Maternal exposure to economic contraction during pregnancy and smoking, alcohol use, and gestational weight gain in a national sample of U.S. women

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Introduction

Maternal health behaviors during pregnancy are important predictors of maternal pregnancy health, birth outcomes, and later life health of both mother and child. Maternal smoking during pregnancy is a strong and consistent risk factor for preterm birth (PTB) and low birth weight (LBW) and is associated with childhood obesity, diabetes, and behavioral problems (Rogers, 2009). Alcohol consumption has been associated with spontaneous abortion, LBW, fetal alcohol syndrome, and behavioral problems in childhood (Andersen et al., 2012; Mills et al., 1984; Sood et al., 2001). Maternal weight gain during pregnancy, although influenced by non-behavioral factors such as metabolism, placental function, and infant growth, is also considered an indicator of diet and physical activity behaviors during pregnancy (Institute of Medicine, 2009) (and is referred to as a "behavior" in this manuscript, for brevity). Both inadequate (below the recommended range) and excessive (above the recommended range) maternal gestational weight gain are associated with increased risk of pregnancy complications, adverse birth outcomes, maternal postpartum weight retention, and childhood overweight (Institute of Medicine, 2009).

In the United States, the prevalence of these behaviors differs substantially across populations defined by race/ethnicity and socioeconomic status (SES). For example, although the overall prevalence of smoking during pregnancy in the U.S. in 2007 was estimated at 10.4 percent, the prevalence among White/non-Hispanic women was 16.3 percent, while the prevalence among Hispanic women was only 2.1 percent (Martin et al., 2010). Prevalence of

smoking during pregnancy also increases with decreasing income and education (Phares et al., 2004). Alcohol use during pregnancy is more common among White/non-Hispanic women but increases with *increasing* education and income (D'Angelo et al., 2007; Martin et al., 2010; Phares et al., 2004). Black women and women with less than a high school education are more likely to gain inadequate weight during pregnancy compared to other race/ethnic groups and those with a high school education, respectively, while non-Hispanic White women have higher rates of excessive gain than other race/ethnic groups (Institute of Medicine, 2009; Martin et al., 2010).

Theory and empirical research suggest that aspects of the human ecology play an important role in determining health behavior (Bronfenbrenner, 1979; Catalano, 1989; Kaplan, 1999; Krieger, 2001). Ecologic factors include the social, economic, structural, and physical aspects of our environment, as well as the interactions between individuals and their environments. Ecologic factors are thought to affect health and health behavior via their impacts on individuals' psychosocial health, access to resources, or collective behavioral norms, all of which may lead to adoption or maintenance of healthy or unhealthy behaviors (Schempf et al., 2009).

Much of the existing research examining ecological influences on maternal health behaviors during pregnancy focuses on the characteristics of neighborhood environments. For example, high same-ethnic density is associated with reduced odds of maternal smoking among US-born Hispanic and Black mothers (Shaw et al., 2010), walkability is associated with lower odds of inadequate gestational weight gain, and physical incivilities are positively associated with smoking and inadequate gestational weight gain (Laraia et al., 2007; Vinikoor-Imler et al., 2011). Neighborhood "risk" (based on a variety of measures of racial and economic

stratification, social disorder, and physical deterioration) is also associated with increased risk of smoking, drinking, and using hard drugs during pregnancy as well as late or no prenatal care (Schempf et al., 2009).

Causal interpretation of this neighborhood research is limited, however, by lack of longitudinal data and analytic approaches to elucidate temporal ordering of exposure and outcome (Oakes, 2004). Ecologic theory, furthermore, suggests that it is *perturbations to*—rather than static differences in—the human ecology that lead to increased incidence of adverse behavior (Catalano, 1979, 1989). This study, therefore, examines the associations between exposure to an ecological perturbation—i.e., economic contraction at the state level—during pregnancy and maternal smoking, alcohol use, and gestational weight gain. I also explore differences in these associations by factors that may affect women's *vulnerability* to ecological perturbations, namely race/ethnicity, poverty status, and educational attainment.

Background

An ecological perspective on health behavior. Ecological theory, originally developed to understand the interactions between living organisms and their environments, may serve as a useful tool when applied to the study of human behavior and can "offer testable explanations of why the incidence of health and [behavior] varies over time in geographically defined populations as well as across such populations at any point in time" (Catalano, 1989; Catton, 1994) An ecological perspective may therefore help us better understand the determinants of maternal pregnancy behaviors and differences in behaviors by race/ethnicity and SES.

A human ecosystem includes humans among the living organisms and, among the environmental elements: human constructs such as the economy, social institutions, and culture;

demographics; and the physical and natural environment. Bronfenbrenner (Bronfenbrenner, 1979) and others (Catalano, 1979; Kaplan, 1999; Krieger, 2001) have described multiple levels—from the macro (e.g., global, national, regional) to the micro (e.g., local, family, work) to the individual (e.g., behavior, physiology)—of a human ecosystem, which act through both separate and interconnected mechanisms to affect human health.

An important ecological principle states that the behavioral and biological characteristics of the living elements in an ecosystem depend in large part on characteristics of the environmental elements (Catalano, 1979). When the environmental aspects of the ecosystem remain constant, change gradually, or fluctuate in an expected pattern, the behavior of the living elements will also either remain constant, change gradually, or fluctuate in predictable ways, respectively (Catalano, 1979, 1989). For example, gradually increasing aridity may lead to gradual out-migration or changes in diet, and seasonal weather variation produces predictable changes in behaviors such as migration, diet and physical activity, and reproduction.

On the other hand, changes that alter the organization of the ecosystem in abrupt or unexpected ways, i.e. "perturbations", may lead to increased incidence of behaviors (and subsequent health outcomes) that appear adverse because they differ from the expected behavior in an unperturbed environment (Catalano, 1979, 1989). Substantial evidence demonstrates associations between ecological perturbations such as economic shocks and terrorist attacks and increased incidence of "adverse" health outcomes, such as depression and anxiety, violent behavior, and alcohol use (Boscarino et al., 2004; Catalano et al., 2010; Vlahov et al., 2006).

Economy. The economy represents one ecological factor with pervasive impacts on individuals, households, and communities. Economic change can affect employment, allocation of public resources, the physical and built environment, and availability of goods and services.

