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ABSTRACT

This study uses within-state variation in taxes over the 1989-1992 time period to test whether maternal smoking and birth outcomes are responsive to higher state cigarette taxes. Data on the outcomes of interest are taken from the Natality Detail files, generating a sample of roughly 10.5 million births. The results indicate that smoking participation declines when excise taxes are increased. The elasticity of demand for cigarettes is estimated to be approximately -0.25. In addition, estimates of two-part models suggest that taxes only alter the probability a mother smokes and not average daily consumption conditional on smoking. Reduced-form models also indicate that higher excise taxes translate into higher birth weights. These two sets of results can be used to form an instrumental variables estimate of the impact of smoking on birth weight. This estimate indicates that maternal smoking reduces average birth weight by 367 grams, which is remarkably close to estimates from random assignment clinical trials.

It is important to note that as a policy tool to improve birth outcomes, cigarette taxes are a blunt instrument. Taxes will be imposed on all smokers, but the benefits received and costs imposed extend beyond the targeted population. Under the naive assumption that the only benefits of the tax are received in the form of improved birth outcomes, we find that an increase in the cigarette tax is not as cost effective in preventing low birth weight as other more targeted public policies such as the Medicaid expansions of the late 1980's.

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Introduction

Of the approximately four million infants born each year in the United States, nearly forty thousand will die during their first year of life. Although the problem of infant mortality is not unique to this country, in international comparisons of infant mortality rates, the United States fares rather poorly.[1] In 1992, the United States ranked twenty-second in the world with an infant mortality rate of 8.5 (National Center for Health Statistics 1996). Given these stark findings, much research has focused on determining the causes of infant mortality. The evidence suggests that three quarters of infant deaths can be attributed to infants being born too small or too early (Paneth 1995). Although recent advances in neonatal intensive care have made it possible to save infants as small as 750 grams (1 pound 10 ounces), such infants are likely to require long term medical care (Shiono and Behrman, 1995).[2] Even moderately low birth weights have been linked to a variety of long lasting health problems for the infants that survive the first year of life.[3] The occurrence of severe brain damage and cerebral palsy is highly correlated with low birth weight. Less serious, yet more common health problems associated with low birth weight include subnormal growth and developmental disorders (Abel 1980; Naeye 1981; Naeye and Peters 1984; Sexton, Fox, and Hebel 1990). Nearly all low birth weight infants will require some special medical attention, whether it is right after birth in a neonatal unit or at some point later in life. Therefore, it is clear that preventing low weight births from occurring is an important step not only in

[1] The infant mortality rate is defined as the number of infant deaths during the first year of life per 1000 live births.

[2] Ethical questions arise when extreme measures are used to save extremely low birth weight infants. Some infants will never be able to lead a full and productive life due to the physical and developmental problems associated with extremely low birth weight. The difficulty lies in determining which infants are so sick or immature that intensive care should not be administered (Tyson 1995).

[3] Infants that weigh less than 2500 grams (5 pounds 8 ounces) at birth are termed low birth weight. Low birth weight can be further broken down. An infant that weighs between 2500 and 1500 grams (3 pounds 5 ounces) is considered moderately low birth weight. Weights below 1500 grams are termed extremely low birth weight.

reducing infant mortality, but also in increasing the overall health and well-being of children in the United States.

In order to address the problem of low birth weight, the factors that cause infants to be born too small must be identified. A baby may be too small at birth because it grew too slowly in utero, was born too soon, or some combination of the two. Despite extensive research, scientists do not have a sound understanding of complex relationships between the biological factors that cause slow fetal growth or preterm delivery.[4] While the exact biological relationships may not be known, observational evidence indicates that three of the most important identifiable risk factors associated with low birth weight are low maternal prepregnancy weight, low maternal weight gain during pregnancy, and maternal smoking during pregnancy (Shiono and Behrman, 1995). It is interesting to note that all of these risk factors are to some extent self inflicted, and as such could possibly be modified by public policy interventions.

Much of the government policy aimed at improving the infant mortality rate has focused on the first two risk factors, and as such have attempted to provide adequate nutrition and access to medical care. The most notable of such policies is the expansion of Medicaid eligibility to a wider array of women in the late 1980's. While programs that provide adequate nutrition and access to prenatal care appear to improve maternal health, there is conflicting evidence as to whether these programs have been effective in improving birth outcomes (Piper et al. 1990; Currie and Gruber 1996). Doctors and nurses providing prenatal care generally counsel against smoking during pregnancy, however, no widespread public policy to date has attempted to deal directly with maternal smoking as a risk factor for low birth weight. One policy instrument that has been suggested but only indirectly studied is cigarette taxes. For such a policy to be effective there are two links in the chain of events that must be causal. First, it must be the case that pregnant women are responsive to changes in the price of cigarettes. Second, maternal

[4]Preterm delivery refers to birth prior to 37 weeks of completed gestation.

smoking during pregnancy must cause bad birth outcomes. There is, however, little empirical evidence that women are sensitive to changes in price of cigarettes. Most studies to date have focused on the population as a whole, not specifically on women. There is clear scientific evidence that maternal smoking has a detrimental effect on infant health, although it is not clear what the magnitude of that effect is. Previous observational studies have generally treated smoking as an exogenous explanatory variable and as such, have likely not produced accurate estimates of the impact of maternal smoking on infant birth weight.

In this study, we use birth record data to estimate reduced-form relationships between cigarette taxes and maternal smoking and between cigarette taxes and infant birth weight. These relationships are then used to construct an instrumental variable estimate of the impact of maternal smoking on infant birth weight. Our estimates are the first to show that taxes do alter the smoking behavior of pregnant women and that increased cigarette taxes have a beneficial impact on infant birth weight. Further, the instrumental variable estimate of the impact of maternal smoking on birth weight is remarkably close to previous estimates from randomized clinical trials.

The paper is organized as follows. The first section briefly discusses some previous research on the impact of taxes on smoking behavior and then describes our statistical model. The birth record and tax data are discussed in the second section. The estimates from a single equation model of the impact of maternal smoking on birth weight are presented in section three as a basis of comparison for the instrumental variable results. The main body of evidence is presented in section four where we discuss the reduced-form estimates. In section five we present the instrumental variable results. In addition, we compare our estimates to results from a previous randomized trials. The last section summarizes our findings and discusses what conclusions can be drawn from this work.

Statistical Model

For taxes to improve birth outcomes, taxes must reduce smoking among pregnant women and this reduction must then generate better birth outcomes. There is a large literature in economics that has examined whether smoking is correlated with taxes and prices. Despite a wide variety in the sources of data and the method of estimation, the results of these studies are surprisingly similar. The majority of studies have found smoking declines in the face of higher taxes and the demand elasticities typically range of -0.4 to -1.0 (Viscusi, 1992). These studies are, however, not very informative about the population of interest -- pregnant women.

There is one previous paper that has indirectly looked at the effect of cigarette prices on the smoking behavior of pregnant women. Rosenzweig and Schultz (1983) estimate a birth production function with maternal smoking as a health input. In order to control for unobserved health heterogeneity, they use cigarette prices as an instrument for smoking behavior. Their reduced-form estimates do not show a statistically significant correlation between either cigarette prices and the smoking consumption of pregnant women or between cigarette prices and infant birth weight.[5]

In contrast, there has been a great deal of evidence that links smoking to birth weight. Most studies rely on cross-sectional correlations between smoking and birth weight and the bulk of the evidence suggests that one average smoking during pregnancy reduces birth weight by 200 grams (U.S. Department of Health and Human Services 1990). In principle, we could multiply estimates of the impact of taxes on smoking by pregnant women by these values to get a predicted impact of the relationship between taxes and outcomes. This procedure has two drawbacks. First, most studies linking smoking to birth weight are potentially subject to an omitted variables bias. The coefficient on smoking in a birth weight production function will only be unbiased if smoking is uncorrelated with the

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[5]Rosenzweig and Schultz (1983) use cross-state variation in prices to identify their model. As we note below, relying on cross-state variation may be problematic since tax levels appear to be correlated with the unobserved, state-specific determinants of both smoking levels and birth weights.

unobserved determinants of birth outcomes. Unfortunately, women who smoke tend to have other health habits that may also impact the health of their infant. For example, smoking mothers are more likely to drink. Using the 1992 Natality data we find that the rate of maternal drinking is 8 percentage points (t-statistic=203.25) higher among women who smoke. Smokers are also 4 percentage points (t-stat=27.79) more likely to gain less than 16 pounds during pregnancy. In addition, the mean difference between smokers and non-smokers in the proportion who initiate prenatal care in the first trimester of pregnancy is 9 percentage points (t-stat=114.25). Smoking during pregnancy is clearly correlated with the other health behaviors that are reported in the Natality data. Further it seems likely that if smoking is correlated with some of the observed characteristics that it is also correlated with other unobserved characteristics. If the researcher cannot sufficiently control for these other attributes, the cross-sectional estimates may overstate the impact of smoking on birth weight.[6] Second, even if the cross-sectional studies are accurate, the estimated effect may not represent the impact of smoking on birth weight for those women who change their behavior in the face of higher taxes (Imbens and Angrist 1994). Consequently, our research strategy will be to estimate both reduced-form links in the process: the impact of taxes on maternal smoking and the impact of taxes on birth weight.

