous section. The next column contains the revenue-maximizing tax-price ratios, computed using the price elasticities, and equation (9). We compare these values to the actual mean tax-price ratios, which comprise the remaining two columns.⁵ The table also includes the mean tax-price ratio before and after the tax levied by Alaska on January 1, 2003 for beer, wine, and spirits as investigated by Kenkel (2005).

The evidence from Table 2 indicates that beer, sold both on-premise (e.g., bars) and off-premise (e.g., stores), is under-taxed. The estimated price elasticities of around two lead to revenue-maximizing tax-price ratios near 0.250. The revenue-maximizing tax-price ratios all exceed the mean tax-price ratios by a sizable margin, even after the excise tax increase. These results hold for all the brands of beer examined in Kenkel (2005).

The findings from Table 2 indicate that wine is also under-taxed. As with beer, in all cases the revenue-maximizing tax-price ratio exceeds the mean tax-price ratio. This holds even after the excise tax increase investigated in Kenkel (2005). The results from Young and Bielinska-Kwapisz (2002) show a much smaller difference in the mean tax-price ratios from the revenue-maximizing values relative to Kenkel (2005). This result most likely stems from the fact that the former study examines wine sold off-premises (1.5 L bottles), while the latter paper looks at wine sold on-premises (6 oz glasses). As with beer, wine sold on-premise exhibits a larger deviation in the actual mean tax ratio from the revenue-maximizing value as compared to wine sold off-premise.

Regarding spirits, as with beer and wine the findings in all cases indicate that those sold on-premises are under-taxed. Even after the excise tax increase, the revenue-maximizing tax-price ratio, exceeds the mean tax-price ratio generally by a considerable amount. This finding holds for all the brands of spirits sold on-premise that Kenkel (2005) examines. On the other hand, the actual mean tax-price ratios for spirits sold off-premise are much closer to their revenue-maximizing values. This includes the result from Young and Bielinska-Kwapisz (2002), based upon 750 ml bottles. For that study as well as for Kenkel (2005) with Jack Daniels, Absolut, and

4. At first pass it may not be apparent that, especially under over-shifting, a rise in the excise tax necessarily results in a higher tax-price ratio. A tax hike also leads to a price increase that is higher than the tax increase, sometimes by a substantial amount. However, more formal examination reveals that the positive relationship unambiguously holds, as $\partial(\tau/P)/\partial\tau = [\beta/(\beta - 1)]g(X_C)/P^2 > 0$.

5. Due to data availability, in all cases we work with an approximation of the mean tax-price ratio, the ratio of the mean excise tax to the mean price.

TABLE 2
Revenue-Maximizing Tax-Price Ratios and Actual Mean Tax-Price Ratios:
Alcoholic Beverages

Study	Price Elasticity	Revenue-maximizing tax-price ratio	Actual mean tax-price ratio	
			Before tax change	After tax change
Beer				
Young and Bielinska-Kwapisz (2002)	2.408	0.243	0.101	
Kenkel (2005)				
Budweiser: on-premise	1.775	0.246	0.026	0.047
Budweiser: off-premise	1.887	0.249	0.080	0.126
Wine				
Young and Bielinska-Kwapisz (2002)	5.167	0.156	0.124	
Kenkel (2005)				
White: on-premise	1.441	0.212	0.023	0.041
Red: on-premise	1.313	0.182	0.023	0.040
Spirits				
Young and Bielinska-Kwapisz (2002)	2.563	0.238	0.156	
Kenkel (2005)				
Jack Daniels: on-premise	1.365	0.196	0.037	0.049
Bacardi: on-premise	1.376	0.199	0.039	0.051
Jack Daniels: off-premise	2.042	0.250	0.153	0.195
Jim Beam: off-premise	2.250	0.247	0.204	0.253
Bacardi: off-premise	2.408	0.243	0.221	0.273
Smirnoff: off-premise	2.493	0.240	0.226	0.279
Absolut: off-premise	1.926	0.250	0.138	0.176
Jose Cuervo: off-premise	1.885	0.249	0.146	0.185

Note: The estimated price elasticity of demand comes from equation (4), based upon the coefficients from the estimated tax effects from the study. The revenue-maximizing tax-price ratio uses equation (9). The actual mean tax-price ratio (before tax change and after tax change) equals the mean tax divided from the mean price from the study. More detail about the data and estimates from previous studies are available from the authors upon request.