Economic contraction, i.e. a reduction in the ability of the economy to provide secure employment to those who desire it, is associated with increased anxiety about job security, even among the employed (Fullerton & Wallace, 2007). Secure employment provides not only income and benefits, but social support, status, and structure to individuals' lives (Catalano et al., 2010). Those who lose jobs during economic downturns suffer increased incidence of depression, anxiety, suicide, and substance abuse (Catalano et al., 2010; Dooley et al., 1996).

Those who do not experience job loss during economic contractions are still impacted by these perturbations. Research has shown, for example, that workers surviving a corporate downsizing work harder and experience more fear of layoff than prior to the downsizing (Vahtera et al., 1997). Spouses of workers with adverse job events also experience increased depression and demoralization (Rook et al., 1991). Family members of job losers may suffer psychosocial stress due to income loss, changing roles, and time structure. Increased unemployment can impact communities by reducing funding for public or social services, decreasing philanthropy, impacting environmental quality, changing community networks, or depleting social support and capital (Catalano, 2007). Although this paper focuses on economic *contraction* because of its relevance to the current global economic climate, it is important to note that economic *expansion* can also have important impacts on individuals, families, and communities as numbers of jobs, working hours, and wages increase.

Pathways from economic contraction to health behavior. Researchers have proposed several mechanisms by which macro-level economic contraction may affect health behavior. First, contracting economies are associated with increased risk of individual-level financial events, other stressful life events (SLEs) (Catalano et al., 1987), and general anxiety about the economy , all of which may lead some to engage in coping behaviors such as increased use of

tobacco or alcohol. Second, work hours may either decrease (for the laid off) or increase (for those who remain employed during recession), leaving individuals more or less leisure time for health-seeking behaviors (Ruhm, 2000). Third, economic contraction may result in changes in spending on tobacco, alcohol, food, physical activity, or preventative care due to real or anticipated income loss (Catalano et al., 2010). In the general population, studies have shown that recessions are associated with reductions in smoking, excess body weight, and physical inactivity (Ruhm, 2000, 2005), although utilization of preventative health care also declines (Ruhm, 2000, 2005). Findings are inconsistent regarding alcohol use—although some studies have reported decreased rates of heavy drinking (Ruhm & Black, 2002), during economic downturns , others have found increases in binge drinking and alcohol-related deaths (Catalano et al., 2010). Because economic contraction impacts not only those who lose jobs or income but members of the general population as well, it is important to understand the impacts of economic contraction—above and beyond the impacts of job loss or unemployment—on health and health behavior.

Understanding the impact of economic contraction on behavior among pregnant women specifically is important for several reasons. Maternal smoking, alcohol consumption, and weight gain are strongly associated with birth outcomes, infant and childhood health, and later-life maternal health. Pregnancy is a critical period in the lifecourse during which women are in frequent contact with health providers, are receptive to messages about health behavior, and have a desire to engage in healthy behavior (Edvardsson et al., 2011; Phelan, 2010); pregnant women's behavioral responses to ecological perturbations may therefore differ from the general population. In addition, a growing body of literature has demonstrated associations between economic contraction and increased incidence of adverse birth outcomes such as small for

gestational age (SGA) (Margerison-Zilko et al., 2011), low birth weight (LBW) (Catalano & Serxner, 1992; Fisher et al., 1985), very LBW (Catalano et al., 1999), and preterm LBW (A. H. Schempf & Decker, 2010), and changes in maternal pregnancy behaviors are one proposed pathway connecting economic contraction to these birth outcomes.

To date little research has examined the association between economic change and maternal behavior during pregnancy. Dehejia and Lleras-Muney examine associations between the unemployment rate in the year of conception and maternal behaviors during pregnancy using US vital statistics natality records from 1975 to 1999 (Dehejia & Lleras-Muney, 2004). They find that that increasing unemployment is associated with decreased smoking and alcohol use during pregnancy among Black mothers but increased smoking and alcohol use among White mothers. The authors attribute these findings to both *selection* into pregnancy as well as changes in health behaviors *during* pregnancy but cannot distinguish between the two explanations.

Differences in vulnerability to economic contraction. The effects of macro-level economic change on maternal behaviors may also depend on women's access to resources, perceptions of the economy, cultural or community norms, or other factors. Previous studies have shown that the effects of economic contraction on individual financial events and subsequent health outcomes are stronger among middle SES individuals than among low or high SES individuals (Catalano, 1991; Catalano & Dooley, 1983). Research has also demonstrated associations between economic change and both birth rates and sudden infant death syndrome (SIDS) among Black, but not White, women (T. A. Bruckner, 2008; Colen et al., 2006), suggesting that Black women may be more vulnerable to changes in the economy. Education may also play an important role in moderating the effects of economic change—women and men

with less education are more likely to lose jobs during recessions (Farber, 1993), suggesting that a greater burden of negative economic pressure is felt in low education households.

Study purpose and objectives.

The purpose of this study is to understand the influence of an ecological perturbation, i.e. economic contraction, on maternal pregnancy behaviors and to assess whether vulnerability to this perturbation differs by maternal characteristics. This study estimates the associations between maternal exposure to state-level unexpected economic contraction during early pregnancy and smoking, alcohol use, and gestational weight gain in a national sample of U.S. women from the National Longitudinal Survey of Youth 1979 (NLSY79). This paper also assesses how associations differ by maternal race/ethnicity, educational attainment, and poverty status and examines the role of maternal job loss during pregnancy as a potential mechanism by which state-level economic contraction may affect maternal pregnancy behaviors.

Methods

Study population and sample. Data on pregnancy behaviors were obtained for women in the National Longitudinal Survey of Youth (NLSY79), a prospective cohort study enrolling youth ages 14-22 in 1979 (Bureau of Labor Statistics, 2008). Women in the NLSY79 were asked a series of questions about their pregnancy in the interview following a birth. The study population included 8,282 singleton births to 4,233 women in 50 states, Washington DC, and Puerto Rico from 1982-2002. Births missing variables needed to calculate economic events during pregnancy—i.e. date of birth (n=1), maternal state of residence during pregnancy (n=222), and length of gestation (n=985)—were excluded, for a study sample of 7,074 births to

3,975 women. (Some women did not participate in the survey in the year following the birth, leading to the large number of births missing length of gestation.) Births included in the study sample were similar to births in the study population in terms of race/ethnicity, educational attainment, poverty status, marital status, parity, employment status, and pre-pregnancy BMI categories (data available upon request).

