2013

The Effect of Excise Taxes on Cigarette Smuggling: An Instrumental Variable Approach

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SUBMITTED TO

Professor Mary Evans

AND

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BY

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for

SENIOR THESIS

Fall 2013
December 2, 2013

Acknowledgements

I would like to thank the CMC Economics Department as a whole for four years of engaging classes and amazing teaching which inspired me to pursue this major. Especially, I would like to thank Professors Mary Evans and Janet Smith for all their help in the writing of this thesis. Their constant feedback and encouragement were essential to overcoming the obstacles along the way and making this paper the best it could be. I would also like to extend a special thank you to Professor Antecol for helping me through the finer points of instrumental variable regressions.

I would also like to thank Michael Lafaive, Todd Nesbit, and Patrick Fleenor for taking their time to give me advice and generously allowing me access to their data. Without their help this paper would not have been possible.

Finally, I would like to thank my friends and family. Your support and company over these four years have been one of the most important parts of my college experience and I have cherished every moment of it.

Abstract

I use an instrumental variable approach to estimate the effect of excise taxes on cigarette smuggling. The IV approach addresses the potential endogeneity of excise taxes while controlling for other determinants of smuggling. I use panel data on 47 states from 1990-2009. The main results confirm the validity of the instrument, the percent of Democrats in the upper house of state legislatures, but do not reject exogeneity of excise taxes. Robustness tests using an alternative measure of cigarette smuggling find the opposite result. All models find that per capita income and the number of federal police per 100,000 residents are significant determinants of smuggling.

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Section I: Introduction

Tobacco taxation is prevalent both in the US and worldwide: the World Health Organization (WHO 2010) finds that only 17 of 182 countries do not have cigarette excise taxes. The nicotine in cigarettes is physically addictive and smoking comes with a variety of health costs to the smoker (e.g. lung cancer) and to others (i.e., from second-hand smoke). Taxes are a way of internalizing the negative external effects of smoking. Higher prices caused by taxes are shown to be effective in reducing smoking among youth, young adults and persons of low socioeconomic status (Bader et al, 2011). Nonetheless, estimates of the price elasticity of demand, with a median of -0.4 based on Gallet and List (2013), indicate that the demand for cigarettes is relatively inelastic. Taxing an inelastic good generally raises more revenue than an elastic one, although the reduction in consumption of the good in response to the tax is smaller. Given the prospects for internalizing the negative externality and raising tax revenue, it is no surprise that cigarette taxation is so popular among states.

However, taxation comes with an important unintended consequence: it creates an incentive to smuggle to avoid higher prices. Most studies find that the leading cause of tobacco smuggling is that geographic differences in cigarette taxes (e.g. between states) create incentives to smuggle to bypass the relatively higher taxes. Taxes average 50% of the retail price of cigarettes worldwide, and can be as high as 80% in some countries (WHO 2010), meaning that even small differences in excise taxes can significantly affect the price. Figure 1 illustrates substantial variation in cigarette excise taxes across U.S. states in 2013. Virginia currently has the lowest tax at thirty cents per pack while New York has the highest at $4.35 per pack. Smugglers exploit these differentials for profits.

Smuggling can occur through a variety of methods. “Casual” smuggling involves crossing state borders to lower-tax areas to illegally buy small quantities of cigarettes. Consumers in the US also can engage in casual smuggling by purchasing cigarettes on Indian reservations and military bases (Thursby and Thursby, 2000) where taxes do not apply, or by ordering online through websites that fail to collect state taxes. Commercial smuggling includes a variety of methods but generally involves transporting large quantities of cigarettes purchased from manufacturers or distributors in low-tax states to high-tax states. International Smuggling is the transportation of cigarettes across international borders without appropriate taxation. International smuggling is not as common in the U.S. as commercial and casual smuggling.[1] The extent of smuggling is debatable but certainly significant, and the implications are serious. In setting taxes, legislators must account for the fact that some of the benefit of raising taxes is lost when smokers avoid them through smuggling.[2] Furthermore, anecdotal evidence suggests that smuggling may funnel profits to criminal organizations,[3] lead to increases in violence, and require higher policing costs.[4]

This paper explores the factors that explain variation in cigarette smuggling across U.S. states between 1990 and 2009 with a particular focus on the role of excise taxes. The paper’s main contribution is to examine whether or not excise taxes are endogenous to cigarette smuggling. Most previous empirical models of smuggling assume exogeneity of excise taxes. If taxes are actually endogenous, then these models yield bias estimates of the true effect of excise taxes on cigarette smuggling. I hypothesize policymakers may choose to adjust the cigarette excise tax if they believe that cigarette smuggling is the result of high taxes and that smuggling is resulting in lost tax revenue or increased crime. If this is the case, then excise taxes are endogenous to cigarette smuggling.

To examine these questions, I use two measures of cigarette smuggling, an estimate produced by Lafaive et al. (2010) and the ratio of cigarettes consumed to reported sales. Using panel data for 47 continental states from 1990-2009, I regress the smuggling measures on a number of independent variables hypothesized to explain the variation in smuggling. I use an instrumental variable (IV) approach to account for the potential endogeneity of excise tax. My main results suggest that my instrument for excise taxes is valid, but find no evidence that excise tax is endogenous. The rest of the paper is organized as follows. Section II reviews the previous literature related to my topic; Section III discusses the econometric model used in my analysis; Section IV details the data used in analysis; Section V discusses the regression results; and Section VI concludes with a discussion of my findings.

Section II: Literature Review

The previous literature shows that smuggling is widespread both in the U.S. and worldwide. Due to the difficulty of measuring smuggling directly, most studies infer the extent of smuggling by comparing expected demand with measurable quantities such as taxed sales and estimates of consumption obtained through surveys. Studies agree that smuggling is present, though its extent and determinants are debatable. Merriman et al. (2000) estimate cigarette smuggling between European countries from discrepancies in reported imports and exports, expert's estimates of smuggling, and price differentials between countries. Their model estimates that between 6% and 8.5% of worldwide cigarette consumption is smuggled. Yurekli and Sayginsoy (2010) estimate worldwide cigarette smuggling by identifying major smuggling routes and regressing sales data on organized smuggling incentives and an estimate cigarette demand. Based on data from 110 countries, they estimate that cigarette smuggling accounts for roughly 3.4% of global cigarette consumption. The difference in values may be accounted for by the wider selection of countries in Yurekli and Sayginsoy's data and the different empirical methods employed.