Jose Cuervo, the findings indicate that spirits sold off-premise are also under-taxed. For these brands, spirits sold off-premise remain under-taxed even after the excise tax increase.

However, several spirits sold off-premise generate a different result. For Jim Beam, Bacardi, and Smirnoff from Kenkel (2005), the evidence indicates that the mean tax-price ratios before the tax change are close to the revenue-maximizing tax-price ratios but below these values. On the other hand, the excise tax increase for these spirits results in mean tax-price ratios that exceed the revenue-maximizing tax-price ratios.

The set of results regarding the alcoholic beverages from the data in Kenkel (2005) are consistent with the actual experience regarding the effect of the January 1, 2003 excise tax increase in Alaska. Total revenue from excise taxes on alcohol rose from approximately

\$14.0 million in 2002 to \$34.7 million in 2004.⁶ Our findings predict that since these beverages are predominantly under-taxed, such a hike in the excise tax would lead to increased tax revenue. In general, a finding that alcoholic beverages are under-taxed puts forth a strong argument for a hike in the excise tax on these goods. Raising the excise tax would serve both as a way to collect increased tax revenue and a deterrent to address negative externalities associated with the use of these goods.

Cigarettes

In terms of the ability of our model to accurately project changes in tax revenue resulting from excise tax increases, the findings for cigarettes are mixed. The data from Hanson and Sullivan (2009) give us mean tax-price ratios of approximately 0.300 before the January 1, 2008 tax increase and over 0.430 afterward. Since these tax-price ratios exceed the maximum value of $(\beta - 1)/\beta^2$ in Figure 1, the model would predict a decrease in tax revenue would occur as a result. This in fact did not happen. State and local tax revenue in Wisconsin increased from \$313.6 million in 2007 to \$485.5 million in 2008.⁷

On the other hand, our model is more consistent with the findings from Goolsbee, Lovenheim, and Slemrod (2010). They discuss the effect of a number of cigarette excise tax increases on tax revenue that took place between 2001 and 2005, highlighting the experience in New Jersey and Louisiana. The authors' results indicate that while Internet penetration led to decreased revenue than what would have taken place in its absence, cigarette tax revenue uniformly increased as a result of the excise tax hikes. Based upon the means of their sample data (Table 1 in Goolsbee, Lovenheim, and Slemrod 2010), we compute the ratios of the mean real state tax to the mean (real wholesale price + real state tax). Using the information in their Table 1, we compute this ratio for all states, the top 10 Internet growth states, and the bottom 10 Internet growth states. In fiscal year 2000, these ratios range from 0.163 to 0.182. Without having knowledge of the price elasticities or even if over-shifting has occurred, these mean tax-price ratios could plausibly be less than the revenue-maximizing values from our model. Moreover, these mean tax-price ratios overestimate the actual measures, since Goolsbee, Lovenheim, and Slemrod (2010) use wholesale rather than retail cigarette prices.

Arguably these mixed results reflect, at least in part, the highly stylized nature of our model. The framework contains a number of highly restrictive assumptions. For instance, the cost function is linear in output and therefore potentially important demand variables do not enter into the closed-form solution for price. And although the assumption of monopolistic competition may hold at the retail level, it may be less likely to hold at the wholesale level. Constant price

6. Source: "State and Local Alcoholic Beverage Tax Revenue, Selected Years 1977–2011" Tax Policy Center, Urban Institute and Brookings Institution. Accessed January 15, 2014. <http://www.taxpolicycenter.org/taxfacts/displayafact.cfm?DocID=399&Topic2id=90&Topic3id=92>.

