An Econometric Exploration of Maternal Smoking and Infant Birth Weight

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Abstract:

This study investigates the determinants of infant birth weight using econometric models that include maternal smoking, gestational length, and additional control variables. Utilizing data from the CDC National Survey of Family Growth, the analysis aims to shed light on the impact of maternal behaviors on neonatal health outcomes. The coefficients provide insights into the associations between maternal smoking, gestational length, and infant birth weight. This research contributes to the broader understanding of factors influencing birth weight outcomes, offering implications for evidence-based policies and interventions aimed at enhancing neonatal health.

Introduction

In the realm of public health and developmental economics, a crucial area requiring thorough investigation is the intricate relationship between maternal behaviors and infant outcomes. Within this context, maternal smoking—before pregnancy, during pregnancy, and post-pregnancy—emerges as a compelling subject of study, carrying profound implications for both maternal and child health (Bharadwaj, Johnsen, Løken, 2014).

As the global community grapples with the intricacies of healthcare provision and the pursuit of optimal child development, gaining a nuanced understanding of the impact of maternal smoking on infant birth weight becomes imperative for evidence-based policy-making (Bernstein, Mongeon, Badger, Solomon, Heil, Higgins, 2005). The objective of this research is to present an economic model that elucidates the effects of maternal smoking on infant birth weight.

Efforts to curb maternal smoking in the United States have been multifaceted, incorporating a blend of public health campaigns, policy initiatives, educational programs, and clinical interventions (Lumley, Chamberlain, Dowswell, Oliver, Oakley, Watson, 2009). Despite notable strides in reducing maternal smoking rates, challenges persist, necessitating ongoing, comprehensive endeavors to tackle this public health issue and enhance outcomes for pregnant women and their infants.

Pregnant women who smoke cigarettes face an increased risk of delivering low birth weight infants (Lewandowska, Więckowska, Sztorc, Sajdak, 2020). Maternal smoking during pregnancy has long been acknowledged as a potentially detrimental factor influencing various

aspects of fetal development, with birth weight serving as a key metric reflecting the overall health and well-being of the newborn. Beyond immediate risks to neonatal health, low birth weight carries lasting consequences, impacting cognitive development, susceptibility to chronic diseases, and shaping the overall trajectory of an individual's life (Wilcox, 1993).

Extensive research on women smoking during pregnancy has unfolded over several decades, with a primary focus on comprehending the risks and consequences associated with maternal smoking for both the mother and the developing fetus (Ward, Lewis, Coleman, 2007).

Offspring born to mothers who smoke during pregnancy exhibit a higher likelihood of having a lower birth weight compared to those born to non-smoking mothers (Cnattingius, 2004). This reduced birth weight emerges as a significant risk factor for various health issues in newborns. Furthermore, maternal smoking has been correlated with an elevated risk of preterm birth—delivery occurring before 37 weeks of gestation—which can lead to a spectrum of health complications for the infant, encompassing respiratory and developmental issues.

Low birth weight stands out as a critical indicator of neonatal health, as infants with lower birth weights face increased risks of complications such as respiratory distress syndrome, infections, and developmental delays (Knopik, Maccani, Francazio, McGeary, 2012).

While numerous studies have delved into the correlation between maternal smoking and infant birth weights, there has been a relative scarcity of economic models in this domain. The establishment of an economic model for maternal smoking and infant birth weight proves advantageous for several reasons, offering a structured framework to comprehend the intricate interplay between economic factors, health outcomes, and public policy.

In summary, the development of an economic model for maternal smoking and infant birth weight enriches our comprehension of the economic repercussions linked to this health behavior. This knowledge is pivotal in shaping evidence-based policies, guiding interventions, and fostering the well-being of both mothers and infants. The objective is not merely to add to existing research but to augment evidence-based recommendations for public health interventions, specifically aimed at mitigating the adverse effects of maternal smoking on infant birth weight.

Data:

This research relies on data sourced from the Centers for Disease Control and Prevention (CDC) National Survey of Family Growth (NSFG), employing it to examine the relationship between maternal smoking and infant birth weight.

The National Survey of Family Growth (NSFG) is a nationally representative survey conducted by the Centers for Disease Control and Prevention (CDC) in the United States. Its primary objective is to gather comprehensive information about family life, reproductive health, contraception usage, pregnancy, and childbirth. The NSFG plays a pivotal role in providing an in-depth understanding of various facets of family dynamics and reproductive behaviors among Americans. The survey meticulously collects data on reproductive health-related topics, including fertility, pregnancy intentions, contraceptive methods used, infertility, and sexual activity. Furthermore, it captures an extensive array of demographic information pertaining to family dynamics, marital status, cohabitation, and household composition, thus offering valuable

insights into the structure of American families. Conducted periodically, the NSFG stands as a longitudinal survey, tracking changes and trends in reproductive behaviors and serving as a cornerstone for understanding the complexities of life.