A wide variety of studies confirm the presence of tobacco smuggling in the U.S. The vast majority infer smuggling using variables including excise tax differentials between states, distance from borders, and measures of enforcement. It is difficult to quote a single rate for tobacco smuggling in the U.S. due to the fairly wide distribution of results and variation in methods. For example, casual smuggling studies have produced several different sets of numbers. Baltagi and Levin (1992) estimate casual smuggling from panel data on 48 U.S. states during the period 1963-1998. They assume that if home state sales go up when neighboring state prices increase, the result is due to border crossing. They find a 0.8% increase in home state sales for every 10% increase in neighboring state prices. Stehr (2005) performs a similar study comparing tax-paid sales and cigarette consumption data to find evidence of smuggling. Interestingly, he finds that 12.7% of cigarettes consumed in 2001 were smuggled, but casual smuggling only accounted for 0.7% of sales in the same year. The variation in these results may be partially driven by the significantly different empirical approaches used.[5]

A more recent study by Lovenheim (2007) finds high estimates of border crossing, using data on price and distance from low price borders combined with micro data on smoking behavior. His results indicate that 13.1% to 25.1% of smokers engage in casual smuggling across borders and that cigarette demand is increasingly elastic to home state prices the closer one gets to the border. However, because the data covers only certain areas in each state (MSAs), he cautions that the results may not be generalizable. Finally, DeCicca, Sing, and Liu (2010) use a similar model to Lovenheim to compare micro data on distance from other state borders with surveys of smokers to determine the rate of excise tax avoidance. Because the survey asks about tax avoidance in buying cigarettes, this study directly observes smuggling behavior. They estimate that 5% of smokers engage in casual smuggling across borders, a much lower figure than Lovenheim but far more than earlier studies. Furthermore, they find that tax avoidance increases with higher taxes. However, their data covers only a small set of observations and must be interpreted cautiously.

Accounting for commercial smuggling and using more detailed models results in still somewhat low but significant smuggling rates. Saba et al. (1995) estimate casual and commercial smuggling by examining a panel of state level cigarette sales data regressed on an estimate of cigarette demand by state. Their model includes variables for border crossing, smuggling from North Carolina,[6] and tourism. They found that 3%-5% of all smokers engaged in border crossing between 1973 and 1986, that commercial smuggling is statistically significant, and furthermore that cigarette demand is more elastic than one would assume in the absence of smuggling. However, few states lost more than 1% of tax revenue to smuggling. A complex econometric model of commercial smuggling in the U.S. by Thursby and Thursby (2000) found similar results for commercial smuggling. In most years, they estimated between 3% and 7% of cigarette consumption is smuggled commercially.

There has been no literature on Internet smuggling until recently. Goolsbee, Lovenheim, and Slemrod (2010) approach the issue of internet-based cigarette smuggling by regressing per-capita taxed cigarette sales on internet penetration, state excise tax, and several other variables. They find that high internet penetration results in significantly less sales within a state and a more negative price elasticity, implying that internet smuggling may be a significant factor.

The paper that serves as the primary motivation for my model is by Lafaive, Fleenor, and Nesbit (2010). They estimated smuggling using data from 47 continental states from 1990-2009. Lafaive et al. use a complex model based on previous literature to create estimates for cigarette smuggling. Their first step is to create a "naïve model" of cigarette sales in each state, in which it is assumed that there is no smuggling and tax-paid sales are equal to consumption. Consumption is defined as:

$$Cons = Smoke * Intensity * R$$

where "Smoke" is the smoking rate in each state, "Intensity" is the average number of packs consumed per year by smokers, and "R" is a value between 0 and 1 that accounts for under-reporting of consumption. Their data on smoking prevalence are taken from the Center for Disease Control Behavioral Risk Factor Surveillance

System (BRFSS) survey. Given the lack of reliable data on smoking intensity, they assume it does not vary across states and follows a linear trend.

If the naïve model is correct, then cigarette tax paid sales should match consumption. If there is variation in tax-paid sales not explained by consumption, then smuggling in or out of the state may account for it. Therefore Lafaive et al. examine the residuals of the naïve model based on several smuggling-related factors to explain the variation. Their model uses the average tax differential between home and border states while accounting for border population density to help explain casual cross-border shopping. They also use dummy variables for the presence of Indian reservations or shared borders with Canada and Mexico. To explain commercial smuggling, they follow the previous literature in assuming North Carolina is the main source of commercially smuggled cigarettes and include a term for the tax differential between NC and the home state. Therefore there is no estimate for smuggling in North Carolina as it is excluded to create the above measure for commercial smuggling. All variables were significant at the 1% level, with the exception of the Canadian border dummy variable, which was not significant.

Given the coefficients of the regression, they estimate “pre-smuggling” sales, which is the difference between tax-paid sales and the estimated volume of smuggling in or out of the state. This is taken as a measure of the in-state consumption if smuggling had not occurred. The final estimates of smuggling are given as the percent of sales that are smuggled in each state. If a state imports smuggled cigarettes, the value of smuggled sales in negative, as it causes observed sales to be less. If the state is a smuggled cigarette exporter, the value is positive.

Few papers examine whether or not there are non-tax incentives related to cigarette smuggling. Goel (2008) approaches the question of cross-sectional differences in state smuggling rates by estimating the effects of both price and non-price incentives on cigarette smuggling. His model examines price differentials on the border as well as factors including average education, literacy, corruption and policing. His model finds income to be significant in one case, but price differential is the strongest effect across all of his regressions.

The literature on public choice theory raises the issue of the potential endogeneity of taxes. Olson (1965) argues that a small interest group might organize more effectively than large ones and thus can secure beneficial taxes or subsidies. Stigler (1971) expands on Olson by arguing large firms can always out-lobby consumer groups in setting regulations, and Peltzman (1976) goes further by examining the political incentives a legislator faces for giving or denying tax benefits to a firm. All these theories contrast with the original assumption that taxes and subsidies are made in a way that maximizes public interest. Smith (1982) wrote two papers based on public choice theory which examine why liquor license regulations differ across states. Her findings suggest that regulations are correlated with the presence of certain interest groups and the size of voter districts. This gives support to the idea that policymaker’s decisions reflect incentives other than those associated with maximizing public interest.