7. The source for all the state and local tax revenue information in this section is: "State and Local Tobacco Tax Revenue, Selected Years 1977–2011" Tax Policy Center, Urban Institute and Brookings Institution. Accessed January 15, 2014. <http://www.taxpolicycenter.org/taxfacts/displayafact.cfm?DocID=403&Topic2id=90&Topic3id=92>.

elasticity of demand, exogenous cost variables, and identical marginal cost across firms (used to derive the tax-price ratio) represent other strict assumptions that may not map well into reality. Imposing any of these restrictions where they do not approximate the actual behavior could be responsible for the model's inaccuracy in predicting the Wisconsin experience. The overall findings from this section suggest that our model can potentially serve as a useful piece of information, although certainly not the final word, for evaluating effects of possible excise tax changes for goods which appear to exhibit over-shifting.

CONCLUSION

This paper illuminates the role of the constant elasticity demand specification under monopolistic competition, put forth by Fullerton and Metcalf (2002) and others, in analyzing tax incidence under over-shifting in excise taxes. Given this demand equation along with a cost function, which is linear in output, a closed-form solution for price exists that implies over-shifting. We examine properties of this solution and the corresponding closed-form solution for output and then apply the results directly to previous empirical studies that have found over-shifting in excise taxes. Our findings point to a wide range of estimated price elasticities, generally pointing to highly price elastic goods sold by individual retail outlets.

The structural model and closed-form solutions for price and output also enable us to examine tax revenue determination under this framework. We derive an explicit condition under this model that maximizes government tax revenue obtained from the good. This includes an approximation that leads to a revenue-maximizing tax-price ratio. A straightforward comparison of the actual excise tax-price ratio to this revenue-maximizing excise tax-price ratio can be made in order to discern the course of action that government(s) should take on the excise tax. Applying our model to examining effects of the excise tax increase in alcoholic beverages in Alaska examined by Kenkel (2005), predictions from the model are consistent with the actual experience. The model, though, generates mixed results when investigating of recent excise tax increases for cigarettes.

Certainly caveats apply here. The highly stylized nature of this model reflects a number of strict assumptions. These include cost functions linear in output, constant price elasticity of demand, monopolistic competition, and exogenous costs. At least in some situations, these restrictions may not approximate reality well and thus may lead to inaccurate predictions. Also, we do not consider the role of taxation in deterring consumption. On the other hand, the model's favorable aspects include tractable closed-form solutions for price and output, the price solutions in particular providing a structural basis to the literature of estimated price responses to excise tax changes that find over-shifting. These solutions also allow for a formal investigation of tax revenue. In this way, our model can offer information, although not the final word, on possible effects of excise tax changes, including tax revenue, on goods that appear to exhibit over-shifting. The decision to raise excise taxes by governments arguably warrants careful investigation in a number of different directions. This could include the use of alternative models that relax at least some of the restrictions from our study. That being said, based upon our overall results at least two additional thoughts emerge.

First, governments may wish to consider levying different excise taxes for alcoholic beverages (and possibly other goods) sold on-premise versus off-premise. The magnitude of over-shifting in the former case appears to be much greater than for the latter, resulting in lower estimated price elasticities and relatively high estimated revenue-maximizing tax-price ratios. Yet the findings suggest that the actual mean tax-price ratios for beer, wine, and spirits sold on-premises are small and much less than the revenue-maximizing values. On the other hand, wine and spirits sold off-premise appear to have mean tax-price ratios close to the revenue-maximizing tax-price ratios. Current excise taxes, based upon a constant tax rate per ounce of alcohol sold, are the same for alcoholic beverages sold on-premise and off-premise. Our results point to the potential benefits for a higher tax for those sold on-premise.