The NLSY79 data is well-suited to these research questions because it includes data on maternal smoking, alcohol use, and gestational weight gain over a period of 20 years and across all 50 states. In the US vital statistics data, in contrast, gestational weight gain is not available until 2003 and is only available in certain states between 2003-present, and measurement of tobacco use during pregnancy is not comparable across years and states (Centers for Disease Control and Prevention, 2009). Furthermore, the NLSY includes detailed data on dates of job loss for mothers.

Variables.

Exposure to unexpected economic contraction. I characterized the economy using monthly state unemployment rates. Previous research demonstrates that state unemployment rates are more strongly associated with depression and stressful life events (and thus, potentially associated with behaviors) than other state-level economic indicators and indicators at the metropolitan area level (Catalano & Dooley, 1977). Furthermore, state unemployment rates are more frequently reported by the media than local measures. Use of the monthly, rather than annual, unemployment rate allowed me to determine whether contractions occurred during pregnancy.

Time series of monthly unemployment rates for all 50 states, Washington DC, and Puerto Rico from 1979-2009 were obtained from the Bureau of Labor Statistics

(http://www.bls.gov/lau/). I defined unexpected economic contractions as months in which the state unemployment rate was significantly higher than its statistically expected value, with the expected value based on the history of the unemployment rate in that state until that time point. These economic contractions (i.e., months with higher-than-expected-values), therefore, represent *perturbations*, rather than expected or predictable changes, to the human ecosystem.

Calculating the statistically expected value of the unemployment rate requires taking into account time-dependent correlation between values. This "autocorrelation" includes secular trends, cycles, and the tendency to remain depressed or elevated following high or low values and implies that "position" in time predicts observed values better than the mean of the series. I used flexible methods for assessing and accounting for autocorrelation in a time series developed by Box and Jenkins and known as ARIMA modeling; these methods model autocorrelation (i.e., autoregressive, integrative, and moving average [ARIMA] parameters) based on the observed data (instead of using pre-specified parameters such as year indicator variables) (Box et al., 1994; McCleary & Hay, 1980). For each state, I estimated an ARIMA model to identify autocorrelation and decompose unemployment rates into expected and residual (difference between observed and expected) values. (Details of the ARIMA equations and examples of observed and expected values can be found in Appendices A and B, respectively.) Months with residual values significantly above the 99% confidence interval (CI) of expected values were classified as unexpectedly contractive. Months with residual values significantly below the 99% confidence interval (CI) of expected values were classified as unexpectedly expansive.

Figure 1 demonstrates the total number of months (among all U.S. states combined) classified as unexpectedly contractive using the method described above from 1980 until 2009. The recession of the early 1980s was, for example, characterized by years with many months of

unexpected economic contractions at the outset, followed by fewer numbers of contractions once the recession was underway and high unemployment became "expected". The recent recession starting in late 2008 is also characterized by a high number of unexpected contractions at the outset.

Figure 1 about here

Results of ARIMA models (i.e., residual values and outliers) were then merged with NLSY data by state. I estimated women's months of pregnancy using date of birth and length of gestation. Pregnancies were then characterized as "exposed" to unexpected economic contraction in the first trimester if any of the first three months of the pregnancy were unexpectedly contractive. (Distribution of exposure by year shown in Appendix C.)

I hypothesized that exposure to economic contraction in the first trimester of pregnancy would be most strongly associated with maternal pregnancy behaviors because exposure in the first trimester provides the longest time window for economic contraction to impact behavior (exposure in the third trimester, in contrast, would be less likely to affect behavior) and because prior research on birth outcomes has shown the first trimester to be the most important period for exposure to ecologic stressors (Glynn et al., 2007; Margerison-Zilko et al., 2011; Torche, 2011).

Maternal pregnancy behaviors. Women in the NLSY79 were asked whether they smoked or drank alcohol during pregnancy in the interview following the birth. Smoking and alcohol consumption was dichotomized as yes/no because current U.S. recommendations suggest that women abstain from both during pregnancy and because distribution of these variables was highly skewed: over 70% of mothers who smoked during pregnancy reported smoking less than

one pack of cigarettes per day, and 73% of mothers who drank alcohol during pregnancy reporting drinking once a month or less.

Gestational weight gain was categorized according to the pre-pregnancy BMI-specific ranges of gain recommended by the Institute of Medicine (IOM): gains within the recommended range were labeled "adequate", gains below the range were labeled "inadequate", and gains above the range were labeled "excessive".

Race/ethnicity, poverty status, and educational attainment. Race/ethnicity was classified by NLSY79 as Black, Hispanic, and non-Black/non-Hispanic. In the original NLSY79 sample, those classified as non-Hispanic/non-Black primarily self-identified as being of European descent (68%), with the rest self-identifying as Asian/Pacific Islander (1%), American Indian (8%), "American" (9%), or other (14%).

I obtained data on women's educational attainment and poverty status from the survey closest to, but prior to, her estimated date of conception (based on the child's birth date and length of gestation). Educational attainment in years was categorized as less than high school (<12), high school (12), and greater than high school (>12).

Maternal job loss during pregnancy. Participants were asked about their employment history since the last survey, including each job held, whether they had left any job, the last date of work at that job, and the reason for leaving that job. Women who reported leaving a job on a date that fell between their estimated first day of gestation and the birth date of the child were classified as having job loss during pregnancy if the reported reason for leaving was: "layoff," "fired," "plant closed," "program ended," or "end of temporary or seasonal job".

Statistical analysis. I first examined the percentage of women reporting smoking, alcohol use, and inadequate and excessive weight gain during pregnancy by race/ethnicity, educational

attainment, and poverty status. Risk ratios comparing pregnancy behaviors among women exposed to unexpected economic contraction during the first trimester of pregnancy to unexposed women were then estimated using generalized linear models (GLMs) with a binomial distribution, adjusted for state and year fixed effects. The same models were then adjusted for maternal characteristics using indicator variables for race/ethnicity, age, educational attainment, marital status, employment status, poverty status, parity, and pre-pregnancy BMI categories; indicator variables were also used for covariates with missing data. The NLSY79 oversampled Hispanic or Latino, Black/non-Hispanic, economically disadvantaged non-Black/non-Hispanic, and military youth, but recommends against using sampling weights in subsamples or regression analyses (Bureau of Labor Statistics, 2008); I therefore included indicator variables for these sampling strata in my multivariable models. Separate GLMs were used to estimate risk ratios for inadequate and excessive gestational weight gain, comparing each to adequate gain.