As policymakers in public choice theory consider all the costs and benefits in making regulations, I expect that lawmakers will set excise taxes considering not only health and tax revenue but also the prevalence of smuggling. Excise taxes may also reflect omitted variables such as attitudes towards smoking, household income, the percent of population of smoking age, or other possible determinants. If this is the case, then excise tax is endogenous to the model and causality is difficult to determine. Furthermore, it is possible that non-tax factors excluded by many models have a significant relationship with smuggling. By examining these possibilities, I hope to shed further light on the nature of cigarette trafficking.

Section III: Model

Figure 2 shows the relationship between average real cigarette excise taxes and smuggled cigarettes as a percent of sales (taken from the Lafaive et al. estimates) over time for the time period I analyze, 1990 to 2009. The figure suggests that over this time period, cigarette taxes and smuggling both increased. To further examine this relationship, I estimate several regression models based on my hypotheses in Section III. All models use heteroskedasticity-robust clustered standard errors.

I begin by estimating a basic linear or ordinary least squares (OLS) regression of my independent variables on the dependent variable of smuggling. For this regression, I pool my data and, as a result, this regression does not account for the panel nature of my data. It is intended to illustrate the basic relationships among variables. Simple OLS regression is defined as:

$$Y_i = X_i' \beta + \varepsilon_i$$

where Y_i is the dependent variable, X_i' is a vector of independent variables with coefficients ß, and ε_i is the error term. Because my data are a panel over the years 1990-2009, I follow by using state fixed effects in my regression,[7] meaning a dummy variable for state is included for each state in my sample. A fixed effect regression appears as:

$$\boldsymbol{Y_{it}=X_{it}'\beta+\gamma_i+\varepsilon_{it}}$$

where γ_i is the state dummy variable and t is the year of the observation.

Finally, I use a panel two stage least squares (2SLS) instrumental variable regression with state fixed effects to account for the possibility that taxes are endogenous. An instrumental variable regression is useful when the coefficient for one independent variable is correlated with the error term of the regression. This can occur for several reasons, one being that the dependent variable may directly affect the independent variable, or they may be determined simultaneously. Correlation with the error may also occur if excise taxes and smuggling are driven by omitted variables or if there is substantial measurement error. OLS will not produce consistent estimates if any variable is correlated with the error term. An instrumental variable is one that is a determinant of the endogenous variable, in this case excise tax, without being itself a determinant of the dependent variable or being correlated with other determinants of it. 2SLS requires 2 conditions to be valid:

i. There must be at least as many instrumental variables as there are endogenous variables in the original regression, or the model will not be identified

ii. The IV is correlated with the endogenous variable conditional on all other exogenous variables in the original regression

The two stages of a 2SLS regression are defined as:

1st stage: $\boldsymbol{Z_{it}=V_{it}'\alpha+\mu_{it}}$

2nd Stage: $\boldsymbol{Y_{it}=X_{it}'\beta+\delta Z_{it}+\varepsilon_{it}}$

where Z_{it} is the endogenous variable, excise tax, with coefficient δ, V_{it}' is a vector of instruments explaining Z with coefficients α, and μ is the error term of the first stage regression. I use the percentage of democrats in the upper and lower houses of the state legislature as the instrumental variables.

Section IV: Data

The first dependent variable for my model is an estimate of the percent of cigarette sales that are smuggled, as produced by Lafaive et al. The data cover 47 continental states from 1990-2009, excluding the District of Columbia and North Carolina. The estimates are given as the percentage of sales that are smuggled, with a negative value if the state is importing smuggled cigarettes and a positive value if it is exporting them.

My second dependent variable is the ratio of cigarettes consumed per capita in each state over the number of recorded cigarette sales per capita. I use this as a rough estimate of smuggling, as a mismatch between reported consumption and sales may be explained by smuggled cigarettes. The primary purpose is to create an estimate that can be compared to the Lafaive et al. measure, as data for consumption are sparse and involve multiple assumptions. Cigarette consumption is measured as number of cigarettes smoked daily. Data are taken from the Tobacco Use Supplement to the Current Population Survey (TUS-CPS), a primarily self-reported survey of persons 18 or older that is conducted by the U.S. Census. The survey is not conducted every year, but one observation per state is available for each of the two year periods 1992-1993, 1995-1996, 1998-1999, 2001-2002, and 2006-2007. I assume that the consumption value for each two year period is the same in both of the two years. Sales data are given as the annual number of cigarette packs sold per capita. Data for sales are taken from "*The Tax Burden on Tobacco*," a publication made by the consulting firm Orzechowski and Walker. As the units are not comparable, I adjust cigarettes consumed to be an annual value, and adjust sales data to be in cigarettes rather than packs. In doing this I assume that there are 20 cigarettes per pack, an assumption I borrow from the TUS-CPS survey. The ratio shows an enormous mismatch between sales and consumption, with an average ratio of 4.08 across all years, though with a substantial standard deviation of 1.24. It is likely that the data collected by TUS-CPS are not representative, considering that the average respondent reports smoking nearly a pack a day. Furthermore, the ratio is never below 1, which would be expected in states that export large numbers of cigarettes and thus have more sales than consumption. There is still some correspondence between this ratio and the Lafaive et al. measure. For example, in 2007 New York had one of the highest estimated percentages of imported cigarettes (29.25%) and one of the highest ratios of consumption to sales (8.7). Likewise, states which tend to export smuggled cigarettes tend to have a ratio below the mean. In 1995, smuggled cigarette exports accounted for 18.87% of sales in New Hampshire, which also had a ratio of consumption to sales of 1.9. I do not consider this measure of smuggling to be superior to the Lafaive et al. model. Rather, I intend to use it for comparison purposes. I expect that both models will reach similar conclusions, assuming they both reflect smuggling. As negative and positive values in the Lafavie et al. model indicate smuggling import or export, it is difficult to interpret the coefficients of regressors. Using the ratio of consumption and sales, it is clear that an increase in the ratio implies a larger amount of smuggling, while a decrease implies the opposite. Therefore, I can better infer what the actual direction of the effect of a variable is if both models come to the same conclusion about how it affects smuggling.

To further explain the variation in smuggling, I use a set of variables not included in the Lafaive et al. model. Table 1 provides descriptions and summary statistics for the variables included in my analysis.

