WASHINGTON STATE CIGARETTE CONSUMPTION REVISITED

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WASHINGTON STATE CIGARETTE CONSUMPTION REVISITED

EXECUTIVE SUMMARY

Purpose: The Washington State Department of Revenue (DOR) annually estimates Washington illegal cigarette purchases and lost tax revenue. The DOR analysis begins with the state's smoking rate, last estimated to be 86 percent of the U.S. per capita rate. This DOR study updates Washington's relative smoking rate based on the latest data.

Result: Washington's smoking rate has declined steadily from 86 percent of the U.S. rate in 1995 to 79 percent in 2004. This implies that higher taxes and prices over the past decade have not resulted in greater illegal sales. Fiscal Year 2006 illegal sales are estimated at 24 percent of total consumption or 82.6 million packs, which are in line with previous years. Lost cigarette and sales tax revenues are an estimated $200 million.

Washington Cigarette Sales: Total, Legal, and Illegal

State authorities have an abiding interest in total cigarette consumption for health, revenue, and enforcement reasons. Health departments are concerned with public health and public health expenditures, revenue agencies are interested in minimizing tax evasion, and other enforcement agencies are concerned with reducing organized crime.

Unfortunately, state authorities do not have good data on total cigarette consumption. Taxed cigarette sales can be measured by counting the number of state cigarette stamps issued. Cigarettes legally exempt from state taxes, such as sales to enrolled Indian tribal members, sales under a tribal compact, or sales on military bases, can also be determined reasonably well. However, state governments cannot pin down total cigarette consumption because the amount of illegal sales are unknown.

The Department of Revenue annually estimates total state cigarette sales so that illegal sales and lost tax revenues can be calculated. These estimates are also used by state health and law enforcement officials. For the past decade DOR estimates have begun with the assumption that Washington's per capita smoking rate is 86 percent of the U.S. per capita rate, based on a 1997 study by Thomas Clarke conducted for the Washington State Department of Health (DOH). Using total U.S. cigarette sales, DOR takes 86 percent of the U.S. per capita rate, subtracts sales that are exempt from state taxes, and compares the remainder to stamps sold—the difference is the estimate for illegal Washington sales.

This 2006 DOR research study uses econometric modeling and the latest available 50-state data to revisit Washington's relative smoking rate. The results of the study indicate that Washington's smoking rate has continued to decline in relation to the U.S. per capita rate. Table 1 below shows the results of this DOR study indicating that the state's cigarette sales have declined steadily to 79 percent of the U.S. rate.

Table 1
Decline in the Washington Smoking Rate
Relative to the U.S. per Capita Rate
From This and Previous Studies

Year Analyzed	WA Relative Smoking Rate	Study Conducted by (and year published)
1983	89%	ACIR* (1985)
1995	86%	WA DOH/Clarke (1997)
1997	84%	WA DOR (2006)
1998	85%	WA DOR (2006)
1999	89%	WA DOR (2006)
2000	85%	WA DOR (2006)
2001	84%	WA DOR (2006)
2002	82%	WA DOR (2006)
2003	78%	WA DOR (2006)
2004	79%	WA DOR (2006)

*The former American Council on Intergovernmental Relations

The Table 1 smoking rate is total Washington packs per capita divided by U.S. packs per capita. Total packs per capita include taxed packs, exempt packs, and illegal packs.

This study's estimated decline in Washington's relative smoking rate, evident in Table 1, is consistent with other data, particularly with surveys conducted by the Washington State DOH and the U.S. Centers for Disease Control (see Table 13, Part Two). Washington cigarette consumption fell from an estimated 75.3 packs per capita in 1997 to 53.3 packs in 2006 (see Table 5, Part Two). The study results indicate that among U.S. states, lower cigarette consumption is associated with higher tax rates and higher levels of income and education. Other factors contributing to Washington's low smoking rates and the containment of illegal sales are enforcement and education efforts and cigarette compacts with Indian tribes.

This study is a continuation of a long line of research in cigarette estimation. The methodology and results for the current DOR effort have been reviewed by a technical advisory group that includes representatives from the Office of Financial Management, the Department of Health, the State Legislature, the Liquor Control Board, and the Economic and Revenue Forecast Council. The study was also reviewed by outside reviewers from academia and other states.

PART ONE:

OVERVIEW OF WASHINGTON CIGARETTE SALES

1-1. Introduction

For twenty years DOR has used Washington's relative smoking rate as the starting point for estimates of total and illegal cigarette sales. In the late 1980s the Department used a relative Washington rate of 89 percent obtained from a 1985 study by the (former) American Council on Intergovernmental Relations (ACIR). For the past ten years the Department has been using a Washington smoking rate of 86 percent of the U.S. per capita rate, obtained from a 1997 DOH study conducted by Thomas M. Clarke. This paper presents the results of the similar 2006 DOR modeling effort that revisits these issues.

DOR uses econometric modeling to measure the impacts of pertinent economic factors on cigarette sales, including those factors associated with illegal activities. The econometric models use multivariate regression equations that estimate the effect of each factor on cigarette sales when many factors are changing at once.[1] Once the effects of illegal factors are identified, they can be dropped from the equations. The remaining factors then provide for the calculation of total cigarette consumption in each U.S. state without the impact of the illegal factors.

Total, per capita cigarette consumption resulting from the DOR 2006 econometric modeling, stated as a percent of U.S. per capita packs, is then used to estimate illegal cigarette sales in Washington State. The procedure for estimating illegal sales is to start with U.S. per capita smoking rates, subtract sales legally exempt from Washington state taxes, and compare the remainder to cigarette tax stamps sold—the difference is estimated illegal packs. Once illegal sales are known, Washington cigarette tax evasion is easily calculated with the use of applicable tax rates.

1-2. Layout of the Study

The rest of the study is structured as follows. Part One is an overview of the methodology and contains all of the study results. Part One is written to stand alone; the later sections are a more in-depth treatment. For brevity, Part One only provides results for Washington State and for the U.S. as a whole, not for each individual state. Part Two provides additional technical materials that detail the variables, methodology, and results. Part Two also has data for each of the 50 states and the District of Columbia. Appendix I shows how the estimated parameters (coefficients) from the DOR models are used to

[1] A regression equation is a statistical procedure used to measure how the change in one variable affects another, e.g. how a change in taxes affects taxed cigarette sales.

calculate the estimates for taxed cigarette sales and for total sales. Appendix II contains more information about the variables, including data sources and a thorough explanation and example of the important border index variables. Appendix III has a brief literature review of some of the recent cigarette research that is not explicitly discussed in the body of the study.

1-3. Factors that Influence Cigarette Sales

A state's per capita cigarette sales depend on a number of factors. Price is typically the first variable analyzed in demand studies; higher prices are assumed to be associated with fewer packs sold, all else being equal. High tax rates also imply less consumption because higher rates are generally reflected by higher prices.

In addition to absolute prices and tax rates, cigarette consumption is affected by the difference in prices or taxes across national, state, or local boundaries. The greater the tax/price difference, the more likely that buyers will casually cross borders in search of a better deal or that organized smuggling will meet market demands. Both casual and organized tax evasion decrease cigarette demand in high price/tax regions and increase demand in low price/tax regions.

Income also affects the number of cigarettes smoked, though it is not obvious if the effect is positive or negative. The demand for goods typically increases as households earn more income, but the evidence strongly suggests that higher incomes are associated with less smoking. Data indicates that high income households also tend to be more educated, and it is reasonable to suppose that educated people make more informed choices about tobacco use.

Demographic factors such as age, ethnicity, and gender may also affect per capita cigarette sales. Analysts generally let the data reveal which groups have higher or lower smoking rates; however, members of some religious denominations are known for following strict prohibitions against tobacco use. Researchers typically try to measure a wide range of potentially relevant population characteristics to determine which may be related to cigarette sales.

There are two other factors that must be differentiated in any cigarette estimate--buyers avoiding state taxes illegally and buyers legally exempt from state taxes. Legal, state exempt sales are primarily composed of three parts: sales on the reservation to enrolled members of Indian tribes, sales under a tribal compact, and sales on military bases to military households. In national models, analysts typically try to model these reductions from state taxed sales with the use of Indian and military shares of state population. However, DOR has Washington specific data that allows for a more accurate assessment of Washington's legal, tax exempt sales.

Illegal purchasers are, for the purposes of this study, those who seek to avoid applicable state taxes (it is more difficult, though not impossible, to evade federal taxes which are

generally collected from cigarette manufacturers). Illegal sales can involve a number of factors: casual purchases when traveling across borders, organized smuggling, remote sales via mail order or the Internet, and illegal sales on Indian reservations or military bases. Analysts use a number of procedures to measure the reduction in state taxed sales resulting from illegal activities. These procedures include an accounting for the number of border residents living in proximity to lower price/tax jurisdictions and the financial incentive for tax evasion as measured by differences in price and/or taxes. Other variables measuring state and regional access to cheap or low tax cigarettes are also employed. Unfortunately, there are no acceptable methods to estimate Internet sales separately from other illegal sales.

The final factor that analysts include when measuring cigarette demand is time, often measured in years. The behavior of buyers and sellers changes over time; for example, per capita smoking rates have been trending down since the 1970s. At the same time, sellers have raised prices in response to the master tobacco settlement of 1997. Institutional factors, such as the laws governing tobacco use, also change with time as illustrated by the expansion of indoor smoking restrictions. Analysts try to capture the effects of such changes by including variables that represent the flow of years.

Taxed packs are hypothesized to vary across states and years based on the variability of the explanatory factors discussed above. Regression analysis, a statistical modeling procedure, was employed to estimate state taxed cigarette sales based on these explanatory factors. Table 2 below lists the variables that represent these factors.

Table 2
Factors Influencing Cigarette Sales

The Type of Factor or Variable	What the Variable Measures
Price of a pack of cigarettes	Buyer response to prices
Total excise tax rate	Buyer response to tax rates
Bachelors degree	Influence of education on smoking
Disposable income	Influence of income on smoking
Hispanic, percent of state population	Influence of demographic factors on smoking
Asian, percent of state population	Influence of demographic factors on smoking
Mormon/Seventh-Day Adventist, St.%	Influence of these groups, known for less smoking
Miles to Raleigh N.C.	Measures shipping costs from tobacco center
Tourists, spending at hotels	Measures legal sales to out of state tourists
Military personnel, percent of St. pop.	Legally exempt sales
Indian reservations and proximity	Legally exempt sales, also potential illegal sales
State border price or tax indices	Proximity to border and incentive to evade taxes
Canada border tax indices	Proximity to border and incentive to evade taxes
Indicators for certain states/regions	Certain states or regions are sources of illegal packs
Years 1997 through 2004	Time trend and other factors

The variables listed in Table 2 are included in the DOR modeling because statistical tests indicate that these variables explain a significant portion of state taxed cigarette sales while other types of variables do not. The next section discusses the 2006 DOR modeling effort, the specific variables used, and the statistical methodology.

1-4. DOR 2006 Cigarette Modeling

Numerous econometric models were tested by DOR in 2006; this paper discusses four similar models, denoted Models 1, 2, 3, and 4. The results for these four linear multiple regression models are presented here because these are the top four models based on a number of criteria (the criteria are discussed below, following Table 3).

For brevity, only the parameter estimates for Model 1 are shown in this section while the full results for Models 2, 3, and 4 are presented in Part Two.[2] All four models, however, test the same general influences on cigarette smoking with each model having but minor differences. These differences concern the use of excise tax rates in place of prices, the inclusion/exclusion of disposable income, and the specific variable used to measure Canadian cross-border cigarette sales. The defining feature of Model 1 is that it contains personal disposable income as an explanatory variable while Models 2, 3, and 4 do not.

Table 3 below lists the specific variables tested in DOR Model 1 and the results estimated by the regression equation. The first results shown are the estimated parameters for each variable, the coefficients which explain how the variable affects taxed sales. Multiplying each coefficient by the actual value of the variable yields an impact in packs per capita. For example, Washington's 1997 inflation adjusted total excise tax rate of 105.68 cents per pack times the corresponding parameter estimate, -0.16, yields -16.9 taxed packs per capita.[3]

The next set of results listed are the t-values (or t-statistics) for each variable in Model 1. These provide evidence about the statistical significance of each variable. At the bottom of Table 3 are other regression results concerning the model's goodness of fit. The t-values and other statistics are discussed below the table. (Table 3 follows on the next page.)

[2] Results for models 2, 3, and 4 are shown in Tables 10 and 11.
[3] See Appendix I, Table A-1, for this data and calculation. Total excise taxes include the cigarette tax and general sales taxes.

Table 3
Model 1: Variables, Parameter Estimates, and Statistics

Variable	Parameter	t-Value
Intercept	148.916	38.96
Total excise tax rate	-0.160	-8.36
Bachelors degree	-94.507	-5.28
Disposable income	-0.001	-2.12
Hispanic	-78.619	-14.54
Asian	-29.443	-2.51
Mormon/Seventh-Day Adventist	-48.956	-9.75
Miles to Raleigh NC	-0.006	-6.40
Tourists, spending at hotels/motels	0.005	7.02
Military personnel	-153.440	-2.10
Indian reservation, within 60 miles	-5.817	-3.86
State border tax index, " 60 miles	0.086	20.28
Canada tax index, within 30 miles	-0.04509	-4.89
Kentucky binary variable (0 or 1)	54.887	17.83
New Hampshire binary variable (")	39.248	11.51
2000 binary variable (either 0 or 1)	-4.542	-3.34
2001 binary variable (")	-6.575	-4.78
2002 binary variable (")	-6.147	-4.37
2003 binary variable (")	-5.858	-4.08
2004 binary variable (")	-7.076	-4.78

R-square = 0.92; adjusted R-square = 0.91; the F-Value = 228
All variables are significant at the 5% level.

