The Impact of the North Carolina Cigarette Excise Tax Increase on Cigarette Sales and Tax Revenue in North and South Carolina

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ABSTRACT

ROBERT PALMER STEEL: The Impact of the North Carolina Cigarette Excise Tax Increase on Cigarette Sales and Tax Revenue in North and South Carolina

This study investigates the impact on sales and revenue in North and South Carolina of the recent cigarette excise tax increase in North Carolina from 5 cents per pack to 30 cents per pack on September 1st, 2005. A public debate concerning cigarette taxes occurs nationwide, especially in the low cigarette excise tax Southern United States.

Understanding the implications of the tax increase on North and South Carolina is particularly important, since the potential for arbitrage profits through smuggling is high given the disparity between North and South Carolina's tax rates and the national average of 91.7 cents per pack. Before the increase, North Carolina's cigarette tax was the lowest in the United States. South Carolina's cigarette tax remains at 7 cents per pack, the lowest in the nation. North Carolina was one of the main sources of smuggled cigarettes in the United States, aided by the lack of tax stamps and high-volume discount outlets.

Making use of preliminary research by Chandra and Chaloupka (2003) into the seasonality of cigarette demand, I model tax-paid cigarette sales in North and South Carolina with month indicators and a general monthly time trend. This study explores numerous variables that, in theory, could influence cigarette sales – employment levels, inflation, climate, gas prices, and sales in a low-tax neighboring state. This is a new approach to incorporating possible seasonal trends as well as variables that affect smuggling activity into a tax-paid cigarette sales model. Only climate and sales in a low-tax neighboring state are found to be significant.

Using the model constructed through this research, cigarette sales are predicted in North and South Carolina over three periods: (1) before the Governor of North Carolina formally called for an increased cigarette tax in late January of 2005; (2) the time period between the Governor's announcement and the tax increase; and (3) the time period following the cigarette tax increase. The fit of the model is analyzed in the pre-announcement period and then applied to the announcement and tax increased periods. The dramatic decrease in sales in North Carolina from September 2005 through January 2006 is shown to be a direct effect of the tax increase. An astounding increase in cigarette sales in South Carolina in January 2006 is also discussed.

One of the core concepts of economics is the downward sloping demand curve. This model will certainly incorporate this concept through analyzing the price effect of the tax increase – higher prices due to the tax increase will cause less packs of cigarettes to be sold due to the price elasticity of demand for cigarettes. Price elasticity estimated from existing studies is incorporated into this research.

By measuring the price effect of the tax increase, the remaining difference between the model and actual sales in the tax increased period is explored. Potential stockpiling before the tax increase is found. Though I cannot conclusively measure the extent of the smuggling effect (with higher taxes, smuggling cigarettes from North Carolina is less profitable), it is clear that smuggling is occurring when the model controls for all other significant variables. These results provide insight into the effectiveness and impact of increasing cigarette taxes, specifically in North Carolina and, by extension, low-tax states where smuggling occurs.

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CHAPTER I

INTRODUCTION

Background

Cigarette excise taxation has been at the forefront of legislative and public health agendas for more than forty years since the release in 1964 of the Surgeon General's report warning of the harmful effects of smoking. State officials often implement cigarette excise tax increases as a two-edged sword aimed at discouraging smoking and raising revenue. Since the beginning of the debate between public health proponents, state revenue advocates, and the tobacco industry, economists have made valuable contributions to the policy debate through evaluating the effect of price on cigarette demand (price elasticity) as well as exploring the nature and impact of cigarette smuggling. With that extensive literature as a foundation, legislators have moved in recent years to increase cigarette taxation even further as a means to reduce cigarette consumption. Taxing cigarettes for revenue purposes due to their inelastic demand has existed in the United States since colonial times, but empirical findings from economists on the significant inverse effect between cigarette price and demand has led to major public and legislative initiatives to increase taxes significantly in an effort to reduce cigarette consumption.

There is an existing literature in the United States devoted to estimating the impacts of cigarette tax increases. Economic research exploring the price elasticity of demand for cigarettes is frequently examined, with consensus estimates ranging from -0.4 to -0.5. Those estimates are well documented in Chaloupka and Warner's summary work *The Economics of Smoking* (2000), as well as in the Surgeon General's report *Reducing*

Tobacco Use (2000). Research with updated figures since 2000 has led to estimated elasticities upwards of -0.66. These estimates are used by economic researchers and fiscal analysts to project potential revenue gains and cigarette sales losses in analyzing potential or implemented cigarette excise tax increases. According to the Surgeon General's report, two major conclusions on the effects of cigarette prices on smoking can be drawn from these empirical studies: (1) "increases in cigarette prices lead to significant reductions in cigarette smoking" ranging from 3-5 percent reduction in consumption based on a 10 percent increase in price; and (2) "the effects of increases in cigarette prices are not limited to reductions in average cigarette consumption among smokers but include significant reductions in smoking prevalence" (*Reducing Tobacco Use*, 2000). In short, increased tobacco prices reduce tobacco use.

Studies have also explored other factors that affect the demand for cigarettes, including numerous sociodemographic characteristics, point of sale advertising, and increased awareness of the health consequences associated with smoking. More recent research by Chandra and Chaloupka (2003) explores a seasonal component of cigarette demand, finding that there is significant evidence of seasonality in cigarette demand. Chandra and Chaloupka (2003) list possible causes of seasonality as the effect of climate on smoking behavior, the timing of tax changes, the timing of the new fiscal year, the timing of the school year, and the timing of quitting efforts tied to New Year's resolutions. Exploring the seasonality component of cigarette sales is worth its own studies, and any study attempting to estimate cigarette sales should incorporate this statistical trend into any sales model. However, the impact of these findings is limited compared to the impact of cigarette excise taxation on cigarette demand.

Cigarette taxation has low administrative costs and high revenues due to its inelastic nature and wide consumer base, as previously discussed. The findings that increased tobacco prices do in fact significantly reduce tobacco use also has led to the implementation of cigarette taxation as a policy tool for reducing consumption and thereby creating a public health benefit. Empirical analyses of the relationship between cigarette taxes and prices have been somewhat varied and inconsistent in their findings. Chaloupka and Warner (2000) documented many of these landmark studies. In 1996, Keeler et al. examined national and state level data from 1960 through 1990 to conclude that cigarette tax increases at the state level increased retail prices in the state by a ratio of 1.11 cents per pack price increase to 1 cent per pack tax increase. This was one of the first studies to include an integrated model of producer and consumer behavior, incorporating the oligopolic nature of the tobacco industry and their response to tax increases. There is also evidence from Becker et al. in 1994 that cigarette companies raise prices in response to tax increases in an effort to extract maximum profit from current, addicted smokers. All of the research documented in Chaloupka and Warner (2000) and in *Reducing Tobacco Use* (2000) reaches the conclusion that cigarette taxation is an effective policy tool for reducing consumption and raising revenues.

There is also an increasing amount of research into the impact of tax increases on smuggling. Smuggling, both casual and organized, is enabled by substantial differences in cigarette excise tax rates across political jurisdictions. These varying rates create arbitrage profit opportunities that can greatly increase revenues in low-tax states while reducing revenues in high-tax states. With many states, including North Carolina, lacking tax stamps, cigarettes having low transportation costs, and the potential profits from smuggling rather large between low- and high- tax states, the smuggling problem can have a significant impact on state revenues. However, the existing research in this field is relatively limited in assessing the impact of price differentials on smuggling activity. All of these studies have found significant evidence of cigarette smuggling from low-tax states that represented a significant number of sales for the exporting and importing states (Saba et al., 1995; Becker at all., 1994; Chaloupka and Saffer, 1992; Baltagi and Levin, 1986; ACIR, 1977, 1985; Manchester, 1976). Economists also have explored a variety of other questions relating to equity and efficiency in cigarette taxation, but the scope of this paper lies in revenue, sales, and smuggling implications of a cigarette tax increase.

A significant criticism of research into the impact of smuggling on cigarette sales in the United States comes from Gruber et al. (2003). Since most of the existing literature uses tax-paid sales data to model cigarette sales, this approach runs the risk of failing to capture non-price factors in smuggling and different functional forms of how price influences smuggling (Gruber et al. 2003). Farrelly and Nimsch's work in 2003 to estimate imports and exports (illegal and personal cigarette smuggling) which are calculated through differences in tax rates weighted by population densities. As Gruber et al. concludes (2003), "this type of approach will capture price incentives for smuggling, and indeed the results using this approach suggest that sales shift from high to low tax states," but fails to measure the actual amount of smuggling that is occurring.

Stehr (2005) approaches cigarette tax avoidance by comparing tax-paid cigarette sales data to cigarette consumption data from the Behavioral Risk Factor Surveillance System. This is an innovative approach that improves upon previous attempts to estimate smuggling, but still suffers from the potential for under-reporting bias in the cigarette consumption data. He finds that the tax avoidance response to tax changes is at least twice the consumption response, accounting for up to 9.6% of cigarette sales examined in his study. This has strong implications for states using cigarette tax increases to achieve decreases in consumption, as “tax paid sales data understate the level of smoking and overstate the drop in smoking.”

Emery et al.’s exploration of tax evasion following the 1999 50 cent per pack cigarette tax increase in California (2002) was conducted in a similar fashion by analyzing the 1999 California Tobacco Surveys. They concluded that “despite the potential savings, tax evasion by individual smokers in California did not appear to pose a serious threat to the state’s excise tax revenues of its tobacco control objectives” (Emery et al. 2002, p. 132). However, they were hesitant to apply their results generally to other environments, since the distance between population centers and low cigarette excise-tax areas was very significant in California whereas it may not be in states with population centers very close to borders with low-tax states. Their research did not attempt to examine the impact of organized smuggling as a result of the tax increase.

With specific respect to North Carolina, Farrelly and Nimsch examined the “impact on cigarette sales and revenues of raising the cigarette excise tax in low-tax southern states to the national average of 70 centers per pack (as of July 1, 2003)” (2003, p. ES-1). They found that the low-tax southern states (in which North Carolina is included) would gain tobacco tax revenue, experience significant consumption declines, and experience shifts in smuggling activity if the tax-increase were not implemented by all of the low-tax southern states. Of those states, only Missippi and South Carolina have not raised their state cigarette excise taxes, with South Carolina's tax rate at $0.07 per pack the lowest in the country (as of January 9, 2006). This literature is also important because it estimates the number of long-distance exports (smuggling) for each state, including North Carolina using the difference in per capita sales and self-reported consumption in the exporting and importing states weighted by population and distance. According to their estimates, more than 105 million packs of cigarettes, or more than 2 billion cigarettes, are smuggled from North Carolina every year.

Purpose

In January of 2005, Governor Easley announced to North Carolina's State Congress his intention to work for a $0.45 per pack increase in the state cigarette excise tax. After seven months of intense political debate, a $0.25 per pack increase, followed by a further $0.05 per pack increase in 2006, was finally passed. In that legislative act, the State of North Carolina moved up from having the lowest cigarette excise tax level in the nation. On September 1st, 2005, the cigarette tax moved from $0.05 per pack to $0.30 per pack, with a corresponding initial price increase of $0.27 cents.