State cigarette excise taxes are considered the main determinant of smuggling and therefore I include them in my model. U.S. state excise taxes are given in dollars per pack of cigarettes, adjusted to real dollars in 2009. Data for excise taxes are taken from the publication, "*The Tax Burden on Tobacco*," which is funded in part by major cigarette companies including the Lorillard Tobacco Company and Reynolds American. I compared these data to census data and find that the excise tax data are unbiased and accurate. I expect that high excise taxes will be correlated with larger amounts of smuggling because high taxes raise the price of cigarettes within the state and incentivize smuggling.

I include per capita income to control for how the wealth of the population affects smuggling. Per capita income represents the total reported annual income of state residents divided by the population size. Data for all states are taken from the Bureau of Economic Analysis survey data and are in real dollars for the year 2009. There is significant variation in the average per capita income across states: Mississippi reported the lowest value in 2009 at $30,013 while Connecticut reported the highest at $52,900. I expect that higher per capita income will correlate with lower smuggling, as wealthier consumers will likely not be as sensitive to price and thus not seek out smuggled cigarettes.

I use percent of the population with a high school degree or higher to represent educational attainment for each state. These data give the percent of adults in each state who have graduated high school or any higher institution. The data are available from the US statistical abstract from 1990, 1998-2000, and 2002-2009. For unobserved years I assume that the change between two observed periods occurred evenly across the unobserved years. These data in particular must be viewed with caution as there are no observations between 1990 and 1998, a long period to make such an assumption over. There is not much variation between states in education; for example, Texas has the lowest percent of high school graduates in 2009 at 79.9%, while Wyoming has the largest at 91.8%. Education may affect smuggling through demand, as more educated people may be more likely to understand the dangers of smoking and avoid it. Previous research has also found a negative relationship between education and propensity to engage in crime (Lochner et al., 2004), which may imply that educated populations will be less likely to participate in the black market for cigarettes. Therefore I expect that higher levels of education will result in lower amounts of smuggling.

I use federal police per 100,000 residents as one proxy for the degree of law enforcement in a state. These data are given as the number of full time officers with federal arrest and firearm authority per 100,000 residents. Data are from the Bureau of Justice Statistics Census of Federal Law Enforcement Officers, a survey covering 73 agencies. Survey data are available for 2008, 2004, 2002, 2000, 1998, 1996, and

1993. For unobserved years I assume that the change between two observed years occurs in equal amounts across the intervening unobserved periods. For example, if 2002 has 15 officers and 2004 is 17 officers, I assume the unobserved year 2003 has 16. As it may be the case that larger numbers of police make smuggling more difficult, I expect this variable to have a positive relationship with the estimated number of cigarettes smuggled.

I use local police per 100,000 residents as my second proxy for law enforcement within each state. These data are given as the number of full time state and local law enforcement personnel per 100,000 residents. These numbers are drawn from the Bureau of Justice Statistic's Census of State and Local Law Enforcement Agencies, which is given every 4 years since 1992. Data are currently available for 2008, 2004, 2000, 1996, and 1992. For unobserved years I assume that the change in two observed years occurs in equal amounts across all intervening unobserved years, as in the federal police variable. There is substantial variation across states: Louisiana has the highest average at 492 police per 100,000 residents while West Virginia has the lowest with 225. There is substantial variation across time as well. As with the federal police variable, I expect that higher numbers of local police per capita will result in less smuggling.

The percent of adults in the state population is included because it may have a relationship with smuggling through demand. The majority of smokers are adults, so I expect that a larger portion of adults within a state will result in higher demand for cigarettes and a larger amount of smuggling. Furthermore, adults can legally drive and thus a larger adult population would be more capable of crossing borders to evade excise taxes. Percent of adults in the population of each state are calculated as the number of people 18 or older divided by the entire state population, given for the years 1990-2009. Data are collected by University of California Santa Barbara and available through the Center for Disease Control (CDC). There is little variation between states: Wisconsin has the highest average percentage at 77.56% adult, while Utah has the lowest at 67.27%. The average standard deviation for each state over time is only 1.08%, showing that the percent of adults in each state changes little over the sample time period.

I use the presence of laws against advertising tobacco as a proxy for attitudes towards cigarettes in each state. It is a binary variable with a value of 1 if a state has laws restricting tobacco advertisements and 0 if it does not. Types of restrictions include banning billboards, restrictions on billboards near schools or churches, prohibition of advertising on public transportation, and several more. These data are collected by the CDC Office of Smoking and Health (OSH). There is little variation across time in this variable, as most states do not vary their advertising laws frequently. For example, the percent of states with advertising restrictions has held constant at 40.4% since 1999. I believe that the presence of advertising restrictions indicates a generally hostile attitude towards smoking in each state, and that the presence of restrictions will be correlated with lower amounts of smuggling. States that are hostile to smoking may be more serious about prosecuting smugglers for bringing in cigarettes. They may also demand fewer cigarettes generally, making such states unattractive targets for smugglers.

I include the number of corruption convictions for state and local officials as a proxy for corruption in each state. This value is given as the total number of convictions of state and local officials per year in each state. Data are available from the Department of Justice Public Integrity Section 2011 report to Congress. The number of corrupt cases varied significantly between states, Texas having the highest average number of convictions at 72.3 and New Hampshire having the lowest at 1.6. I expect that a larger number of corruption convictions will be correlated with a larger degree of smuggling. States with a reputation for corruption may attract smugglers who believe they are less likely to be prosecuted. A culture of corruption may lower the transaction costs of certain forms of smuggling, for example by making counterfeit tax stamps more available.

To create an estimate of a state's reliance on tourism, I follow the method used by Saba et al. (1995). Essentially, I assume that states with a higher than average number of people employed in hotels have a larger amount of tourism. I use annual data on number of paid employees working in accommodation services from the Census County Business Patterns survey, available from 1998-2011. I adjust these data to find the per capita number of employees in each state, as well as the average for each year across the entire US. I take the ratio of accommodation employees per capita in each state over the average for the US in each year to find how each state compares to the average. I subtract 1 from the result so that a state with the average number of people employed in hotels is given a value of "0." My expectation is that higher reliance on tourism will result in greater amounts of smuggling, as states with more accommodations will have more traffic flowing through them.