The primary variables of interest in our models are measures of birth weight (Y), level of smoking during pregnancy (S) and the taxes faced by the women during her pregnancy (T). As we note below, the data set we use contains observations that vary across individuals, states, and time. Since excise taxes on cigarettes vary across states, in principle, we can use the cross-state variation in taxes to identify the models of interest. We believe that this identification strategy has some potential shortcomings. If the level of taxation in a state is correlated with some underlying characteristics about

[6]In the models we estimate we do not control for maternal drinking, weight gain, or prenatal care because they are potentially endogenous variables for which good instruments do not exist. This is not problematic because these variables should be uncorrelated with state tax on cigarettes and therefore, in our instrumental variables models, excluding them should not generate an omitted variables bias.

the state (e.g., states with a small fraction of smokers are more likely to tax cigarettes heavily), then cross-sectional correlations may be subject to an omitted variables bias. As an alternative, we use a within-group estimator where we examine the changes in smoking and birth weights in a state before and after cigarette tax increases. The reduced-form within-group models we estimate can be characterized by the equations

(1) $$Y_{ist} = X_{ist}\,\theta_1 + T_{st}\,\theta_2 + u_{1s} + v_{1t} + \epsilon_{1ist}$$

and

(2) $$S_{ist} = X_{ist}\,\gamma_1 + T_{st}\,\gamma_2 + u_{2s} + v_{2t} + \epsilon_{2ist}$$

where X is a vector of demographic characteristics, u_{js} are state-effects, v_{jt} are time effects, and ϵ_{jist} is a random error.

If taxes alter smoking and improve birth weights, we can potentially use the estimates from these two equations to obtain an estimate of the impact of smoking on birth weight. To see this, note that $\gamma_2=\partial S/\partial T$ and the coefficient $\theta_2=(\partial Y/\partial T)$ measures the joint product of the impact of taxes on smoking participation and the impact of smoking on birth weight, or $\theta_2=(\partial Y/\partial S)(\partial S/\partial T)$. Dividing θ_2 by γ_2 would then provide an estimate of the gradient $\partial Y/\partial S$. Consequently, the equations outlined above can then be thought of as reduced-forms from a model of the impact of maternal smoking during pregnancy on birth weight. This model is of the form

(3) $$Y_{ist} = X_{ist}\,\beta_1 + S_{ist}\,\beta_2 + u_{3s} + v_{3t} + \epsilon_{3ist}$$

where terms are defined as above. Estimating this model by instrumental variables where the tax is the instrument for S is equivalent to the indirect least squares estimates outlined above. The estimate for β_2 will be unbiased so long as tax increases are uncorrelated with the unobserved determinants of birth weight. This is probably a reasonable assumption. States typically raise cigarette taxes for fiscal reasons rather than for public health concerns, although the health benefits often enter into the public justification. The changes in state tax rates can therefore be considered exogenous. There is no reason to believe a priori that changes in state cigarette excise taxes should independently be correlated with changes in birth weight except through the impact on maternal smoking.

To facilitate comparisons of our estimates to those from other papers, we will translate the estimate of γ_2 from equation (2) into a price elasticity of demand. This is important because while taxes are the policy lever, it is the price of cigarettes that alters behavior. To calculate the price elasticity of demand we assume that the prices consumers face are a function of the taxes levied on cigarettes. In that case, the effect of taxes on smoking behavior can be expressed as $\partial S/\partial T=(\partial S/\partial P)(\partial P/\partial T)$ where P is the retail price on cigarettes and $(\partial P/\partial T)$ is the change in price with respect to a change in tax rates. The relationship between the price elasticity and the tax effect is then given by the following expression

$$(4) \qquad e_d = \frac{\gamma_2}{\frac{\partial P}{\partial T}} \; \frac{\bar{p}}{\bar{s}}$$

where $\bar{p}$ and $\bar{s}$ are average values for price and smoking. Empirical evidence has shown that on average more than one hundred percent of an increase in the tax on cigarettes is passed on to the consumer; the derivative is approximately 1.15 (Harris 1987; Huang 1996). The ability of the producer to pass on more than one hundred percent of the tax increase is typically interpreted as an indication of market power in the cigarette industry (Sumner 1981; Sullivan 1985; Stern 1987).

Data

Birth Record Data

To estimate the models outlined above, data is needed on birth outcomes, maternal smoking, demographic and socioeconomic characteristics of the mother, and the state in which the birth occurred. Although there are a number of data sets that include the necessary variables, very few can provide the number of observations required to identify a statistically significant effect.[7] The data set that we use, The Natality Detail File (National Center for Health Statistics 1992a, 1992b, 1993, 1994), is a census of births in the United States in a given year. The Natality data are taken directly from birth records and contains information regarding birth outcomes, demographic characteristics, and maternal smoking, as well as other information. Since much of the information is collected at the time of the birth by the health care provider, birth outcome information should be reported accurately. The Natality data does not include as detailed information on socioeconomic status as some other data sets. It does, however, include data on the mother's education level and marital status which can be used as a proxy for socioeconomic status.

In choosing the Natality Detail files, we are limited to data from the years 1989 through 1992. Prior to 1989, the smoking information was not reported in the public use tapes and when we began this study, data after 1992 was not yet available. In our sample period, smoking data is not reported by four states (California, New York, Indiana, and South Dakota) which comprise about 24 percent of all births.

Studies have shown that approximately 39 percent of women who smoked before pregnancy quit smoking while pregnant, with the vast majority quitting as soon as they found out they were pregnant (Fingerhut, Kleinman, and Kendrick 1990).[8] This result indicates that the decision whether to continue to smoke is made early on in the pregnancy. Therefore, the tax rate that is relevant to the decision is one that is measured near the beginning of pregnancy. We use the tax measured during the month of

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[7]Another problem with many of the available data sets is that most rely completely on retrospective survey data. Data taken from surveys is prone to measurement error and recall bias. For example, in the National Longitudinal Survey of Youth (NLSY), birth weight, which is reported by the mother, shows a large spike at seven and a half pounds. Vital Statistic Data reveals that although the mean birth weight in the United States is close to seven and a half pounds, the distribution around the mean is smooth. The spike in the NLSY data suggests that respondents do not accurately recall the birth weight of their children. Recall problems such as this reduce the variation in the data and make it difficult to identify the true effect of smoking on birth weight.

[8]27 percent of women who smoked before pregnancy quit when they found out they were pregnant. Therefore, 70 percent of those women who quit smoking, quit immediately.

conception. The month of conception is estimated by using information about the month of birth and the clinical estimate of gestation.