1-5. Does Model 1 Explain Taxed Cigarette Sales Well?

Three sets of results indicate that Model 1 explains taxed cigarette sales well.

i. How well does the entire model explain the sale of taxed cigarettes?

The statistics at the bottom of Table 3 indicate that this model is a good predictor of state taxed packs for the years 1997 through 2004. The R-square and adjusted R-square mean that Model 1 explains 91-92 percent of the variation in taxed cigarette sales, a good result for cross-sectional data with states as observations. The difference between the R-square and adjusted R-square is trivial, 0.004, implying that important explanatory variables are not missing from the equation. The high F-value implies a trivial probability, 1 in 10,000, that taxed sales are unrelated to the other variables.

Note that Table 10 in Part Two shows that Models 2, 3, and 4 also have R-squares and adjusted R-squares of 0.91-0.92, have similar F-values, and have estimated parameters that differ little from those of Model 1.

ii. How good are each of the estimated explanatory variables?

Table 3 also provides information about each variable tested. Each t-value larger than 1.96 (in absolute value) indicates that the associated variable is statistically significant at the 5 percent confidence level. Therefore, all of the variables in Model 1 can be said to be statistically related to taxed packs sold. Variables not included in the model, such as gender, age, or other ethnic groups, are generally not statistically significant (note that some variables for states other than Kentucky and New Hampshire were excluded despite the fact that they tested significant, as discussed in Part Two).

With the exception of the Canadian tax index, all the variables in the model have the expected effect on taxed cigarette sales.[4] Total excise tax rates have the expected negative sign. To interpret this, note in Table 3 above that the estimated excise tax parameter of (-) 0.16 means that a one cent higher excise tax rate implies 0.16 packs fewer taxed packs per capita, all else equal (or, a ten cent higher tax implies 1.6 fewer taxed packs per capita). Note also that total excise taxes and prices are very similar variables; the primary reason that prices differ across states is because excise tax rates differ. Model 1 uses excise taxes instead of cigarette prices, whereas Model 4 uses prices.[5]

Likewise, the next five variables listed are factors that have a negative impact on smoking. The population with Bachelor's degrees, average disposable income, and Mormon/Seventh-Day Adventist all have the expected negative impact on state smoking rates. Hispanic and Asian, the only two ethnic groups that were statistically significant, have lower smoking rates than the general population.

The number of miles to the center of the tobacco industry in North Carolina, reflecting shipping costs, also has the expected negative impact on the per capita sales of taxed packs. Hotel/motel spending, a proxy for out-of-state tourists buying in-state cigarettes, has the expected positive sign. The military personnel variable, with the expected negative sign, captures the ability to legally purchase tax exempt cigarettes on the base.

The variable for Indian reservations reflects all persons living in census blocks within 60 miles of the reservation, including the reservation itself (a 30-mile variation was also tested, but it had a smaller t-value). The expected negative sign captures a certain amount of the legal purchases on the reservation as well as illegal sales.

The state and Canadian border tax indices are index variables that incorporate each state's percentage of residents living in proximity to the border (the opportunity) and the price/tax difference across the border (the incentive). DOR tested price and tax indices for the U.S. states as well as 30-mile and 60-mile indices for both the U.S. and Canada. The specific state border variables used in Model 1, shown in Table 3, had the highest t-value for the states, but the Canada binary variable did have a higher t-value than the

[4] There is further discussion of all the variables, including the Canadian tax index and its unexpected sign, in Part Two and in Appendix II. The intercept term is also discussed in Part Two.
[5] The four models are discussed in Part Two.

index used in this model. The sign of the state border index turns out to be positive, but for the entire U.S. it could have been either.[6] However, the sign on the Canadian index was expected to be positive, not negative; Canadians should be buying cigarettes in the U.S. market where tax rates and prices are lower. The Canadian conundrum is explained in Part Two, section 2-3, with the use of Models 2 and 3.

The Kentucky and New Hampshire binary variables are expected to be positive because these two states are known to be sources of other states' illegal sales. Both have a positive sign with Kentucky selling nearly 55 additional packs to out-of-state residents and New Hampshire selling an additional 39 packs, on a per capita basis.

Binary variables were tested for all years, but only 2000 through 2004 were statistically significant. The binary variable for 2000 takes on a value of one in the year 2000 and zero otherwise. The parameter estimate means that per capita sales in 2000 are 4.5 packs lower than they would be otherwise. The negative sign was expected due to declining U.S. smoking and to the impacts of the master (tobacco) settlement agreement.

Note that Part Two has more detail on the explanatory variables.

iii. How do the Model 1 estimates compare to actual, taxed cigarette sales?

The last indication that Model 1 accurately estimates the demand for state taxed cigarettes is to examine the residual, the difference between actual sales and the model's estimates (e.g. the model's predicted values). The Washington residuals, averaged over eight years, are shown in Table 4 below.

Table 4
Washington Actual, Estimated, and Residual
Taxed Packs Per Capita; Model 1,
1997-2004 Averages

Washington; average, actual taxed packs	49.1
Washington; average, estimated taxed packs	49.5
Difference = the average residual	0.4

The residual in Table 4, the difference between actual taxed sales and the model estimate, is only four-tenths of a pack per capita.[7] Residuals for other states are as small or smaller than previous estimates, as shown in Part Two, Table 8.

[6] Exhibit A-1 in Appendix II discusses the construction of the border index and provides a detailed example.

[7] The Table 4 estimated values are derived by multiplying each variable's parameter (coefficient) times its Washington value, then summing. This is done for each of the eight years (so, this requires 8 times 19 = 152 multiplications). The results are then averaged over the 1997-2004 period. Actual taxed packs are also averaged over the period. The same operations are repeated for each state. The Washington Model 1 calculations are shown in Appendix I, Table A-1. The same procedures are followed for Models 2, 3, and 4, but those detailed calculations are not shown.

1-6. Washington Total Sales and Relative Smoking Rate

The purpose of the DOR 2006 modeling effort is to estimate Washington's relative smoking rate which includes cigarettes purchased from all sources: state taxed, state tax exempt, and illegal non-taxed. [8] The procedure is to identify those variables associated with illegal sales and remove them from the model. Packs per capita then rise when the calculation is done without the influence of the illegal activity.

Variables associated with illegal activity are:[9]

-proximity to Indian reservations (60 miles)
-state border tax index (60 miles)
-Kentucky binary
-New Hampshire binary
-Canadian tax index (30 miles).

Using the estimated parameters to recalculate Models 1 through 4, but without the above variables associated with illegal activity, yields estimated total Washington per capita sales.[10] The results for Models 1 through 4 are shown in Table 5 below. Also shown for comparison is the declining U.S. trend in packs per capita.

Table 5
Washington and U.S. Trends
Total Packs per Capita,
Models 1 through 4

	Estimated, Total Washington Packs per Capita				**WA, Avg. of**	*Actual U.S.*
Year	Model 1	Model 2	Model 3	Model 4	**Models 1-4**	*Packs/Capita*
1997	75.0	74.0	77.1	75.2	**75.3**	*90.2*
1998	73.3	72.9	75.9	73.2	**73.8**	*86.8*
1999	71.7	71.4	74.4	70.7	**72.0**	*81.1*
2000	65.3	65.2	68.1	66.3	**66.2**	*77.6*
2001	62.9	62.8	65.7	63.6	**63.8**	*75.6*
2002	58.4	57.8	60.6	64.5	**60.3**	*73.5*
2003	55.2	54.3	57.1	56.1	**55.6**	*71.6*
2004	53.4	53.2	55.8	55.7	**54.5**	*68.6*

Projected out to 2006, Washington per capita consumption = **53.3** packs; U.S. = 67.5.
Note, total packs per capita means all consumption, including tax exempt and illegal.

[8] Before estimating total cigarette sales per capita, there is a further step concerning state tax exempt sales. For brevity, this is not discussed here. See Part Two, section 2-5, for details, as well as Appendix II.
[9] There are also three additional variables other than those listed here that may be associated with illegal sales: the absolute level of taxes and prices, and illegal U.S. imports. These are discussed in Part Two and Appendix II.
[10] Estimated Washington sales, without the influence of the illegal variables, are calculated for Model 1 in Appendix I, Table A-2. This requires the same type of calculations described in the footnote to Table 4 above. The result is Washington total consumption per capita, shown in Table 5. These can then be stated as a percent of U.S. consumption, yielding Table 6.

Table 5 shows Washington's declining trend; these are total, per capita packs sold estimated with Models 1 through 4. Consumption is also trending down for the U.S. How does Washington compare to the nation? Table 6 below provides the trend for the relative Washington smoking rate (the average of the estimated total Washington per capita rates divided by the actual U.S. rate).

Table 6
Washington Total Packs per Capita
As a Percent of U.S. Packs per Capita

Year	Model 1	Model 2	Model 3	Model 4	**Average for Models 1-4**
1997	83%	82%	85%	83%	**84%**
1998	84%	84%	87%	84%	**85%**
1999	88%	88%	92%	87%	**89%**
2000	84%	84%	88%	85%	**85%**
2001	83%	83%	87%	84%	**84%**
2002	80%	79%	82%	88%	**82%**
2003	77%	76%	80%	78%	**78%**
2004	78%	78%	81%	81%	**79%**

Table 6 above shows that Washington's estimated smoking rate has declined relative to the U.S. per capita rate. This declining trend is similar across all four model specifications. By 2004 the Washington rate, averaged across Models 1 through 4, was 79 percent of the U.S. per capita rate. This rate is used in the following concluding section to calculate illegal Washington sales and lost tax revenues.

The DOR model results indicate that, for those factors testing significant, Washington's high and increasing tax rate and high levels of income and education have the strongest influences on the declining smoking rate. Note that other models tested by DOR and other studies indicate that tobacco control expenditures and tobacco control policies also contribute to declining tobacco use.[11]

[11] For example, Tauras et al. find that tobacco control expenditures reduce youth smoking. Farrelly et al. use models similar in some respects to the DOR models, but with different specifications and data, and find evidence that increased funding for state tobacco control programs does reduce tobacco use. DOR also found that tobacco control expenditures and tobacco control policies tested significant in a number of models, but not in the top DOR models. There is a more detailed discussion in a footnote that follows Table 13 at the end of section 2-9, Part Two. See also the discussions regarding "variables that were not significant" in Part Two and in Appendix II.

1-7. Conclusion; Illegal Sales and Lost Revenues

The purpose of this study is to update the Washington per capita smoking rate, relative to the U.S. rate, last estimated by DOH/Clarke to be 86 percent. The results of the top four DOR models presented here indicate that Washington per capita total cigarette sales have declined as a share of U.S. sales. By 2004 the relative Washington rate had fallen to 79 percent of the U.S. per capita rate.

To determine illegal Washington sales and lost tax revenues, DOR starts with U.S. per capita consumption of 67.5 packs in Fiscal Year 2006.[12] Washington consumption was 79 percent of that, or 53.3 packs. Washington taxed packs per capita were only 33.2 which leaves 20.1 untaxed per capita, or 127.9 million untaxed packs.

The next step is to subtract sales that are legally exempt from state taxes: sales on military bases to military households, sales to enrolled members of Indian tribes, and sales under a tribal compact.[13] Some 45.3 million packs can be attributed to legitimate military and Native American sales. This leaves 82.6 million illegal packs sold.

These 82.6 million illegal packs represent 24 percent of all, taxed, exempt, and illegal cigarettes sold in Washington. The study results imply that the illegal sales have been remarkably flat since 1996, averaging just about 24 percent of total sales despite substantial increases in prices and taxes.[14] Enforcement, tobacco control policies, and compacts with Indian tribes are among the factors that have kept illegal sales in check.

Using applicable cigarette and state sales tax rates, as well as DOR samplings of retail prices, $200 million in state revenues were lost to tax evasion in Fiscal Year 2006. Note that the previous Washington estimate of 86 percent of U.S. per capita sales, rather than 79 percent, would have resulted in a 2006 evasion estimate of $271 million instead of the current $200 million.

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[12] DOR uses total U.S. consumption as the starting point because it is readily available in a timely manner from the consulting firm of Orzechowski and Walker and from the semiannual U.S. Department of Agriculture publication *Tobacco Outlook*.

[13] Tax exempt, Native American sales are a share, equal to state per capita sales, that is allocated to each enrolled tribal member for personal consumption. Sales under a tribal compact refer to cigarettes affixed with qualifying tribal tax stamps that tribal retailers sell to consumers. The first compact providing for tribally taxed cigarettes was implemented in 2001, but the volume of compact sales in the initial years was small. Compact sales increased slowly to some eight million packs in Fiscal Year 2004, the last year covered by the study. Subsequently implemented compacts have boosted 2006 compact sales to 31 million packs. DOR estimates that the implementation of tribal taxes under the compacts has resulted in the sale of at least 12 million additional state taxed packs in Fiscal Year 2006. In other words, packs that would otherwise have been lost to 2006 illegal activity were converted into 31 million tribally taxed packs and 12 million state taxed packs (the latter because price savings at tribal outlets have greatly diminished).

[14] Illegal sales peaked at approximately 26 percent of total sales after previously released estimates are restated using the new Washington rate of 79 percent of U.S. per capita sales (instead of the old 86 percent figure). Previously published estimates for 2002 through 2004 had been 28 to 32 percent.