This study is particularly significant since North Carolina is the leading producer of tobacco in the U.S. and home to the three biggest producers of cigarettes in the U.S. – Phillip Morris, Reynolds American, and Lorillard tobacco companies. Suffice it to say that North Carolina has a lengthy history of being a tobacco-friendly state. Furthermore, home to the United State's self-proclaimed largest retailer of cigarettes, JR Tobacco, as well as other discount outlets, North Carolina is also one of the main sources for smuggled cigarettes in the U.S. With no tobacco stamps, low-price outlets, and little done to prevent cigarettes from being illegally exported, North Carolina has long been frequented by smugglers looking to make a hefty arbitrage profit at the expense of other states' taxation efforts. In 2002, a group linked with the terrorist group Hezbollah was convicted of smuggling nearly $8 million worth of cigarettes from North Carolina to Michigan. The impact of an increased cigarette tax on a state with such a long, pro-tobacco history and the source of extensive smuggling operations will provide insight into determinants of cigarette consumption and test sales and revenue projections from conceptual economic studies.

North Carolina also shares a border with what is now the lowest cigarette excise tax state in the nation – South Carolina. The North Carolina tax increase further merits close examination and study due to the potential shift in smuggling activity from North to South Carolina. If this shift can be documented, then substantial, empirical evidence of smuggling activity will exist and estimates of the extent of illegal smuggling refined.

Nature of the Study

The present paper builds on the existing literature in several important areas. First, the significance of the seasonality component is built into my empirical model of cigarette sales, providing for better monthly cigarette sale estimates. I also explore some potential factors of the seasonality component, including monthly mean temperature and precipitation. This analysis considers seasonal trends by incorporating a month vector into the empirical model as well as including general time trends. Chandra and Chaloupka (2003) found statistical significance of seasonality in North Carolina, and that finding will be confirmed, but more importantly, as previously mentioned, built into the cigarette sales model of this paper.

Second, the effect of smuggling will be clearer by process of elimination. With North Carolina's cigarette tax increase, South Carolina is left as the only state with a cigarette excise tax level below $0.10/pack. This is of particular interest since North Carolina and other low-tax southern states have long been primary sources of smuggled cigarettes through the U.S. With South Carolina's price per pack the lowest in the nation (thus representing the highest potential arbitrage profit for organized cigarette smugglers), smuggling can reasonably be expected to shift towards South Carolina. Although my research will suffer from the same shortcomings as much of the previous literature, in that smuggling will not be explicitly included in my empirical model, but estimated by accounting for other effects.

Finally, my research is directly applicable to the State of North Carolina. The analysis will shed light on the effectiveness of the tax increase on reducing consumption and increasing revenues. Stockpiling and smuggling effects will be explored, applying theory and past findings to North Carolina's experience before and after the tax increase.

The paper proceeds as follows. An explanation of the dependent and explanatory variables used in my research is presented in Chapter II. The empirical model for sales in North and South Carolina is constructed and discussed in the first part of Chapter III. The rest of Chapter III uses the empirical model for analysis of the impact of North Carolina's cigarette tax increase on revenue, sales, and smuggling in North and South Carolina. Chapter IV summarizes my research and offers some conclusions.

CHAPTER II

DATA

Theory suggests that several variables may explain variation in cigarette sales over time. These include climate, employment, CPI, and gas price variables. While different measures of cigarette consumption exist, this study uses tax-paid cigarettes sales for North and South Carolina. This chapter details data construction and summary statistics for all variables in the analyses.

Dependent Variables

Revenue figures for North Carolina were obtained from the North Carolina Office of the State Controller. The monthly Summary of Financial Condition reports provide Cigarette Excise Tax Revenue figures in millions of dollars. These reports are archived online through June 1997, with current reports existing through January 2006. Thus, June 1997 through January 2006 (with updates made as more recent reports become available) defined the time period of this study.

Revenue figures for South Carolina were obtained by request from the South Carolina Department of Revenue. These figures were reported for the time period of the study, with updates made as more data became available. Like the North Carolina revenue figures, the South Carolina figures were reported in millions of dollars.

Cigarette sales figures are derived from the tax-paid revenue data for each state. The Excise Tax Revenue for North and South Carolina are divided by their respective tax rates (per cigarette) to calculate cigarette sales. The tax rate for South Carolina is unchanged across the time period of analysis (tax per cigarette = $0.0035), while the tax rate for North Carolina was $0.0025 per cigarette until September 2005, when the tax was increased to $0.0125 per cigarette. Cigarettes sold are then divided by 1,000,000 to more easily analyze and report the data.

Packs of cigarettes sold in North Carolina are calculated by dividing cigarettes sold by 20 since all tax-paid packs consist of 20 cigarettes. In South Carolina, packs of cigarettes sold are calculated by dividing cigarettes sold by the weighted average of (.1*25 + .9*20), since the South Carolina Department of Revenue estimates that approximately 10 percent of tax-paid packs sold in South Carolina consist of 25 cigarettes, while 90 percent of tax-paid packs sold in SC consist of 20 cigarettes.

Figure 1 below displays cigarette sales over time in North and South Carolina. Table 1 displays summary statistics for the dependent variables.

Figure 1. Cigarette Sales in North and South Carolina

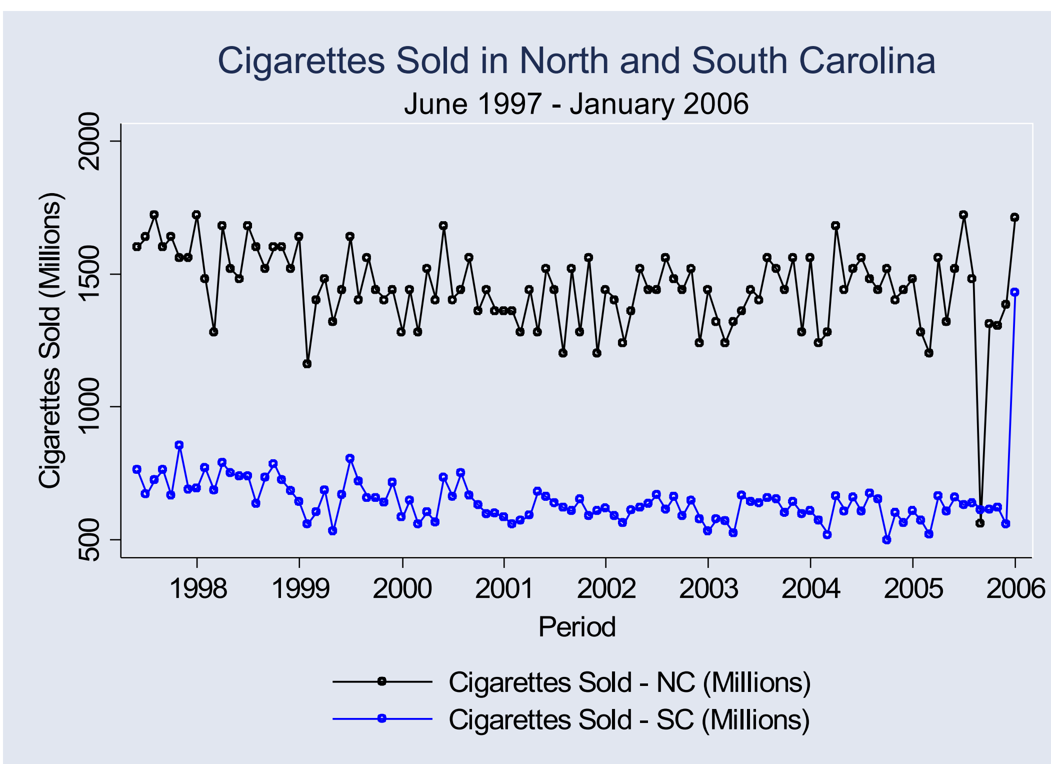

Table 1. Summary Statistics for Dependent Variables

First Line: June 1997 – Jan 2005 (NC Excise Tax per Cigarette = .0025)
Second Line: June 1997 – Jan 2006 (Entire Data Period)
Third Line: Feb 2005 – Jan 2006 (Tax Increase Announced and Implemented)

	Mean	Std. Dev.	Min	Max
<u>Revenue</u>				
Excise Tax Revenue - NC (Millions)	3.64	0.32	2.90	4.30
	4.22	2.81	2.90	21.40
	8.63	7.00	3.00	21.40
Excise Tax Revenue - SC (Millions)	2.25	0.24	1.74	2.99
	2.27	0.36	1.74	5.00
	2.37	0.84	1.82	5.00
<u>Cigarette Sales</u>				
Cigarettes Sold - NC (Millions)	1455.65	129.64	1160.00	1720.00
	1444.92	159.92	560.00	1720.00
	1362.67	303.47	560.00	1720.00
Packs of Cigarettes Sold - NC (Millions)	72.78	6.48	58.00	86.00
	72.25	8.00	28.00	86.00
	68.13	15.17	28.00	86.00
Cigarettes Sold - SC (Millions)	643.66	69.57	496.59	853.26
	647.48	102.84	496.59	1429.63
	676.70	240.71	519.44	1429.63
Packs of Cigarettes Sold – SC (Millions)	31.40	3.39	24.22	41.62
	31.58	5.02	24.22	69.74
	33.01	11.74	25.34	69.74

Explanatory Variables

As detailed in Chapter III, variation in cigarette sales over time may be explained by several different variables. Table 2 summarizes values of these variables over the relevant time periods of the analysis.

Climate data was obtained from the National Climatic Data Center, with the mean monthly temperature available in degrees Fahrenheit and monthly precipitation available in inches.

Employment data was obtained from the Bureau of Labor Statistics through public database queries (PDQs) into the BLS's databases. Each sector of employment reported by the BLS is included, in thousands of workers employed. Also included is the total employment of non-farm employees in North Carolina, reported in millions of workers. The unemployment rate and mass layoffs are included in the dataset as well. The latter are in the form of mass layoff events per month and total initial mass layoff claimants per month.

Consumer Price Index data was also obtained from the Bureau of Labor Statistics via a public database query. CPI data for the Southern Region of the United States was used, since state level CPI data was not available. All values are relative to a base period of 1982-1984.

Gas prices were obtained from the Energy Information Administration of the US Department of Energy through Petroleum Marketing Monthly report archives. The Regular Gasoline Retail Sales Average Price is used and includes local, State, and National taxes. The US City Average Retail Price was obtained from the Energy Information Administration with taxes included.