A small number of births were missing data on maternal smoking (n=18) or alcohol use (n=10); analyses for each outcome were conducted only among births not missing that data. Analyses of gestational weight gain were restricted to term births (n=5,916) only, as the IOM guidelines are for full-term pregnancies. In addition, the sample size for these analyses was smaller than the total sample size due to a) more missing data for gestational weight gain (n=741) and b) excluding excessive gainers from models of inadequate gain and vice versa.

Next, I assessed moderation of associations between exposure to economic contraction and maternal behavior outcomes by race/ethnicity, educational attainment, and poverty using two-way interaction terms between exposure to economic contraction and indicator variables for race/ethnicity, education, and poverty (in three separate models). Wald tests were used to assess whether interactions achieved statistical significance ($p<0.10$).

I also examined whether maternal job loss was independently associated with maternal pregnancy behaviors as well as the impact of adjusting for maternal job loss on the association between state-level economic contraction and maternal pregnancy behaviors. Several tests were conducted to assess the robustness of my findings to changes in modeling strategies. First, I examined the associations between maternal pregnancy behaviors and exposure to economic contraction in the first or second trimester of pregnancy combined (i.e., the first six months). Economic expansion as well as contraction may represent an ecologic perturbation with impacts on behavior; I therefore examined the associations between economic expansion in the first trimester and maternal pregnancy behaviors. Because the data include more than one birth to some mothers, and correlation between births to the same mothers may have affected standard errors, I restricted analyses to the first birth to all mothers in the dataset. Finally, to assess the impact of missing data on covariates, I estimated models using a complete case analysis that included only births with complete data on all variables. All analyses were conducted using SAS Version 9.2 (Cary, NC).

Results

Descriptive analyses of maternal pregnancy behaviors. Table 1 displays characteristics of the births in the study sample. Of the 7,074 births in the sample, 5.3 percent were exposed to unexpected economic contraction in the first trimester of pregnancy. Approximately one-quarter of mothers reported smoking during pregnancy and 31 percent reported using alcohol. Approximately 29% of women gained inadequate weight during pregnancy, and over 40 percent gained excessive weight. One quarter of births were to women of Black race/ethnicity, and

about 20% were to women of Hispanic race/ethnicity. One-fifth of births were to women with less than a high school education, and 23 percent were to mothers in poverty.

White women were more likely to smoke and use alcohol compared to women of other race/ethnicities (Table 2). Women in poverty were more likely to smoke compared to women not in poverty, and smoking increased with decreasing educational attainment. Alcohol use increased with increasing educational attainment. Inadequate gestational weight gain was most common among Black/non-Hispanic and Hispanic women, those with less than a high school education and those in poverty, while excessive gain was most common among those a high school education and those not in poverty.

Associations between exposure to unexpected economic contraction in the first trimester and pregnancy behaviors. In multivariate models adjusting for state and year fixed effects only, exposure to unexpected economic contraction during pregnancy was not significantly associated with maternal smoking (RR: 1.12, 95% CI: 0.96, 1.30), alcohol consumption (RR: 1.02, 95% CI: 0.89, 1.19) or inadequate (RR: 0.99, 95% CI: 0.85, 1.15) or excessive (RR: 0.88, 95% CI: 0.76, 1.02) weight gain (compared to adequate weight gain). After adjusting for maternal characteristics as well as state and year fixed effects, exposure to economic contraction during pregnancy was not significantly associated with the prevalence of maternal pregnancy behaviors (Table 3).

Moderation of associations by maternal characteristics. The associations between unexpected economic contraction and maternal alcohol consumption differed significantly by race/ethnicity (p-value for interaction =0.08). Women of Black/non-Hispanic race/ethnicity had a significantly higher risk of alcohol consumption during pregnancy when exposed to economic contraction during the first trimester compared to unexposed women (RR: 1.34, 95% CI: 1.03,

1.76), whereas the risk of alcohol consumption did not differ among exposed vs. unexposed women of Hispanic and non-Black/non-Hispanic race/ethnicity (RR: 0.99, 95% CI: 0.62, 1.57; RR: 0.94, 95% CI: 0.79, 1.12, respectively).

Predicted probabilities were calculated for each individual, using the coefficients from the GLM and the individuals' own values for each covariate, under the conditions of exposed and not exposed and averaged across individuals within race/ethnic groups (Ahern et al., 2009). Figure 2 demonstrates the predicted probabilities of alcohol consumption under exposed and unexposed conditions by race/ethnicity.

Figure 2 about here

When not exposed to economic contraction, Black/non-Hispanic and Hispanic women were less likely to use alcohol during pregnancy than non-Black/non-Hispanic women. However, when exposed to economic contraction, the probability of alcohol consumption increased most substantially among Black/non-Hispanic women (from 0.19 to 0.24). Including maternal job loss in these models did not change the significance of the interaction terms or the estimated risk ratios by race/ethnicity. The associations between exposure to first-trimester economic contraction and maternal pregnancy behaviors did not differ significantly by education or poverty status.

The data demonstrated similar findings for exposure to economic contraction during the first or second trimester of pregnancy—exposure was not significantly associated with maternal smoking or gestational weight gain (Appendix D). There was also a significant interaction between exposure and race/ethnicity for the maternal alcohol consumption outcome. Women of Black/non-Hispanic race/ethnicity had a higher risk of alcohol consumption when exposed to economic contraction in the first or second trimester of pregnancy compared to unexposed

women (RR: 1.37, 95% CI: 1.12, 1.69), while the association among Hispanic and non-Black/non-Hispanic women was null.

Additional tests demonstrated that exposure to economic expansion in the first trimester of pregnancy was not significantly associated with maternal pregnancy behaviors (Appendix D), and there were no significant interactions between economic expansion and race/ethnicity. Moreover, maternal job loss was not associated with maternal pregnancy behaviors (Appendix D). Results of models restricted to first births in the dataset and the complete case analysis demonstrated similar findings to models on the full sample (Appendix D).