I use percent of Democrats in the lower and upper house of the state legislature as instrumental variables to control for the endogeneity of excise taxes. The variables are calculated as the number of Democrats divided by the total number of legislators in each body, using data available from the Census's US statistical abstracts. Observations are available for even years from 1990-2000, as well as 2001-2003 and 2005-2011. In unobserved years, I make the assumption that the partisan composition of the legislature remains the same as the previous year. Furthermore, I omit Nebraska as the state has a non-partisan unicameral legislature.

It has long been a part of the Republican Party platform to oppose increases in taxes, while the Democratic Party has generally been more in favor of slightly higher tax rates to pay for government programs. Therefore, I assume that the percent of Democrats in the state legislature will affect taxes, most likely resulting in higher excise taxes than in states with more Republicans. I do not expect the percent of Democrats in each state to affect smuggling except through the mechanism of higher excise taxes.

Section IV: Results

Please see Tables 2 and 3 for the results of OLS and 2SLS regressions, respectively. In summary, I find that my instrumental variable is valid for the Lafaive et al. model, but neither IV model is as efficient as OLS. Because of the panel nature of my data, fixed effects regression is the preferred model. The variables for excise tax, per capita income, and federal police per 100,000 residents are significant and in the expected direction for both dependent variables.

The pooled OLS regression results are mostly in line with my expectations, though some results do not match my hypotheses. Both pooled regression models explain over 60% of the variation in my two measures of smuggling. Across both dependent variables, real cigarette excise tax is significant at the one percent level and the coefficient is in the expected direction: an increase in tax results in an increase in the Lafaive et al. model's estimate of imported cigarettes as well as an increase in the ratio of consumption to in-state sales. Per capita income is highly significant and in the expected direction: a $1000 increase in average per capita income results in a .6 percentage point increase in the Lafaive et al. measure, implying that there is either less smuggling or more cigarette export.

The consumption to sales ratio model indicates that higher per capita income results in a smaller ratio, suggesting a smaller amount of smuggling. However, the magnitude is negligible in the latter case. Federal and local police per 100,000 residents are significant at 1% in both models, but with coefficients that suggest larger amounts of law enforcement per capita result in increased amounts of smuggling. This result is the opposite of my hypothesis, but may be a product of the pooled model as it disappears with fixed effects. The percent of adults in the population is significant at 1% and has an extremely large magnitude. This affect disappears in fixed effects regression. Corruption is significant in both cases and the coefficients are in the expected direction, though with small magnitudes. Tourism is only significant in the Lafaive et al. model, with the result that higher tourism is related to greater cigarette smuggling export or possibly less import.

Fixed effects regression is a better match for my data, as I want to account for changes across states over time. This is evident in the ratio model as the R-squared increases by roughly 10%, though it actually decreases in the Lafaive et al. model by about 7%. The fixed effects model shows fewer independent variables to be significant, though those that were aligned mostly with my expectations. Excise tax remained significant at 1%, with the same direction and slightly smaller magnitude. Per capita income remained at the same level of significance for both models, though with greater magnitudes by nearly a factor of 10 in each case. For example, a $1000 increase in the average per capita income will result in a 1% increase in the Lafaive et al. estimate of smuggling. Federal police per 100,000 residents switches signs in both cases, and becomes barely significant at the 10% level in the Lafaive et al. model. This is more in line with my expectations, as it is now associated with fewer cigarettes smuggled into the state and a reduction in the ratio of cigarettes consumed over state sales. However, the magnitude is small in the case of the Lafaive et al. estimates, as a 1 officer per 100,000 residents increase correlates with only a .084 percentage point increase in the Lafaive et al. estimate of smuggling.

My 2SLS regression on the Lafaive et al. estimates gave evidence that my instrumental variable is valid, but indicated that OLS remains the most efficient estimator. The first stage regression F-statistic for model is significant at the 1% level and the model explained 30.75% of the variation in excise taxes, suggesting that the regression is significant and the fit is good. The percent of Democrats in the upper house of the state legislature is statistically significant at the 5% level, giving evidence that it is a valid instrument. The percent of Democrats in lower house was not statistically significant, likely because it has a very strong correlation with the percent of Democrats in the upper house (r=.82). An overidentification test of all instruments returns a p-value of .41, which fails to reject the joint null that the instruments are uncorrelated with the error term and are correctly excluded from the estimated equation. The underidentification test returns a p-value of .0023, rejecting the null that the excluded instruments are uncorrelated with the endogenous regressor. Together these give strong evidence that the percent of Democrats in the upper house is a valid instrumental variable. However, an endogeneity test[8] on excise tax variable returns a p-value of .36, which fails to reject the null that excise tax is exogenous.

The consumption to sales ratio model is not significant and the instrument is not valid. While the model explains 74.89% of the variation in the ratio of per-capita cigarette consumption to per capita sales, the F-statistic of the first stage regression is too low to reject the null that all the regression coefficients are 0. This suggests that the regression model does not fit the data well. Furthermore, I find that neither of the instrumental variables is a significant determinant of excise tax, implying that they are not valid instruments in this case. This is confirmed by the underidentification test p-value of .21, which does not reject the null that the instruments are uncorrelated with the endogenous regressor. The overidentification test p-value is .68, which implies that the instruments are not correlated with the error term and are properly excluded. Nevertheless, this does not imply that the instruments are valid as overidentification tests are robust to weak instruments. The endogeneity test has a similar result to the Lafaive et al. model, giving a p-value of .64 which does not reject the null that excise tax is exogenous to my model of smuggling.

Please see Tables 4 and 5 for the OLS and 2SLS results of the model without the corruption variable. To test the robustness of my results, I drop the corruption variable because it significantly reduces the number of observations in my regressions. This change increases the observations for the Lafaive et al. and consumption to sales ratio models by roughly 200 and 140, respectively. Dropping the corruption variable has little effect on the Lafaive et al. predictions but significantly changes the outcome of the consumption to sales ratio model. For the Lafaive et al. dependent variable, the federal police per 100,000 residents variable loses its significance in the fixed effects model, and the education and tourism variables become more significant in the pooled regression. The F-statistic for the first stage of the Lafaive et al. 2SLS regression triples and both instruments become significant at the 1% level, implying that the instruments remain valid. There is no material change to the second stage regression results, except that the federal police variable is no longer significant and the per capita income variable loses some significance. The endogeneity test does not reject the null that tax is exogenous.