The focal independent variable in this study is maternal smoking, and the dataset obtained from the CDC encompasses variables related to maternal smoking habits: 6 months before pregnancy, smoking awareness during pregnancy, and smoking during the pregnancy itself. For the purpose of this study, maternal smoking has been transformed into a binary variable, with '1' indicating smoking and '0' representing non-smoking.

Additionally, several covariate variables are controlled for in this study. These include the age at the time of conception (*Figure 1*) and the gestational length in the case of a live birth. The incorporation of these covariates allows for a more nuanced analysis, ensuring that potential confounding factors are considered in the examination of the relationship between maternal smoking and infant birth weight.

Method:

Establishing an econometric model to explore the connection between maternal smoking and infant birth weight entails formulating a statistical model that encapsulates the intricacies of this relationship. In this study, a model was derived using the National Survey of Family Growth 2017-2019 to fulfill this purpose.

The empirical model utilized for this investigation is outlined as follows:

$$infantbirthweight_{it} = \beta_0 + \beta_1 maternalsmoking_{it} + \beta_2 gestationallength_{it} + \beta' X + u$$

The dependent variable in this model is *infant birth weight*, represented as a categorical dummy variable. A value of 1 indicates that the infant delivered had a low birth weight, while a value of 2 indicates that the infant did not have a low birth weight. The independent variable *maternal smoking* is a binary variable encompassing three components related to maternal smoking: whether the mother smoked within the 6 months before becoming pregnant, if she smoked once aware of the pregnancy, and the extent of smoking throughout the pregnancy.The dependent variable, representing the infant's birth weight for observation *i* at time *t.*

Additionally, the independent variable *gestational length* is a categorical variable denoting the duration of gestation for infants resulting in live births. Specifically, a value of 1 signifies an early preterm birth (< 34 weeks), 2 signifies a preterm birth (34-36 weeks), 3 signifies a term birth (37-40 weeks), and 4 signifies a post-term birth (> 40 weeks).

The term 'X' in the model represents a vector encompassing control variables. Incorporating control variables allows for the isolation of the specific effect of maternal smoking on birth weight, mitigating the influence of potential confounding factors. Variables such as maternal age, and other relevant factors that could independently impact birth weight are included in the model to enhance the precision of the analysis.

The estimation method employed in this study is Ordinary Least Squares (OLS) for certain parts of the analysis and Logistic Regression (LOGIT) for assessing the binary outcomes related to maternal smoking and infant birth weight, interpreted by marginal effects. Both methods are essential in capturing and understanding the nuanced relationship between maternal smoking and its impact on birth weight outcomes.

By utilizing both OLS and LOGIT estimation methods provides a comprehensive understanding of the multifaceted relationship between maternal smoking and infant birth weight. The incorporation of marginal effects from the LOGIT model adds a layer of robustness, offering valuable insights into the practical implications of maternal smoking on the probability of low birth weight outcomes. This dual-method approach strengthens the study's analytical framework and contributes to a more nuanced interpretation of the research findings.

There are limitations to this study, this includes data limitations, self-reporting bias, external validity and control variables. The study relies on available data, and the accuracy and reliability of the results are contingent on the quality of the data collected. Incomplete or inaccurate information, or the absence of certain variables, might introduce biases. Maternal smoking status and other behaviors are often self-reported, introducing the potential for recall bias or social desirability bias. Pregnant women may underreport or misreport their smoking habits due to societal stigma associated with smoking during pregnancy. The study's findings may be specific to the population or time period under investigation. Extrapolating the results to different populations or time frames requires caution, as variations in healthcare systems,

socioeconomic conditions, or cultural factors may impact the relationship. While efforts have been made to include control variables, the study might not account for all potential confounding factors that influence birth weight. Unobserved variables, such as specific genetic factors or individual lifestyle choices, could impact the results.

Results:

Various models were employed in this study to examine the relationship between maternal smoking and birth weight. The initial or base model considers birth weight as the dependent variable and maternal smoking as the independent variable. The outcomes of this regression, as well as subsequent models (1 through 5), are presented below. Notably, Models (4) and (5) lack additional control variables.