Discussion

This study examines the association between exposure to an ecological perturbation—unexpected economic contraction—during the first trimester of pregnancy and maternal smoking, alcohol consumption, and gestational weight gain in a national sample of U.S. births from 1982 to 2000. Findings suggest that exposure to unexpected economic contraction during early pregnancy is not associated with maternal smoking or gestational weight gain. However, among Black/non-Hispanic women only, exposure to unexpected economic contraction is associated with a 34% increased risk of maternal alcohol use during pregnancy. Predicted probabilities demonstrated that exposure increased the likelihood of alcohol consumption from approximately 19 to approximately 24 percent among Black/non-Hispanic women.

This research employs a multilevel design to examine the association between state-level economic perturbations and individual-level maternal pregnancy behaviors, enabling adjustment for potential confounding and exploration of differences in associations by individual-level maternal characteristics. This work makes a novel contribution to existing literature by defining

economic perturbations based on theory that the "unexpectedness" of environmental stimuli affects the degree to which organisms respond. As defined in this study, exposure to an unexpected economic contraction occurs when the unemployment rate in a woman's state of residence is significantly above its expected value (based on the history of the unemployment rate in that state) during the first trimester of pregnancy.

Previous work reported that increases in the unemployment rate in the year prior to birth were associated with decreased smoking and alcohol consumption during pregnancy among Black women and increased smoking and alcohol consumption among White women (Dehejia & Lleras-Muney, 2004). This study specifically identifies relations between economic change *during* pregnancy and maternal behaviors, while this previous work could not distinguish between effects of selection into pregnancy and behavior change during pregnancy. The current study also specifically examines perturbations to the economy, whereas Dehejia and Lleras-Muney examine linear increases in the unemployment rate. These differences in definition of exposure could account for the differences in findings between these two studies.

Prior research in the general population has demonstrated that smoking, excess body weight, and physical inactivity decline during recessions (Ruhm, 2000, 2005). The current findings show that, among pregnant women, economic contraction does not appear to be related to these behaviors. It remains possible that economic contraction has both positive and negative effects on smoking and gestational weight gain, depending on individual women's experience of or reaction to economic change—equal and opposite effects could cancel each other out, leading to null associations on average.

Research in the general population has also demonstrated increased drinking during recessions (Catalano et al., 2010); my data show a similar response, but only among Black/non-

Hispanic women compared to other race/ethnic groups. Other related research has also demonstrated stronger associations between economic contractions and perinatal outcomes among Black women. Colen et al. found that falling unemployment was associated with decreased fertility among young Black mothers (Colen et al., 2006), and Bruckner and Catalano reported that lower employment was associated with higher numbers of deaths due to SID, especially among Black and Hispanic women (T. Bruckner & Catalano, 2006).

The length (approximately 20 years) and large sample size of the NLSY79 ensured ample variation in state economies over the study period. The NLSY79 sample, moreover, represents a diverse group of U.S. women and has a high retention rate over the study period (77.8% as of 2008) (Bureau of Labor Statistics, 2008). This dataset has several important limitations, however. Although there is little choice but to assess smoking and alcohol use with self-report, gestational weight gain could be assessed more accurately using measured weights from before pregnancy and delivery. However, accuracy of self-report is unlikely to vary by exposure to economic contraction, making any measurement error in gestational weight gain non-systematic and resulting in bias towards the null.

As in any longitudinal survey, some births in the NLSY79 dataset are missing data. Births in the study sample (n=7,074) were, however, similar to the study population (n=8,282) in terms of maternal age, race/ethnicity, educational attainment, poverty status, marital status, parity, employment status, and pre-pregnancy BMI categories. Although my study sample included 7,074 births, subgroup analyses by race/ethnicity, poverty, and education were limited by small numbers of births. Additionally, the non-Hispanic/non-Black racial/ethnic group included women of multiple races/ethnicities. These subgroup findings should therefore be considered exploratory, and future studies should utilize larger datasets such as vital statistics

records to further examine these associations by race/ethnicity as well as by educational attainment.

These data allowed assessment of only one of many potential pathways connecting state-level economic contraction and individual-level maternal behavior. Maternal job loss was not associated with maternal pregnancy behaviors and did not explain the association between economic contraction and alcohol use among Black/non-Hispanic women. Many other potentially important mechanisms remain, however, untested. For example, household- or community-level job loss could lead to psychosocial stress and increased consumption of alcohol as a coping mechanism. Research has shown that non-white individuals are more likely to lose jobs during recessions (Farber, 1993); increased job loss in Black/non-Hispanic households or communities could explain the stronger association between economic contraction and alcohol consumption in this group, or this difference could be due to differences in coping mechanisms, social support, or cultural norms. Future research should attempt to identify data sets that can also explore household job or income loss, psychosocial stress, changes in work hours or responsibilities, or community-level effect of increased unemployment.

The economy represents an important aspect of the human ecosystem, and perturbations such as economic contractions likely impact individuals, families, and communities in ways that may impact health behavior and outcomes among pregnant women. Previous work has linked economic contraction to increased risk of SGA (Margerison-Zilko et al., 2011) and other adverse birth outcomes (Margerison Zilko, 2010) and hypothesized that these findings may be due to increased incidence of maternal behaviors such as smoking, alcohol consumption, and inadequate or excessive gestational weight gain during economic contractions. The current study, however, suggests that impacts of economic contraction in early pregnancy on maternal

behavior change are modest and may be limited to certain subgroups. Much work still remains to understand how pregnant women respond to economic change and how these responses differ by race/ethnicity and SES, but such information may ultimately help public health professionals identify groups particularly vulnerable to negative economic pressures. Furthermore, developing a better understanding of how pregnancy behaviors respond to ecologic perturbations will enhance our knowledge about the multilevel determinants of these behaviors.

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Table 1. Characteristics of gestations in study sample: singleton births between 1982 and 2000 to women in National Longitudinal Survey of Youth 1979 (n=7,074).