The changes in the ratio model are more substantial. Reflecting the Lafaive et al. model, the variable for federal police becomes much less significant in the fixed effect regression. Tourism becomes significant at 10% across pooled and fixed effects regressions, and the variables for local police and advertising laws become more significant in the pooled regression. The F-statistic nearly triples for the first stage 2SLS regression and instruments for the percent of Democrats in the lower and upper house are significant at the 10% and 5% levels, respectively. This implies that the first stage regression is significant and the instruments are valid. The underidentification test now rejects the null that the instruments are uncorrelated with the endogenous regressor and the overidentification test does not reject the null that the instruments are uncorrelated with the error term and excluded correctly. This gives further evidence that the instruments are valid in this case. The endogeneity test rejects the null that tax is exogenous at the 10% level. The second stage shows excise tax to be strongly correlated with an increase in the ratio of consumption to sales, implying a larger amount of smuggling and keeping with my expectations and previous results. The per capita income variable is also significant at the 1% level but is associated with an increase in the ratio, which is not in line with my hypothesis. Federal police per capita is strongly correlated with a decrease in the ratio and thus an implied decrease in cigarette smuggling, as my hypothesis predicted.

Section V: Conclusion

This paper examines two questions: whether or not cigarette excise taxes are endogenous to estimates of smuggling, and if there are other important determinants of smuggling besides taxes. My IV model finds a valid instrument for excise tax, but does not suggest that cigarette excise tax is endogenous to the estimates of smuggling. While this might suggest that the amount of smuggling does not have an effect on excise taxes, further research in this area is needed. Furthermore, my results suggest that variables measuring per capita income and federal police protection appear to be associated with lower amounts of smuggling. However, changing my model by dropping the variable measuring corruption resulted in a significant change in my results, suggesting that they are sensitive to the specification of my model. Future studies should continue to explore the determinants of smuggling and the endogeneity of excise taxes.

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APPENDIX: Tables and Figures

Figure 1: State Excise Taxes, courtesy of the Tax Foundation[9]

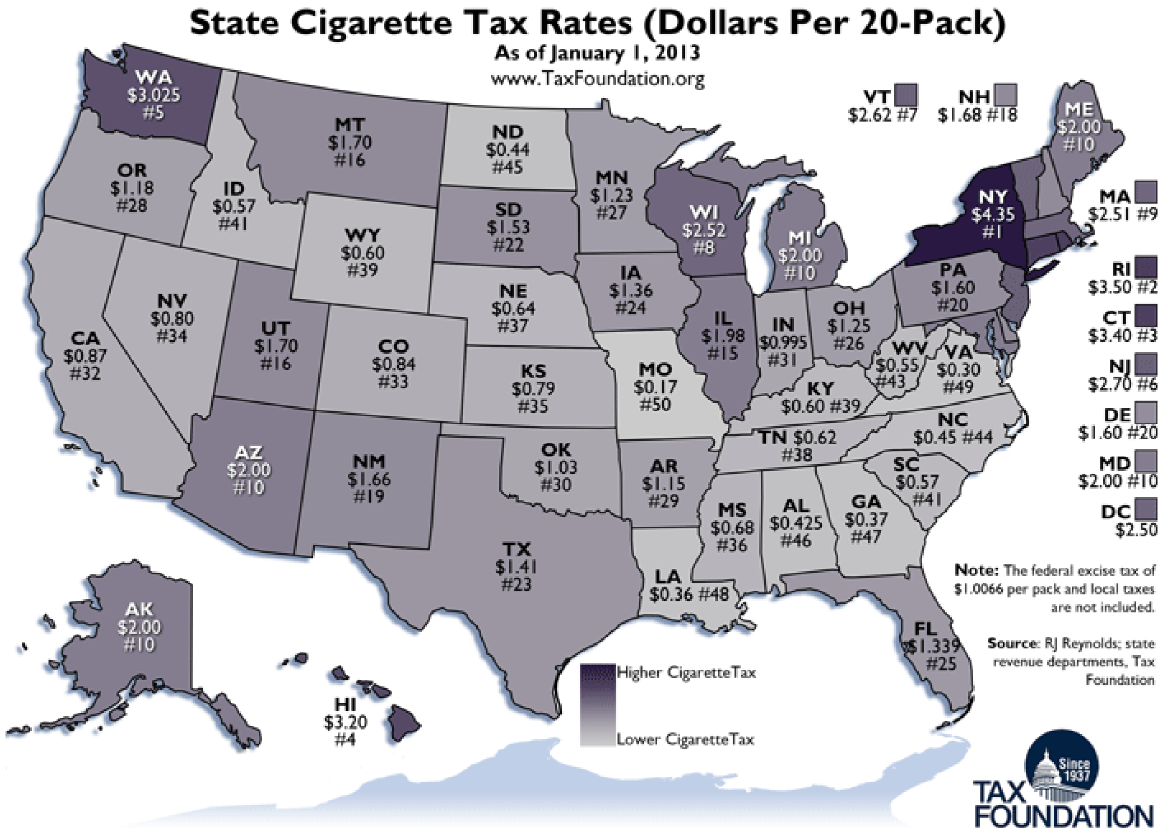
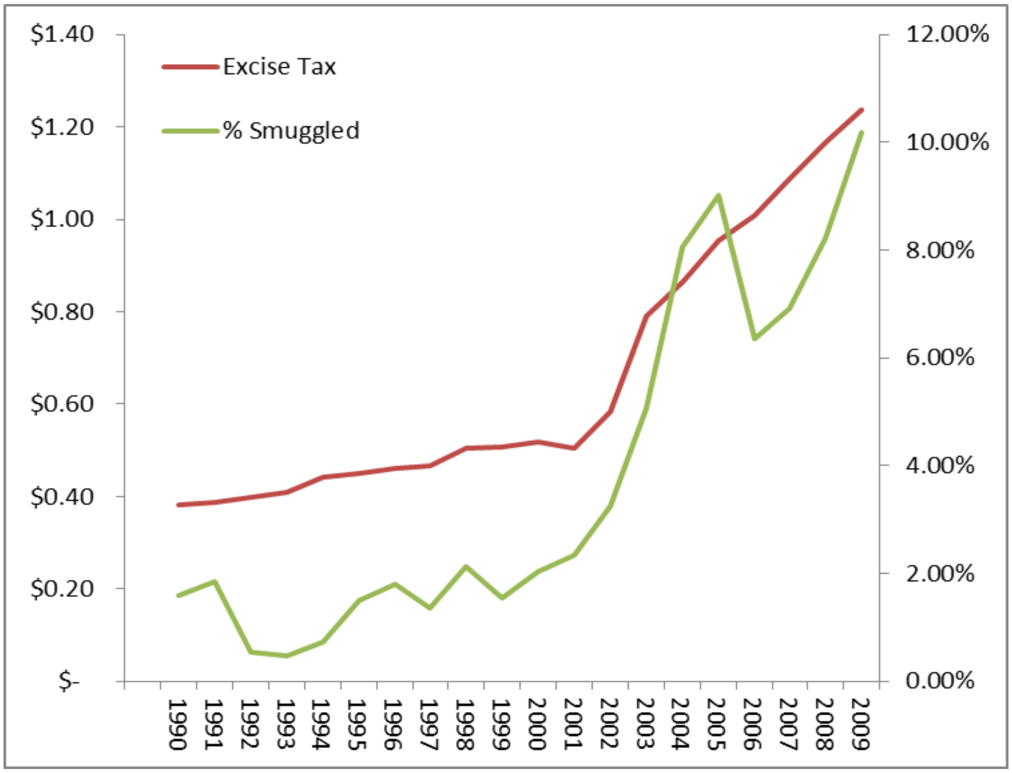