Table 1 presents the results of Ordinary Least Squares (OLS) regression models with variations in the dependent variable (LBW1, representing low birth weight) and independent variables (Maternal Smoking and Gestational Length) across different specifications (Columns 1 to 5).

The interpretation of the coefficient Maternal Smoking: This coefficient represents the estimated change in the dependent variable (LBW1) associated with a one-unit change in the independent variable (Maternal Smoking). In Model (1) the coefficient is 0.218. This suggests that a one-unit increase in Maternal Smoking is associated with a 0.218 increase in the probability of low birth weight (LBW1). The coefficient is highly statistically significant (*** $p<0.01$), indicating a robust relationship. In model (3) both gestational term and age at time of

pregnancy are controlled for the coefficient of Maternal Smoking is 0.0136. This suggests that a one-unit increase in Maternal Smoking is associated with a 0.0136 increase in the probability of low birth weight (LBW1). The coefficient is statistically significant (* $p<0.1$).

The interpretation of the coefficient Gestational Length: This variable's coefficient represents the estimated change in the dependent variable (LBW1) associated with a one-unit change in the Gestational Time Period. This coefficient is controlled for in models (2)-(5). In Model (2) the coefficient is 0.596. This implies that a one-unit increase in Gestational Length is associated with a 0.596 decrease in the probability of low birth weight (LBW1). The coefficient is highly statistically significant (*** $p<0.01$). In Model (5) the coefficient is 0.628. This implies that a one-unit increase in Gestational Length is associated with a 0.628 decrease in the probability of low birth weight (LBW1). The coefficient is highly statistically significant (*** $p<0.01$).

The numbers in brackets beneath the coefficients represent the standard errors, indicating the precision of the estimated coefficients. Smaller standard errors suggest more precise estimates. The OLS regression results suggest that Maternal Smoking has a statistically significant association with Low Birth Weight (LBW1) across different model specifications. The coefficients and their significance levels provide insights into the strength and statistical reliability of these relationships.

Table 2 presents the results of Logistic Regression (LOGIT) models examining the relationship between maternal smoking and the likelihood of low birth weight (LBW1) across different specifications (Columns 1 to 5). Here's an interpretation of the key elements:

The coefficient Maternal Smoking represents the change in the log-odds of the probability of low birth weight associated with a one-unit change in Maternal Smoking. In

Model (3), where both gestational time and age at time of pregnancy are controlled for, the coefficient is 0.0136. This suggests that a one-unit increase in Maternal Smoking is associated with a 0.0136 increase in the log-odds of low birth weight. The coefficient is statistically significant (* $p<0.1$).

The coefficient Gestational Time indicates the change in the log-odds of low birth weight associated with a one-unit change in Gestational Time: In Model (2), a one-unit increase in Gestational time is associated with a 0.596 decrease in the log-odds of low birth weight, and this relationship is highly statistically significant (*** $p<0.01$). In Model (5) the coefficient is 0.628. This means that a one-unit increase in Gestational Time is associated with a 0.628 decrease in the log-odds of low birth weight. The coefficient is highly statistically significant (*** $p<0.01$).

Across all columns, Maternal Smoking consistently shows a positive association with the log-odds of low birth weight, while Gestational Length consistently shows a negative association, indicating its protective effect against low birth weight. The statistical significance of these coefficients strengthens the confidence in these observed relationships.

Conclusion:

In conclusion, this comprehensive analysis sought to unravel the complex relationship between maternal smoking and infant birth weight. Employing various models, including Ordinary Least Squares (OLS) and Logistic Regression (LOGIT), the study consistently reveals that maternal smoking has a significant and adverse impact on infant birth weight. The coefficients across different specifications consistently indicate a positive association between maternal smoking and the likelihood of low birth weight, while Gestational Length emerges as a protective factor, exhibiting a negative association.

The findings underscore the importance of recognizing the detrimental effects of maternal smoking on neonatal health outcomes. The evidence from both OLS and LOGIT models consistently points to the critical role of addressing maternal smoking as a modifiable risk factor to improve birth weight outcomes. These results are particularly pertinent for informing evidence-based policies, interventions, and public health initiatives aimed at reducing maternal smoking rates and enhancing neonatal well-being.

As this study contributes to the ongoing discourse on the impact of maternal behaviors on infant health, it reinforces the imperative for continued research and multifaceted strategies to mitigate the adverse effects of smoking during pregnancy. Ultimately, the collective evidence strongly supports the notion that maternal smoking does indeed influence infant birth weight, emphasizing the urgency for concerted efforts to promote healthier maternal behaviors and, consequently, improve outcomes for the next generation.