PART TWO:

ECONOMETRIC MODELING

Part Two provides a more detailed presentation of the DOR methodology and results. This includes descriptions and results for Models 2 through 4, further technical modeling details, and data for the 50 states and Washington, D.C.

2-1. A Brief History of Washington Cigarette Estimation

The 2006 DOR study is a continuation of a long line of research, and the results compare well with the previous work. The presentation below discusses the current modeling effort within the context of this previous research.

In 1985 the former American Council on Intergovernmental Relations (ACIR) followed previous efforts by the Bureau of Alcohol, Tobacco, and Firearms and constructed a linear cross-sectional model that used observations from the 50 states and Washington, D.C. The variable explained was per capita taxed packs sold. The explanatory variables that drove consumption were prices, taxes, personal income, price and tax differences between states, demographics, tobacco control policies, the presence of Indian reservations and military bases, and other state characteristics that may affect smoking rates. By manipulating the model the ACIR found Washington total sales to be 89 percent of the U.S. per capita rate, a value used by DOR to estimate illegal sales until 1997.

In the 1997 DOH/Clarke study, *Cigarette Consumption in Washington State*, Clarke used a similar approach but modified the procedure in an innovative manner using two models, a cross-sectional model for the U.S. with a separate Washington time series model incorporating state time trends. Clarke found Washington total sales per capita to be 86 percent of the U.S. rate for 1995, a percentage used by DOR until the present.

Patrick Fleenor's 1998 Tax Foundation publication, *How Excise Tax Differentials Affect Interstate Smuggling and Cross-Border Sales of Cigarettes in the U.S.*, incorporated in one model both cross-sectional data (state by state) and time series data (year by year). Such datasets, tracking observations on a specific set of people, states, countries, etc., over a period of time, are called panel data; the models used with panel data are cross-sectional time series.

The 2006 DOR econometric modeling uses a linear, cross-sectional time series approach that builds upon the ACIR, Clarke, and Fleenor models. The four DOR multivariate models presented here make use of data from the 50 states and D.C. over the period 1997-2004. The DOR modeling effort is explained in the next section.

2-2. DOR 2006 Modeling Procedure

The DOR linear, cross-sectional time series approach uses eight years of data from the U.S. states and Washington, D.C. To help visualize the data employed and the type of model being estimated, Table 7 below has an excerpt from the dataset.

Table 7
Data Layout

State	Year	Per Capita Packs	Real Avg Price	Real Excise Tax	Tourism	Asian %	Hispanic %	Under 18	Average Income	Military Personal	Canada Border	Canada Index
Alabama	1997	104.9	176.0	25.8	104.7	0.6%	0.9%	25.6%	19,483	1.3%	0	0.00
Alaska	1997	81.7	225.4	30.5	410.0	3.7%	3.8%	30.7%	24,989	3.5%	1	9.83
Arizona	1997	64.6	233.4	72.6	410.0	1.6%	22.8%	26.7%	20,144	0.8%	0	0.00
Arkansas	1997	108.7	190.6	42.6	123.3	0.6%	1.1%	25.7%	18,322	0.8%	0	0.00
:	:	:	:	:	:	:	:	:	:	:	:	:
Washington	1997	55.6	278.8	105.7	263.9	4.9%	6.0%	25.8%	24,420	1.1%	1	67.71
W. Virginia	1997	114.5	169.2	29.4	183.2	0.5%	0.6%	23.0%	18,086	0.6%	0	0.00
Wisconsin	1997	91.9	211.0	56.8	167.1	1.4%	2.7%	25.8%	22,118	0.5%	0	0.00
Wyoming	1997	108.8	172.6	12.6	528.5	0.6%	6.2%	27.1%	21,465	1.4%	0	0.00
Alabama	1998	106.2	188.0	25.5	107.8	0.7%	1.1%	25.5%	20,313	1.1%	0	0.00
:	:	:	:	:	:	:	:	:	:	:	:	:
Wyoming	1998	102.9	175.8	12.5	541.2	0.6%	6.2%	26.8%	22,514	1.4%	0	0.00
:	:	:	:	:	:	:	:	:	:	:	:	:
Alabama	2004	87.9	298.9	32.2	104.4	0.9%	2.1%	24.2%	23,320	0.9%	0	0.00
:	:	:	:	:	:	:	:	:	:	:	:	:
Wyoming	2004	47.5	328.7	69.3	727.0	0.7%	6.9%	23.1%	28,741	1.3%	0	0.00

The actual dataset contains a row for each state by each year starting with Alabama in 1997 and ending with Wyoming in 2004 (only a few states and years are presented in Table 7). Including the District of Columbia, 51 observations for each of the eight years result in a total of 408 rows.

Running along the top of the table are a small portion of the variables or data fields. The first two columns are state and year, followed by per capita (taxed) packs of cigarettes sold in each state for each year. The "per capita packs" field is the dependent variable explained by the regression models.

The remaining ten columns are the types of independent or explanatory variables that may affect per capita smoking rates in each state. Like most goods, cigarette sales depend on the price, consumer income and preferences, and other factors. Thus, each state's per capita purchases depend on variables similar to those in Table 7: average prices; average income; the number of tourists; and various demographic factors such as the percentage of the state's population that is Asian, Hispanic, and under 18 years old. Cigarette sales may also depend on other demographic factors not shown above.

Cigarette purchases will also be influenced by cigarette excise taxes, the opportunity to purchase legal, but untaxed cigarettes, and the opportunity to purchase illegal cigarettes; the excise tax field and the last three columns concerning military personnel and Canada deal with these issues. The fields listed in Table 7 are only a small sample of variables tested in the various models. The full dataset has approximately 185 fields.

Numerous models and specifications were tested. The results of the top four DOR models are discussed because the four similar models perform better on a number of criteria than alternative models do. Models 1, 2, 3, and 4 have practically the same R-squares and adjusted R-squares explaining 91-92 percent of the variation in taxed packs sold. All four models also have large F-values implying that there is little chance that taxed sales are unrelated to the variables in the model. In addition, the four models all have similar sets of statistically significant explanatory variables and yield small average residuals for the 50 states (and D.C.).

2-3. Evaluating the Independent Variables

In discussing the independent variables and the results, an attempt is made to show the continuity between this modeling effort and the works cited above. The methodology and results are better understood within the context of the past research. Note also that all dollars and cents are in real terms (constant dollars, 2000 base year). There is more information on the variables, their construction, and data sources in Appendix II.

Intercept: The intercept has no economic meaning. In this linear regression model the intercept shows the hypothetical number of taxed packs per capita when all of the explanatory variables have a value of zero, something that is outside the range for which these models are designed, and a scenario that is not realistic.

Prices and total excise taxes: Prices and taxes are in cents. Taxed sales are widely believed to be inversely related to tax rates. In addition, the excise tax variable behaves in these models in a manner very similar to retail cigarette prices. In all the models tested, the excise tax variable was found to have higher t-statistics and higher R-squares than the retail price variable.

The ACIR models also rejected the price variable in favor of the excise tax rate for the same reasons, though both Clarke and Fleenor working in the 1990s found price models did better. However, the choice of excise tax or price makes little difference because the overall explanatory power is similar for either type of model. Model 4 is the comparable retail price model with prices replacing taxes; it has the same overall explanatory power of 91-92 percent of the variation.

There are other reasons for preferring the excise tax models over the retail price models. The primary reason why prices differ across states is because of tax differences; variations in shipping and other dollar costs are relatively small in comparison. In addition, price data is not as accurate as tax rate data. Data for national price trends are reasonable, but price data for a given state in a given year are not as reliable. Therefore, we report excise taxes along with, or in place of, retail prices.

Bachelor's Degree and Disposable Personal Income: These two are discussed together because they behave in the models as if they are the same variable. Generally speaking, college degrees and income vary together; not only does a degree imply a greater earning

potential, but the probability of earning a degree rises with income. On the other hand, smoking is inversely correlated with both income and education. The two variables are therefore highly correlated.

A researcher has a few options when faced with such correlations (e.g. multicollinearity). The first and most common option is to do nothing--though the effects of the two cannot be disentangled and the parameter estimates are therefore unreliable, the overall explanatory power of the model is unimpaired. Since we're not concerned with these two specific parameter estimates, we simply do nothing and report the variables when they are found to be significant. (Another alternative is to bring in more data as in Fleenor's 38-year model, 1960-1997.)

Bachelor's degree is significant in most of the models and has the expected negative sign. Personal disposable income is also significant in Model 1 and has the correct sign, but it was generally weaker and was typically not significant unless Bachelor's degree was omitted. Income was not significant in the other three models discussed in this paper.

Note: Bachelor's degree is stated in terms of the percent of the state population, while real per capita disposable income is in dollars ("disposable" means after taxes).

Demographic variables: The percentage of a state's population identified as Hispanic, Mormon, Seventh-Day Adventist, or Asian. Other studies have shown that these groups have lower smoking rates than the general population, as the negative coefficients verify. Other population characteristics did not test significant.

Note that Seventh-Day Adventist had large standard errors when tested alone. Like multicollinearity (which is often the cause), large standard errors imply that the parameter estimate may be unreliable, though the entire equation is unimpaired. In this situation researchers often combine two similar variables, as was done here with the single variable Mormon/Seventh-Day Adventist. This variable also has the expected negative sign.

Tourists/spending at hotels: Spending by visitors from out of state will increase the number of cigarettes sold in that state; this is proxied here by the revenues of the hotel industry (contributions to gross state product, in dollars per capita).

Miles to Raleigh, North Carolina: North Carolina is the center of the tobacco industry and miles from Raleigh are a proxy for shipping costs, which are expected to be negatively related to smoking. The "Miles" variable is also acting as a regional indicator. The ACIR uses an East/West regional binary variable as well as a Plains binary, though Clarke found neither of them significant. Fleenor used two versions of cross-border price indices, an East and a West version; his variable for distance to a low tax state also functions as a regional indicator.

A number of variables indicating distance or region were tested in the DOR models. Distance variables included: distance from the nearest low tax state, a miles-to-Raleigh/

gasoline-cost variable, and the log of miles to Raleigh. Regional binaries included: East-West, North-South, Pacific, Pacific Rim, New England, Northeast, Southeast, and others. Also tested were population density variables. In comparison with other variables reflecting East/West regional differences, Miles to Raleigh was significant in nearly every DOR model and it generally had the highest R-square. Note that variables indicating "West" are also expected to have a negative sign because greater Western distances make smuggling less attractive.

The other regional variable that plays a role in this modeling concerns Northern states and is discussed in terms of the Canadian border index below.

Military personnel: Military personnel may legally purchase, at military stores or commissaries, cigarettes that are legally exempt from state excise taxes. Prior to November 1, 1996, military bases were believed to be the source of widespread illegal sales because cigarette prices at military commissaries and exchanges were discounted up to 75 percent of retail prices. Policy changes in 1996 had the effect of substantially raising prices at military outlets. Since 2001 military policy requires that prices be no less than 95 percent of the local market price, though the market price in many locations may not include local taxes (the regulations are not specific and are not interpreted uniformly). Because of these changes, military bases no longer appear to be a notable source of illegal sales. Therefore, the 2006 DOR study does not consider the military personnel variable a factor related to illegal activity.

The number of active duty and national guard/reserves in each state, as a percentage of state population, is used to measure those personnel who are likely to live a reasonable distance from a military base where state tax exempt cigarettes are sold. Military presence has the expected negative sign and is significant in the three excise tax models, but not in the price model.

Indian reservation, 60 miles: People living near Indian reservations may have an opportunity in some states to illegally purchase cigarettes that have not been taxed by the state in which they are sold. These cigarettes may carry the stamp of a lower tax state or no state tax stamp at all. Therefore, the expected sign on this variable is negative.

To measure the influence of Indian reservations the ACIR and Clarke tested a number of different measures of proximity to reservations, but to no avail. Fleenor, with his large dataset, was able to obtain results for a compound variable that included a binary for the presence of a reservation combined with the percentage of a state's population that was Native American. However, a problem with Fleenor's approach is that the 38-year time span is too long to have confidence in some of the estimates because many of the behavioral relationships have changed markedly over the period (e.g. state policies on Indian cigarette sales).

The DOR models improved significantly upon previous work by using geographical information systems (GIS) data. DOR tested three measures of proximity to Indian reservations: the percentage of a state's population that lived in census blocks

intersecting reservation boundaries, the percent in census blocks within 30 miles of reservations and the percent living in census blocks within 60 miles of a reservation. The 60-mile reservation variable was significant in nearly every model tested. Though the 60-mile variable was best, the 30-mile variable added almost as much explanatory power to our equations and had t-values almost as high. This indicates that the additional 30 miles garners few additional buyers.

Native Americans consumers can also purchase legal, state tax exempt cigarettes, which would also be expected to have a negative effect on state taxed consumption. In a number of states Native Americans also sell cigarettes that carry tribal tax stamps instead of state stamps; in Washington these sales are under the authority of tribal compacts. To measure the impact of state tax exempt sales, DOR tested models with the share of Native Americans in each state and with the share of enrolled tribal members (a much smaller population). Like Clarke and the ACIR, the DOR efforts were not successful because the sale of tax exempt cigarettes is related to the presence of reservations, and therefore to the proximity to reservations variable (60-mile). No method was found to decompose these effects on taxed packs sold.