Organizing the data by the month of conception illustrates that although the Natality Detail File is a census of births within a given calendar year, there is still a potential sample selection problem at the beginning and end of the sample. The problem stems from the fact that not all babies conceived in the same month will make it into the sample. For example, most children conceived in April of 1988 will be born in January of 1989, the first month in our sample. Some children, however, will be born before the ninth month of pregnancy and thus, will not be included in our sample. Likewise, babies born in December of 1992 were conceived at some point between February and August of 1992. The only observations included in the sample for babies conceived in August of 1992 are those that were born preterm. In Figure 1, we present the number of babies in the sample per month of conception. The results in the figure show a dramatic difference in the number of observations between the beginning, end and interior months of the sample. In Figure 2, we report average birth weight (in grams) by month of conception. Since the first few months exclude preterm infants, the average birth weight is high whereas the final few months only include preterm infants and the average birth weights decline considerably. For these reasons, we limit the analysis to the interior months of the sample. The sample begins with conceptions in of June 1988 and ends with babies conceived in February of 1992, a total of forty-five months. We impose two final restrictions on the data. First, we restrict the sample to singleton births and births to women 15-44 years of age. After the exclusion of the four states not reporting the smoking information and the sample restrictions discussed above, the final data contains approximately 10.5 million birth records out of a possible 16 million births over this time period.

The potential covariates included in the Natality data can be broken down into two categories: demographic variables and proxies for socioeconomic status. The demographic variables include the age and race of the mother and the sex of the infant. The proxies for socioeconomic status are educational level, marital status, and parity of the birth.

The outcome of interest in this study is infant birth weight. There are a number of ways in which this outcome can be measured. First, a continuous measure of birth weight can be used. It is also of interest, particularly from a public health standpoint, to create indicator variables for moderately low birth weight and extremely low birth weight.

Two measures of smoking behavior are reported in the Natality Detail files. The woman's smoking status is obtained from her medical record. If she reports being a smoker, she is then asked to indicate the average number of cigarettes smoked per day during pregnancy. As in any survey that uses self-reported smoking data, there is the possibility that smokers understate cigarette consumption. By chemically testing adult for cotinine, a by product of nicotine, researchers have found that adults tend to accurately report smoking participation (Pojer et al. 1984; Pierce et al. 1987). However, aggregating national surveys of cigarette consumption generates only 60 percent of cigarette sales indicating that individuals tend to underreport their cigarette consumption (Evans and Farrelly 1997). Women may underreport their cigarette consumption for a variety of reasons. One possibility is that the negative public sentiment toward smoking in general causes women to lie about their cigarette consumption (Lapham et al. 1991). A second possibility is that some women may be unable to recall accurately how much they smoked on average, especially if they quit smoking during the early months of their pregnancy. Systematic under reporting, such as this, would bias the estimate of the effect of smoking on birth weight. Since smoking participation appears to be more accurately reported in adults, possibly more weight should be given to results from models that use this variable.

State Level Tax Data

The state tax on cigarettes during the month the mother conceived is the proposed policy lever and instrument for maternal smoking behavior during pregnancy. As such, we need information on state level cigarette taxes over the period June 1988 to February of 1992. The cigarette tax data is taken from *The Tax Burden on Tobacco* (The Tobacco Institute, 1995). Using the specific date at which the tax rate changed, we can compute monthly observations on state excise taxes. In addition, monthly values of the consumer price index are used to adjust for inflation. As a result, the real tax rate will vary from month to month even if there is no nominal change in the tax rate.

The excise taxes on cigarettes vary widely across states and over time. For instance, in 1989 the nominal value of the state cigarette tax in North Carolina was $0.02 per pack while in Connecticut it was $0.40 per pack. In addition, over the 1989 to 1992 time period, twenty-nine states changed the rate at which cigarettes are taxed at least once. One of the largest changes took place in Washington, D.C. where the tax rate rose from $0.17 in 1989 to $0.50 by 1992. That there is significant variation in the tax rate within states and over time is important because it enables us to identify the effect of tax changes on smoking behavior. Further, it is important to note that because there is the cross sectional and time series variation in taxes, we can include state and time fixed effects in the model. The time effects capture those factors that change smoking over time that impact all women, such as changing attitudes towards smoking. The state effects on the other hand capture permanent differences in smoking across states. The state of Utah provides an example of why state fixed effects are very important. Utah has a relatively high tax rate on cigarettes and low rate of smoking participation. On the surface, it would appear that the high taxes are causing the low smoking participation rate. Another possibility, however, is that Utah has a large population of Mormons, a religious group that discourages smoking among its members. Thus, there may be a higher than average negative public sentiment toward smoking in Utah, making it more politically feasible to increase state excise taxes on cigarettes. Tobacco producing states are also good examples of why the inclusion of state fixed effects is necessary. In such states taxes are low and smoking rates are relatively high. It is not clear that the low tax leads to high rates of participation. It is likely that the tobacco growers are a strong lobby in these states, making it difficult to raise cigarette taxes. Further, public acceptance of smoking behavior may be higher than average, as many residents' livelihoods depend on the health of the tobacco industry. Therefore, without state fixed effects to control for such problems, the estimate of the effect of taxes on smoking behavior will likely be subject to an omitted variables bias.

Merging the Individual and State Level Data

The individual level data is merged together with the tax data based on the state where the birth occurred and the month the infant was conceived. The Natality data reports both the state of occurrence of the birth and the state of residence of the mother, which, in the vast majority of cases is the same. For those women where these differ, it is difficult to determine what the relevant tax rate is. We have chosen to use the tax rate from the state of occurrence because it is the only state that we know for certain that the woman was in during the pregnancy.

Table 1 defines the main variables used and reports their sample means and standard deviations. The average birth weight in the sample is 3366.28 grams (7 pounds 6 ounces). Approximately 6 percent of the births are moderately low birth weight and 1 percent are extremely low birth weight. Maternal smoking during pregnancy is not uncommon in this sample. Roughly 17 percent of mothers report being a smoker with the average number of cigarettes smoked per day is 2.2. This mean, however, includes zeros for all non smokers. Among women who smoke during pregnancy, the average number of cigarettes smoked per day is approximately 13.

Smoking participation rates broken down by a number of different demographic characteristics are presented in Table 2. Between different subgroups of the sample the smoking participation rate varies significantly. Education appears to be a strong predictor of smoking behavior. Twenty-seven percent of women who have less than a high school education smoke during pregnancy, while only 4 percent of women who graduated from college smoke while they are pregnant. As with smoking rates for all adults, among pregnant women, whites smoke at higher rates than blacks.

Aspects of the relationship between smoking and birth weight can be seen by plotting the mean of each variable by the month of conception. Figures three and four show that while there appears to be a slight downward trend in birth weights during the sample period, there are wide seasonal variations. A similar pattern is seen for smoking participation rates. What is interesting to note is that the troughs in smoking participation correspond directly with the peaks in birth weight. This relationship suggests that maternal smoking does negatively impact birth outcomes. Further, observed seasonal patterns in births indicate that July and August are the months in which there is the smallest number of conceptions. July and August also appear to be the months of conception with the lowest smoking participation rates and the highest ultimate birth weights. There is evidence to suggest that hot weather depresses conceptions (Lam and Miron 1993; Ringel 1996).[9] As a result, it is possible that high ambient temperatures alter the mix of planned and unplanned conceptions in the hot summer months. Couples that are trying to become pregnant may not be deterred by high temperatures in the same way that couples who are not planning to become pregnant. Thus, it is possible that a greater number of those who conceive during the summer were trying to become pregnant. If this is the case, then the means of the smoking participation and infant birth weight would suggest that women who were planning to become pregnant are less likely to smoke during pregnancy than are women whose pregnancy was unplanned.

A Note About Sample Sizes

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[9]Hot weather is believed to depress conceptions through two distinct avenues. The physiological argument indicates that high temperatures decrease sperm quality and thus, reduce the probability of conception. The behavioral argument suggests that hot weather makes people uncomfortable and reduces the frequency of sexual intercourse, thus reducing the risk of conception.