	N (%)
Exposure to economic contraction in first trimester of pregnancy	376 (5.3)
Job loss during pregnancy	432 (6.1)
Maternal smoking during pregnancy (missing = 18)	1871 (26.5)
Maternal alcohol during pregnancy (missing = 10)	2198 (31.1)
Maternal gestational weight gain[a] (missing = 741)	
Inadequate	1474 (28.5)
Adequate	1580 (30.5)
Excessive	2121 (41.0)
Maternal age	
<20	286 (4.0)
20-29	4781 (67.6)
30-39	1960 (27.7)
>=40	47 (0.7)
Maternal race/ethnicity	

Black/non-Hispanic	1765 (25.0)
Hispanic	1361 (19.2)
Non-Black/non-Hispanic	3948 (55.8)
Maternal educational attainment (missing = 491)	
< 12 years	1324 (20.1)
12 years	2838 (43.1)
> 12 years	2421 (36.8)
Mother married (missing = 485)	3930 (59.6)
Mother in poverty (missing = 1098)	1397 (23.4)
Nulliparous	2548 (36.0)
Maternal pre-pregnancy BMI (missing = 852)	
<18.5	497 (8.0)
18.5-24.9	4156 (66.8)
25.0-29.9	992 (15.9)
>=30	577 (9.3)
Maternal employment status (missing = 771)	
Employed	3024 (48.0)
Unemployed	344 (5.5)
Keeping house	2279 (36.2)
Out of the labor force	656 (10.4)

[a]Based on recommendations by Institute of Medicine, specific to maternal pre-pregnancy BMI, among term births only (n=5,916)

Table 2. Number (percentage) of women reporting maternal pregnancy behaviors by race/ethnicity, educational attainment, and poverty status.

	N (%)			
	Smoking[a] (n=7,056)	Alcohol use[b] (n=7,064)	Inadequate gestational weight gain[c] (n=5,175)	Excessive gestational weight gain[c] (n=5,175)
Race/ethnicity				
Black/non-Hispanic	476 (27.1)	432 (24.5)	414 (33.0)	514 (41.0)
Hispanic	194 (14.3)	306 (22.5)	305 (31.4)	391 (40.3)
Non-Black/non-Hispanic	1201 (30.5)	1460 (37.0)	755 (25.6)	1216 (41.2)
Educational attainment				
Less than high school	579 (43.8)	380 (28.7)	340 (33.4)	389 (38.1)
High school	873 (30.8)	922 (32.5)	634 (28.5)	943 (42.3)
Greater than high school	305 (12.6)	784 (32.4)	484 (25.8)	768 (41.0)
Missing education	114 (23.3)	112 (22.9)	16 (29.1)	21 (38.2)
Poverty status				
Not in poverty	1054 (23.1)	1489 (32.6)	956 (26.5)	1520 (42.1)
In poverty	550 (39.4)	424 (30.4)	372 (34.9)	389 (36.5)

[a]Sample size reflects that 18 observations were missing data on maternal smoking

[b]Sample size reflects that 10 observations were missing data on maternal alcohol use

[c]Sample size reflects that analyses of gestational weight gain were restricted to full-term pregnancies (n=5,916) and that 741 of those observations were missing data on weight gain.

Table 3. Risk ratios (95% confidence intervals) for maternal pregnancy behaviors.

	Smoking[a] (n=7,056)	Alcohol use[b] (n=7,064)	Inadequate gestational weight gain[c] (n=3,054)	Excessive gestational weight gain[c] (n=3,701)
Exposure to economic contraction in first trimester				
Exposed	1.08 (0.96, 1.21)	1.02 (0.88, 1.17)	1.00 (0.86, 1.16)	0.95 (0.89, 1.02)
Unexposed	(ref)	(ref)	(ref)	(ref)
Maternal age				
<20	0.82 (0.71, 0.94)	0.56 (0.43, 0.71)	0.92 (0.77, 1.09)	1.00 (0.92, 1.09)
20-29	(ref)	(ref)	(ref)	(ref)
30-39	1.12 (1.01, 1.24)	1.05 (0.93, 1.18)	1.11 (0.96, 1.27)	1.02 (0.97, 1.07)
>=40	1.34 (0.88, 2.04)	1.03 (0.57, 1.88)	1.34 (0.54, 3.31)	1.00 (0.74, 1.35)
Race/ethnicity				
Black/non-Hispanic	0.82 (0.76, 0.89)	0.68 (0.61, 0.75)	1.21 (1.09, 1.35)	1.02 (0.98, 1.06)
Hispanic	0.68 (0.61, 0.75)	0.62 (0.55, 0.70)	1.28 (1.14, 1.45)	1.02 (0.98, 1.07)
Non-Black/non-Hispanic	(ref)	(ref)	(ref)	(ref)
Educational attainment				
Less than high school	1.24 (1.15, 1.34)	0.98 (0.88, 1.09)	1.02 (0.92, 1.13)	1.00 (0.95, 1.04)
High school	(ref)	(ref)	(ref)	(ref)
Greater than high school	0.71 (0.66, 0.77)	1.09 (1.00, 1.18)	0.99 (0.90, 1.09)	0.98 (0.94, 1.01)
Marital status				
Not married	(ref)	(ref)	(ref)	(ref)

Married	0.77 (0.72, 0.82)	0.79 (0.73, 0.86)	0.88 (0.8, 0.96)	0.96 (0.93, 0.99)
Poverty status				
Not in poverty	(ref)	(ref)	(ref)	(ref)
In poverty	1.04 (0.96, 1.13)	0.99 (0.89, 1.1)	1.00 (0.90, 1.12)	0.95 (0.91, 1.00)
Parity				
Parous	(ref)	(ref)	(ref)	(ref)
Nulliparous	0.88 (0.83, 0.94)	1.00 (0.93, 1.08)	0.92 (0.84, 1.00)	1.04 (1.01, 1.07)
Pre-pregnancy body mass index				
<18.5	1.12 (1.03, 1.23)	1.00 (0.88, 1.14)	1.04 (0.92, 1.18)	0.96 (0.90, 1.02)
18.5-24.9	(ref)	(ref)	(ref)	(ref)
25.0-29.9	0.94 (0.86, 1.02)	0.87 (0.78, 0.97)	0.76 (0.66, 0.87)	1.10 (1.06, 1.14)
>=30	0.90 (0.81, 1.01)	0.87 (0.76, 1.01)	1.41 (1.24, 1.59)	1.18 (1.13, 1.24)
Employment status				
Employed	(ref)	(ref)	(ref)	(ref)
Unemployed	1.04 (0.92, 1.19)	0.88 (0.75, 1.03)	0.98 (0.83, 1.16)	1.01 (0.94, 1.08)
Keeping house	1.03 (0.96, 1.10)	0.87 (0.80, 0.94)	1.03 (0.94, 1.13)	1.00 (0.96, 1.03)
Out of the labor force	1.11 (1.00, 1.22)	0.97 (0.86, 1.10)	0.99 (0.86, 1.13)	0.99 (0.94, 1.05)

[a]Sample size reflects that 18 observations were missing data on maternal smoking

[b]Sample size reflects that 10 observations were missing data on maternal alcohol use

[c]Sample size reflects that analyses of gestational weight gain were restricted to full-term pregnancies (n=5,916), that 741 of those observations were missing data on weight gain, and that models of inadequate gain excluded excessive gainers and vice versa

Figure 1. Total number of months (among all U.S. states combined) classified as unexpectedly contractive by year from 1980-2009.