State border tax index, 60 miles: This measures the incentive and opportunity to purchase illegal cigarettes across state borders; it is probably the most important variable in the dataset. Some variant of a border tax/price variable has been significant in every study done, and our state border tax/price variables had higher t-statistics and more explanatory power than any other variable tested.

Like the proximity to Indian reservations, the border tax variable uses GIS data to locate populations living within 30 or 60 miles of a state border. The variable has two components; the difference in prices (or taxes) between two adjacent states measures the incentive, while those living in census blocks 30 or 60 miles from a border measures the opportunity. Using census blocks is more precise than the previously available technology which employed counties lying within 60 miles of a state border.

DOR tested both price differentials and tax differentials and found that cigarette excise tax variables yield better results. Like Indian reservations, the 60-mile variant was marginally better than the 30-mile variant, but the results indicate that most activity is from within 30 miles.

Washington's index is calculated by multiplying the tax (or price) difference with Oregon by the number of Washington border residents stated as a percent of Washington's population, since those Washington residents have the opportunity to import illegal cigarettes. Likewise, if Oregon's taxes (prices) were higher, then *Washington's index* would include border Oregonians as a percentage of Washington's population.

The Washington-Idaho border is treated the same and the two components are summed. Thus, a state's index has a component for each border state. Missouri has eight adjacent states, therefore Missouri's indices are the sum of eight separate components. A state's border index can be either positive or negative and can change sign during the eight-year

period. Appendix II provides a detailed explanation of border indices with Exhibit A-1 an example of index construction.

Kentucky and New Hampshire binary variables: These two states are known for discount cigarettes and are therefore expected to have positive coefficients. Though New Hampshire is not a low tax-low price state, its cigarettes are a bargain by Northeast standards. The ACIR found both a New Hampshire binary and a Kentucky/North Carolina binary significant while Clarke successfully employed binaries for Kentucky/Tennessee and New Hampshire/Vermont.

Note that the explained variation can be pushed up to approximately 97 percent of the total variation in taxed sales by adding state binaries until some 15 states test significant. However, this is not a desirable procedure because the additional state binaries act as proxies for the economic variables that we are interested in and those variables then become statistically insignificant. Thus, state binaries must be added carefully and only when there are economic and statistical reasons to do so.

In models without state binaries, Kentucky's average residual was almost twice as high as New Hampshire, and New Hampshire's average residual was twice as high as the next state. Therefore, Kentucky and New Hampshire binaries were included despite the desire to minimize the number of such state variables. The large, positive coefficients on these binary variables is a measure of the two states' role as a source of illegal cigarettes. These two state binaries add approximately 8 percent to any model's explained variation and are always highly significant.

Canada tax index, 30 miles: This is similar to the border index for U.S. states, though the Canadian taxes were always higher (except in one case).[15] Canadian census divisions lying within 30 or 60 drivable miles of a state border were tested (the Strait of Juan de Fuca is not drivable, while the Great Lakes and the Saint Lawrence River are drivable via only a few bridges).

Neither the ACIR or Clarke found a relationship between smoking and Canadian border variables, but Fleenor's indices were significant for both Canada and Mexico. DOR did not find the Mexican border significant, but the various Canadian tax indices tested were significant in most models. There was no gain from using the 60-mile Canadian index instead of the 30-mile Canadian index.

Interestingly, all Canadian border indicators tested are significant in all models, but all have unexpected negative signs.[16] If true, a negative sign implies that Washington and other U.S. border residents are net purchasers of illegal, higher priced, Canadian cigarettes. Moreover, Canadian border binaries, which only carry values of one or zero,

[15] Weighted average tax rates are used where states bordered two provinces. Values are stated in real, U.S. dollars.

[16] The indices tested were a border binary, 30 and 60-mile tax indices, and 30 and 60-mile population indices.

exert more pronounced effects on the R-squares and have higher t-values than do index variables which also incorporate magnitude.[17]

One explanation for this unexpected negative sign is that the Canadian border variables are acting as regional, North-South indicators. Most Northern states have higher cigarette excise taxes; tax rates for the Northern border states averaged 35 percent higher than non-border states. Other North-South binaries yield results similar to the Canadian border variables. Therefore, only the Canadian border variables were used in the models.

Using the Canadian border variables allowed for the following experiment to measure the impact of Canadian purchases on border state cigarette sales. Dropping personal disposable income from Model 1 yields Model 2, replacing the Canadian border binary in Model 2 with the Canada 30-mile tax index yields Model 3. Models 2 and 3 are identical except for the different version of the variable measuring Canadian cross-border purchases. (Section 2-8 and Table 10 describe Models 2 and 3; note that income is not significant in models with the border binary and was dropped from the analysis.)

By comparing the results of Models 2 and 3, almost identical models with very similar parameter estimates, we can separate out the Canadian binary's effect from the Canadian indices' effect. The Canada index variables are composites. A binary component has a value of zero for non-border states and one for border states. These binary values are then multiplied by the magnitude component. (See Table 7 for an example of a Canadian border binary and a Canadian border index.)

This procedure for estimating Canadian cross-border purchases does not rely on the estimated parameters for the Canadian border binary or border index--the estimates of these border parameters are unreliable since the two are correlated. The procedure instead relies on the results of the two models in general which contain all of the statistically significant variables. Model 3, the border binary model, estimates that Washington's non-taxed sales (legal exempt plus illegal sales) averaged 17 packs per capita during the 1997-2004 period; Model 2, the border index model, estimates non-taxed packs per capita at 13.7 over those years (as can be seen in Table 11 below).[18]

The binary component of the border index reduces consumption because Washington is a Northern, high tax, high income state; the magnitude component, based on tax differences and population proximity, acts the opposite way and adds to Washington sales. Hence, the difference between the two models implies that Canadians are responsible for an average of 3.3 packs per capita worth of Washington cigarette sales over the period. This represents 5 percent of total Washington sales, or 17 million packs in 2004.[19] Because the estimated parameters of the two models differ slightly there are also small impacts for non-border states, but these are in the range of a fraction of a pack

[17] The magnitude comes from the tax differential times the border population share. The index variable for excise tax ranges from just under zero to a value of 525.
[18] The calculation of non-taxed sales, a primary goal of this project, is discussed in section 2-6.
[19] These may or may not have a Washington tax stamp. British Columbia Finance officials estimate that illegal sales from all sources were 15-20 percent of the B.C. market in FY 2004, or 34 to 49 million packs.

per capita and may be interpreted as interstate shifts to accommodate Canadian purchases.

Binary 2000-2004: The four annual binary variables measure the changing structure of the market during these years. The binaries for 1997-1999 were not significant (one binary would have to be dropped in any event; DOR tried dropping different years to ensure that we were not dropping a significant year). Clarke used two models, a cross-sectional U.S. model for 1995 and a separate 1975-1995 time series model for Washington only. Fleenor used a time trend variable rather than annual binaries, which would have been impractical with his 38 years. Substituting a trend variable into the DOR models, as Fleenor did, yielded results substantially similar to the models with annual binaries. Since smoking is trending down, the annual binaries were expected to have a negative trend.

Other variables that were not significant: A wide range of other variables did not test significant. These include other ethnic categories, age groups, regional binaries, and others. Some 30 (anti) smoking policy variables were also tested; per capita tobacco control expenditures and smoke free air laws (banning smoking in a range of public places) tested significant with the expected sign in a number of models but not in the four top DOR models. Also tested were per capita master (tobacco) settlement distributions. See also the discussion following Table 13 and in the section "variables that were not significant in the DOR top models" in Appendix II.

2-4. Comparison Between Actual and Predicted

Table 4 above showed the Washington residual for Model 1; the residual is the difference between the model estimate and actual taxed packs per capita. To show that the model predicts well, Table 8 below presents the same information for all states and D.C.: actual taxed packs per capita, estimated taxed packs, and the residuals, all averaged over the 1997-2004 period (note that the estimated value is often referred to as the predicted value).

Because this work is a follow-up to the DOH/Clarke study, Clarke's 1995 residuals are also included in Table 8 for comparison. Washington Model 1 residuals are calculated by multiplying each parameter estimate times that variable's Washington value for that year, then summing the results for all the variables. The residuals shown in Table 8 are the average over 1997-2004. The Washington calculations are detailed in Appendix I, Table A-1.[20] The other state residuals shown in Table 8 are calculated in the same manner. Table 8 is found on the next page.

[20] The detailed calculations for Models 2, 3, and 4 are the same as those for Model 1, but the calculations for those models are not shown.

Table 8
Actual, Estimated, and Residual Taxed Packs Per Capita, Model 1; 1997-2004 Averages

State	Average, Actual Packs Per Capita	Average, Estimated Packs Per Capita	Difference = Average Residual	Clarke's 1995 Residuals (for Comparison)
Alabama	94.2	100.9	6.7	6.7
Alaska	69.1	63.4	-5.7	-6.8
Arizona	56.0	55.8	-0.2	2.7
Arkansas	97.8	99.7	1.9	-6.9
California	42.3	42.8	0.6	4.9
Colorado	72.0	69.5	-2.5	-6.6
Connecticut	68.0	75.2	7.2	1.9
Delaware	147.6	142.5	-5.1	2.6
District of Columbia	47.3	51.7	4.4	-1.6
Florida	82.9	79.6	-3.3	-3.0
Georgia	87.9	97.6	9.7	4.6
Hawaii	42.7	43.1	0.4	0.2
Idaho	68.9	74.7	5.8	11.7
Illinois	68.9	71.0	2.1	1.4
Indiana	121.5	106.8	-14.6	-10.7
Iowa	88.7	91.6	3.0	8.3
Kansas	76.6	78.4	1.9	5.4
Kentucky	165.4	165.4	0.0	-7.7
Louisiana	95.3	96.7	1.4	1.1
Maine	84.0	86.1	2.2	-9.7
Maryland	60.8	68.9	8.1	7.6
Massachusetts	56.3	54.4	-1.9	-6.4
Michigan	76.6	79.8	3.2	-2.3
Minnesota	76.7	74.2	-2.5	1.8
Mississippi	97.4	102.2	4.8	0.5
Missouri	111.4	100.7	-10.6	-11.6
Montana	78.1	82.2	4.1	7.3
Nebraska	76.3	81.3	5.0	9.3
Nevada	90.5	89.1	-1.5	-8.2
New Hampshire	153.7	153.7	0.0	5.9
New Jersey	60.1	55.5	-4.6	5.8
New Mexico	54.1	56.7	2.6	2.0
New York	51.7	61.0	9.3	4.9
North Carolina	108.2	100.4	-7.8	-8.8
North Dakota	71.7	80.6	8.8	15.0
Ohio	99.0	98.0	-0.9	1.6
Oklahoma	107.4	90.3	-17.0	-7.9
Oregon	72.1	69.7	-2.4	5.9
Pennsylvania	85.2	91.2	6.1	12.8
Rhode Island	78.9	63.5	-15.5	-11.8
South Carolina	105.8	104.7	-1.1	1.7
South Dakota	79.0	87.3	8.4	7.7
Tennessee	107.4	97.8	-9.6	7.7
Texas	64.7	64.7	-0.1	-3.6
Utah	41.7	40.0	-1.7	-1.9
Vermont	89.0	87.4	-1.6	-5.9
Virginia	98.9	93.3	-5.6	-9.0
Washington	**49.1**	**49.5**	**0.4**	**0.4**
West Virginia	112.0	118.9	6.9	-0.4
Wisconsin	79.9	83.3	3.4	4.9
Wyoming	94.5	92.0	-2.5	-10.4

The residual column in Table 8 above shows that the model's predictions compare well for most states. The results are also consistent with Clarke's residuals for 1995, shown in the last column; states with large residuals in the DOR model also have large residuals in the Clarke model. The absolute values of the average U.S. residuals in the current DOR model are also smaller than those from the 1995 model.

Our interest is with Washington sales, thus a small residual for the state is desirable. Washington's average residual in Model 1 is only 0.4 packs per capita which makes Model 1 best on this measure. Over the 1997-2004 period Washington residuals for Models 2, 3, and 4 respectively were 1.1 packs, 0.7 packs, and 2.7 packs per capita. Clarke's 1995 residual is also 0.4 packs per capita, the same as Model 1.

2-5. State Taxed Exempt Sales

Before illegal sales can be determined, sales that are legally exempt from state taxes must be accounted for. State tax exempt sales are primarily sales to military personnel on U.S. military bases, sales to enrolled tribal members on Indian reservations, and sales under tribal compacts. These legal, non-taxed sales must then be added to taxed sales to determine the total legal market.

Federally taxed sales are greater than the sum of the taxed sales in the individual states because federally taxed sales also include state exempt sales (all tobacco consumed in the U.S. pays federal taxes, normally at the producer level). However, note that total sales for the nation are about the same regardless of whether illegal sales are considered or not. This is because most illegal sales net out across the country--illegal imports in one state are typically state taxed exports of another (lower tax) state. However, total sales in any one state, which include illegal sales, may differ from state taxed sales.

Before we can estimate total and illegal sales at the state level we must determine state exempt sales at the national level and find a method to apportion these sales to each state. National total state tax exempt sales can be estimated by subtracting the sum of state taxed sales from federally taxed consumption (called federal taxed removals). Averaged over the 1997-2004 period, this measure yields an estimate of 3 percent of federally taxed sales.[21]

The next step is to apportion state tax exempt sales, the 3 percent of U.S. sales, to each state. The procedure is to modify the estimated coefficient on the total excise tax variable when the model contains excise taxes or the retail price coefficient when the model contains retail prices.