Second, this study points to the potential effectiveness of taxation by local governments. Municipalities generally have more versatility in changing taxes relative to federal and state governments. In this way, they can place a tax based upon the specific properties of the market for a chosen good in their individual localities. This can help to avoid possible inefficiencies that arise from varied responses to a uniform tax from different markets for the good across the state or even the nation. In the context of our work, this argument pertains to an individual good that exhibits over-shifting and is under-taxed. Local governments may be effectively able to levy a change in the excise tax whose magnitude will cover the difference between the existing tax-price ratio, based upon federal, state, and possibly local taxes, and the revenue-maximizing value. The literature on tax incidence has generally focused on state rather than local taxation, with Sullivan and Dutkowsky (2012) an exception. Our results indicate that further research in the area of excise taxation by local governments may be promising.

ACKNOWLEDGMENTS

The authors thank without implication four anonymous referees for a number of very beneficial comments on a previous version as well as Kathleen Bailey for editorial assistance. The views expressed in this document are those of the authors and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

REFERENCES

- Anderson, Simon P., André de Palma, and Brent Kreider. 2001. "Tax Incidence in Differentiated Product Oligopoly." *Journal of Public Economics*. 81: 173–192.
- Barzel, Yoram. 1976. "An Alternative Approach to the Analysis of Taxation." *Journal of Political Economy*. 84 (6): 1177–1197.
- Center for Disease Control. 2011. Economic Facts About U.S. Tobacco Production and Use. Accessed June 19. http://www.cdc.gov/tobacco/data_statistics/fact_sheets/economics/econ_facts/
- Chaloupka, Frank J. and Kenneth E. Warner. 2000. "The Economics of Smoking." In *The Handbook of Health Economics, Volume 1B*, edited by Anthony and Joseph Newhouse, 1539–1627. Amsterdam: Elsevier.
- Coats, Morris R. 1995. "A Note on Estimating Cross-Border Effects of State Cigarette Taxes." *National Tax Journal*. 48: 573–584.
- DeCicca, Phillip, Donald S. Kenkel, and Feng Liu. 2010. "Excise Tax Avoidance: The Case of State Cigarette Taxes." NBER Working Paper No. 15941, National Bureau of Economic Research. Cambridge, MA.