Table 2. Summary Statistics for Explanatory Variables

First Line: June 1997 – Jan 2005 (NC Excise Tax per Cigarette = .0025)
Second Line: June 1997 – Jan 2006 (Entire Data Period)
Third Line: Feb 2005 – Jan 2006 (Tax Increase Announced and Implemented)

	Mean	Std. Dev.	Min	Max
Climate				
NC Mean Temperature (Degrees	59.80	13.22	35.70	79.00
Fahrenheit)	59.80	13.23	35.70	79.20
	59.78	13.88	40.40	79.20
NC Precipitation (Inches)	4.20	1.99	0.10	13.30
	4.20	1.92	0.10	13.30
	4.23	1.25	2.43	6.58
SC Mean Temperature (Degrees	63.02	12.91	38.30	82.00
Fahrenheit)	63.00	12.89	38.30	82.00
	62.84	13.31	44.00	81.20
Employment				
NC Total Nonfarm Employees (Millions)	3.84	0.07	3.66	3.97
	3.84	0.07	3.66	3.97
	3.89	0.03	3.85	3.96
NC Construction Employees (Thousands)	219.94	8.22	202.20	234.40
	220.64	8.04	202.20	235.20
	226.01	3.23	222.20	235.20
NC Educational and Health Services	394.55	35.38	337.70	456.10
Employees (Thousands)	402.40	39.84	337.70	476.10
	462.60	5.82	454.80	476.10
NC Financial Activities Employees	183.92	6.93	170.10	194.30
(Thousands)	185.27	7.55	170.10	199.50
	195.64	1.90	192.00	199.50
NC Government Employees (Thousands)	623.77	23.70	574.20	666.80
	627.92	25.18	574.20	673.70
	659.72	6.43	651.00	673.70
NC Information Employees (Thousands)	76.37	4.32	68.10	84.60
	75.82	4.38	68.10	84.60
	71.56	1.72	69.90	76.50

NC Leisure and Hospitality Employees (Thousands)	323.50	15.11	293.40	349.70
	326.74	16.91	293.40	363.80
	351.56	5.33	346.10	363.80
NC Manufacturing Employees (Thousands)	700.55	84.79	576.10	802.80
	685.79	89.68	563.00	802.80
	572.58	5.07	563.00	578.90
NC Natural Resources and Mining Employees (Thousands)	8.05	0.73	6.20	9.20
	7.85	0.88	6.10	9.20
	6.35	0.17	6.10	6.80
NC Professional and Business Services Employees (Thousands)	417.11	20.85	359.70	443.60
	420.55	21.91	359.70	454.70
	446.94	6.23	435.30	454.70
NC Trade, Transportation, and Utilities Employees (Thousands)	729.92	13.58	708.50	758.20
	729.60	12.87	708.50	758.20
	727.15	4.15	722.30	735.00
NC Total Initial Claimants, Mass Layoffs	1788.53	1116.54	297.00	6680.00
	1734.91	1078.59	297.00	6680.00
	1323.83	609.61	601.00	2588.00
NC Mass Layoff Events	15.65	7.73	3.00	46.00
	15.34	7.55	3.00	46.00
	12.92	5.70	6.00	25.00
NC Unemployment Rate	4.88	1.34	3.10	6.90
	4.93	1.27	3.10	6.90
	5.24	0.37	4.30	5.70
<u>CPI</u>				
Southern Consumer Price Index, All Urban Consumers	169.40	8.24	157.00	183.70
	171.66	10.01	157.00	192.50
	188.98	2.47	184.70	192.50
<u>Gas Prices</u>				
NC Regular Gasoline Retail Sales Average Price	131.25	26.47	85.25	190.95
	141.47	40.15	85.25	291.55
	226.88	32.89	184.65	291.55
US City Average Retail Price	142.07	27.45	95.50	204.10
	151.87	39.63	95.50	292.70
	233.83	29.89	191.80	292.70

CHAPTER III

ANAYLSIS OF THE IMPACT OF NORTH CAROLINA'S CIGARETTE EXCISE TAX INCREASE ON SALES AND REVENUE

This section presents an empirical analysis of the impact on sales and revenue in North and South Carolina of North Carolina's cigarette excise tax increase of 25 cents on September 1st, 2005 from 5 cents per pack to 30 cents per pack. I will first explore the effect of the increased tax on cigarettes sales in North Carolina and South Carolina. With only one tax increase spanning the entire data set, I will first model cigarette sales during the period before North Carolina's cigarette tax was even announced by the Governor. The announcement period is not included in this first model as there are possible effects on price or consumption stemming from a government's serious consideration of a tax increase. For example, it is likely that consumption increased prior to the tax increase as individual consumers and possibly even smugglers stockpiled cigarettes. There also exists an incentive for cigarette producers and wholesalers to drop prices before the tax increase in an effort to addict more consumers. The Governor's announcement in February 2005 of his intention to work towards a tax increase is used as the cut-off date so as to exclude any possible externalities on sales from this announcement.

Using an empirical model that explains variations in cigarette sales based on data prior to the announcement period, cigarette sales will be forecasted with explanatory data from the announcement and the tax increase periods. Using different price elasticities consistent with existing literature, I will then attempt to measure the price effect of the increase on consumption and isolate any remaining effects for further analysis. Those effects include cross-border sales, long-distance smuggling, public awareness of the dangers of smoking, and hoarding. Those effects will be discussed, building upon findings in existing literature, and measured as best as possible. Once cigarettes sales have been thoroughly analyzed and different effects measured, the change in revenue for each effect from the price increase can be measured. I will present predicted, actual, and potential revenue scenarios, laying out clearly the impact of the cigarette tax increase on North Carolina State tax revenues.

An Empirical Model of Cigarette Sales

Cigarettes sales in North Carolina ranged from 1.16 billion to 1.72 billion during the period from June 1997 to January 2005. Chandra and Chaloupka (2003) suggest that sales may be influenced by seasonality, as well as general time trends. Let S_t indicate cigarette sales in month t. A vector $M_t = (M_{1t}, \ldots, M_{12t})$ denotes month indicators where $M_{6t} = 1$ if sales are observed in June, for example, and $M_{6t} = 0$ otherwise. (The omitted dummy is March as sales tend to be lowest during this month, in general.) A general monthly time trend, t, is also included. A quadratic time trend provided the best fit. Hence, my basic model is:

$$S_t = \alpha_0 + \alpha'_1 M_t + \alpha_2 t + \alpha_3 t^2 + \varepsilon_t \qquad (1)$$

Due to the potential for serial correlation that exists when analyzing cigarette sales over time (Coats 1995), testing for serial correlation is necessary to determine whether the Ordinary Least Squares method (OLS) is the best linear unbiased estimator. Serial correlation occurs when error terms for consecutive time periods are correlated. If present, serial correlation would cause the parameter estimates of Equation (1) to be inefficient and the standard errors of those estimates biased downwards, causing variables to appear to be more statistically significantly different than zero than they really are. The error terms capture that part of sales that is not explained by the independent variables, thus it is necessary to have reliable estimates of parameters' standard errors. First-order autoregression can be used to model serial correlation:

$$\varepsilon_t = \rho\varepsilon_{t-1} \tag{2}$$

That is, the error term at time t is a function of ρ (the autocorrelation coefficient) times the error term at time t-1. The Durbin-Watson test is calculated to test for first-order autoregression in the error terms. The Durbin-Watson statistic for the model in Equation (1) is 2.659. Taking into account the number of estimated parameters (14) and the number of observations (92), the model's Durbin-Watson statistic of 2.659 indicates that the model may suffer from negative autocorrelation. This means that the error term of a "previous observation" may negatively affect the error term of the "next observation." To correct for this potential autocorrelation, the Cochrane-Orcutt transformation is applied to the model. The Cochrane-Orcutt transformation corrects for the inefficiencies of the OLS method and corrects the autocorrelation to produce correct estimates of the standard errors of estimated parameters. The results of the model in Equation (1), with the Cochrane-Orcutt transformation applied, are below:

Table 3. Regression on Cigarettes Sold in NC, Seasonality and Time Variables Only

Cigarettes Sold – NC (Millions)	Coefficient	Std. Err.	t-stat	95% Conf. Interval
January	196.42	45.77	4.29	[105.28, 287.55]
February	58.29	57.13	1.02	[-55.48, 172.06]
April	213.88	57.35	3.73	[99.68, 328.07]
May	123.52	47.04	2.63	[29.86, 217.18]
June	221.98	50.65	4.38	[121.12, 322.83]
July	219.06	48.16	4.55	[123.17, 314.96]
August	195.77	48.35	4.05	[99.50, 292.05]
September	225.85	48.18	4.69	[129.92, 321.78]
October	167.90	48.33	3.47	[71.67, 264.13]
November	209.10	47.97	4.36	[113.58, 304.62]
December	85.37	49.02	1.74	[-12.24, 182.99]
Time	-8.62	1.10	-7.86	[-10.81, -6.44]
Time Squared	7.63	1.14	6.71	[5.37, 9.90]
Constant	1476.15	41.45	35.61	[1393.60, 1558.70]

R-squared = 0.6654

Durbin-Watson statistic (original) 2.659
Durbin-Watson statistic (transformed) 2.092

Notice the transformed Durbin-Watson statistic (calculated after the Cochrane-Orcutt transformation) of 2.092. This indicates that the model has been successfully corrected for autocorrelation and that there is no presence of first-order autoregression.

Consistent with Chandra and Chaloupka's (2003) findings, the model shows that June through September are "high" season for sales, and that February and March are "low" season for sales in North Carolina. Chandra and Chaloupka (2003) found that June was the most frequent high month, followed by July, in North Carolina and that February and March were the most frequent low months

Building upon this model of seasonality and time, I then tested different functional forms of variables that at least, in theory, have the potential to influence cigarette sales. These variables were added to Equation (2) and then regressed, with the necessary Cochrane-Orcutt transformation.

CPI was tested first under the hypothesis that inflation could affect demand for cigarettes if cigarette prices did not adjust at the same rate as other goods. For example, if actual cigarette prices remained constant while 5% inflation occurred, then the real price of cigarettes would fall, leading to increased cigarette sales. This scenario seems highly plausible, since wholesale cigarette price increases are not common on a yearly basis and the cigarette tax rate in NC was constant over the period examined. CPI was found to have no significant effect, indicating that price adjustments at the distributor and retail levels must have occurred, or that actual price did not significantly change but the change in real price had no statistically significant effect on demand.

Second, different sectors of employment were tested under the hypothesis that changes in any sector that has high or low prevalence of smoking would have an impact upon sales. For example, the Educational Employment Sector could be expected to have less smoking prevalence than the Construction Employment Sector. If this prevalence was significantly different between sectors, than an increase in a high prevalence sector could be expected to lead to increased cigarette sales while an increase in a low prevalence sector could be expected to lead to decreased cigarette sales. Likewise, if smoking were prohibited in certain sectors of employment, then those sectors would be expected to lead to decreased cigarette sales. Since prevalence numbers were not available for comparison, levels of employment in each sector were analyzed individually. Ten different sectors of employment were tested, but none were found to have any statistically significant effect upon cigarettes sales in North Carolina.

Next, I tested Total Non-farm Employment in the State of North Carolina. This variable was tested under the hypothesis that changes in total employment would cause changes in cigarettes sales since changes in consumers' discretionary income would lead to changes in cigarette sales and the low prevalence of smoking on the job could lead to decreased cigarette sales when employment increases. Total Non-Farm Employment was also found to have no statistically significant effect upon cigarette sales in North Carolina. The unemployment rate, mass layoff claimants, and mass layoff events were also tested based on similar assumptions, and all were found to be statistically insignificant.