Figure 2: Average Cigarette Excise Tax per Pack and smuggled cigarette consumption as a percentage of sales, 1990-2009*



*: Estimates are taken from Lafaive et al. 2010. I adjusted their estimates by taking the percentage of smuggled cigarettes imported as a positive. Therefore in 2009 cigarettes smuggled into the state average 10% of sales.

Table 1: Summary Statistics for Dependent Variables

DEPENDENT VARIABLE	Label	Mean	SD	Observations
Total % Cigarette Sales Smuggled (estimate)	-	-3.15%	15.51%	940
Ratio of Cigarette Consumption to Sales	-	4.08	1.24	470
INDEPENDENT VARIABLES	Label	Mean	SD	Observations
pc Income ($)	pcinc	28,016.40	7,233.05	940.00
Tourism	tourism	-0.07	1.53	658.00
Public Official Corruption Convictions	corrupt	20.45	22.70	384.00
Adult % of State Population	adult	0.75	0.02	940.00
% High School Diploma or Higher	educ	0.84	0.06	940.00
State and Local Police per 100,000 Residents	localpolice	327.31	77.21	748.00
Federal Police per 100,000 Residents	feds	26.36	16.60	752.00
Excise Tax per Pack of Cigarettes ($)	tax	0.53	0.50	940.00
Laws Restricting Advertising (Binary)	adlaws	0.38	0.49	705.00
% Democrats in the Upper House	upperdems	0.52	0.16	920.00
% Democrats in the Lower House	lowerdems	0.52	0.17	940.00

Table 2: Regression Results for Pooled and Fixed Effects regressions.

Variable	Dependent: Lafaive et al. Estimate		Dependent: Consumption/Sales	
	Pooled Regression	Fixed Effects	Pooled Regression	Fixed Effects
tax	-.22*** (.012)	-.17*** (.016)	1.54*** (.13)	.91*** (.14)
pcincome	.0060*** (.0014)	.010*** (.0037)	.000042** (.000017)	.00015** (.000059)
feds	-.0015*** (.00029)	.00084* (.00049)	.015*** (.004)	-.029*** (.0069)
localpolice	-.00037*** (.000095)	-.00029 (.00023)	.0025* (.0014)	-.0046 (.0032)
educ	.0024 (.0018)	-0.0032 (.0037)	.000058 (.025)	.13** (.051)
adult	2.76*** (.36)	-0.312 (.99)	-37.91*** (6.55)	10.61 (15.039)
adlaws	-.0054 (.014)	-.0071 (.0084)	.18 (.17)	-.96* (.099)
corrupt	-.00081*** (0.00029)	-0.00022 (.00022)	.0063* (.0036)	-.0089 (.0059)
tourism	.017** (.0067)	.0053 (0.0028)	.019 (.025)	-.18 (.18)
Constant	-2.19*** (.34)	-.182 (.58)	28.76*** (5.096)	-17.79* (10.37)
R-squared	63.11%	56.45%	67.14%	76.94%
Observations	329	329	141	141

*: Significant at the 10% level
**: Significant at the 5% level
***: Significant at the 1% level
†: Per capita income is scaled by a factor of 1/1000. To use the Pooled Regression model as an example, a $1000 increase in average per capita income results in a .6 percentage point increase in the Lafaive et al. estimate of smuggling.

Table 3: Instrumental Variable 2SLS Regression Results

Variable	Dependent: Lafaive et al. Estimate IV First Stage	Dependent: Lafaive et al. Estimate IV Second Stage	Dependent: Consumption/Sales IV First Stage	Dependent: Consumption/Sales IV Second Stage
tax	(Dependent Variable)	-0.23*** (.062)	(Dependent Variable)	.63 (.59)
pcincome†	.029* (.015)	0.012*** (.0043)	-.000018 (.000038)	.00016*** (.000050)
feds	.0046 (0.0032)	0.0011* (.00062)	.012 (0.010)	-.026** (.011)
localpolice	.0037*** (.0013)	-.00013 (.00027)	.0038*** (.0029)	-.00042 (.0029)
educ	.026 (.017)	-.0014 (.0038)	.019 (.043)	.14*** (.053)
adult	10.20* (5.29)	1.07 (1.07)	34.07 (13.75)	20.28 (22.65)
adlaws	-.14 (.12)	-.013 (.016)	.18 (.19)	-.96*** (.13)
corrupt	0.0014 (.0021)	-.00016 (.00029)	0.0027 (.0045)	-.0084 (.0053)
tourism	.012 (.018)	.0057 (.0086)	-.20 (.15)	-.25 (.22)
upperdems	1.21** (.61)	-	1.55 (1.16)	-
lowerdems	0.56 (.58)	-	-.19 (1.05)	-
R-squared	30.75%	51.39%	45.83%	74.89%
F Statistic	11.3	18.37	6.37	43.33
Observations	322	322	138	138
Underidentification Test Statistic††	13.31 P=.0013		3.11 P=.21	
Overidentification Test Statistic†††	.225 P=.64		.167 P=.68	
Endogeneity Test‡	.752 P=.39		.225 P=.64	

*: Significant at the 10% level
**: Significant at the 5% level
***: Significant at the 1% level
†: Per capita income is scaled by a factor of 1/1000.
††: The underidentification test returns the the Kleibergen-Paap rk LM statistic.
†††: The overidentification test returns the Hansen J-statistic.
‡: See endnote 8 for details of the endogeneity test.