At first blush, some may consider our use of 10.5 million observations as overkill. We should note at the outset that given the question we want to address, extremely large sample sizes are required. Until very recently there have been modest year-to-year changes in state tax rates on cigarettes. If previous estimates of the elasticity of demand for smoking are any guide in this context, the change in smoking from these tax hikes will alter smoking slightly and therefore, any subsequent change in birth weight should be quite small. Given these small changes, the number of observations needed to detect a statistically significant link between taxes and birth weight is staggering. To see this, consider the following simple thought experiment. Suppose taxes are increased for a certain population by ΔT cents per pack. Let the indicator $t_i=1$ if women i was subject to a tax increase and 0 otherwise. The change in birth weight brought about by the tax hike is given by the difference in means $\hat{d}_n = [(\bar{y}|t_i=1) - (\bar{y}|t_i=0)]$ and the variance of this estimate is defined as $Var(\hat{d}_n)=(\hat{\sigma}^2_1/n_1)+(\hat{\sigma}^2_2/n_2)$ where n_t is the number of observations for t=1 or 0 and $\hat{\sigma}^2_t$ is the variance in birth weight for this group. For simplicity, assume that $n=n_1=n_2$ and $\hat{\sigma}^2=\hat{\sigma}^2_1=\hat{\sigma}^2_0$.[10] The magnitude of $\hat{d}_n$ will be a function of i) the size of the tax change, ii) the impact if taxes on smoking, and iii) the impact of smoking on birth weight. Using the notation from the estimation equations above, $\hat{d}_n = \Delta T\, \gamma_2\, \beta_2$. Noting from equation (4) that $\gamma_2= e_d(\partial P/\partial T)(\bar{s}/\bar{p})$, we can write $\hat{d}_n$ as $\Delta T\, \beta_2\, e_d(\partial P/\partial T)(\bar{s}/\bar{p})$. For the estimate of $\hat{d}_n$ to be statistically significant, it must be the case that $|\hat{d}_n/(2\,\hat{\sigma}^2/n)^{.5}|>1.96$ which implies that $n>2(1.96)^2\,\hat{\sigma}^2/\hat{d}_n^{\,2}$ or $n>2(1.96)^2\,\hat{\sigma}^2/[\Delta T\beta_2 e_d\,(\partial P/\partial T)(\bar{s}/\bar{p})]^2$. This calculation demonstrates that the required number of observations necessary to detect a statistically significant impact declines as either the tax change, the elasticity of demand, or the impact of smoking on birth weight increased.

[10]The variance of the means of the control and treatment groups are not expected to be the same in practice. Since the mean birth weight for the treatment group (the group that faces the higher cigarette tax) is expected to be larger, the variance for the treatment group should then be slightly larger than the variance of the mean birth weight in the control group.

To give some indication as to how many observations are needed under different scenarios, we conducted a simple simulation. First, we fixed a number of parameters. From previous work, we set $(\partial P/\partial T)=1.15$, from Table 1, $\hat{\sigma}=573.1$ and $\bar{s}=0.17$. Data from the *Tax Burden on Tobacco* also indicates that the average retail price per pack ($\bar{p}$) in real 1982-4 dollars is 120 cents, Among those states that experienced nominal changes in the tax on cigarettes during the 1989 to 1992 period, the average difference in real tax rates (ΔT) between the beginning and end of the sample period is about five cents. A mid-range estimate of the participation elasticity of demand (e_d) is -0.3, and a ballpark estimate suggests that smoking reduces birth weight by 300 grams (β_2) . These numbers would suggest that we would need 4.7 million observations in both the treatment and control group, or 9.4 million observations in all to detect a statistically significant relationship between taxes and birth weight.

While the number of observations from the Natality data appears adequate to detect an impact of taxes on birth weight, the data set is too small to detect an impact of taxes on low birth weight frequencies. Suppose smoking increases the probability of a low birth weight birth by 0.06 percentage points which is roughly equal to the sample mean. From table 1, we note that $\hat{\sigma}^2=0.2348$. Holding all other parameters constant, our estimates suggest that given the modest tax changes that occurred over the 1989-1992 time period, we would need 19.7 million observations in each of the treatment and control groups, or 39.4 million observations in total to detect a statistically significant impact of taxes on low birth weight rates.[11] Although we do not expect to detect an impact of taxes on low birth weight rate, we still generate estimates for this outcome.

[11]In recent years, a number of states have instituted rather large hikes in cigarette taxes. These changes greatly reduce the sample sizes necessary to detect the effects of interest. For example, in May of 1994, Michigan increased taxes by 50 cents per pack. Given a tax change of this magnitude and holding all other parameters constant, we would only need 45,600 observations in both the treatment and control groups to detect an impact on birth weight and 197,000 observations in each of the samples to detect an effect on low birth rates. Since there are roughly 150,000 births per year in Michigan, comparing the changes in outcomes for the 18 months before and after the tax hike in Michigan to similar changes in well-chosen control states should provide adequate sample sizes.

The Impact of Smoking on Birth Weight: Some OLS Estimates

It is often of useful when employing an instrumental variable procedure to first look at the single equation estimates of interest which can be used as a basis of comparison for the instrumental variable estimates. Using the natality data, we estimate a number of single equation models of the effect of maternal smoking during pregnancy on infant birth weight. The first four models estimated focus on the effect of the smoking participation during pregnancy, but vary with respect to the other covariates that are included. In each successive model, we add another group of covariates. In the most simple model, the smoking variable is accompanied by only state and month of conception effects on the right-hand side. The second model adds the group of demographic variables: age and race of the mother, as well as the sex of the infant. Next, we include state specific time trends which are used to control for state-level factors that may be changing over time. Finally, in the fourth model, we add the socioeconomic status proxy variables: parity of the birth, educational attainment of the mother, and marital status. The results in table three suggest that the effect of smoking on birth weight is robust across all specifications. The estimated reduction in birth weight attributed to smoking participation ranges between 238 and 253 grams (8.4 and 8.9 ounces). These results are quite similar to those found in previous observational studies that did not control for the possible endogeneity smoking behavior. The consensus from these studies is that maternal smoking reduces birth weight in the range of 150 to 250 grams (5.3 to 8.8 ounces) (Aronson et al. 1993). The ordinary least squares estimates also indicate that there is a dose-response relationship between cigarettes and birth weight. The results suggest that, on average, infant birth weight is decreased by approximately 15 grams per cigarette smoked per day.

As seen in the second row of table 3, smoking participation increases the probability of having a low birth weight baby by 5 percentage points. Given that the mean rate of low birth weight in the population is 5.8 percent, this is a large effect. The low birth weight equations also indicate a dose-response relationship. The risk of low birth weight increases by 0.3 percentage points per cigarette smoked per day. A similar pattern of results is found in the very low birth weight equations. Smoking participation increases the mean risk of very low birth weight by nearly 50 percent.

Reduced-Form Estimates

Even if women are responsive to changes in the price of cigarettes, it may be the case the effect is too small to translate into identifiable birth weight benefits. In this section, we present estimates of the reduced-form relationships between taxes and maternal smoking and taxes and birth weight. The results suggest that women are responsive to changes in the price of cigarettes and that higher taxes can in fact improve birth outcomes.

The Effect of Cigarette Taxes on Maternal Smoking Behavior

Although there is a considerable body of evidence showing that the population in general is responsive to changes in cigarette prices, no study to date has shown this to be true specifically for pregnant women. Regardless of the lack of empirical evidence, some public health officials have advocated the use of cigarette taxes to reduce cigarette consumption among pregnant women. We estimate eight variations of the general model. The first four models use the smoking participation indicator as the dependent variable, but vary in terms of the explanatory variables that are included. The first variation includes only the state effects, time effects, and the real tax rate on the right-hand side. Each successive variation builds on the previous model by adding a new set of covariates. A similar set of models is estimated using the average number of cigarettes smoked per day as the dependent variable. The results from the various specifications are presented in Table 4.

The first-stage estimates indicate that pregnant women are responsive to changes in cigarette taxes. As you move across row 1 of table 3, it is evident that the effect of the cigarette tax on smoking participation is robust to model specification. As more covariates are added, the absolute value of the coefficient falls from 0.0005 to 0.0004. These estimates indicate that a one cent real tax increase would lead to approximately a 0.04 percentage point reduction in the mean rate of smoking participation. The price elasticity of participation ranges between -0.23 and -0.33 depending on the model specification.