The coefficient on the total excise tax variable measures buyer response to changes in taxes, e.g. the excise tax parameter for Model 1 in Table 3 above indicates that a one cent increase in excise taxes is associated with 0.16 fewer packs per capita.

[21] See Appendix II for further details on the methodology and data.

The tax (or price) coefficients can be modified (the absolute value reduced) so that the sum of state sales increase to account for the additional 3 percent consumption nationwide (reducing the value of the negative parameter increases a model's calculated packs per capita). Thus, the Model 1 coefficient on excise taxes declines from a negative 0.16 to a negative 0.13.[22] Modifying the tax (or price) coefficients in this manner is also germane to the next section.

2-6. Using the Model to Determine Total Sales

The purpose of the modeling effort is to estimate Washington's relative smoking rate which includes cigarettes purchased from all sources: state taxed, state tax exempt, and illegal non-taxed. Again, the procedure is to calculate packs sold after those variables associated with illegal sales are removed from the model.

The variables associated with illegal activity are:

-proximity to Indian reservations (60 miles)
-state border tax index (60 miles)
-Kentucky binary
-New Hampshire binary
-Canadian tax index (30 miles).

Two additional variables that in part affect illegal sales are the absolute levels of prices and excise taxes (prices in the price model, taxes in the tax models).[23] Higher prices or taxes result in both less consumption and more illegal activity. The reduced tax (or price) coefficients discussed above effectively reduce the elasticity response of smokers. Given a price or tax change, the models with the reduced coefficients now reflect changes in total packs, not taxed packs. That is, the models using the reduced tax/price coefficients reflect only the impact on actual smoking; a portion reflecting shifts to illegal cigarettes has been excluded.

Recalculating the model with the adjustments described above yields the second column in Table 9 below, estimated, total sales per capita for Model 1.[24] Washington total consumption of 64.4 packs per capita is 82 percent of the U.S. rate of 78.1 packs, averaged over the eight-year period. Also shown are Model 1 estimated non-taxed sales which are the difference between taxed and total sales. Note that non-taxed sales include both state tax exempt and illegal sales.

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[22] Further detail is provided in Appendix I and Appendix II.

[23] One other illegal cigarette variable is illegal U.S. imports. Imports into the U.S. have been rising recently along with prices and taxes. Tax authorities believe that illegal imports are rising at least as fast. However, there is little data on illegal imports. Fleenor's 38-year model estimated that one-half of 1 percent of sales were illegal imports from Mexico, but Mexican border variables did not test significant in the eight-year DOR models. Some information on taxed U.S. imports is found at the end of Appendix II.

[24] The Table 9 recalculation is done in the same manner that the Table 8 calculations are, except that the illegal variables are left out, the excise tax parameter has been reduced, and the residual is not calculated. See Appendix I, Table A-2 for the Washington Model 1 calculations. Other states and Models 2, 3, and 4 are calculated in a similar manner.

Table 9
Total and Non-Taxed Sales; Mode1 1
Packs Per Capita; 1997-2004 Averages

	Estimated Taxed Sales	Estimated Total Sales	Estimated Non-Taxed Sales
Alabama	100.9	103.5	2.6
Alaska	63.4	67.5	4.1
Arizona	55.8	64.7	8.9
Arkansas	99.7	103.2	3.5
California	42.8	49.4	6.6
Colorado	69.5	70.3	0.8
Connecticut	75.2	72.4	-2.8
Delaware	142.5	94.4	-48.1
District of Columbia	51.7	67.0	15.3
Florida	79.6	85.8	6.2
Georgia	97.6	98.4	0.8
Hawaii	43.1	47.7	4.6
Idaho	74.7	77.3	2.6
Illinois	71.0	78.5	7.5
Indiana	106.8	102.0	-4.8
Iowa	91.6	94.3	2.6
Kansas	78.4	84.5	6.1
Kentucky	165.4	106.7	-58.7
Louisiana	96.7	100.2	3.4
Maine	86.1	92.9	6.7
Maryland	68.9	79.7	10.8
Massachusetts	54.4	71.4	17.0
Michigan	79.8	88.9	9.1
Minnesota	74.2	82.9	8.7
Mississippi	102.2	107.1	4.9
Missouri	100.7	98.3	-2.4
Montana	82.2	92.9	10.8
Nebraska	81.3	88.5	7.2
Nevada	89.1	96.4	7.3
New Hampshire	153.7	88.8	-64.9
New Jersey	55.5	69.9	14.4
New Mexico	56.7	62.2	5.4
New York	61.0	71.6	10.6
North Carolina	100.4	102.0	1.6
North Dakota	80.6	91.2	10.7
Ohio	98.0	98.1	0.0
Oklahoma	90.3	94.4	4.1
Oregon	69.7	75.3	5.6
Pennsylvania	91.2	94.0	2.8
Rhode Island	63.5	78.7	15.3
South Carolina	104.7	106.8	2.1
South Dakota	87.3	94.0	6.6
Tennessee	97.8	102.8	5.0
Texas	64.7	67.7	3.1
Utah	40.0	49.1	9.1
Vermont	87.4	90.7	3.3
Virginia	93.3	90.0	-3.3
Washington	**49.5**	**64.4**	**14.9**
West Virginia	118.9	111.9	-7.0
Wisconsin	83.3	91.0	7.7
Wyoming	92.0	89.6	-2.4
U.S.	**76.4**	**78.1**	**1.7**

Table 9 above has the sought-after Model 1 results, total cigarette sales by state; the table shows both total Washington consumption and the U.S. per capita rate. Note that Table 9 results are for Model 1 only, they include all states, and the values are averaged over the 1997-2004 period. Tables 5 and 6 in Part One, on the other hand, show results for all four models, year by year, and document Washington's declining trend (relative to the U.S. per capita). The Model 1 detailed Washington calculations are shown in Appendix I, Table A-2.

Before showing the results of Models 2, 3, and 4 in more detail and the annual Washington consumption, we briefly discuss estimates of Washington illegal sales.

2-7. Washington Illegal Sales

Illegal sales for each state can be calculated with the model results, but for a number of reasons DOR does not directly use these estimates to calculate the state's illegal sales and lost tax revenues. The DOR annual estimates also consider Washington specific data such as: cigarettes allocated for tax free Indian consumption, cigarettes sold to consumers under tribal compacts, and annual DOR samplings of retail prices. Cigarette tax laws in other states also have idiosyncratic features that national models cannot easily incorporate. In addition, the data needed for the full model are not available in a timely manner. Therefore, Washington's annual estimates start with the state's relative consumption rate and with federal data for U.S. cigarette sales.

For these reasons we follow Clarke's example and do not estimate illegal activity state by state.

2-8. Results for DOR Models 2, 3, and 4

Numerous models were tested, but the study presents only the four top DOR models. These four similar models yield the highest R-squares with the minimum number of state binaries. The four models employ those variables that economic theory and research indicate are important and yield reasonably small residuals. The models are described by the variables in which they differ. Models 2, 3, and 4 are shown in Table 10, below.

Model 1, shown in Table 3 above, is an excise tax model and the only model to contain both Bachelor’s degree and personal disposable income. It also uses the Canada border tax index 30 miles.

Model 2, shown in Table 10 below, is the same as Model 1 except that it drops personal disposable income. Model 2, therefore, is an excise tax model with Bachelor’s degree and Canada border tax index 30 miles.

Model 3 is the same as Model 2 but with the Canadian border binary instead of the tax index 30 miles. It also has excise taxes and Bachelor’s degree. Income is not significant.

Model 4 is the retail price model; prices are substituted for cigarette excise taxes. The retail price model also has Bachelor's degree and Canada border tax index 30 miles. Note also that the military personnel variable has been dropped along with income because neither is significant.

Table 10 below shows the variables, parameter estimates, and regression statistics for Models 2, 3, and 4. Note that all results shown in Tables 3, 4, 8, and 9 above are for Model 1 only.

Table 10
Variables, Parameter Estimates, and Statistics; Models 2, 3, and 4

	DOR Model 2		DOR Model 3		DOR Model 4	
Model	Total excise tax rate BA, no personal income Canada border index 30		Total excise tax rate BA, no personal income Canada border binary		Retail price BA, no income or military Canada border index 30	
Statistics	R-Square 0.92 Adj R-Sq 0.91 F value 239		R-Square 0.92 Adj R-Sq 0.91 F value 243		R-Square 0.91 Adj R-Sq 0.91 F value 239	
Variable	**Parameter Estimate**	**t-Value**	**Parameter Estimate**	**t-Value**	**Parameter Estimate**	**t-Value**
Intercept	142.554	59.8	143.467	61.0	160.375	54.0
Retail price	-	-	-	-	-0.132	-9.5
Total excise tax rate	-0.180	-10.8	-0.163	-9.4	-	-
Bachelors degree	-125.248	-11.8	-127.733	-12.2	-125.616	-12.3
Disposable income	-	-	-	-	-	-
Hispanic	-77.531	-14.3	-81.635	-14.7	-78.230	-14.7
Asian	-27.386	-2.3	-38.333	-3.1	-43.698	-3.7
Mormon-7Day Adventist	-45.592	-9.5	-46.682	-9.8	-46.426	-9.5
Miles to Raleigh NC	-0.005	-6.1	-0.005	-4.8	-0.005	-5.4
Tourists spending/hotels	0.004	6.8	0.004	6.1	0.004	6.5
Military personnel	-139.288	-1.9	-136.750	-1.9	-	-
Indian reservation 60 miles	-5.307	-3.6	-5.641	-3.8	-6.329	-4.5
State border tax index, 60"	0.083	20.5	0.082	20.6	0.088	21.9
Canada tax index, 30 miles	-0.037	-4.4	-	-	-0.044	-5.1
Canada border binary	-	-	-6.163	-5.1	-	-
Kentucky binary variable	55.220	17.9	54.798	17.9	54.779	17.3
New Hampshire binary "	39.756	11.6	44.416	12.8	41.474	12.0
2000 binary	-4.862	-3.6	-4.839	-3.6	5.210	2.9
2001 binary	-7.020	-5.1	-6.969	-5.2	4.692	2.5
2002 binary	-6.828	-5.0	-7.411	-5.4	6.959	3.4
2003 binary	-6.319	-4.4	-7.177	-5.1	7.578	3.3
2004 binary	-7.638	-5.2	-8.658	-5.9	4.952	2.1

Models 2, 3, and 4, described above yield estimates for total cigarette sales in per capita packs. Table 11 below shows these estimated total packs per capita averaged over the eight-year period. Also shown in Table 11 are non-taxed packs per capita.

Table 11
Total and Non-Taxed Sales; Models 2, 3, and 4:
Packs per Capita; 1997-2004 Averages

	Model 2		Model 3		Model 4	
	Total Sales	Non-Taxed	Total Sales	Non-Taxed	Total Sales	Non-Taxed
Alabama	103.1	2.4	103.8	2.5	102.7	3.8
Alaska	68.6	4.0	72.0	9.8	67.2	4.1
Arizona	63.0	8.4	64.6	8.7	64.6	8.9
Arkansas	102.5	3.4	103.8	3.3	103.3	4.0
California	49.5	6.3	50.1	6.4	50.2	6.1
Colorado	70.0	0.8	70.2	0.8	68.6	2.1
Connecticut	74.4	-3.0	75.3	-2.5	75.1	-3.4
Delaware	95.7	-46.7	95.8	-45.9	94.6	-48.4
District of Columbia	66.9	14.9	66.6	14.6	71.3	15.0
Florida	86.0	5.9	86.2	6.0	86.5	7.0
Georgia	98.6	0.7	98.7	0.8	98.3	1.9
Hawaii	47.3	4.5	47.8	4.5	46.6	3.6
Idaho	77.4	2.3	79.3	7.6	79.7	3.1
Illinois	78.7	7.3	79.5	7.2	80.0	7.1
Indiana	103.0	-4.7	103.9	-4.6	103.9	-4.4
Iowa	93.8	2.5	95.0	2.6	94.8	3.2
Kansas	83.3	5.8	84.4	5.9	85.0	6.8
Kentucky	106.5	-58.9	107.0	-58.4	107.9	-57.5
Louisiana	99.2	3.2	100.2	3.3	99.3	4.5
Maine	91.1	6.1	93.0	10.1	92.0	6.1
Maryland	78.8	10.5	79.1	10.4	79.3	10.7
Massachusetts	70.6	16.2	71.8	16.3	68.1	16.7
Michigan	88.7	8.7	90.5	14.6	89.6	8.2
Minnesota	82.1	8.1	83.4	14.0	82.8	9.1
Mississippi	105.7	4.6	106.6	4.7	107.2	5.9
Missouri	98.1	-2.4	98.6	-2.3	96.9	-1.1
Montana	91.4	9.4	93.1	10.9	93.2	11.7
Nebraska	88.4	6.9	89.7	7.0	89.0	7.9
Nevada	95.8	6.8	95.2	7.1	95.8	7.9
New Hampshire	88.8	-64.9	89.5	-64.2	86.5	-67.1
New Jersey	70.6	13.9	71.1	13.8	70.5	13.6
New Mexico	60.7	5.0	60.7	5.3	61.7	6.5
New York	71.5	10.0	72.1	15.3	67.6	10.0
North Carolina	102.2	1.5	102.1	1.5	102.1	3.0
North Dakota	90.5	9.6	92.4	13.2	93.9	11.2
Ohio	98.0	0.1	98.7	6.2	98.8	0.4
Oklahoma	93.6	3.7	94.7	4.0	94.9	5.3
Oregon	74.3	5.3	76.7	5.5	74.1	5.8
Pennsylvania	94.3	2.6	95.2	2.7	95.8	2.8
Rhode Island	77.4	14.6	79.0	14.7	80.8	14.5
South Carolina	106.6	2.0	106.8	2.0	107.1	3.4
South Dakota	93.5	6.2	95.1	6.4	95.2	7.6
Tennessee	102.9	4.8	103.4	4.8	103.7	5.9
Texas	68.1	3.0	68.2	3.0	69.3	3.3
Utah	48.1	8.6	49.4	8.8	48.8	9.6
Vermont	87.9	1.6	89.0	-2.4	89.1	2.5
Virginia	89.5	-3.3	88.9	-3.2	89.0	-2.0
Washington	**63.9**	**13.7**	**66.8**	**17.0**	**65.6**	**13.9**
West Virginia	112.1	-6.7	112.9	-6.6	113.7	-6.6
Wisconsin	90.7	7.2	92.2	7.5	91.0	7.9
Wyoming	92.0	-2.4	93.2	-2.2	92.9	-1.3

Washington's relative smoking rate, averaged over the period, is calculated by dividing total sales from Table 11 above by the U.S. rate of 78.1 packs per capita (from Table 9).