- . 2013. “Who Pays Cigarette Taxes? The Impact of Consumer Price Search.” *Review of Economics and Statistics*. 95 (2): 516–529.
- Delipalla, Sophia and Owen O’Donnell. 2001. “Estimating Tax Incidence, Market Power and Market Conduct: The European Cigarette Industry.” *International Journal of Industrial Organization*. 19 (6): 885–890.
- Fullerton, Don and Gilbert E. Metcalf, 2002. “Tax Incidence.” In *Handbook of Public Economics, Volume 4*, edited by Alan J. Auerbach and Martin Feldstein, 1787–1872. Amsterdam: Elsevier Science B.V.
- Goolsbee, Austan, Michael Lovenheim, and Joel B. Slemrod. 2010. “Playing With Fire: Cigarettes, Taxes, and Competition from the Internet.” *American Economic Journal: Economic Policy*. 2: 131–154.
- Gruber, Jonathan and Botond Koszegi. 2002. “A Theory of Government Regulation of Addictive Bads: Optimal Tax Levels and Tax Incidence for Cigarette Excise Taxation.” NBER Working Paper No. 8777, National Bureau of Economic Research. Cambridge, MA.
- Hanson, Andrew R. and Ryan S. Sullivan. 2009. “The Incidence of Tobacco Taxation: Evidence from Geographic Micro-Level Data.” *National Tax Journal*. 62 (4): 677–698.
- Harding, Matthew, Ephraim Leibtag, and Michael Lovenheim. 2012. “The Heterogeneous Geographic and Socioeconomic Incidence of Cigarette Taxes: Evidence from Nielsen Homescan Data.” *American Economic Journal: Economic Policy*. 4 (4): 169–198.
- Harris, Jeffrey E. 1987. “The 1983 Increase in the Federal Cigarette Excise Tax.” In *Tax Policy and the Economy*, edited by Lawrence H. Summers, 87–111. Cambridge, MA: MIT Press.
- Johnson, Terry R. 1978. “Additional Evidence on the Effects of Alternative Taxes on Cigarette Prices.” *Journal of Political Economy*. 86 (2): 325–328.
- Keeler, Theodore E., Teh-Wei Hu, Paul G. Barnett, Willard G. Manning, and Hai-Yen Sung. 1996. “Do Cigarette Producers Price-Discriminate by State? An Empirical Analysis of Local Cigarette Pricing and Taxation.” *Journal of Health Economics*. 15 (4): 499–512.
- Kenkel, Donald S. 1996. “New Estimates of the Optimal Tax on Alcohol.” *Economic Inquiry*. 34 (2): 296–319.
- . 2005. “Are Alcohol Tax Hikes Fully Passed Through to Prices? Evidence from Alaska.” *American Economic Review Papers and Proceedings*. 95 (2): 273–277.
- Orzechowski, Bill and Rob Walker. 2010. Tax Burden on Tobacco, Historical Compilation, Volume 45. Accessed December 30, 2010. http://nocigtax.com/upload/file/148/Tax_Burden_on_Tobacco_vol_45_FY2010.pdf
- Pogue, Thomas F. and Larry G. Sgontz. 1989. “Taxing to Control Social Costs: The Case of Alcohol.” *American Economic Review*. 79 (1): 235–243.
- Salop, Steven C. 1979. “Monopolistic Competition With Outside Goods.” *Bell Journal of Economics*. 10: 141–156.
- Sullivan, Ryan S. and Donald H. Dutkowsky. 2012. “The Effect of Cigarette Taxation on Prices: An Empirical Analysis Using Local-Level Data.” *Public Finance Review*. 40 (6): 687–711.
- Tax Policy Center. 2013. Tax Facts. Accessed March 5. <http://www.taxpolicycenter.org/taxfacts/listdocs.cfm?topic2id=80>
- Young, Douglas J. and Agnieszka Bielinska-Kwapisz. 2002. “Alcohol Taxes and Beverage Prices.” *National Tax Journal*. 55 (1): 57–73.

APPENDIX A

Derivation of the Optimal Price and Output Equations

This appendix presents a detailed description of the optimization problem and derivation of the solutions for price and output. For $i = 1, 2, 3, \dots, N$, the i th firm under monopolistic competition with excise tax τ_i maximizes profits, denoted by π_i , given by:

$$\pi_i = P_i Q_i - g(X_{C,i}) Q_i - \tau_i Q_i \quad (\text{A1})$$

subject to its demand function:

$$Q_i = f(X_{D,i}) P_i^{-\beta} \quad (\text{A2})$$

with all other variables having been defined previously. Therefore, the constrained optimization problem can be written as:

$$\Lambda_i = P_i Q_i - g(X_{C,i}) Q_i - \tau_i Q_i + \lambda_i [f(X_{D,i}) P_i^{-\beta} - Q_i] \quad (\text{A3})$$

where λ_i is the Lagrange multiplier pertaining to the constraint for the i th firm.

Assuming interior solutions, optimizing with respect to price, output, and the Lagrange multiplier results in the following first-order conditions:

$$Q_i - \lambda_i \beta f(X_{D,i}) P_i^{-(\beta+1)} = 0 \quad (\text{A4})$$

$$P_i - g(X_{C,i}) - \tau_i - \lambda_i = 0 \quad (\text{A5})$$

$$f(X_{D,i}) P_i^{-\beta} - Q_i = 0 \quad (\text{A6})$$

Solving the system (A4), (A5), and (A6) for P_i , Q_i , and λ_i yields the solutions for price and output reported in equations (2) and (5).