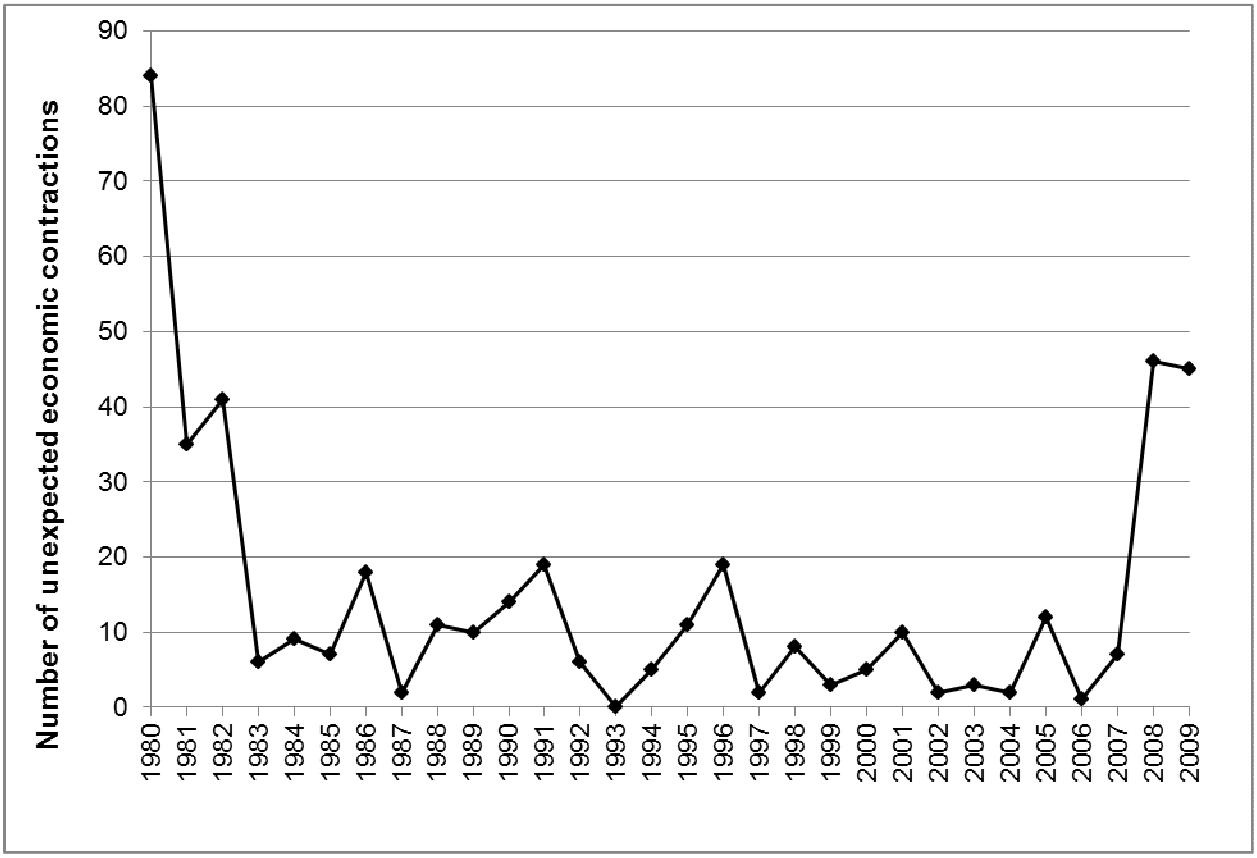
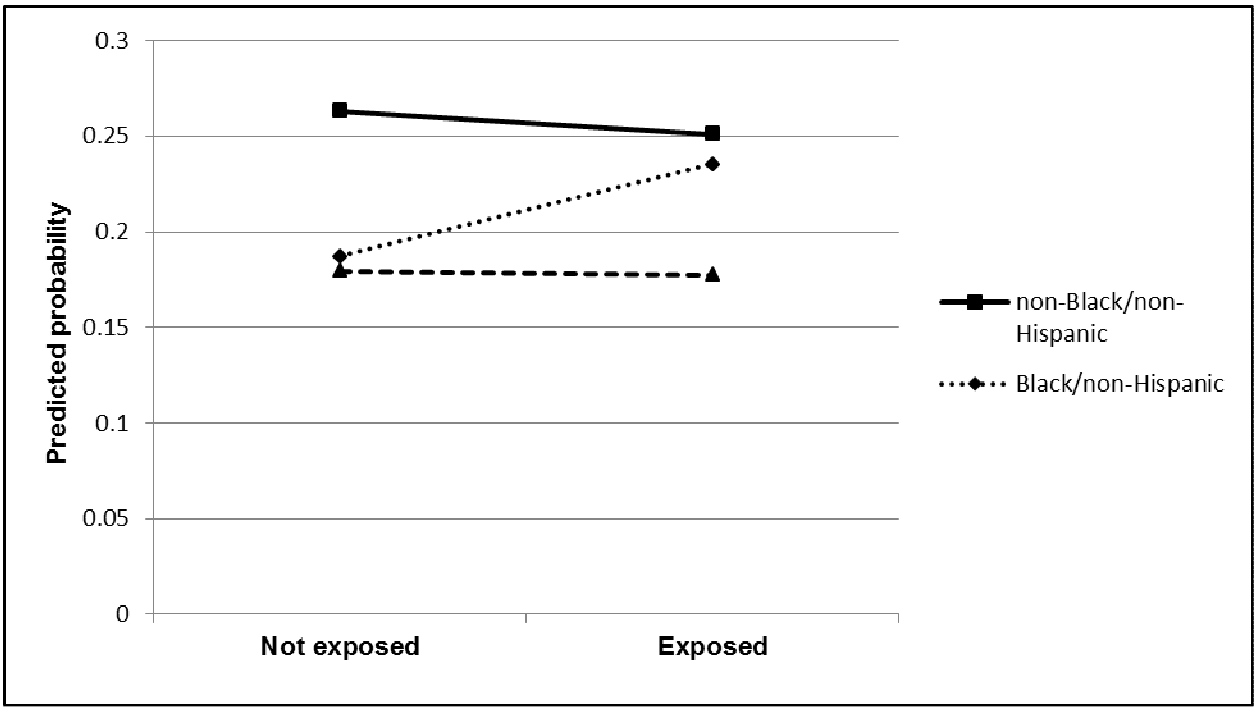