In addition to the seasonality component already present in the model in the form of month indicators, I also tested climate variables in North Carolina to measure their potential influence on cigarette sales. The rationale behind this hypothesis is that during cold and wet weather, smoking behavior would decrease, and during mild to hot weather, smoking behavior would increase. Thus, temperature is hypothesized to have an inverse relationship with cigarette sales and precipitation would have an even greater inverse relationship with cigarette sales. Temperature was found to be statistically significant, with a t-statistic of 3.46 when regressed with the seasonality variables and time variables against cigarette sales. Surprisingly, precipitation was not found to be statistically significant, with or without controlling for temperature. Temperature is clearly the more significant climate variable. To further test the influence of climate, a "Climate" variable was constructed consisting of Temperature times Precipitation. This variable was also found to be statistically insignificant, further clarifying that temperature is the significant driver behind climate-driven seasonal effects. Temperature (C_t) was added to the basic model in Equation (1) to construct:

$$S_t = \alpha_0 + \alpha'_1 M_t + \alpha_2 t + \alpha_3 t^2 + \alpha_4 C_t + \varepsilon_t \quad (3)$$

The results of the model in Equation (3), with the Cochrane-Orcutt transformation applied, are below:

Table 4. Regression on Cigarettes Sold in NC, Seasonality, Time, and Temperature

Cigarettes Sold – NC (Millions)	Coefficient	Std. Err.	t-stat	95% Conf. Interval
January	266.40	55.35	4.81	[159.16, 376.63]
February	105.59	62.45	1.69	[-18.80, 229.97]
April	147.59	66.57	2.22	[15.01, 280.17]
May	-2.32	74.55	-0.03	[-150.80, 146.15]
June	44.47	97.41	0.46	[-149.55, 238.49]
July	21.19	103.71	0.20	[-185.37, 227.74]
August	5.39	101.41	0.05	[-196.58, 207.36]
September	80.46	83.10	0.97	[-85.05, 245.96]
October	98.45	58.50	1.68	[-18.06, 214.97]
November	199.86	48.07	4.16	[104.11, 295.60]
December	144.89	56.85	2.55	[31.66, 258.12]
Time	-8.50	1.03	-8.28	[-10.55, -6.46]
Time Squared	7.53	1.07	7.07	[5.41, 9.66]
NC Mean Temperature	7.43	3.46	2.15	[0.55, 14.32]
Constant	1097.14	180.76	6.07	[737.13, 1457.16]

R-squared = 0.6986

Durbin-Watson statistic (original) 2.747
Durbin-Watson statistic (transformed) 2.135

This regression is interesting because as Chandra and Chaloupka (2003) hypothesized, climate (in the form of temperature) is a strong component of the seasonality of cigarette sales in North Carolina. When controlling for temperature, the "hot months" of June, July, and August all lose their statistical significance on cigarette sales. This indicates that the seasonal effect during “hot” months (which, in previous analysis, were shown to have the strongest effect on cigarette sales) is largely due to temperature. Also very interesting is that in some months such as January, April, November, and December maintained or gained significance on cigarette sales when controlling for temperature. This indicates that there is not a strong “cold” negative effect (e.g. November, December, and January), and that other strong seasonal factors exist.

Gas prices, for North Carolina as well as city averages for the U.S., were also tested. I hypothesized that changes in gas prices in NC as well as across the country would influence the number of cigarettes sold to cross-border purchasers and long-distance smugglers. Since one of the fundamental components, according to Coats (1995), of the arbitrage opportunities that exist from substantial differences in state excise taxes is low transportation costs, increases or decreases in those transportation costs could affect cigarette sales to out-of-state consumers who purchase cigarettes in North Carolina or smugglers. However, gas prices in North Carolina and the U.S. were found to be statistically insignificant on cigarette sales in NC. This indicates that smuggling operations and cross-border sales are not influenced by gas prices. Thus, increases in transportation costs must not be significant enough to reduce profits to the level where smugglers would seek a different locale; or that smuggling operations no longer rely upon car and truck transportation of goods (i.e. shipping goods could be more cost effective).

Equation (3) is the model that I used to forecast cigarette sales in North Carolina once the tax increase was announced and then implemented. This same model was applied to South Carolina to model cigarette sales in South Carolina before the North Carolina tax increase announcement and implementation:

$$S^{SC}_t = \beta_0 + \beta_1 M_t + \beta_2 t + \beta_3 t^2 + \beta_4 C^{SC}_t + \varepsilon^{SC}_t \quad (4)$$

The regression results from Equation (4) are listed below:

Table 5. Regression on Cigarettes Sold in SC

Cigarettes Sold – SC (Millions)	Coefficient	Std. Err.	t-stat	95% Conf. Interval
January	39.45	33.03	1.19	[-26.34, 105.23]
February	34.62	30.83	1.12	[-26.77, 96.02]
April	49.30	32.97	1.50	[-16.36, 114.96]
May	34.65	44.40	0.78	[-53.78, 123.07]
June	73.42	56.37	1.30	[-38.86, 185.70]
July	60.14	61.28	0.98	[-61.92, 182.20]
August	59.06	59.07	1.00	[-58.60, 176.72]
September	67.73	47.49	1.43	[-26.85, 162.30]
October	40.31	32.08	1.26	[-23.60, 104.21]
November	78.11	25.87	3.02	[26.58, 129.63]
December	57.14	32.31	1.77	[-7.21, 121.49]
Time	-3.82	0.78	-4.87	[-5.38, -2.26]
Time Squared	2.52	0.81	3.11	[0.91, 4.14]
SC Mean Temperature	1.14	2.18	0.52	[-3.20, 5.47]
Constant	627.09	122.38	5.12	[383.35, 870.82]

R-squared = 0. 5813

Durbin-Watson statistic (original) 2.110
Durbin-Watson statistic (transformed) 1.969

One interesting result from Equation (4) is the lack of statistical significance that January has on cigarette sales in South Carolina. This indicates that a January seasonal effect of some sort is present in North Carolina, but not present in South Carolina.

I also sought to include sales in the neighboring state into my model (e.g. South Carolina cigarette sales in the North Carolina model). Using a seemingly unrelated regressions model, I tested Equation (3) for North Carolina and Equation (4) for South Carolina. Using the Breusch-Pagan test of independence ($chi^2 = 5.298$), the two models are shown to have correlation between their error terms and simultaneity. The correlation coefficient between the two equations is 0.24, indicating a degree of positive correlation (e.g. when sales in North Carolina go up, sales in South Carolina increase as well). Since these results indicated that including cigarette sales in a neighboring state would skew the predictions, the models do not include these variables.

Using Equation (3) for North Carolina and Equation (4) for South Carolina, the results of those regressions, when corrected for autocorrelation, are then used to predict cigarette sales for every time period in the dataset (June 1997 through January 2006). The estimated cigarette sales are predicted by applying linear estimation to each respective model. Once estimated, the predicted cigarette sales before the announcement period (June 1997 through January 2005) will be compared to the actual cigarette sales before the announcement period to measure the accuracy and effectiveness of the model in predicting cigarette sales. After the degree of the model's fit to actual data is determined, the estimated model will be applied to the announcement and tax increase periods to gauge the impact of the North Carolina cigarette excise tax increase upon sales.

Comparing the model's predictions with actual cigarette sales from February 2005 through August 2005, the impact of North Carolina state government's serious consideration of a tax increase can be analyzed. The difference between predicted and actual cigarette sales can be calculated and compared historically with that same difference in the period before the announcement by the Governor. The model and the difference it produces will be analyzed at 95% and 99% confidence intervals. Cigarette sales outside of the model's confidence interval during the tax announcement period can be considered as potential stockpiling by consumers, smugglers, and retailers; or even the effect of demand on lower prices as cigarette wholesalers and retailers increase promotions and/or decrease prices to attract more consumers.

In a similar manner, the model's predictions will be compared with actual cigarette sales immediately following the North Carolina cigarette excise tax increase to 30 cents on September 1st, 2005. The differences between the model and actual sales will be compared historically with the model and sales data before the announcement period. To further analyze the impact of the tax, different estimated price elasticities of cigarette demand will be applied to the model to quantify the drop in sales that is price related and isolate any other effects. These price elasticities are dependent upon cigarette prices before and after the tax increase. From McMahon (2006) and Lindblom's (2005) work on state tax levels, the price per pack in North Carolina increased by 27 cents as a result of the tax increase, from $3.35 to $3.62 (25 cents from the cigarette excise tax increase, 2 cents from a corresponding increase in sales tax per pack at a rate of 7%). These figures are incorporated with the model's predictions to measure the tax's price effect. The stockpiling effect before the tax increase and the price effect of the tax increase will be measured and deducted from the difference between predicted and actual cigarette sales, allowing for a discussion and exploration of other possible effects, including the loss of long-distance smuggling activity in North Carolina.

Loss of cigarette sales in North Carolina due to cross-border effects (i.e. purchasing cheaper cigarettes in South Carolina) and/or changes long-distance smuggling activity will also be examined through South Carolina's cigarette sales. In a manner similar to the analysis of the model in North Carolina, actual cigarette sales in South Carolina will be compared with the model's predicted cigarette sales before the announcement and then after the North Carolina cigarette excise tax increase. South Carolina is examined in this way since it is the lowest-tax neighboring state and the most likely candidate to gain sales from long-distance smuggling activity following North Carolina's tax increase. Since South Carolina does not experience a tax increase and no acknowledged cigarette price changes occur in SC, then effects outside of the model predictions are analyzed as stemming from North Carolina's tax increase.

Using the results from Equations (3) and (4), the predicted cigarette sales are multiplied by the respective tax rate (0.0025 or 0.0125 for NC, 0.0035 for SC) to generate predicted cigarette excise tax revenue for North and South Carolina. These numbers are then compared with the actual revenue numbers in the same fashion as the aforementioned analysis of cigarette sales. This provides insight into the fiscal impact of North Carolina's cigarette excise tax increase on North and South Carolina. Predicted sales at different elasticities will also be incorporated into the analysis, showing how much is lost or gained by each state as a result of the cigarette tax increase, and which specific effects cause the largest loss/gain. For example, the stockpiling effect can be measured as lost potential revenue for NC since the cigarettes were purchased atypically at a lower tax rate. The cross-border effect can be measured as lost potential revenue for NC and gained revenue for SC. Any changes in long-distance smuggling activity will also be analyzed in this way.

Results

The first and most critical part of the results of my research is how well the model predicted figures match reality. In Table 6 general summary statistics for the principal estimated variables are shown. For reference and comparison, the same summary statistics for actual revenue and cigarette sales data are given below in Table 7. As can be seen in cigarettes sold outside of the model's predictions, in the pre-announcement period, cigarettes sales in NC were within an 85.98 standard deviation of the model-predicted sales. With an estimated mean of 1456.28, a standard deviation that is 5.90% of the estimated mean indicates that the actual sales do not deviate from the model at a significant level.