The estimates of the effect of excise taxes on the average number of cigarettes smoked per day are consistent with the finding that pregnant women are responsive to changes in cigarette prices. One puzzling result, however, does arise. The price elasticities of demand that are indicated by this model are either similar to or smaller than the participation elasticities. It should be the case that the elasticities of demand from the quantity of cigarettes smoked model encompass both the participation effect and the quantity effect. The expected result would thus be that the participation elasticities are smaller than the quantity elasticities. One explanation for the results in this study is that the effect of taxes on smoking works solely through participation. If this is the case, then the two sets of elasticities should be the same. This phenomenon can be investigated by estimating the price elasticity of demand for cigarettes for a sample that includes only those women who are smokers. The results of this estimation indicate that for those that continue to smoke, taxes do not affect the quantity smoked. As seen in table four, we find that for smokers the price elasticity of demand for cigarettes is only -0.01 and is not statistically significant. The reduction in smoking that is found in the full sample appears to be driven entirely by the women who quit smoking.

The Effects of Excise Taxes on Birth Weight

The previous estimates indicate that the tax rate is correlated with smoking behavior. In this section, we examine whether these tax increases actually translate into better birth outcomes. If smoking has a causal impact on birth weight, a tax increase should cause smoking participation among pregnant women to fall and thus, birth weight to increase. Such a result can be seen in the reduced-form estimates in Table 5. Two variations of each reduced-form model are estimated. The first includes only state and month of conception effects as additional covariates. The second model builds on the first by adding the exogenous variables on the right-hand side.

As expected, the reduced-form estimates indicate that taxes have a positive effect on birth weight. In moving from column one to column two in the first row in table five, the effect of taxes on birth weight increases slightly. In the first model, a one cent increase in the state tax rate on cigarettes increases average birth weight by 0.14 grams. When the exogenous covariates are added to the model, the birth weight increase is approximately 0.16 grams per one cent increase in the tax.

The results in Table 5 also suggest that higher cigarette taxes decrease the fraction of low birth weight infants, but this estimate is not statistically distinguishable from zero. As we noted above, however, the lack of statistical significance is expected. As we show below, however, the results is of plausible magnitude. More interestingly however is the impact of taxes on the fraction of extremely low birth weight infants. The estimates in the final two columns of Table 5 suggest that higher taxes actually increases the fraction of these infants. A cynical interpretation of this results would be that smoking actually improves prospects for very low birth weight infants. However, we believe the exact opposite is possibly indicated. Studies have shown that smoking during pregnancy increases the risk of fetal loss (Stein et al. 1981; Ahlborg and Bodin 1991; Armstrong et al. 1992). This result suggests that if higher taxes reduce maternal smoking then the higher taxes may also change the composition of babies that make it into our sample. The Natality data tapes only include live births. If smoking reduces the chance that a baby is born alive and these babies are small relative to the population, a tax increase may actually increase the fraction of extremely low birth weight babies by having more infants survive until birth. Since this is a small fraction of children, the changing sample composition may contaminate the very low birth weight results.

Instrumental Variables Estimates -- The Impact of Smoking on Birth Weight

There is clear scientific evidence that there is a negative correlation between maternal smoking during pregnancy and infant birth weight. That this relationship is causal, however, is not so clear. It has been argued that smokers have different discount rates that non-smokers (Farrell and Fuchs, 1982; Evans and Montgomery, 1994). If smokers put less value on the future, they may be more likely to have other bad habits that will affect their long term health. If the smoking participation indicator is a proxy for the discount rate, the single equation estimate would overstate the effect smoking on birth weight. It is also possible that the unobserved health habits may modify the effects of smoking on birth weight. In this case the direction of the bias of the single equation estimate will be ambiguous because the relationship between smoking participation and the unobserved characteristics is unknown. In this section, we use the reduced-form estimates from the previous section to isolate the effect of maternal smoking on birth weight. In this case, we use the variation in smoking generated by changes in state excises taxes as an instrument for smoking in a birth weight production function. Since the model is exactly identified, the IV estimates are simply the ratio of the tax coefficients in the birth outcomes and smoking participation equations.

Estimates

The instrumental variable (IV) estimates of equation (3) are presented at the bottom of Table 5. The first two columns present the IV estimates from the birth weight equations. The estimates of the moderately and extremely low birth weight indicator equations are presented in the following four columns. For each set of equations, four models are estimated. The first two include the smoking participation indicator as the endogenous variable of interest, but vary with respect to the covariates that are included. Similarly, two models are estimated where the average number of cigarettes smoked per day is the endogenous right-hand side variable. The estimates of the effect of smoking participation on infant birth weight indicate that smoking during pregnancy causes mean birth weight to decrease by approximately 367 grams (13 ounces).[12] Two interesting results should be noted. First, that maternal smoking does have a causal impact on birth weight and second, that the effect is larger than what is found in single equation studies. The unobserved heterogeneity story suggests that smokers have a variety of other bad health habits that confound the problem of low birth weight. Such an argument would indicate that the single equation estimates overstate the effects of tobacco use as it is serving as a proxy for all the unobserved characteristics. That we find an instrumental variable estimate that is larger than the single equation estimate suggests that this argument is not correct. One explanation for this finding could be that an increase in cigarette taxes leads those with the highest marginal benefit of reducing cigarette consumption to quit. As a result, the instrumental variable estimate will be larger than the ordinary least squares estimate.[13] We shall return to this issue in detail below.

Although the precision of the instrumental variable estimates seems low based on the number of observations used in the study, recall the earlier simulation. The simulation indicated that approximately 10 million observations would be needed in order to identify an effect of the magnitude we found. After imposing the necessary sample restrictions, the data set used contains more than 10.5 million observations. Thus, a t-statistic of 2.16 on the coefficient of smoking participation in the birth weight equation is about as high as we can reasonably expect to obtain.

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[12]The importance of controlling for permanent differences across states can be seen when we estimate some of the basic models without state effects. In the reduced-form models where we use taxes, month of conception effects and the basic demographic variables as the covariates, the coefficients (standard errors) on tax in the smoking participation and birth weight equations are -0.001119 (0.000015) and 1.068 (0.0228) respectively, which are two and seven times the size of the estimates with state effects. The smoking participation price elasticity for this model is about -0.73. The implied 2SLS impact of smoking on birth weight is -963 grams, about 2.5 times the impact of our estimates and the results from clinical trials.

[13]A similar argument is made by David Card (1994) in a survey of the returns to education literature. He suggests that instruments such as proximity to a four year college induce those with the greatest marginal benefit to obtain additional education. Thus, the resulting change in wages is greater than what the ordinary least squares estimates would predict.

Comparison of Estimates from Instrumental Variable Procedures and Randomized Trials

As noted above, one unexpected aspect of our IV estimates is that the impact of smoking on birth weight appears to be larger in the IV models than in the OLS estimates. The hypotheses we offered above all suggest that the OLS estimate should be biased upward. According to the evaluation models of Imbens and Angrist (1994) and Angrist, Imbens, and Rubin (1996), IV estimates measure the average impact of the endogenous covariate of interest on the outcome for those individuals whose behavior is changed as a result of receiving the instrument. In this case, the IV estimate measures the average impact of smoking on birth weight for those women who changed their smoking behavior due to a small change in the cost of cigarettes. If these women are in some respects different from other smokers, then the IV estimate may be either smaller or larger than the OLS estimates.

Fortunately for our research, there is a randomized clinical trial that allows us to gauge whether our results are in some respects reasonable. The advantage of controlled trials is that the random assignment of subjects into treatment and control groups allows the researcher to isolate the effect of the treatment without omitted variables bias. For the case of maternal smoking, the use of randomized trials raises some ethical issues. Researchers are not prepared to force some pregnant women to consume cigarettes while they are pregnant so that effects of smoking can be measured. As a result, researchers have been forced to design experiments that avoid selection issues, but do not encourage or promote poor health outcomes. Sexton and Hebel (1984) provide a unique solution to the problem. Their study focused only on pregnant women who were smokers at the time of the initial interview. These women were randomized into either the treatment group where they received standard prenatal care as well as extensive smoking cessation counseling during their pregnancies, or a control group that received only standard prenatal care.