One additional result should be mentioned in this section, smoker responsiveness to price changes, or price elasticity. A wide range of elasticities are found in the literature due to researchers' different methodologies and specifications. A price elasticity can be calculated from Model 4, the price model, but DOR does not directly use such a figure in the calculation of illegal sales and lost tax revenues (section 2-7 explains why illegal Washington sales are not calculated directly with model results).

Nonetheless, for 1997-2004 the U.S. price elasticity of total sales, measuring actual reductions in cigarette purchases (not just taxed sales) is estimated by DOR to be -0.40. This is consistent with other recent elasticity estimates found in the literature, such as -0.45 to -0.47 for Canada in Gruber et al. (2003), and -0.41 for the U.S. in Huang et al. (see Appendix III, the literature review).

2-9. Trends in the Washington Smoking Rate

Table 12 below shows the estimates of Washington's relative smoking rate stated as a percentage of the U.S. per capita smoking rate. The four estimates were derived with the use of DOR Models 1 through 4. The average of the four estimates is shown in the right-hand column.

Table 12
Washington Per Capita Smoking Rate; Models 1 through 4,
Relative to the U.S. Per Capita Rate

Year	Model 1 Excise Tax BA and Income CanadaIndex30	Model 2 Excise Tax BA, no Income CanadaIndex30	Model 3 Excise Tax BA, no Income CanBorder Binary	Model 4 Retail Price BA, no Income CanadaIndex30	**Average** **Average of Models 1 through 4**
1997	83%	82%	85%	83%	**84%**
1998	84%	84%	87%	84%	**85%**
1999	88%	88%	92%	87%	**89%**
2000	84%	84%	88%	85%	**85%**
2001	83%	83%	87%	84%	**84%**
2002	80%	79%	82%	88%	**82%**
2003	77%	76%	80%	78%	**78%**
2004	78%	78%	81%	81%	**79%**

The “Average” column on the right side of Table 12 has the estimates for Washington's relative cigarette consumption that were presented in Table 1. Given the declining trends in both U.S. consumption and Washington relative consumption, the 2004 estimate of 79 percent is most relevant to future estimates of illegal sales.

Table 13 below compares the average results from DOR Models 1 through 4 from Table 12 with smoking prevalence data from the U.S. Centers for Disease Control (CDC).[25] The CDC data expresses Washington prevalence as a percent of the prevalence of the median U.S. state. Prevalence is not directly comparable with DOR per capita smoking rates because prevalence measures the percent of the population that smokes, not the number of packs sold. Data indicates those Washington residents who do smoke consume fewer packs, on average, than smokers in the median state.

Table 13
DOR Estimated Washington Smoking Rate and
Centers for Disease Control Survey Data

	DOR 2006 Estimates	U.S. CDC Survey Data
	Average of DOR Models 1 through 4	Smoking "Prevalence" (% of pop. who smoke) (not packs sold)
Year	WA as % of U.S. per capita	WA as % of the U.S. Median State
1997	84%	103%
1998	85%	93%
1999	89%	99%
2000	85%	89%
2001	84%	99%
2002	82%	93%
2003	78%	88%
2004	79%	92%

Table 13 shows that the averaged result of the four DOR models has a declining trend similar to that of the CDC prevalence data, though the latter series is somewhat higher (it averages 14 percentage points higher). Note that this declining trend that is evident in both series is not only a decrease in Washington's per capita smoking rate but is also a decline relative to the U.S. rate which is itself shrinking.

The DOR models indicate that the significant variables having the strongest impact on this declining trend are Washington's high and increasing tax rate and high levels of income and education. Note that per capita tobacco control expenditures and tobacco control policies may also have a role in the declining Washington trend; these variables also tested significant in a number of models but not in the top DOR models. Two other recent studies also find that tobacco control expenditures reduce smoking.[26]

[25] The Washington DOH collaborates with the CDC on the Washington survey.

[26] Tauras et al. with respect to youth smoking, Farrelly et al. for all persons (Farrelly). Farrelly uses 20-year (1981-2000) cross-sectional time series models in some respects similar to the DOR models. However, the Farrelly focus is on tobacco control expenditures while the DOR concern is total and illegal packs, hence the models are specified differently. The two studies also use somewhat different data for tobacco control expenditures; the DOR series contains expenditures for only a few states prior to 1999 while Farrelly obtained data for more states prior to 1999. This limitation of the DOR tobacco control expenditures data is more apparent then real because the DOR models begin with 1997; however,

2-10. Conclusion; Illegal Sales and Lost Revenues

The conclusions for Part Two are the same conclusions found in Part One. The purpose of this study is to update the ten-year-old DOH/Clarke estimate that Washington residents smoke 86 percent as many cigarettes as U.S. residents, on a per capita basis. The top four DOR models presented here indicate that total per capita cigarette sales in Washington, including taxed and untaxed cigarettes, have declined as a share of U.S. sales. The 2004 Washington rate is only 79 percent of the U.S. per capita rate.

The determination of illegal Washington sales and lost revenues starts with total U.S. consumption of 67.5 packs per capita in Fiscal Year 2006. Washington residents consume 79 percent of that amount, or 53.3 packs. State taxed packs per capita in Washington, however, totaled only 33.2 packs, leaving 20.1 packs untaxed.

Washington's population of almost 6.4 million implies 127.9 million packs of untaxed cigarettes. Subtracting 45.3 million legally exempt sales on military bases, to enrolled tribal members, and sales under tribal compacts leaves 82.6 million illegal packs.

Based on the new 79 percent figure, these 82.6 million illegal packs are 24 percent of all taxed, exempt, and illegal cigarettes sold in Washington. These results imply that the level of illegal sales has been remarkably flat since 1996, averaging just about 24 percent of total sales despite substantial increases in prices and taxes (this is after recalculating estimates previously based on the old 86 percent figure, as section 1-7 notes).

Applicable cigarette and state sales tax rates result in $200 million of state revenues lost to evasion in Fiscal Year 2006.[27] If the old 86 percent figure were used instead of 79 percent, the 2006 evasion estimate would be $271 million.

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expenditures prior to 1999 were scant in comparison to expenditures thereafter when the master (tobacco) settlement raised spending several fold. DOR also tested per capita tobacco control expenditures and master settlement distributions, as well as tobacco control indices measuring intensity of tobacco control policies (such as youth purchase restrictions, indoor smoking restrictions, etc.). Tobacco control expenditures and an index of smoking restrictions were significant in a number of DOR models but not the top four models reported here.

Farrelly and DOR use different methods to deal with multicollinearity. The Farrelly models use individual state indicators and state specific time trends. Specified this way, the variation due to demographic and other variables included in the DOR model are explained by the state and state-time variables. Hence, demographic and other variables are not significant in Farrelly, as they are in the DOR models.

In the DOR models, annual binary variables provide idiosyncratic parameter estimates for each year rather than forcing a trend estimate for the entire period (annual binaries are more feasible in the DOR eight-year models). The DOR annual binary parameters, therefore, account for some of the variation due to rising tobacco control expenditures. Thus, DOR finds the years 2000-2004 significant because this is when the master settlement distributions and tobacco control expenditures experience sudden, large increases. DOR is also concerned with illegal interstate sales, which make the individually estimated Kentucky and New Hampshire parameters particularly useful. However, DOR individual state binaries also explain some of the variation due to state tobacco control variables, so the latter are less likely to be significant than in the Farrelly models.

See also the discussions regarding "variables that were not significant" above and in Appendix II, and note the literature review.

[27] Sales tax calculations also require prices. A DOR sampling yielded a 2006 average of $4.68 per pack.

APPENDIX I:

DETAILED CALCULATIONS For Model 1 Results

Appendix I provides tables showing the detailed calculations that yield the Model 1 results for Washington. The other states and Models 2, 3, and 4 require similar calculations; however, those 406 additional tables are not shown.

DOR employed linear, multivariate cross-sectional time series models. Cross-sectional means that the observations were the 50 U.S. states and the District of Columbia. Time series means that eight years of data were used, Fiscal Years 1997 through 2004. A linear model has the form:

$$Y = x_1*A + x_2*B + x_3*C\ldots,$$

where Y is the dependent variable, A, B, and C... are independent or explanatory variables and x_1, x_2, and x_3 are the parameters or coefficients (or slopes) of the independent variables. Multivariate means more than one independent variable. Hence, Model 1 can be represented by:

Taxed packs per capita = an intercept
+ x_1*total excise tax rate
+ x_2*Bachelor's degree
+ x_3 *disposable income
+ x_4*Hispanic
+ x_5*Asian
+ x_6*Mormon/Seventh-Day Adventist
+ x_7*miles to Raleigh, N.C.
+ x_8*military personnel
+ x_9*Indian reservation, 60 miles
+ x_{10}*state border tax index, 60 miles
+ x_{11}*Canada tax index, 30 miles
+ x_{12}*Kentucky binary variable (0 for Washington)
+ x_{13}*New Hampshire binary variable (0 for Washington)
+ x_{14}*2000 binary variable (0 or 1)
+ x_{15}*2001 binary variable (0 or 1)
+ x_{16}*2002 binary variable (0 or 1)
+ x_{17}*2003 binary variable (0 or 1)
+ x_{18}*2004 binary variable (0 or 1).

Appendix Table A-1 below shows how the Model 1 estimated parameters (coefficients) are used to calculate the model's estimate of Washington taxed packs per capita. Each estimated parameter value is multiplied by the data value in the top of the table yielding the corresponding packs per capita value in the bottom half of the table. Since this is a linear model, the packs per capita for each year are summed vertically.

Appendix Table A-1
Model 1, Detailed Calculations
for Washington Taxed Packs Per Capita
and the Residual, 1997-2004 and Average

Variable	Model 1 Parameter Estimates	Actual Washington State Data (dollar values in real or inflation adjusted terms) 1997	1998	1999	2000	2001	2002	2003	2004
Actual Packs per Capita		55.6	56.4	55.1	52.8	50.2	45.0	40.1	37.7
Intercept	148.916								
Total excise tax rate	-0.160	105.68	105.73	108.1	107.5	106.3	138.6	164.5	160.4
Bachelors degree	-94.507	26.52%	27.19%	27.89%	28.60%	28.67%	28.73%	28.80%	28.87%
Disposable income	-0.001	24,420	25,641	26,257	27,309	27,603	28,214	28,220	29,469
Hispanic	-78.619	6.02%	6.48%	6.97%	7.50%	7.76%	8.03%	8.29%	8.58%
Asian	-29.443	4.89%	5.07%	5.26%	5.46%	5.65%	5.84%	6.02%	6.22%
Mormon/7th-Day Adventist	-48.956	3.78%	3.77%	3.76%	3.74%	3.73%	3.72%	3.70%	3.69%
Miles to Raleigh NC	-0.006	2,140	2,140	2,140	2,140	2,140	2,140	2,140	2,140
Tourists, hotel spending	0.005	263.9	250.8	254.6	256.5	241.7	243.0	246.0	241.2
Military personnel	-153.440	1.14%	1.04%	0.94%	1.02%	1.01%	1.08%	1.09%	1.06%
Indian reservation, 60 miles	-5.817	94.52%	94.45%	94.39%	94.32%	94.26%	94.19%	94.12%	94.06%
State border tax index, 60	0.086	-17.2	-13.3	-14.0	-14.2	-14.1	-24.1	-20.5	-17.8
Canada tax index, 30 miles	-0.04509	67.7	59.0	56.1	52.9	47.6	104.5	125.9	137.0
Kentucky binary variable	54.887	0	0	0	0	0	0	0	0
New Hampshire binary	39.248	0	0	0	0	0	0	0	0
2000 binary variable	-4.542	0	0	0	1	0	0	0	0
2001 binary variable	-6.575	0	0	0	0	1	0	0	0
2002 binary variable	-6.147	0	0	0	0	0	1	0	0
2003 binary variable	-5.858	0	0	0	0	0	0	1	0
2004 binary variable	-7.076	0	0	0	0	0	0	0	1