Table 6. Summary Statistics for Predicted Variables

First Line: June 1997 – Jan 2005 (NC Excise Tax per Cigarette = .0025)
Second Line: June 1997 – Jan 2006 (Entire Data Period)
Third Line: Feb 2005 – Jan 2006 (Tax Increase Announced and Implemented)

	Mean	Std. Dev.	Min	Max
Revenue				
Predicted Excise Tax Revenue - NC	3.64	0.25	3.05	4.20
(Millions)	4.42	3.47	3.05	20.54
	10.41	8.27	3.29	20.54
Predicted Excise Tax Revenue - SC	2.25	0.19	1.92	2.73
(Millions)	2.24	0.18	1.92	2.73
	2.16	0.11	1.92	2.29
Cigarettes Sold				
Predicted Cigarettes Sold - NC (Millions)	1456.28	99.15	1218.54	1679.85
	1464.63	101.69	1218.54	1679.85
	1528.60	102.23	1315.26	1642.83
Predicted Cigarettes Sold - SC (Millions)	643.82	53.04	547.90	779.49
	640.71	51.70	547.90	779.49
	616.83	32.43	549.70	653.52
Cigarettes Sold (Predicted vs. Actual)				
Cigarettes Sold, Deviation from Model -	-0.63	85.98	0235.72	190.89
NC (Millions)	-19.70	139.48	-1067.86	190.89
	-165.93	307.63	-1067.86	122.62
Cigarettes Sold, Deviation from Model - SC	-0.16	45.60	-129.54	113.22
(Millions)	6.77	92.62	-129.54	830.67
	59.87	244.23	-50.40	830.67

Table 7. Summary Statistics for Main Variables

First Line: June 1997 – Jan 2005 (NC Excise Tax per Cigarette = .0025)
Second Line: June 1997 – Jan 2006 (Entire Data Period)
Third Line: Feb 2005 – Jan 2006 (Tax Increase Announced and Implemented)

	Mean	Std. Dev.	Min	Max
<u>Revenue</u>				
Excise Tax Revenue - NC (Millions)	3.64	0.32	2.90	4.30
	4.22	2.81	2.90	21.40
	8.63	7.00	3.00	21.40
Excise Tax Revenue - SC (Millions)	2.25	0.24	1.74	2.99
	2.27	0.36	1.74	5.00
	2.37	0.84	1.82	5.00
<u>Cigarettes Sold</u>				
Cigarettes Sold - NC (Millions)	1455.65	129.64	1160.00	1720.00
	1444.92	159.92	560.00	1720.00
	1362.67	303.47	560.00	1720.00
Cigarettes Sold - SC (Millions)	643.66	69.57	496.59	853.26
	647.48	102.84	496.59	1429.63
	676.70	240.71	519.44	1429.63

This conclusion is more further explored using confidence intervals. The 95% confidence interval for Cigarettes Sold, Deviation from Model - NC (Millions) in Table 8 indicates that there is only a 2.5% chance that the model will overestimate sales by more than 18.44 million and only a 2.5% chance that the model will underestimate sales by more than 17.17 million. Thus, 95% of the model's predicted cigarettes sold fall within the confidence interval [-18.44, 17.17]. 18.44 million is less than 1.27% of the mean number of cigarettes sold in NC (1.46 billion), indicating that the model very accurately predicts cigarette sales. Even at a 99% confidence interval of [-24.22, 22.95], the model accurately predicts cigarette sales – 24.22 million is only 1.66% of the mean number of cigarettes sold in the pre-announcement period in North Carolina.

Table 8. Model vs. Reality

First Line: June 1997 – Jan 2005 (NC Excise Tax per Cigarette = .0025)
Second Line: June 1997 – Jan 2006 (Entire Data Period)
Third Line: Feb 2005 – Jan 2006 (Tax Increase Announced and Implemented)

	Mean	Std. Err.	95% Conf. Interval	99% Conf. Interval
Modeled Sales				
Predicted Cigarettes	1456.28	10.34	[1435.75, 1476.82]	[1429.09, 1483.48]
Sold - NC (Millions)	1464.63	9.97	[1444.85, 1484.40]	[1438.46, 1490.80]
	1528.60	29.51	[1463.64, 1593.56]	[1436.94, 1620.26]
Predicted Cigarettes	643.82	5.53	[632.84, 654.81]	[629.27, 658.37]
Sold - SC (Millions)	640.71	5.07	[630.65, 650.76]	[627.40, 654.01]
	616.83	9.36	[596.22, 637.43]	[587.75, 645.90]
Actual Sales				
Cigarettes Sold - NC	1455.95	13.52	[1428.80, 1482.50]	[1420.09, 1491.21]
(Millions)	1444.92	15.68	[1413.82, 1476.02]	[1403.77, 1486.08]
	1362.67	87.60	[1169.85, 1555.48]	[1090.59, 1634.75]
Cigarettes Sold - SC	643.66	7.25	[629.26, 658.07]	[624.58, 662.75]
(Millions)	647.48	10.08	[627.48, 667.48]	[621.01, 673.94]
	676.70	69.49	[523.76, 829.64]	[460.89, 892.51]
Model vs. Actual Sales				
Cigarettes Sold,	-0.63	8.96	[-18.44, 17.17]	[-24.22, 22.95]
Deviation from Model -	-19.70	13.68	[-46.83, 7.42]	[-55.60, 16.19]
NC (Millions)	-165.93	88.81	[-361.39, 29.53]	[-441.75, 109.88]
Cigarettes Sold,	-0.16	4.75	[-9.60, 9.28]	[-12.67, 12.35]
Deviation from Model -	6.77	9.08	[-11.24, 24.78]	[-17.07, 30.60]
SC (Millions)	59.87	70.50	[-95.30, 215.05]	[-159.09, 278.84]

The fit of the model to actual sales over the entire time period studied is shown in Figure 2. As can be seen in Figure 2 and will be explored further, the deviation from the model immediately preceding and following the tax increase is unprecedented over the period studied. Figure 3 displays the model and actual cigarette sales in North Carolina for

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Figure 2. Predicted vs. Actual Cigarettes Sold in North Carolina

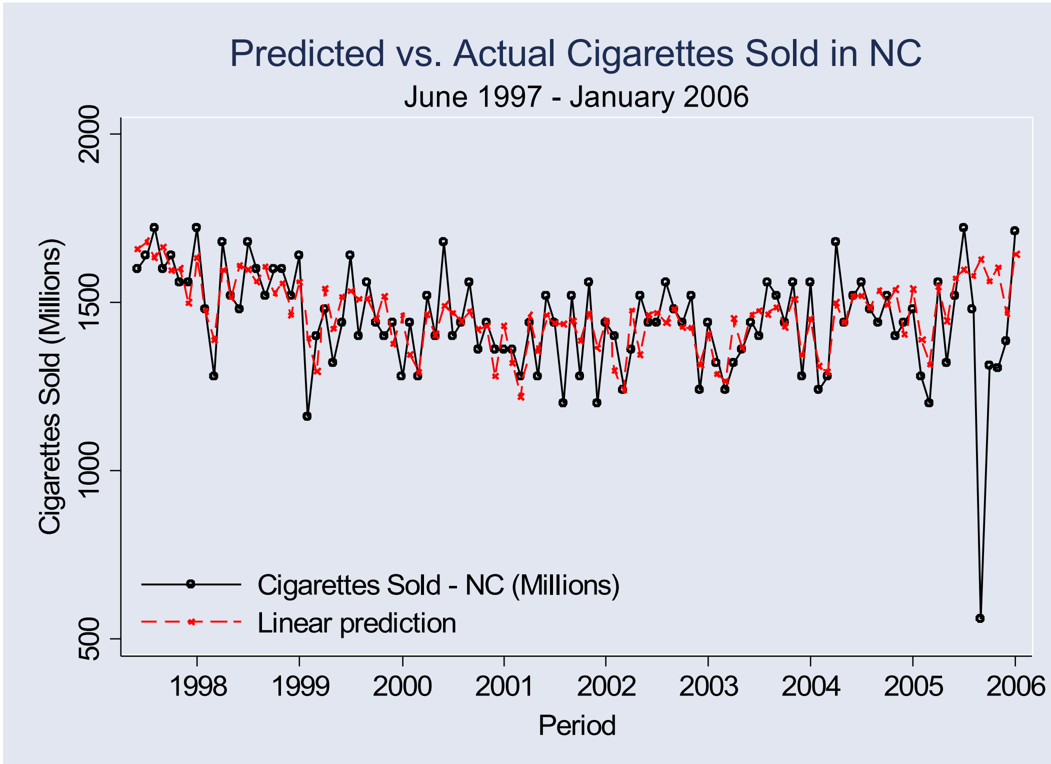
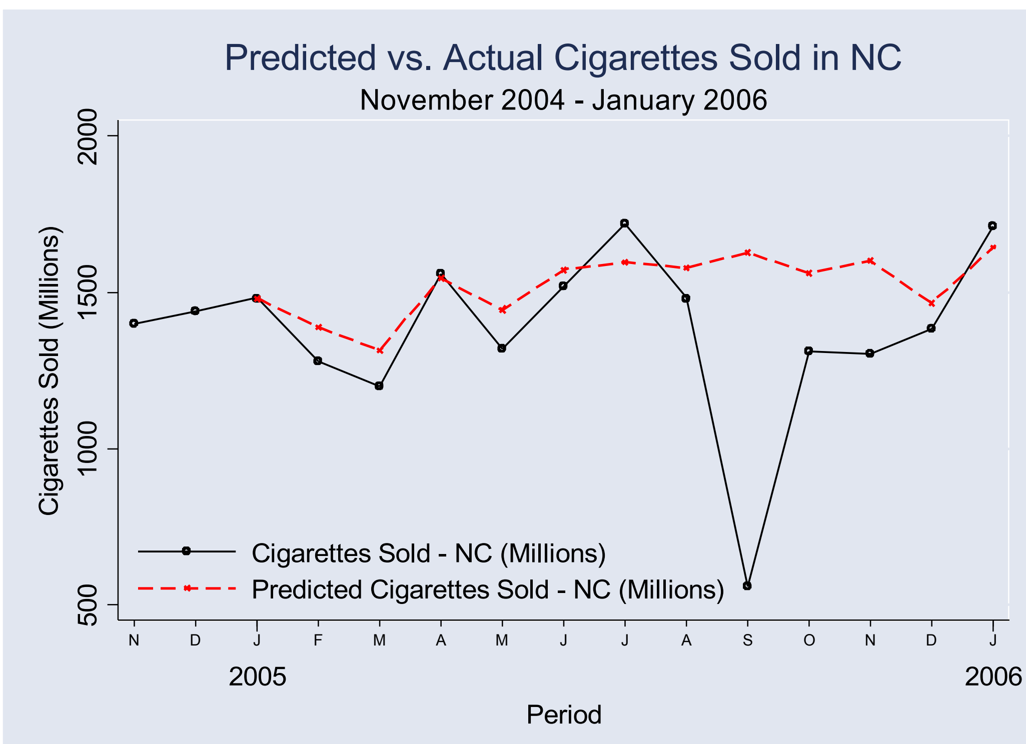


Figure 3. Predicted vs. Actual Cigarettes Sold in NC, November '04 – January '06



the announcement period (February 2005 through August 2005) and the tax increased period (September 2005 through January 2006). As can be seen in both figures, the drop in September 2005 and the decreased sales in the months following are unprecedented over the time period studied. In Table 9, the same information is explored, but in percentages. As can be seen in Table 9, the model for NC and SC fit the cigarette sales data before the announcement period extremely well, and that the impact of the tax increase clearly can be seen in the unprecedented deviations from the model in NC and SC following the tax increase.

Table 9. % Difference in Predicted vs. Actual Cigarette Sales

First Line: June 1997 – Jan 2005 (NC Excise Tax per Cigarette = .0025)
Second Line: Feb 2005 – Jan 2006 (Tax Increase Announced and Implemented)

	Mean	Std. Dev.	Min	Max	95% Conf. Interval
<u>% Difference in Sales</u>					
Predicted vs. Actual	-0.03%	5.95%	-16.70%	13.07%	[-1.26%, 1.20%]
Cigarettes Sold in NC	-10.65%	18.87%	-65.60%	7.68%	[-22.64%, 1.34%]
Predicted vs. Actual	-0.02%	6.91%	-19.57%	15.48%	[-1.45%, 1.41%]
Cigarettes Sold in SC	10.04%	40.75%	-8.28%	138.6%	[-15.85%, 35.93%]

Building upon the conclusions of the model for the time period preceding the announcement (June 1997 through January 2005), Table 10 displays the numeric and percentage difference between predicted and actual cigarettes sold in North Carolina. By comparing the announcement and tax increased periods with historical cigarette sales data in Table 11 the sales data in Table 10 can be understood more clearly. Cigarette sales in February through June are certainly consistent with the historical data and reasonably consistent with the model. In July 2005, the model predicts 1.597 billion cigarettes sold, while 1.720 billion cigarettes are sold in reality.