Table 2: Regression Results for Pooled and Fixed Effects regressions.

Variable	Dependent: Lafaive et al Estimate		Dependent: Consumption/Sales	
	Pooled Regression	Fixed Effects	Pooled Regression	Fixed Effects
tax	-.22*** (.010)	-.17*** (.014)	1.60*** (.11)	1.03*** (.093)
pcincome	.0044*** (.0010)	.0056** (.0028)	.038*** (.011)	.11** (.049)
feds	-.0016*** (.00024)	.00040 (.00044)	.016*** (.0029)	-.014* (.0072)
localpolice	-.00037*** (.000070)	-.00012 (.00018)	.0025*** (.00089)	-.0022 (.0029)
educ	.0035*** (.0012)	.0016 (.0013)	.0071 (.015)	-.0017 (.011)
adult	2.52*** (.27)	.35 (.78)	-29.72*** (3.86)	6.95 (10.87)
adlaws	-.011 (.010)	.057 (.0051)	.219** (.097)	-.61* (.34)
tourism	.024*** (.0067)	.014 (0.0015)	-.030* (.018)	-.30* (.16)
Constant	-2.06*** (.25)	-.52 (.54)	22.11*** (3.04)	-4.20 (6.90)
R squared	63.30%	60.15%	67.55%	74.00%
Observations	517	517	282	282

*: Significant at the 10% level
**: Significant at the 5% level
***: Significant at the 1% level

Table 5: Instrumental Variable 2SLS Regression Results, Omitting Corruption Variable

Variable	Dependent: Lafaive et al Estimate IV First Stage	Dependent: Lafaive et al Estimate IV Second Stage	Dependent: Consumption/Sales IV First Stage	Dependent: Consumption/Sales IV Second Stage
tax	(Dependent Variable)	-.18*** (.025)	(Dependent Variable)	1.53*** (.30)
pcincome†	.037*** (.012)	.006** (0.0024)	.27 (.018)	.093*** (.032)
feds	.0043* (0.0025)	.00048 (.00043)	.0090* (0.0052)	-.019*** (.0055)
localpolice	.0012 (.00090)	-.00013 (.00017)	.0014 (.0011)	-.0021 (.0018)
educ	.024*** (.0063)	.018 (.014)	.0099 (.0078)	-.0035 (.011)
adult	13.55*** (2.92)	.53 (.59)	16.81*** (5.33)	-1.87 (8.81)
adlaws	-.065 (.067)	-.056 (.027)	.059 (.077)	-.58* (.32)
tourism	.0013 (.0013)	.014 (.0089)	-.046 (.069)	-.27** (.11)
upperdems	1.29*** (.32)	-	1.03** (.41)	-
lowerdems	0.93*** (.35)	-	.86* (.46)	-
R squared	44.95%	59.96%	48.79%	69.28%
F Statistic	34.85	26.29	18.65	49.95
# Observations	506	506	276	276
Underidentification Test Statistic††	45.35 P=.0000		17.70 P=.0001	
Overidentification Test Statistic†††	2.54 P=.11		.032 P=.86	
Endogeneity Test‡	.09 P=.76		3.28 P=.07	

*: Significant at the 10% level
**: Significant at the 5% level
***: Significant at the 1% level
†: Per capita income is scaled by a factor of 1/1000.
††: The underidentification test returns the the Kleibergen-Paap rk LM statistic.
†††: The overidentification test returns the Hansen J-statistic.
‡: See endnote 8 for details of the endogeneity test.

[1] See Lafaive et al., 2008. Few other papers make reference to international smuggling within the US.
[2] Luccasen, R.Andrew, R. Morris Coats, and G. Karahan. "Cigarette Smuggling Mitigates the Public Health Benefits of Cigarette Taxes." *Applied Economics Letters* 12.12 (2005): 769-73. *EconLit*. Web. 24 Sept. 2013.
[3] Brady, Brittany. "NY Cigarette-Smuggling Ring May Have Terror Link." *CNN*. Cable News Network, 01 Jan. 1970. Web. 24 Sept. 2013. <http://www.cnn.com/2013/05/17/us/new-york-cigarette-ring/index.html>.
[4] "Where There's Cigarette Taxes, There's Smuggling." *YouTube*. YouTube, 17 Dec. 2010. Web. 1 Oct. 2013. <http://www.youtube.com/watch?v=IxFrZCl-0Ig>.
[5] Both papers used different data to estimate smuggling, perhaps accounting for some of the difference. Furthermore, Stehr may have had downward bias because he measured tax differentials between states from the average tax difference between the home state and higher-tax border states, among other issues. Baltagi and Levin account for sales, price, and neighboring price but do not include variables for commercial smuggling or consider border populations.
[6] North Carolina is generally held in the literature to be the origin of most commercial cigarette smuggling, because of previous evidence in the literature that commercial smuggling out of the state has a significant effect on sales in North Carolina. For a complete discussion of this issue, please see:
Jensen, Richard A., Jerry Thrusby, and Marie Thursby. "Smuggling, Camouflaging, and Market Structure." *The Quarterly Journal of Economics* 106.3 (1991): 789-814. Print.
[7] A random effects model was run, but a Hausman test found fixed effects to be the more effective model (P=.03).
[8] The null hypothesis of the endogeneity test assumes that the variable can be treated as exogenous. The test is defined as the difference between two Sargan-Hansen statistics, the first for the model in which the variable is treated as endogenous and the second for the model where it is treated as exogenous. The test statistic is numerically equivalent to a Hausman test statistic under homoskedasticity, although the test is heteroskedasticity robust. The test statistic is always positive and is chi-squared distributed with degrees of freedom equal to the number of endogenous variables.
[9] Kasprak, Nick. "Monday Map: State Cigarette Tax Rates, 2013." *Taxfoundation.org*. The Tax Foundation, 1 Apr. 2013. Web. 12 Oct. 2013. <http://taxfoundation.org/blog/monday-map-state-cigarette-tax-rates-2013>.