	Average 1997-2004 Taxed Packs/Capita DOR Model 1	Impact of Each Variable on Taxed Packs per Capita, DOR Model 1, 1997-2004 (Calculated by multiplying the parameter estimate times the actual data value) 1997	1998	1999	2000	2001	2002	2003	2004
Intercept	**148.9**	148.9	148.9	148.9	148.9	148.9	148.9	148.9	148.9
Total excise tax rate	**-19.9**	-16.9	-16.9	-17.3	-17.2	-17.0	-22.2	-26.3	-25.6
Bachelors degree	**-26.6**	-25.1	-25.7	-26.4	-27.0	-27.1	-27.2	-27.2	-27.3
Disposable income	**-16.5**	-14.9	-15.6	-16.0	-16.6	-16.8	-17.2	-17.2	-17.9
Hispanic	**-5.9**	-4.7	-5.1	-5.5	-5.9	-6.1	-6.3	-6.5	-6.7
Asian	**-1.6**	-1.4	-1.5	-1.5	-1.6	-1.7	-1.7	-1.8	-1.8
Mormon/7th-Day Adventist	**-1.8**	-1.9	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8
Miles to Raleigh NC	**-12.3**	-12.3	-12.3	-12.3	-12.3	-12.3	-12.3	-12.3	-12.3
Tourists, hotel spending	**1.3**	1.4	1.3	1.3	1.3	1.2	1.2	1.3	1.2
Military personnel	**-1.6**	-1.7	-1.6	-1.4	-1.6	-1.5	-1.7	-1.7	-1.6
Indian reservation, 60 miles	**-5.5**	-5.5	-5.5	-5.5	-5.5	-5.5	-5.5	-5.5	-5.5
State border tax index, 60	**-1.5**	-1.5	-1.1	-1.2	-1.2	-1.2	-2.1	-1.8	-1.5
Canada tax index, 30 miles	**-3.7**	-3.1	-2.7	-2.5	-2.4	-2.1	-4.7	-5.7	-6.2
Kentucky binary variable	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Hampshire binary	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000 binary variable	**-0.6**	0.0	0.0	0.0	-4.5	0.0	0.0	0.0	0.0
2001 binary variable	**-0.8**	0.0	0.0	0.0	0.0	-6.6	0.0	0.0	0.0
2002 binary variable	**-0.8**	0.0	0.0	0.0	0.0	0.0	-6.1	0.0	0.0
2003 binary variable	**-0.7**	0.0	0.0	0.0	0.0	0.0	0.0	-5.9	0.0
2004 binary variable	**-0.9**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-7.1
Avg. estimated packs/capita	**49.5**	61.4	60.4	58.8	52.6	50.4	41.4	36.6	34.7
Avg. actual packs/capita	**49.1**								
DOR Model 1 Residual	**0.4**	**(Washington State)**							

See variable description in Appendix II for units (i.e. taxes are in cents per pack). Note: The almost constant real tax rate in FY 1997-98 (105.68, 105.73) is due to an increase in cigarette prices and hence in sales tax paid, which roughly offsets the effects of inflation.

Table A-1 uses the Model 1 parameter estimates to recalculate taxed sales and then to compare the model's estimate (or prediction) to actual taxed sales. The residual, calculated at the very bottom, is the difference between the Model 1 estimate and actual.

Appendix Table A-2 shows how the model is used to estimate total Washington packs per capita. First, the variables associated with illegal sales are excluded from the calculation. In addition, the reduced excise tax parameter is used to reflect the fact that the buyer response to a tax increase is not as large for total packs as it is for taxed packs. These changes increase the model's calculation for per capita packs, so Table A-2, total packs, yields more packs than does Table A-1, taxed packs.

Appendix Table A-2
Model 1, Detailed Calculations
for Total Washington Packs Per Capita
1997-2004

	Model 1 Parameter Estimates	Actual Washington State Data (dollar values in real or inflation adjusted terms) 1997	1998	1999	2000	2001	2002	2003	2004
Actual Packs per Capita		55.6	56.4	55.1	52.8	50.2	45.0	40.1	37.7
Intercept	148.916								
Total tax rate (modified)	**-0.126**	105.68	105.73	108.1	107.5	106.3	138.6	164.5	160.4
Bachelors degree	-94.507	26.52%	27.19%	27.89%	28.60%	28.67%	28.73%	28.80%	28.87%
Disposable income	-0.001	24,420	25,641	26,257	27,309	27,603	28,214	28,220	29,469
Hispanic	-78.619	6.02%	6.48%	6.97%	7.50%	7.76%	8.03%	8.29%	8.58%
Asian	-29.443	4.89%	5.07%	5.26%	5.46%	5.65%	5.84%	6.02%	6.22%
Mormon/7th-Day Adventist	-48.956	3.78%	3.77%	3.76%	3.74%	3.73%	3.72%	3.70%	3.69%
Miles to Raleigh NC	-0.006	2,140	2,140	2,140	2,140	2,140	2,140	2,140	2,140
Tourists, hotel spending	0.005	263.9	250.8	254.6	256.5	241.7	243.0	246.0	241.2
Military personnel	-153.440	1.14%	1.04%	0.94%	1.02%	1.01%	1.08%	1.09%	1.06%
Indian reservation, 60 miles State border tax index, 60 Canada tax index, 30 miles									
Kentucky binary variable New Hampshire binary									
2000 binary variable	-4.542	0	0	0	1	0	0	0	0
2001 binary variable	-6.575	0	0	0	0	1	0	0	0
2002 binary variable	-6.147	0	0	0	0	0	1	0	0
2003 binary variable	-5.858	0	0	0	0	0	0	1	0
2004 binary variable	-7.076	0	0	0	0	0	0	0	1

	Impact of Each Variable on Taxed Packs per Capita, DOR Model 1, 1997-2004 (Calculated by multiplying the parameter estimate times the actual data value) 1997	1998	1999	2000	2001	2002	2003	2004
Intercept	148.9	148.9	148.9	148.9	148.9	148.9	148.9	148.9
Total excise tax rate (modified parameter)	-13.3	-13.3	-13.6	-13.5	-13.3	-17.4	-20.7	-20.1
Bachelors degree	-25.1	-25.7	-26.4	-27.0	-27.1	-27.2	-27.2	-27.3
Disposable income	-14.9	-15.6	-16.0	-16.6	-16.8	-17.2	-17.2	-17.9
Hispanic	-4.7	-5.1	-5.5	-5.9	-6.1	-6.3	-6.5	-6.7
Asian	-1.4	-1.5	-1.5	-1.6	-1.7	-1.7	-1.8	-1.8
Mormon/7th-Day Adventist	-1.9	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8
Miles to Raleigh NC	-12.3	-12.3	-12.3	-12.3	-12.3	-12.3	-12.3	-12.3
Tourists, hotel spending	1.4	1.3	1.3	1.3	1.2	1.2	1.3	1.2
Military personnel	-1.7	-1.6	-1.4	-1.6	-1.5	-1.7	-1.7	-1.6
Indian reservation, 60 miles State border tax index, 60 Canada tax index, 30 miles								
Kentucky binary variable New Hampshire binary								
2000 binary variable	0.0	0.0	0.0	-4.5	0.0	0.0	0.0	0.0
2001 binary variable	0.0	0.0	0.0	0.0	-6.6	0.0	0.0	0.0
2002 binary variable	0.0	0.0	0.0	0.0	0.0	-6.1	0.0	0.0
2003 binary variable	0.0	0.0	0.0	0.0	0.0	0.0	-5.9	0.0
2004 binary variable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-7.1
	75.0	73.3	71.7	65.3	62.9	58.4	55.2	53.4

See the notes below Table A-1.

Table A-2 (bottom row) yields the Model 1 estimate for total Washington packs per capita. These are the same results reported in Part One, Table 5 "Washington Results…," under the "Model 1" heading. The Washington relative smoking rate is the total rate divided by the U.S. total packs per capita as reported in Table 6 under the "Model 1" heading. The same analysis is carried out for all states and all four models.

APPENDIX II:

VARIABLES, DATA CONSTRUCTION, AND SOURCES

This section provides further information about the data. This information includes the manner in which the variables were constructed because some of the variables require a fair amount of calculation. Also discussed are important variables that were not significant and therefore excluded from the models—these too provide important evidence about the market for cigarettes. In addition, all data sources are provided.

Note that all dollar values are in constant, year 2000 dollars (real dollars). That is, dollars and cents are adjusted for changes in the price level (inflation). The price deflator for personal consumption expenditures was used to deflate dollar values (source, Washington State Economic and Revenue Forecast Council).

Annual binary variables, 2000-2004: no source; described in Part Two, section 2-3.

Canadian border binary:

Takes on a value of 1 for a U.S. state on the Canadian border and 0 otherwise.

Canadian tax index:

The construction of the Canadian tax indices were the same as the tax indices for the U.S. states,[28] but Canadian taxes were higher throughout the period (except for one observation with a trivially lower Canadian tax). The tax indices include the populations of all those Canadian census divisions that lie within 30 or 60 miles of the U.S. border (a 30-mile and a 60-mile index were tested). Data on Canadian census divisions was obtained from Environmental Systems Research Institute (ESRI). This includes drawings of census division borders in geographic information system (GIS) format, and it includes census division populations. Population increases in each census division were assumed to be the same as the province as a whole. Water features and bridges were determined with a Rand-McNally atlas.

Tax data is from Statistics Canada. Applicable taxes include: provincial tobacco taxes, federal excise tax on tobacco, federal excise duty, provincial sales tax, and federal general sales tax (GST). Weighted, average (Canadian) provincial tax rates were used to construct indices for those states bordering more than one province. The Canadian consumer price index (CPI) series is from the Bank of Canada. The exchange rate is from the U.S. Federal Reserve Board.

[28] The indices for U.S. states are described below.

Both types of Canadian border variables, the simple border binary, or the more complex border indices, also act as indicator of "North," thereby making redundant other North or South binary variables (the difference in R-square is trivial).

Cigarette excise tax rate (total rate):

This variable is the total of the cigarette excise tax and general sales tax paid on each pack of cigarettes, in cents per pack. Source, *The Tax Burden on Tobacco, Historical Compilation*, Volume 39, 2004, by the economic consulting firm of Orzechowski and Walker.

The cigarette excise tax rate is the weighted, real, state cigarette tax rate in cents per pack. The individual state cigarette tax rates are from Table 20, pages 251-301. For those years with a mid-year rate change, the rate used was an average weighted by the number of days the different rates were applicable.

The excise tax rate also includes the real, general sales tax rate paid on a pack of cigarettes, in cents per pack. This data is from Orzechowski and Walker, Table 15, pages 159-205. Note that unlike the cigarette excise tax, this data is not weighted for changes in sales tax rates, for a number of reasons. First, the total sales tax rate typically is not a uniform rate applicable to the entire state but is often a sum of state and local rates. Thus, there may be a number of incremental changes to the statewide effective rate. In addition, total cents collected from the general sales tax depends on the price of each pack of cigarettes sold and prices often vary during the course of the year and from location to location. Finally, economists and government officials do not have particularly accurate data on cigarette prices; the Orzechowski and Walker data (discussed next) is the best available.

The inability to accurately construct a weighted sales tax, like the cigarette tax, probably has minor impacts only on model results because the 1997-2004 sales taxes per pack in most states were only a small fraction of the cigarette tax rate (sales taxes were a larger percent prior to 1997). However, the dataset does include 53 observations (out of 408 in total) where the general sales tax contributed more to total excise taxes than did the cigarette tax. These observations involved eight states: Indiana (2002), Mississippi (1999-2004), Tennessee (2001-04), West Virginia (2001-02), Wyoming (2001-03), and Kentucky, North Carolina, South Carolina, and Virginia (1997-2004).

Note that total cigarette excise taxes and cigarette prices are related variables and yield similar results (see cigarette prices below).

Cigarette prices:

Cigarette prices are from *The Tax Burden on Tobacco, Historical Compilation*, Volume 39, 2004, Table 15, pages 159-205. Cigarette prices are stated in real terms. Accurate

price data is often problematic in economic studies. The Orzechowski and Walker annual survey of cigarette prices is the only state-by-state data available; however, despite heroic efforts, the price data can be unreliable for some states in some years due to a poor response rate. This may be the reason why total excise taxes had greater explanatory power than prices did in the 2006 DOR models as well as the 1985 ACIR model. Farrelly et al. also use excise taxes rather than prices. Note that the difference in cigarette prices across states is primarily due to the difference in total cigarette excise taxes, and the results of using one or the other are similar.

Demographic variables--Hispanic, Asian, Mormon/Seventh-Day Adventist:

Hispanic, percent of the state population. Source: U.S. Census population estimates.
Asian, percent of the state population. Source: U.S. Census population estimates.

Mormon/Seventh-Day Adventist, in *Religious Congregations and Membership in the United States 2000: An Enumeration by Region, State, and County Based on Data Reported by 149 Religious Bodies,* by Jones, Dale E., Sherri Doty, James E. Horsch, Richard Houseal, Ma Lynn, John P. Marcum, Kenneth M. Sanchagrin, and Richard H. Taylor, 2002. Copyright 2002 ASARB. Available: {CD-ROM}, Nashville, TN: Glenmary Research Center.

The Glenmary databases contain data on religious membership and affiliation in 1990 and in 2000. We followed precedent and used the wider measure, religious affiliation (U.S. = 141 million in 2000), rather than membership (49 million). Years 1997-1999 and 2001-2004 were interpolated. As is common practice, Mormon and Seventh-Day Adventist were combined into one variable because both are known for anti-tobacco behaviors and because the standard error of Seventh-Day Adventist was very high (though both groups had negative signs and were significant when included separately).

Other demographic data, including various age groupings, were not significant and were therefore excluded from the models. Interpolation was used for some groups in some years.