Table 10. Predicted vs. Actual Cigarettes Sold in NC (Millions)

Period	Predicted	Actual	Difference	% Difference
February	1389.25	1280	-109.25	-7.86%
March	1315.26	1200	-115.26	-8.76%
April	1545.88	1560	14.12	0.91%
May	1443.47	1320	-123.47	-8.55%
June	1572.11	1520	-52.11	-3.31%
July	1597.38	1720	122.62	7.68%
August	1579.01	1480	-99.01	-6.27%
September	1627.86	560	-1067.86	-65.60%
October	1562.57	1312	-250.57	-16.04%
November	1601.65	1304	-297.65	-18.58%
December	1465.92	1384	-81.92	-5.59%
January (2006)	1642.83	1712	69.17	4.21%

Table 11. Historical Cigarette Sales Data in NC (Millions) by Month, June '97 – January '05

Deviations in this table describe the actual data's deviation from the model.

Period	Low	High	Mean	Largest Neg. Dev.	Largest Pos. Dev.	Mean Dev.
January	1280.00	1720.00	1490.00	180.00	110.48	0.99
February	1160.00	1480.00	1342.86	232.63	103.35	-3.27
March	1240.00	1400.00	1285.71	108.30	104.84	1.27
April	1320.00	1680.00	1497.14	131.26	182.62	-0.50
May	1280.00	1520.00	1405.71	100.26	175.73	0.19
June	1440.00	1680.00	1515.00	128.68	190.89	-7.30
July	1400.00	1680.00	1525.00	73.33	106.11	2.84
August	1200.00	1720.00	1495.00	235.72	120.26	-1.11
September	1440.00	1600.00	1525.00	95.40	87.59	0.43
October	1280.00	1640.00	1465.00	106.25	73.04	-0.17
November	1400.00	1600.00	1505.00	137.52	95.44	0.07
December	1200.00	1560.00	1380.00	162.83	78.88	-0.03

This difference of +122.62 million cigarettes (or 7.68% of the predicted cigarettes sold) could indicate stockpiling in anticipation of the tax increase, as the cigarettes sold in July 2005 surpass the previous historical high of 1.680 billion, with the largest deviation from the model in the month of July for the entire dataset However, since August does not have any unusual numbers, and the numbers for July are not drastically larger than previous numbers, no conclusive evidence for cigarette stockpiling is found.

In September 2005, the impact of the tax increase is clearly evident. Sales are 66% less than predicted, have reached a historical low for any month during the studied time period, and is well outside the historical bounds for September. The tax increased caused an estimated decline in sales of 1.068 billion cigarettes for September alone! This is truly unprecedented for the State of North Carolina, and clearly indicates the effect of the tax increase. Cigarette sales in October and November also are clearly influenced by the tax increase, with a combined estimated decline in sales of 548.22 million cigarettes. However, the numbers for October and November are significantly higher than the sharp decline in sales seen immediately following the tax increase in September. Consistent with Farrelly, Nimsch, and James' (2003) findings, it appears that cigarettes sales are settling on a new sales level lower than the sales level before the cigarette excise tax increase. In Farrelly, Nimsch, and James' work "State Cigarette Excise Taxes: Implications for Revenue and Tax Evasion" (2003), monthly cigarette sales in California, Maryland, Michigan, and Utah followed a similar trend. However, the North Carolina data is somewhat inconsistent after November, since December cigarette sales are consistent with the model's predicted sales and the historical sales data for December. Measuring 69.17 million cigarettes more than the model's predicted cigarettes sold, January 2006 is not consistent with the cigarette sales settling on a lower level following the tax increase. December's data also seems to indicate that cigarette sales in North Carolina are in fact returning to a sales level similar to that prior to the tax increase.

To analyze the impact upon cigarette sales in South Carolina, a similar analysis is performed. Once again referencing Table 6 and Table 7, actual cigarette sales in SC were within a 45.60 standard deviation of the model-predicted sales. With an estimated mean of 643.82, a standard deviation that is 7.08% of the estimated mean indicates that the actual sales for South Carolina also do not deviate from the model at a significant level. This conclusion is more further explored using confidence intervals. The 95% confidence interval for Cigarettes Sold, Deviation from Model - SC (Millions) in Table 8 indicates that there is only a 2.5% chance that the model will overestimate sales by more than 9.60 million and only a 2.5% chance that the model will underestimate sales by more than 9.28 million.

Thus, 95% of the model's predicted cigarettes sold fall within the confidence interval [-9.60, 9.28]. 9.28 million is less than 1.50% of the mean number of cigarettes sold in SC (643 million), indicating that the model very accurately predicts cigarette sales. Even at a 99% confidence interval of [-12.67, 12.35], the model accurately predicts cigarette sales – 12.67 million is only 1.97% of the mean number of cigarettes sold in the pre-announcement period in South Carolina.

The fit of the model to actual sales over the entire time period studied is shown in Figure 4. The North Carolina cigarette excise tax increase does not appear to have as strong an effect on South Carolina. However, as can be seen in Figure 4 and will be explored further, the deviation from the model in January of 2006 is astounding and unprecedented over the period studied. Figure 5 displays the model and actual cigarette sales in South Carolina for the announcement period (February 2005 through August 2005) and the tax increased period (September 2005 through January 2006).

Figure 4. Predicted vs. Actual Cigarettes Sold in South Carolina

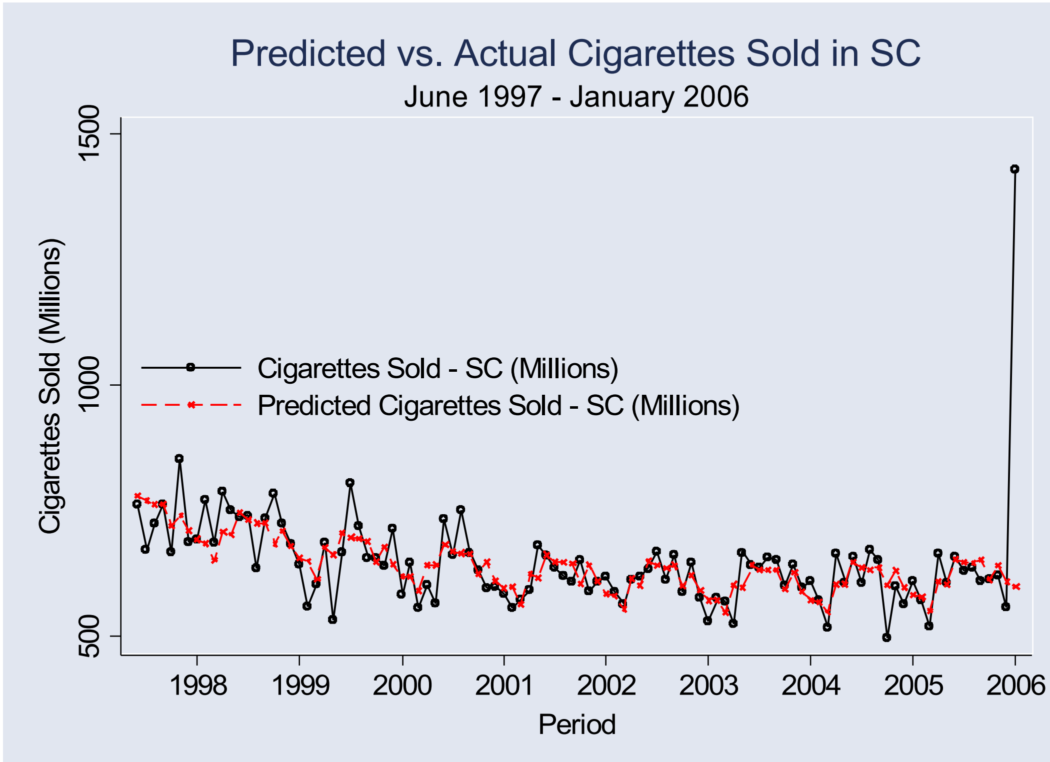
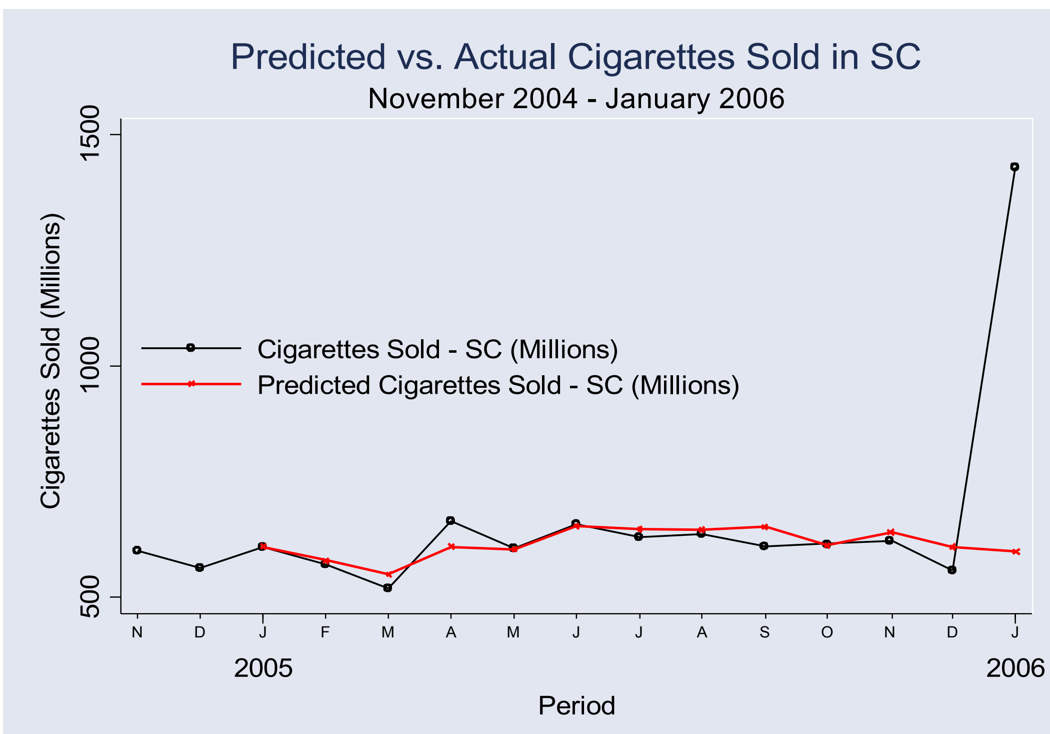


Figure 5. Predicted vs. Actual Cigarettes Sold in SC, November '04 – January '06



As can be seen in both figures, the drastic increase in January 2006 is unprecedented over the time period studied. The drop in predicted cigarettes sold for September 2005 is partly due to the functional form of the model, which incorporates cigarette sales in North Carolina (e.g. the drastic decrease in sales in North Carolina drives the predicted value down). In Table 9, the same information is explored, but in percentages. As can be seen in Table 8, the model for NC and SC fit the cigarette sales data before the announcement period extremely well, and that the impact of the tax increase clearly can be seen in the unprecedented deviations from the model in NC and SC following the tax increase.