Sexton and Hebel found that the smoking cessation intervention was successful. After random assignment, the fraction of women that smoked in the treatment group was 23 percentage points lower than it was in the control group. Birth outcomes were also better in the treatment group with mean birth weight being 92 grams higher than comparable levels for the control group. The fraction of low birth weight babies also fell by 2.1 percentage points as a result of the treatment. Interestingly, the fraction of very low birth weight babies increased by 1.1 percentage points.

In an extension to the earlier work, Permutt and Hebel (1989), use the data from the clinical trial to estimate the impact of smoking during pregnancy on infant birth weight. They use the intervention as an instrument for smoking behavior to obtain an estimate of the causal impact of smoking on birth weight. Consider a bivariate regression model

(5) $$y_i = \alpha + \beta x_i + \epsilon_i$$

where y_i is birth weight and x_i is a measure of the average number of cigarettes that a woman smoked per day during her pregnancy. Let z_i denote the binary instrument which is equal to one if the woman received smoking cessation counseling (was a member of the treatment group). The instrumental variable estimate of the effect of smoking in this model is given by

(6) $$\beta_{IV} = [(\bar{y}|z_i=1) - (\bar{y}|z_i=0)] / [(\bar{x}|z_i=1) - (\bar{x}|z_i=0)]$$

where $(\bar{y}|z_i=1)$ is the mean of y_i for those observations for with $z_i=1$ and the other terms are similarly defined. This is the now famous Wald estimate that was introduced into evaluation research by Angrist (1990). Given this model, the causal impacts of smoking on birth weight can be calculated from the data collected in the controlled trial. The IV estimates (standard errors) of smoking on birth weight, low birth weight, and very low birth weights from the controlled experiment are -400 (177), 0.091 (0.074), and -0.034 (0.034).

The similarity between the instrumental variable estimate and the randomized trial results are striking. Our instrumental variable estimate for the birth weight equation is only 33 grams (1 ounce) smaller than the estimate in Permutt and Hebel. It appears that the instrumental variable procedure is able to replicate the randomized trial results relatively well. Similarly, our estimate of the impact of smoking on low birth weight probabilities of 0.11 is only 20 percent larger than the results from the trial. Lastly, the random trial also generates estimates that smoking cessation increases the fraction of very low birth weight babies with our IV estimate being 1 percentage point larger than the estimates from the randomized trials. The results from our evaluation of the tax hike experiment appear to be very close to estimates from clinical trials.

Summary and Conclusions

The consumption of cigarettes is believed to have significant adverse effects on the health of smokers as well as on the health of those around them. As a result, health policy makers have searched for effective methods of reducing the rate of smoking participation in the population. One policy that has been widely used at both the state and federal levels are excise taxes on cigarettes. Supporters of sin taxes put forth a barrage of arguments in favor of excise taxes on cigarettes. These arguments range from internalizing externalities associated with smoking to improving smokers' perception of the risks associated with cigarette consumption. In the case of maternal smoking, policy makers expect increased excise taxes to discourage maternal smoking during pregnancy. The problem, however, is that there is little scientific evidence that such a reduction would actually lead to birth weight improvements and thus, there is no basis for making a judgement as to the benefits of such a policy. The estimates from this study provide a basis for determining the birth weight benefits associated with an excise tax increase.

The first-stage estimates indicate that pregnant women are responsive to changes in the price of cigarettes. To obtain a better understanding of the magnitude of these effects, consider a fifty cent per pack cigarette tax increase.[14] An increase of this size reduces the mean rate of smoking participation by roughly eight percent (one percentage point). Our estimates also suggest that the tax changes are

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[14]A fifty cent tax increase in 1997 dollars is equal to a thirty-one cent increase in 1982-84 dollars. The calculations determining the impact of the tax change on birth weight and smoking behavior use the real value of the tax increase.

translated directly into higher birth weights. In fact, the results indicate that a fifty-cent tax increase would prevent 6200 low weight births from occurring in a given year.[15]

It is important to keep in mind, however, that cigarette taxes are a blunt policy instrument. It is not possible to selectively tax specific consumer groups such as pregnant women. Taxes will be imposed on all smokers, but the benefits received and costs imposed extend beyond the targeted population. As such, in making any sort of policy judgement the full costs and benefits must be considered.

One way to measure the cost of increasing the cigarette tax is the change in the excess burden generated by the tax hike. Inefficiencies in the cigarette industry are generated by both the fact that cigarettes are not priced at marginal cost and that they are subject to an excise tax. Suppose cigarettes are produced with constant returns to scale technology. If P1 is the current retail price for cigarettes (inclusive of taxes) and MC is the marginal cost of production, then area I in Figure 5 is the current excess burden in the industry. If after a tax hike retail prices rise to P2, the marginal excess burden generated by the tax hike is areas II+III. If demand is linear from Q2 to Q1,[16] then this area can be approximated by [0.5(P2-P1)+(P2-MC)](Q1-Q2).

In 1995, the *Tax Burden on Tobacco* notes that there were 23.2 billion packs of cigarettes sold at an average retail price of $1.758/pack. Based on evidence presented earlier, a 50-cent increase in taxes will increase retail prices by 1.15*50=57.5 cents to $2.333 per pack, which is a 32.7 percent increase in price. If the elasticity of demand is -0.5 which is a reasonable number, then demand should be expected to fall by 16.4 percent to 19.4 billion packs per year. To obtain an estimate of the marginal cost, we note that Roberts and Samuelson (1988) found that the two largest cigarette manufactures operate at constant returns to scale, so estimates of average variable cost should be a good proxy for marginal cost. Howell *et al.* (1994) note that in 1990, cigarette manufactures produced about 675 billion cigarettes (for both

[15]This calculation is based on there being 4,000,000 births recorded in a given year.

[16]This is not a critical assumption since area II is small relative to area III.

domestic consumption and export) and spent roughly $6.25 billion on materials and labor, which is 18.5 cents per pack or 21.57 cents/pack in 1995 dollars. Using these figures, we calculate that the 50-cent tax hike will generate an additional $6.94 billion in excess burden which is $1.09 million per prevented low birth weight. To put this figure in perspective, using estimates from a recent paper by Currie and Gruber (1996) we calculate that the targeted Medicaid expansions of the late 1980's cost nearly 194,000 dollars per low birth weight birth prevented. Under the naive assumption that the only benefits of the tax are received in the form of improved birth outcomes the excise tax does not appear to be a cost-effective policy.[17]

Given the evidence presented in this paper we can conclude that for the targeted group, pregnant smokers, taxing cigarettes may be a very effective policy. However, the mean effects of the policy will be very small. Approximately 83 percent of pregnant women will not be affected by the tax change and thus, will not receive any birth weight benefits. In addition, the excess burden of the tax is quite large, reflecting the fact that the tax is imposed on all smokers not just pregnant women. As a consequence we must realize that taxing cigarettes is not a magic bullet that will solve the problems of low birth weight and infant mortality.

[17]There are clearly other health benefits that will accrue to a broader range of people who reduce their cigarette consumption as a result of the increased cigarette taxes. As such, the estimate of cost effectiveness presented could be seen as an upper bound.