Works Cited

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Appendix:

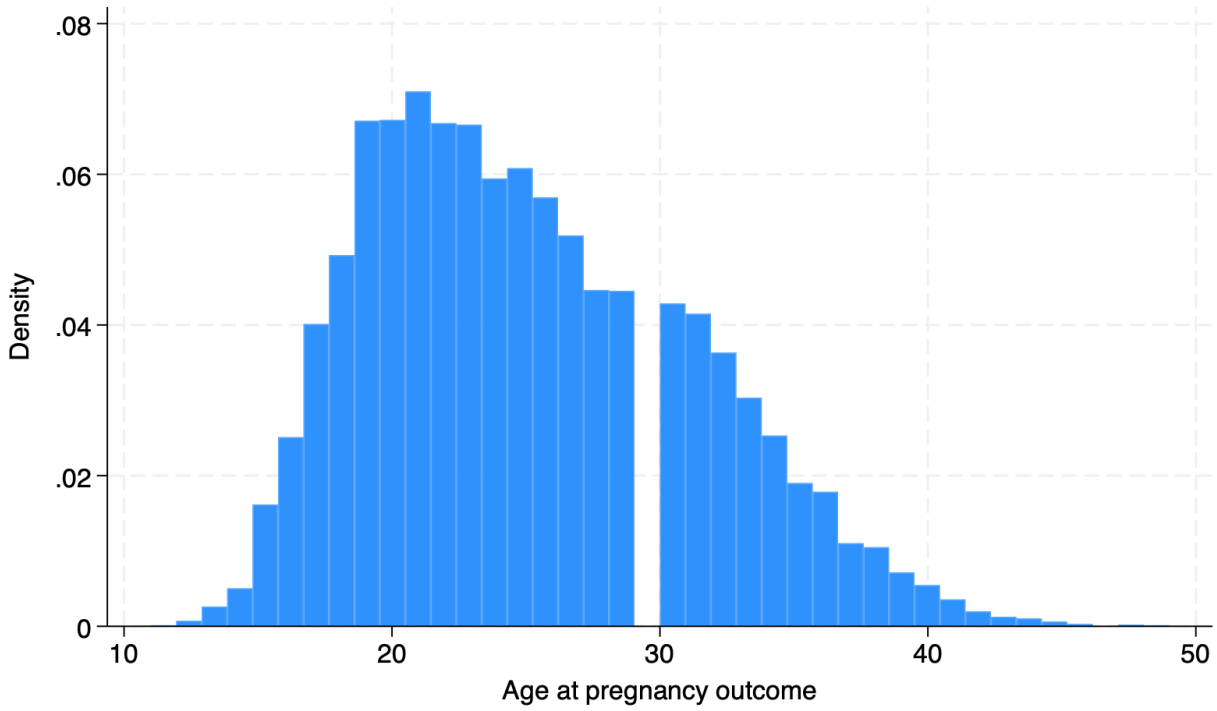

Figure 1 Histogram of a woman's age at the time of infant birth.

OLS Models

VARIABLES	(1) Low Birth Weight	(2) Low Birth Weight	(3) Low Birth Weight	(4) Low Birth Weight	(5) Low Birth Weight
Maternal Smoking	0.218***	0.0169**	0.0136*	1.515***	0.0463***
	[0.0224]	[0.00745]	[0.00776]	[0.0328]	[0.00744]
Gestational Term		0.596***	0.593***		0.628***
		[0.00207]	[0.00215]		[0.00131]
Constant	1.297***	0.104***	0.113***		
	[0.00992]	[0.00529]	[0.00556]		
Observations	10,215	10,215	10,022	10,215	10,215
R-squared	0.009	0.891	0.887	0.173	0.965

Standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table 1 OLS regression output of models (1) through (5)

LOGIT models

VARIABLES	(1) Low Birth Weight	(2) Low Birth Weight	(3) Low Birth Weight	(4) Low Birth Weight	(5) Low Birth Weight
Maternal Smoking	0.562***	0.0169**	0.0136*	1.515***	0.0463***
	[0.0598]	[0.00745]	[0.00776]	[0.0328]	[0.00744]
Gestational Length		0.596***	0.593***		0.628***
		[0.00207]	[0.00215]		[0.00131]
Constant	0.770***	0.104***	0.113***		
	[0.0237]	[0.00529]	[0.00556]		
Observations	10,215	10,215	10,022	10,215	10,215
R-squared		0.891	0.887	0.173	0.965

Standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table 2 LOGIT output of models (1) through (5)