Building upon the conclusions of the model for the time period preceding the announcement in North Carolina (June 1997 through January 2005), Table 12 displays the numeric and percentage difference between predicted and actual cigarettes sold in South Carolina. By comparing the announcement and tax increased periods with historical cigarette sales data in Table 13 the sales data in Table 12 can be understood more clearly.

Table 12. Predicted vs. Actual Cigarettes Sold in SC (Millions)

Period	Predicted	Actual	Difference	% Difference
February	579.00	571.94	-7.06	-1.22%
March	549.70	519.44	-30.26	-5.51%
April	609.39	664.58	55.19	9.06%
May	603.69	606.02	2.33	0.39%
June	653.52	658.11	4.59	0.70%
July	647.48	630.14	-17.34	-2.68%
August	646.30	637.03	-9.27	-1.43%
September	652.30	610.00	-42.30	-6.48%
October	612.25	613.87	1.62	0.26%
November	640.90	621.61	-19.29	-3.01%
December	608.43	558.04	-50.39	-8.28%
January (2006)	598.96	1429.63	830.67	138.68%

Table 13. Historical Cigarette Sales Data in SC (Millions) by Month, June ‘97 – January ‘05

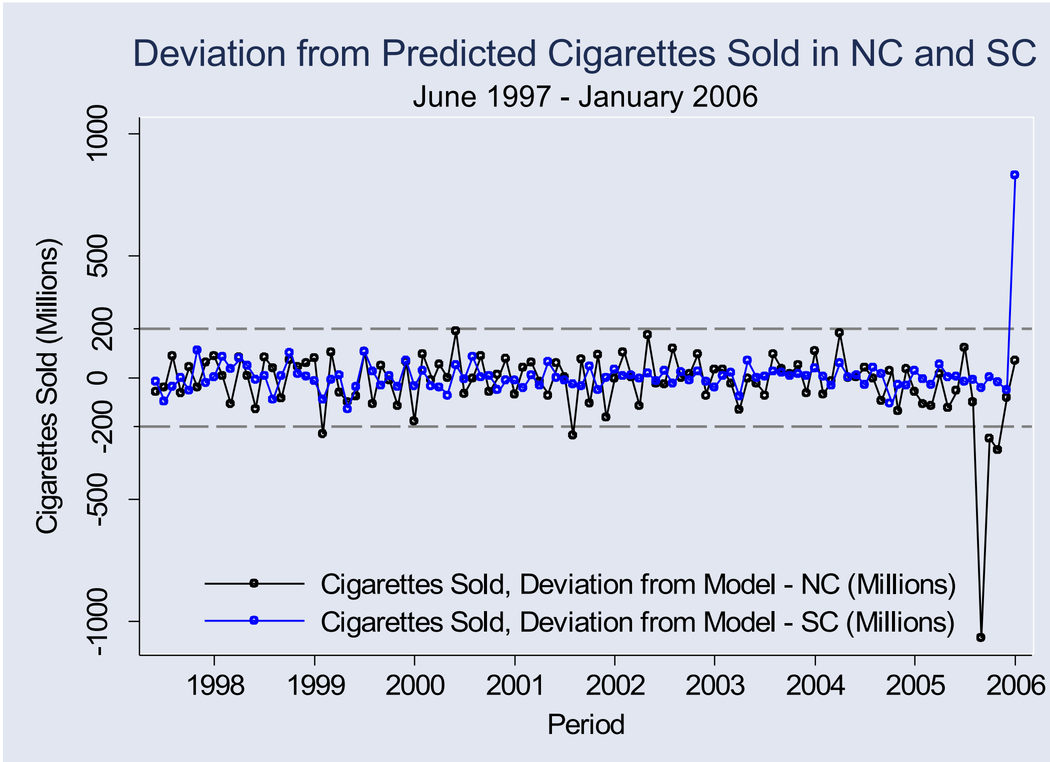
Deviations in this table describe the actual data’s deviation from the model.

Period	Low	High	Mean	Largest Neg. Dev.	Largest Pos. Dev.	Mean Dev.
January	530.43	693.06	608.97	40.20	38.33	0.00
February	556.81	771.09	610.29	89.63	85.88	0.22
March	516.58	685.79	581.28	34.17	34.79	-0.01
April	524.82	788.17	638.70	76.78	80.25	0.0007
May	532.38	750.76	631.59	129.54	68.79	-0.00004
June	634.58	762.54	687.14	38.33	50.78	-2.12
July	606.59	804.42	678.30	98.79	107.80	0.12
August	612.41	751.10	674.19	89.19	86.52	-0.01
September	609.33	762.85	674.41	35.81	22.74	0.0004
October	496.59	784.47	634.64	105.24	100.93	-0.00003
November	589.89	853.26	661.72	51.51	113.22	0.000008
December	563.83	713.73	628.62	33.09	71.01	0.000008

The increase to over 1.4 billion cigarettes sold in January 2006 is by far the most interesting result of the South Carolina model.

The level of cigarette sales in South Carolina during January 2006 is truly amazing. It is a completely unprecedented leap from South Carolina’s historical level of cigarette sales examined in this study. It is no doubt an effect of the increased cigarette excise tax in North Carolina, but the model and analysis thus far fail to account for or explain the increase. Likewise, the severe decrease in cigarette sales in North Carolina during September 2005, though consistent with existing literature, is well beyond the impact of a price effect. Figure 6 displays the outlying large deviations that the model has thus far been unable to explain.

Figure 6. Deviation from Model-Predicted Sales in North and South Carolina



To measure the price effect of the North Carolina cigarette tax increase, different price elasticities of demand for cigarettes are applied to the predicted levels of cigarette sales. Numerous studies have estimated the price elasticity of demand for cigarettes. This study will use four different elasticities, gathered from the Surgeon General's report Reducing Tobacco Use (2000). Although most estimates are between the range of -0.3 and -0.5, I chose the lowest and highest estimated elasticity studied in the Surgeon General's report:

E_L - Lowest Estimated Elasticity = -0.14

E_H - Highest Estimated Elasticity = -1.12

I also used the lowest and highest estimated elasticities from studies based on state tax-paid sales data, as this is the nature of my study:

E_{LSTD} - Lowest Estimated Elasticity Based on State Tax Data = -0.3

E_{HSTD} - Highest Estimated Elasticity Based on State Tax Data = -0.5

The estimated level of cigarette sales when applying these elasticities to the predicted level of cigarette sales are shown in Table 14. These numbers were calculated by solving for what the predicted level of cigarettes sales would have been following a price increase

$$Q^2_D = E_D*((P^2_D-P^1_D))/P^1_D)*Q^1_D + Q^1_D$$

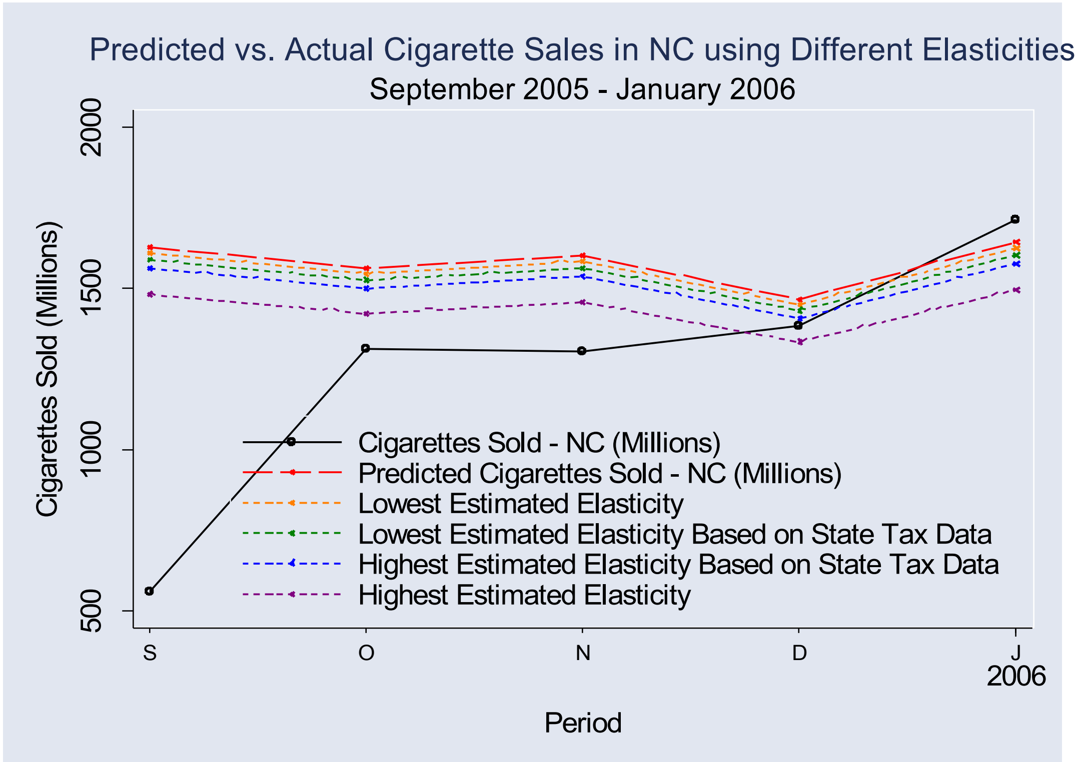
where Q^2_D is equal to the predicted level of cigarettes sales following the price increase, Q^1_D is equal to the predicted level of cigarette sales, P^2_D is equal to the price following the tax increase ($3.62), P^1_D is equal to the price preceding the tax increase ($3.35), and E_D is the price elasticity of demand used. The results are also shown graphically in Figure 7.