Figure 1: Number of Observations, By Month of Conception, 1989-92

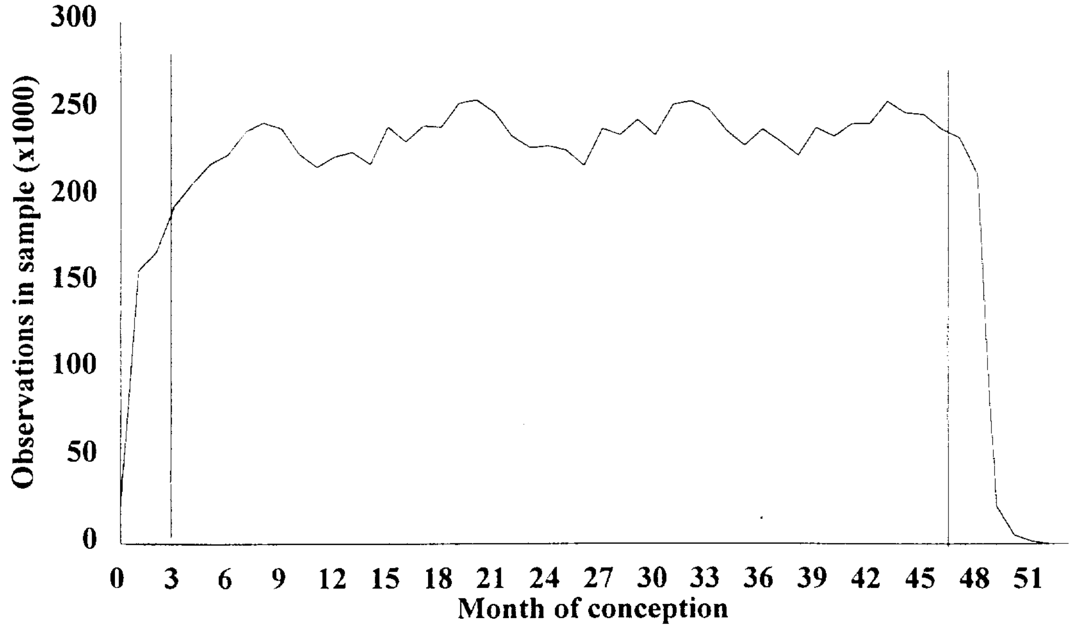

Figure 2: Average Birth Weight, By Month of Conception, 1989-92

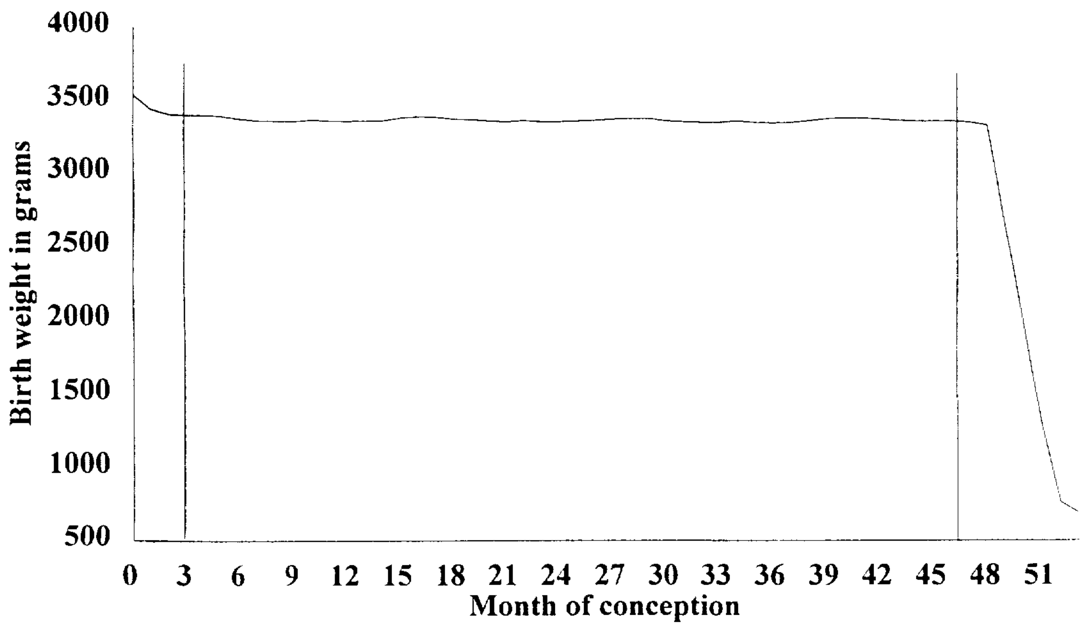

Figure 3: Average Birth Weight
By Month of Conception

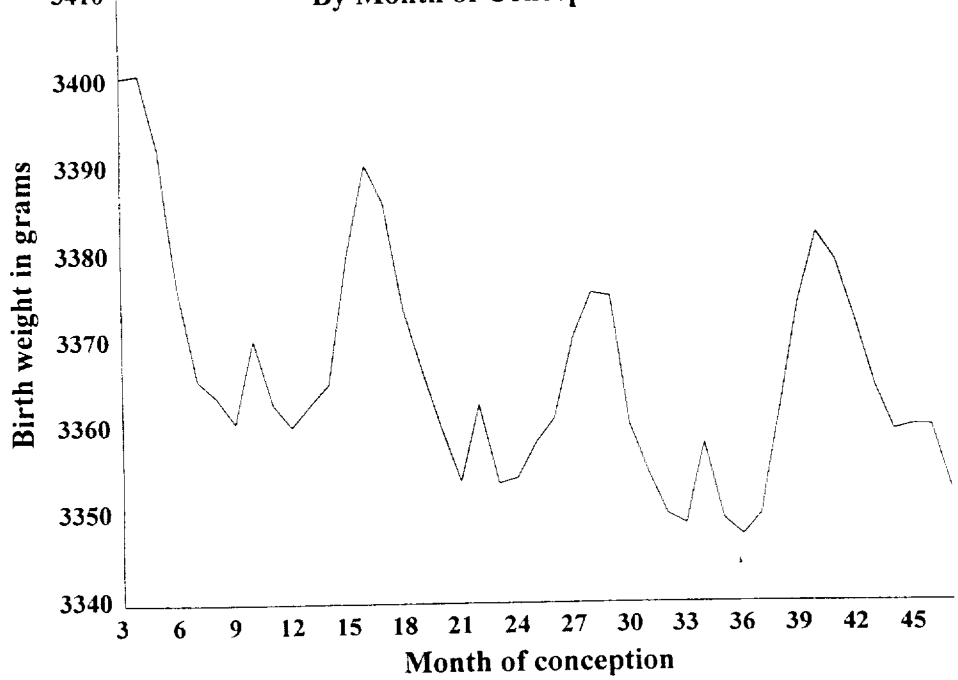

Figure 4: Smoking Participation
By Month of Conception

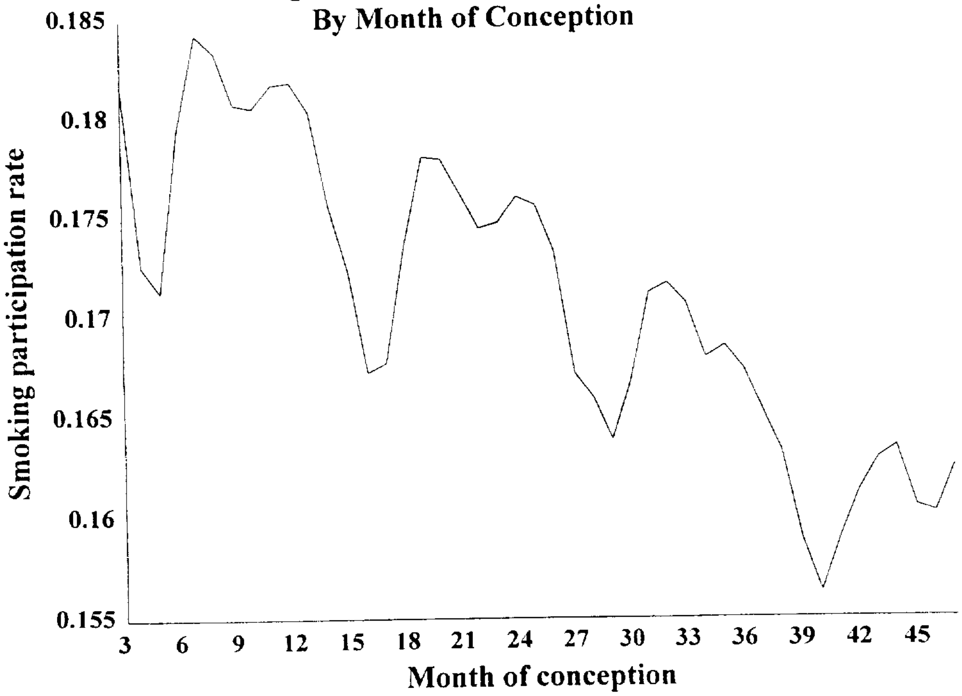

Figure 5: Marginal Excess Burden

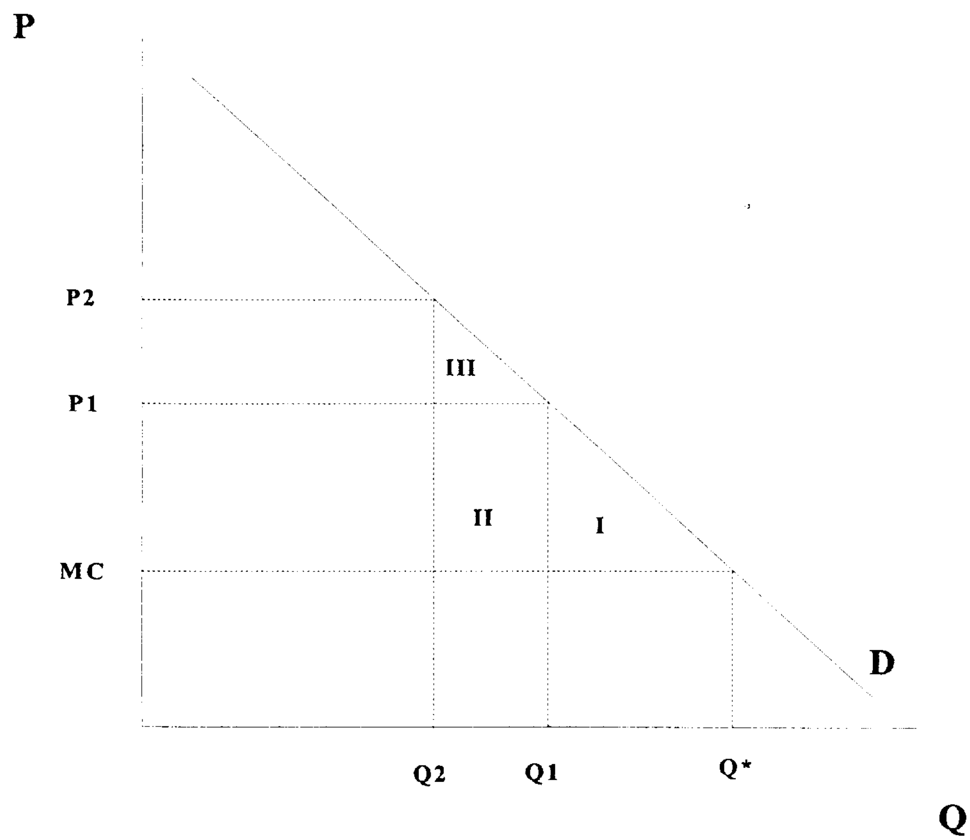

Table 1
Descriptive Statistics
Natality Detail Data, 1989-1992

Variable	**Definition**	**Mean (standard deviation)**
Birth weight	Birth weight in grams	3366.28 (573.11)
≤2500 grams	Indicator variable, =1 if birth weight ≤2500 grams	0.0586 (0.2348)
≤1500 grams	Indicator variable, =1 if birth weight ≤1500 grams	0.0092 (0.0956)
Smoker	Indicator variable, =1 if mother smoked during pregnancy	0.1709 (0.3765)
Cigarettes/day	Average cigarettes smoked per day during pregnancy (non-smokers equal 0)	2.191 (5.876)
Tax	Average real tax per pack (State+Federal) in cents (1982-84 dollars)	30.466 (7.820)

Table 2
Smoking Participation Rates
Natality Detail File, 1989-1992

	Fraction of sample in each subgroup	Rate of smoking participation
Age Groups		
age 19 and below	0.1311	0.1909
age 20 to 24	0.2689	0.2052
age 25 to 29	0.3028	0.1652
age 30 to 34	0.2114	0.1424
age 35 and above	0.0858	0.1238
Education Levels		
less than high school diploma	0.2357	0.2707
high school graduate	0.3786	0.1992
attended some college	0.2048	0.1188
college graduate	0.1808	0.0407
Parity of birth		
first birth	0.4102	0.1420
second birth	0.3271	0.1720
third birth	0.1621	0.2051
fourth or greater birth	0.1006	0.2304
Racial Groups		
White	0.7899	0.1801
Black	0.1760	0.1444
Other Race	0.0341	0.0952
Marital Status		
Married	0.7287	0.1365
Single	0.2713	0.2636
Sex of child		
boy	0.5121	0.1709
girl	0.4879	0.1709

Table 3
Single Equation Estimates,
Smoking Equations,
Natality Detail Data, 1989-1992
Number of Observations = 10,547,199

Dependent Variable	Coefficient (standard error) on *Smoker*				Coefficient (standard error) on *Cigarettes/day*			
Birth weight	-242.73 (0.4648)	-252.59 (0.4555)	-252.62 (0.4555)	-237.94 (0.4827)	-13.80 (0.0298)	-15.13 (0.0292)	-15.13 (0.0292)	-14.16 (0.0307)