Disposable income:

Real, per capita disposable personal income was obtained from Bureau of Economic Analysis (BEA), a division of the U.S. Department of Commerce. Personal income is a comprehensive measure of income that includes: wages and salaries, proprietor's income, interest, dividends, rental income, net transfer payments, etc. Disposable income is income net of current personal taxes.

Indian Reservation, within 60 miles:

The GIS drawings of Indian reservation borders were taken from the Census Bureau. The variable used was the percent of a state's population that lived in a census block that came within 60 miles of a reservation. There was only a very small improvement in the 60-mile models relative to the 30-mile models.

There is further discussion of Native American sales below concerning state tax exempt sales.

Military personnel:

The variable used was the sum active duty plus national guard/reserve, as a percent of each state's population. Data was from the annual *U.S. Statistical Abstracts*. The *Abstract* had active duty data for four of the eight years only; the other four years were interpolated. Reserve/national guard data existed only for 2003; the other years were assumed to be the same percentage of active duty. Therefore, all of the variability in the data came from active duty personnel.

Given the pricing changes of November 1, 1997, and in 2001, it is assumed that illegal sales on military bases are an immeasurably small share of total illegal sales. Information about military pricing policies came from Brad Taft, Health Promotion Outcomes Researcher, USACHPPM-DHPW. There is further discussion of legal and illegal military sales below concerning state tax exempt sales.

Miles to Raleigh, North Carolina:

Raleigh, N.C. is in the heart of the historic tobacco growing/processing region. Miles to Raleigh is a proxy for shipping costs. Miles from Raleigh to each state were measured with GIS software from Environmental Systems Research Institute, ESRI. "Miles" also acts as an East-West regional indicator, making redundant an East or West binary variable. "Miles" had greater explanatory power than other East-West binaries.

State binary variables: no source; described in Part Two, section 2-3.

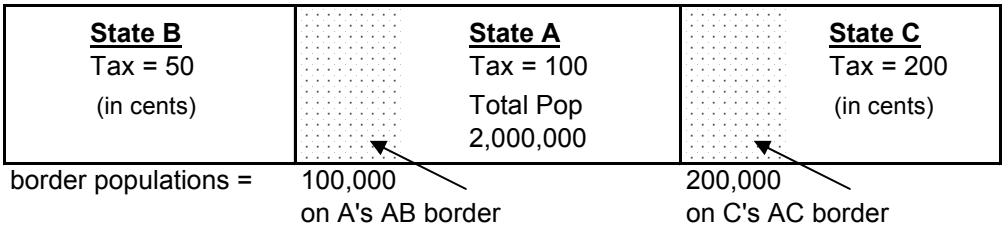
State border price or tax indices:

Census block data was obtained from the Census Bureau. GIS information on state borders was from ESRI. Index values use real (constant dollar) prices and tax rates.

The following is an example of the calculation of a state border tax index.

Let cigarette excise taxes in adjacent states A, B, and C be 100 cents, 50 cents, and 200 cents respectively (see exhibit A-1 below) and let tax rates be denoted by t_a, t_b , and t_c respectively.

Exhibit A-1
State Border Indices



State A's border tax index is then given by:

$$(t_b - t_a) * (\% \text{ border population}) + (t_c - t_a) * (\% \text{ border population})$$

where the % border population is given by:

if $t_a > t_b$, then % border population = $\frac{\text{(state A's pop. along the AB border)}}{\text{state A's total population}}$.

This represents the proportion of state A's population that has the opportunity to shift demand out of state, thereby reducing state A's taxed sales. The other alternative is:

if $t_a < t_c$, then % border population = $\frac{\text{(state C's pop. along the AC border)}}{\text{state A's total population}}$

because we are still constructing state A's index. This represents state C's residents who have the opportunity to shift demand to state A's market, thus expanding state A's taxed sales.

Therefore, state A's border tax index is:

$$= (50-100)*(100,000/2,000,000) + (200-100)*(200,000/2,000,000)$$

$$= -50*5\% + 100*10\% = -2.5 + 10 = 7.5$$

The same methodology is also used for the price indices and for the Canadian border tax indices.

State taxed sales:

State taxed sales are from Table 20 in *Tax Burden on Tobacco* by Orzechowski and Walker.

State tax exempt sales:

The ACIR and Clarke both calculate total (U.S.) state tax exempt sales by subtracting state taxed sales from federally taxed "removals." Both studies calculate state tax exempt sales to be 2.5 percent of federally taxed sales (the ACIR found that the figure had varied from 8.5 percent in 1970 to 2.5 percent in 1983).

DOR tried unsuccessfully to measure state tax exempt sales with the parameters estimated by the models. However, it is not easy to differentiate between illegal Indian sales versus tax exempt sales and sales under a compact.[29] DOR tested models with sales to enrolled tribal members measured by the Native American share of state population and illegal sales measured by the population share living in census blocks within 30 or 60 miles of a reservation. Because the Native American population variable was not significant, however, it was not possible to differentiate between legal, tax exempt Indian sales and illegal sales.

The comments regarding Native American sales also apply to the difficulty in differentiating between legal versus illegal military sales prior to November 1, 1997, and to a lesser extent, prior to 2001. Since 2001 it is believed that illegal military sales are a very small fraction of the total illegal sales and not a compliance issue.

Therefore, DOR used the ACIR/Clarke method, federally taxed consumption minus state taxed consumption. There are two different potential sources for federally taxed sales, Table 3 in *Tax Burden on Tobacco* by Orzechowski and Walker and the original source, federal "removals" in Table 1 of the USDA's annual publication, *Tobacco Outlook*, by Tom Capehart. State taxed sales are from Table 20, Orzechowski and Walker.

Estimates for state exempt sales differed with the two sources for federally taxed sales. The estimates also varied from year to year, ranging from 6 percent to (-)1.5 percent over the 1997-2004 period. The variance is related to timing, adjustments, and other difficulties in estimating federally taxed consumption, but the series over time reflects economic fundamentals more accurately than any given year. State tax exempt sales averaged 3 percent of federally taxed sales over the eight-year period for both the *Tax Burden* and the *Tobacco Outlook* data, so DOR used 3 percent.

The ACIR attributed the state tax exempt sales to each state by apportioning a fixed percentage across all of the states. DOR followed Clarke's procedure and used the reduced version of the estimated coefficients on retail prices or excise taxes, as described in Part Two.

[29] Indian sales under a tribal compact are explained in a footnote to section 1-7.

Total U.S. packs per capita:

Total U.S. packs per capita were from Table 3 in *Tax Burden on Tobacco* by Orzechowski and Walker. Cigarettes per capita were converted to 20 cigarette/pack equivalents.

Years:

All years are fiscal years unless otherwise specified.

Variables that were not significant in the DOR top models:

Three important and related variables that did not test significant in the top DOR models were those concerning anti-smoking policies, youth access laws, and tobacco control expenditures. The Roswell Park Cancer Institute has compiled for Impacteen.org a comprehensive index of some 25 measures relating to state tobacco control laws. DOR tested each measure individually and in various combinations. The smoke-free air variables, representing a total score on 12 types of smoking bans (in workplaces, health care facilities, malls, schools, bars, etc.) were often significant in models containing no state binaries but were not significant in the models with the Kentucky and New Hampshire binaries (or other states). However, the Kentucky and New Hampshire binaries substantially raised the R-squares of the DOR models, and the binaries were necessary to accurately measure the large number of illegal cigarettes supplied by the two states. The authors feel that the significance of smoke-free air policies will likely be more robust to different model specifications in the future as states continue to enact such laws. The youth anti-tobacco policies were generally not significant in models tested by DOR. The experience with per capita tobacco control expenditures was similar to anti-smoking policies, testing significant in some DOR equations but not in the top four models. Tobacco control expenditures were from Campaign for Tobacco Free Kids via Washington DOH. See also the detailed footnote following Table 13 in Part Two.

Though Canadian border binaries and index variables were significant, Mexican border variables were not. DOR tested Mexican border binaries and the percent of state populations living within 30 or 60 miles of the border. There is a fair amount of hearsay evidence indicating that the Mexican border is a nontrivial source of illegal cigarettes, and Fleenor's 38-year model estimated that one-half of 1 percent of total U.S. sales came illegally from that source in 1997. Unfortunately, DOR was not able to find consistent data regarding prices or taxes on the Mexican side of the border.

Many regional binary variables were also tested and rejected. Some were not significant, but a number were discarded because they did not perform as well as those used. As mentioned above, the "Miles to Raleigh" variable added more explanatory power and had higher t-values than did any other combination of East and/or West binaries—this is

undoubtedly due in part to the fact that the "Miles" variable contains at least as much information as a similar binary but also adds magnitude.

The situation with the Canadian border variables was somewhat different. The Canadian border variables were not necessarily the best of all North-South indicators tested, but for all practical purposes they performed just about as well as the best. The Canadian border tax index in particular was designed to measure the incentive and opportunity to purchase illegal cigarettes across the international border, so it was not desirable to replace the index with a Northern States binary that yielded a trivially higher R-square.

The impact of the master tobacco settlement agreement, the MSA, was tested using dollar amounts received by each state, per capita MSA amounts, and a binary MSA variable—the latter took on the value of "1" for a few states in 1998, for almost all states in 1999-2000, and for all states in 2001-2004. These variables were generally not significant in models with annual binaries or a time trend. Note that the significant annual binaries for all models reported in the body of the study, as well as in most models tested, were those annual binaries representing the years 2000-2004, the approximate period covered by the MSA. Thus, the annual binary variables reflect the influence of the MSA as well as other factors not captured by the variables in the models. The state MSA payments were from the National Association of Attorneys General, as reported by the Campaign for Tobacco Free Kids, July 13, 2006.

Not tested due to lack of data are imports of illegal cigarettes into the U.S. The U.S. has traditionally been a large cigarette exporter, not an importer. However, imports have been rising along with excise taxes and prices. For example, 1997 taxed imports were 0.4 percent of U.S. cigarette output and 0.7 percent of U.S. consumption. By 2004 imports were 1.6 percent of output and 5.9 percent of consumption.[30] Illegal cigarette imports have likely increased at least as fast as taxed imports during the 1997-2004 period, and tobacco enforcement officials have reason to believe that illegal imports are growing even faster—unfortunately, state level data on this is difficult to come by.

[30] Table 1, *Tobacco Outlook,* September 26, 2006.

APPENDIX III:

REVIEW OF THE LITERATURE

Parts One and Two discuss those works most related to the history of the Washington DOR modeling effort. This section reviews other recent empirical work not discussed at length in the body of the study or aspects of the work not already mentioned. Any results given below are for the U.S. and not specific to Washington State.

Adda and Cornaglia (2005) use large, representative, but previously unexploited data reporting both the cigarettes smoked and measure of nicotine in the blood. They show that smokers respond to price/tax changes by smoking cigarettes more intensively in order to maintain nicotine levels.

Farrelly, Pechacek, and Chaloupka (2003) use cross-section time series models with state indicators and state-time trends to estimate the effects on tobacco use of current, lagged, and cumulative tobacco control expenditures (per capita) as well as the effects of cross-border imports and exports, the high school dropout rate, and the unemployment rate. Real, per capita tobacco control expenditures are shown to be related to reduced tobacco use over the period 1981-2000.

Fleenor's (1998) work was discussed in the body of the study, but his resulting estimates of illegal activity were not. He estimated that 13 percent of total 1997 sales were illegal with organized smuggling the largest share at 8 percent.

Goolsbee and Slemrod (2004) estimate the impact of illegal Internet sales on the sensitivity of state cigarette tax revenues to changes in tax rates. Along with *Tax Burden on Tobacco* data, they use data from the Current Population Survey, the Centers for Disease Control's Behavioral Risk-Factor System (CDC, BRFSS), a large Forrester Research survey of Internet use, and other surveys. They conclude that the tax sensitivity of taxed packs has almost doubled from 1980 to 2001. They therefore estimate that revenue gains from a large tax increase in states with high Internet usage may be only 40 percent to 70 percent of expected due to the purchase of illegal cigarettes over the Internet. The authors do not explicitly measure Internet cigarette sales.

Gruber, Sen, and Stabile (2003) use two methods to estimate smuggling-corrected elasticities for Canada: excluding provinces and years where smuggling was greatest, and using household level expenditure data. Their elasticity estimates range from -0.45 to -0.47.

Huang, Yang, and Hwang (2004) reject the hypotheses of a unit root in cigarette panel data. Thus, they employ conventional modeling techniques to estimate the demand for cigarettes. They use a double logarithmic model, with 42 states and D.C., and estimate a price elasticity of -0.41 and an income elasticity of 0.06.

Ross and Chaloupka (2003) use a large, national survey of high school students to measure the impact of prices on youth smoking. The data allows them to use a two-step procedure, first measuring the probability that a student will smoke, then the intensity of smoking. Their results confirm that higher prices reduce the probability of youth smoking; there is also some evidence that higher prices reduce youth smoking intensity.

Stehr (2005) compares taxed cigarette sales data with Behavioral Risk-Factor System (BRFSS) and finds that the tax avoidance response to a price change is at least twice as great as the consumption response, that tax avoidance accounted for up to 9.6 percent of sales between 1985 and 2001, and that data on taxed sales understates smoking and overstates the response to price changes.

Tauras, Chaloupka, Farrelly, Giovino, Wakefield, Johnston, O'Malley, Kloska, and Pechaeck (2005) use a two-part model of cigarette demand and a nationally representative survey of 15,000 to 19,000 eighth, tenth, and twelfth grade students to find that real, per capita tobacco control expenditures have a negative impact on student smoking.

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