Table 14. Predicted vs. Actual Cigarettes Sold in NC using Different Elasticities (Millions)

E_L - Lowest Estimated Elasticity
E_H - Highest Estimated Elasticity
E_{LSTD} - Lowest Estimated Elasticity Based on State Tax Data
E_{HSTD} - Highest Estimated Elasticity Based on State Tax Data

Period	Predicted	Actual	Sales(E_L)	Sales(E_H)	Sales(E_{LSTD})	Sales(E_{HSTD})
September	1627.86	560.00	1609.50	1480.92	1588.50	1562.26
October	1562.57	1312.00	1544.94	1421.52	1524.79	1499.60
November	1601.65	1304.00	1583.58	1457.07	1562.92	1537.10
December	1465.92	1384.00	1449.38	1333.60	1430.48	1406.85
January	1642.83	1712.00	1624.29	1494.54	1603.11	1576.63

Figure 7. Predicted vs. Actual Cigarette Sales in NC using Different Elasticities



As can be seen in both Table 14 and Figure 7, even when accounting for the price increase of 27 cents, there is deviation from the model's predicted cigarette sales. Although the highest estimated elasticity comes close to predicting cigarette sales in October through January, the sharp drop in sales in September is not explained. Furthermore, it is more consistent with existing literature and theory to interpret the price effect using an elasticity based on state tax-paid sales data. Using the highest estimated price elasticity on demand of cigarettes based on state tax-paid sales data in conjunction with the model's predicted level of cigarette sales, the price effect of the increased cigarette excise tax in North Carolina is shown in the table below:

Table 15. Estimating the Price Effect on Cigarette Sales in North Carolina

Period	Predicted	Actual	Difference	Price Effect
September	1627.86	560.00	-1067.86	-65.60
October	1562.57	1312.00	-250.57	-62.97
November	1601.65	1304.00	-297.65	-64.55
December	1465.92	1384.00	-81.92	-59.07
January	1642.83	1712.00	69.17	-66.20

The price effect is definitely a significant component of the effect of the cigarette tax increase on sales in North Carolina. September clearly is indicative of the trends documented by Farrelly and Nimsch (2003) of cigarette sales declining sharply after a cigarette tax increase. In December, the price effect accounts for 72% of the sales decline. For October and November, the price effect accounts for 22%-28% of the sales decline. In January, sales are greater then they should be when taking into account the decline in price. Although the price effect does appear to be significant, there is clearly a loss of sales from the cigarette tax increase that cannot be explained by the model or through a price effect on demand. Certainly some of this effect could be related to the increased publicity of the health concerns of cigarette smoking surrounding the tax increase. The small amount of cigarettes stockpiled before the tax increase could also contribute to the sales decline following the tax increase, although this effect would be minor and short-lived as there is no evidence of massive stockpiling by consumers. Rather, I hypothesize that the majority of this unexplained sales decline is evidence of a decline in smuggling in North Carolina due to the increased price per pack and thus decreased profit opportunities.

Building upon the previous analysis of the impact of North Carolina's cigarette tax increase on cigarette sales in North Carolina, Table 16 displays cigarette excise tax revenue for North Carolina from February 2005 through January 2006. The predicted revenue figures from the model display the revenue expectations of the State, assuming no decrease in sales related to the price increase. As can be seen in the table, $24.30 million in potential cigarette excise tax revenue was lost as sales declined as a result of the cigarette tax increase. However, it is also important to note that the data are consistent with Farrelly and Nimsch's (2003) finding that tax avoidance and smuggling efforts after a tax increase only diminish the revenue gains of the state, but do not lead to a drop in revenue. In addition to the predicted revenue figures from the model and the actual revenue figures from the data, Table 17 also displays different estimated revenues, based on a decline in sales from the increase in price. Assuming that sales declined at a level consistent with the highest estimated price elasticity on demand of cigarettes based on state tax-paid sales data, North Carolina still lost an estimated $21.27 million in potential tax revenue. As 17.03% of the estimated potential revenue gains from the increased tax revenue following the cigarette tax increase, this number is definitely significant and, like cigarette sales, can only be attributed to effects outside of the model – which I hypothesize the most significant to be a decrease in cigarette smuggling from North Carolina.

Table 16. Cigarette Excise Tax Revenue for North Carolina (Millions of Dollars)

Period	*Predicted*	*Actual*	*Rev.(E_L)*	*Rev. (E_H)*	*Rev.(E_{LSTD})*	*Rev.(E_{HSTD})*
February	$3.47	$3.20	$3.47	$3.47	$3.47	$3.47
March	$3.29	$3.00	$3.29	$3.29	$3.29	$3.29
April	$3.86	$3.90	$3.86	$3.86	$3.86	$3.86
May	$3.61	$3.30	$3.61	$3.61	$3.61	$3.61
June	$3.93	$3.80	$3.93	$3.93	$3.93	$3.93
July	$3.99	$4.30	$3.99	$3.99	$3.99	$3.99
August	$3.95	$3.70	$3.95	$3.95	$3.95	$3.95
September	$20.35	$7.00	$20.12	$18.51	$19.86	$19.53
October	$19.53	$16.40	$19.31	$17.77	$19.06	$18.75
November	$20.02	$16.30	$19.79	$18.21	$19.54	$19.21
December	$18.32	$17.30	$18.12	$16.67	$17.88	$17.59
January (2006)	$20.54	$21.40	$20.30	$18.68	$20.04	$19.71
Total Revenue	**$124.87**	**$103.60**	**$123.75**	**$115.95**	**$122.48**	**$120.89**
Total Revenue (after Tax Increase)	**$98.76**	**$78.40**	**$97.65**	**$89.85**	**$96.37**	**$94.78**
Net Difference between Estimated and Actual	-$21.27	N/A	-$20.15	-$12.35	-$18.88	-$17.29
% Difference between Estimated and Actual	-17.03%	N/A	-16.28%	-10.65%	-15.41%	-14.30%
Net Difference between Estimated and Actual (after Tax Increase)	-$20.36	N/A	-$19.25	-$11.45	-$17.97	-$16.38
% Difference between Estimated and Actual (after Tax Increase)	-20.62%	N/A	-19.71%	-12.74%	-18.65%	-17.28%

In a similar fashion, Table 17 displays cigarette excise tax revenue for South Carolina from February 2005 through January 2006. After the North Carolina cigarette excise tax increase, South Carolina experienced a 23.18% gain, or $2.53 million, in cigarette excise tax revenue. This gain is due almost exclusively to the drastic increase in cigarettes sales in January 2006 for South Carolina. Clearly South Carolina is benefiting monetarily from North Carolina's cigarette excise tax increase, and if the January 2006 levels indicate a new level of cigarette sales in South Carolina, then South Carolina will see a doubling in tax revenue at the same tax rate.

Table 17. Cigarette Excise Tax Revenue for South Carolina (Millions of Dollars)

Period	*Predicted*	*Actual*
February	$2.03	$2.00
March	$1.92	$1.82
April	$2.13	$2.33
May	$2.11	$2.12
June	$2.29	$2.30
July	$2.27	$2.21
August	$2.26	$2.23
September	$2.28	$2.14
October	$2.14	$2.15
November	$2.24	$2.18
December	$2.13	$1.95
January (2006)	$2.10	$5.00
Total Revenue	**$25.91**	**$28.42**
Total Revenue (after Tax Increase)	**$10.89**	**$13.42**
Net Difference between Estimated and Actual	$2.52	N/A
% Difference between Estimated and Actual	9.74%	N/A
Net Difference between Estimated and Actual (after Tax Increase)	$2.53	N/A
% Difference between Estimated and Actual (after Tax Increase)	23.18%	N/A

From the data, it is clear that the North Carolina cigarette excise tax has had a significant impact on cigarette sales and tax revenue in North and South Carolina. Taking into account the history of North Carolina as the principal low-tax source for smuggled cigarettes and existing literature on the impact of cigarette tax increases on smuggling activity, the data seems to suggest a shift in smuggling activity from North to South Carolina. Tax revenue levels should be monitored closely in the coming months to either verify or dispute this claim.

CHAPTER IV

CONCLUSION

Building upon the enormous existing literature on the price elasticity of demand for cigarettes, state cigarette excise taxes, and cigarette smuggling, my research has found a significant and strong link between North Carolina's cigarette tax increase of $0.25 per pack of cigarettes on September 1st, 2005 and cigarette sales and excise tax revenue in North and South Carolina. Potential cigarette smuggling is also explored and hypothesized as the most significant component in the cigarette sales decline in North Carolina and cigarette sales increase in South Carolina. The empirical model used to estimate cigarette sales in the pre-announcement period proved effective at predicting cigarette sales and was thus very useful in measuring the impact of the cigarette tax increase. The following is a summary of the key findings of this study:

(1) North Carolina's cigarette tax increase led to a decrease in tax-paid cigarette sales of 1.99 billion cigarettes in the first 5 months following the tax increase.

(2) North Carolina's cigarette tax revenue increased dramatically to $78.4 million, or an increase of $57.7 million from expected tax revenue at the $0.05 per pack tax rate, in the first 5 months following the tax increase.

(3) Although North Carolina gained $57.7 million in revenue in the 5 months following the tax increase, the corresponding decline in sales led to a loss of $21.3 million dollars in potential revenue if sales had remained the same.

(4) Assuming a reasonable decline in sales based on a price elasticity of demand estimate of -0.5, $4.0 million of that lost potential revenue is due to the price effect.

(5) South Carolina benefited from North Carolina's cigarette tax increase through an increase in tax-paid cigarette sales of 718.5 million cigarettes (or just over one third of the decline in cigarette sales experienced by North Carolina) in the first 5 months following the tax increase.

(6) The drastic increase of tax-paid cigarette sales in South Carolina led to South Carolina gaining $2.5 million in cigarette tax revenue in the first 5 months following the tax increase.

(7) With an estimated 318.4 million in cigarette sales due to the decline in price and by attributing a significant amount of the sharp decline of in September 2005 to individual tax avoidance efforts or temporarily decreased consumption, the remaining decline in cigarette sales in North Carolina is very close to the corresponding increase in cigarette sales in South Carolina.

(8) Organized smuggling and cross-border purchases theoretically would shift from the higher-taxed cigarettes of North Carolina to the lower-taxed cigarettes of South Carolina, consistent with the findings in (7).

(9) If organized smuggling activities have indeed shifted to South Carolina, South Carolina stands to benefit significantly at their current tax rate with increased cigarettes sales and thus increased cigarette tax revenue.

(10) Despite the potential significant decline in smuggling activities within the state of North Carolina, North Carolina still experiences significant revenue

gains due to the increased tax rate, as well as the public health benefit of an estimated 9% decrease in consumption.

REFERENCES

Chaloupka, F. and K. Warner (1999). The Economics of Smoking, prepared for *The Handbook of Health Economics*, pp. 37-46.

Chandra, S. and F. Chaloupka (2003). Seasonality in cigarette sales: patterns and implications for tobacco control, *Tobacco Control*, 12:105-107.

Coats, R. (1995). A note on estimating cross-border effects of state cigarette taxes, *National Tax Journal*, Vol. 48, 4:573-584.

Emery, S. et al (2002). Was there significant tax evasion after the 1999 50 cent per pack cigarette tax increase in California?, *Tobacco Control*, 11:130-134.

Farrely, M. and C. Nimsch (2003). "Impact of Cigarette Excise Tax Increases in Low-Tax Southern States on Cigarette Sales, Cigarette Excise Tax Revenue, Tax Evasion, and Economic Activity," RTI International.

Gruber, J. et al (2003). Estimating price elasticities when there is smuggling: the sensitivity of smoking to price in Canada, *Journal of Health Economics*, 22:821-842.

Keeler, T. et al (1996). Do cigarette producers price-discriminate by state? An empirical analysis of local cigarette pricing and taxation, *Journal of Health Economics*, 15:499-512.

Lindblom, E. (2005). "State Cigarette Prices, Taxes, and Costs per Pack," Campaign for Tobacco Free Kids.

McMahon, K. (2006). "State Cigarette Tax Rates & Rank, Date of Last Increase, Annual Pack Sales & Revenues, and Related Data," Campaign for Tobacco Free Kids.

Schmidt, S. (2005). *Econometrics*, New York: McGraw-Hill Irwin.

Stehr, M. (2005). Cigarette tax avoidance and evasion, *Journal of Health Economics*, 24:277-297.

U.S. Department of Health and Human Services (2000). *Reducing Tobacco Use: A Report of the Surgeon General*, Chapter 6 – Economic Approaches, Centers for Disease Control and Prevention, pp. 295-359.