≤2500 grams	0.0516 (0.0002)	0.0544 (0.0002)	0.0544 (0.0002)	0.0482 (0.0002)	0.0030 (0.0001)	0.0033 (0.00001)	0.0033 (0.00001)	0.0029 (0.00001)
≤1500 grams	0.0047 (0.00008)	0.0053 (0.00008)	0.0053 (0.00008)	0.0044 (0.00008)	0.0002 (0.00001)	0.0003 (0.00001)	0.0003 (0.00001)	0.0003 (0.00001)
Month effects?	yes	yes	yes	yes	yes	yes	yes	yes
State effects?	yes	yes	yes	yes	yes	yes	yes	yes
Demographic covariates?		yes	yes	yes		yes	yes	yes
State-specific time trends?			yes	yes			yes	yes
Socioeconomic covariates?				yes				yes

Table 4
First-Stage Estimates
Natality Detail Data, 1989-1992
Number of Observations = 10,547,199

(Standard errors in parentheses)

Variable	*Smoker* equations				*Cigarettes/day* equations				Only Smokers *Cigarettes/day* equations			
Cigarette tax	-0.0005 (0.00005)	-0.0004 (0.00005)	-0.0004 (0.00007)	-0.0004 (0.00007)	-0.0044 (0.0008)	-0.0028 (0.0007)	-0.0045 (0.0011)	-0.0047 (0.0011)	-0.00079 (0.0029)	-0.0015 (0.0028)	-0.0009 (0.0038)	-0.0015 (0.0038)
Implied elasticity of demand	-0.33	-0.27	-0.23	-0.23	-0.21	-0.13	-0.21	-0.22	-0.006	-0.01	-0.007	-0.01
R^2	0.016	0.032	0.032	0.123	0.014	0.028	0.028	0.111	0.020	0.063	0.062	0.095
Month effects?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
State effects?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Demographic covariates?		yes	yes	yes		yes	yes	yes		yes	yes	yes
State-specific time trends?			yes	yes			yes	yes			yes	yes
Socioeconomic covariates?				yes				yes				yes

Table 5
Reduced-Form and 2SLS Estimates,
Natality Detail Data, 1989-1992
Number of Observations = 10,547,199

(Standard errors in parentheses)

Variable	*Birth Weight*		*Low Birth Weight*		*Extremely Low Birth Weight*	
	Reduced-form Estimates		Reduced-form Estimates		Reduced-form Estimates	
Cigarette tax	0.1411 (0.0770)	0.1623 (0.0750)	-0.00005 (0.00003)	-0.00005 (0.00003)	0.00002 (0.00001)	0.00002 (0.00001)
	2SLS Estimates		2SLS Estimates		2SLS Estimates	
Smoker	-261.30 (142.77)	-368.86 (170.45)	0.0926 (0.0554)	0.1136 (0.0608)	-0.0315 (0.0158)	-0.0432 (0.0216)
	2SLS Estimates		2SLS Estimates		2SLS Estimates	
Cigarettes/day	-32.07 (17.52)	-57.96 (26.78)	0.0114 (0.0068)	0.0179 (0.0107)	-0.0039 (0.0020)	-0.0068 (0.0034)
Month effects?	yes	yes	yes	yes	yes	yes
State effects?	yes	yes	yes	yes	yes	yes
Demographic covariates?		yes		yes		yes

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