Figure 2. Predicted probabilities[1] of alcohol consumption during pregnancy under conditions of exposure to unexpected economic contraction during pregnancy compared to no exposure, by race/ethnicity.



[1]Predicted probabilities based on generalized linear models with interaction terms between exposure to economic contraction and indicator variables for Black/non-Hispanic and Hispanic race/ethnicity; calculated for each woman under conditions of exposed and not exposed using her own values for all covariates and averaged across individuals by race/ethnicity.

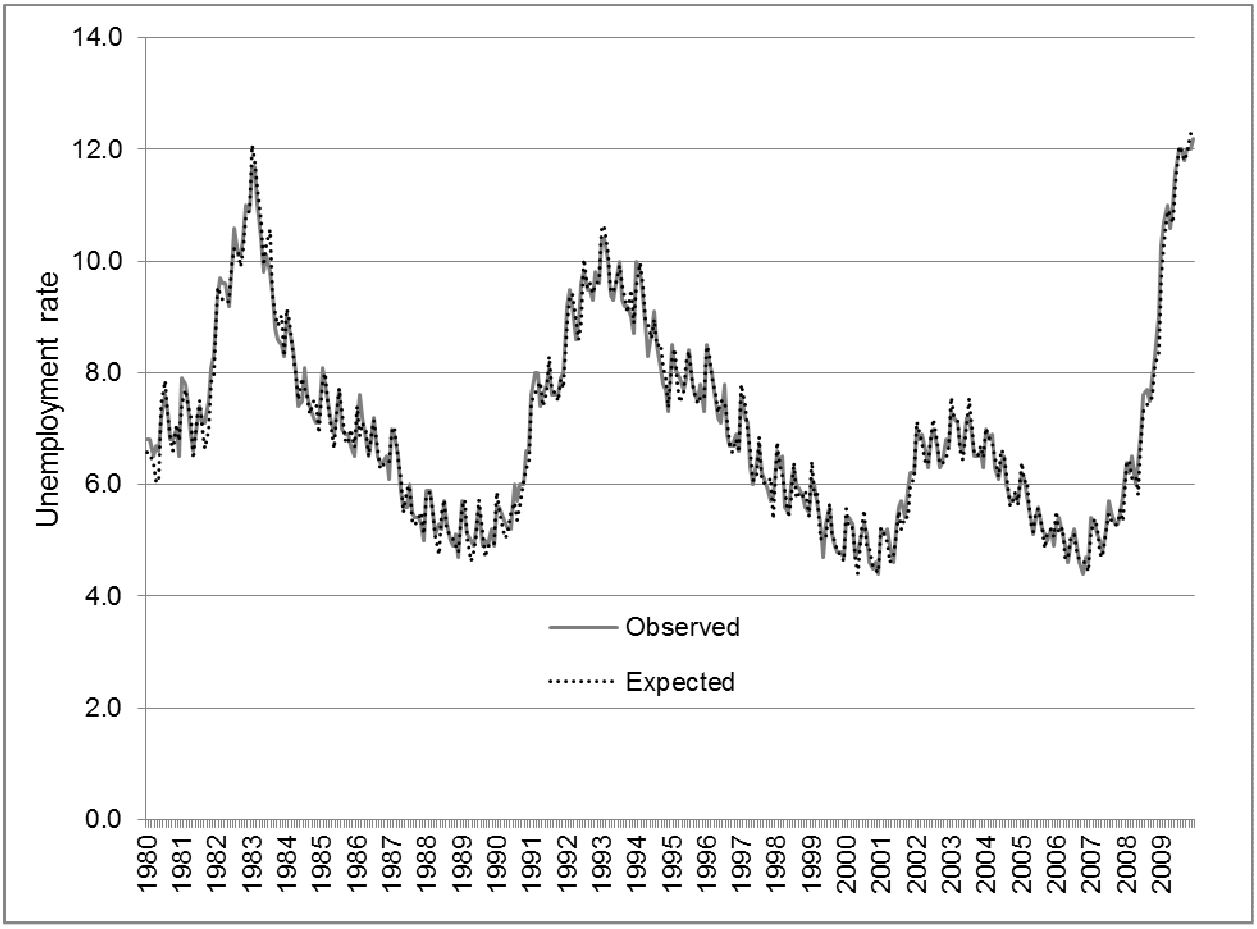
Appendix A. Best-fitting ARIMA models for each U.S. state, Washington D.C., and Puerto Rico

State	ARIMA equation
Alabama	$\nabla\nabla_{12}Z_t = \frac{(1-\theta B^{12})\,a_t}{(1-\phi_1 B-\phi_2 B^2)}$
Alaska	$\nabla\nabla_{12}Z_t = \frac{(1-\theta B^{12})\,a_t}{(1-\phi B)}$
Arizona	$\nabla\nabla_{12}Z_t = (1-\theta_1 B-\theta_2 B^2)(1-\theta_3 B^{12})a_t$
Arkansas	$\nabla\nabla_{12}Z_t = (1-\theta B^{12})\,a_t$
California	$\nabla\nabla_{12}Z_t = (1-\theta_1 B-\theta_2 B^2-\theta_3 B^3)(1-\theta_4 B^{12})\,a_t$
Colorado	$\nabla\nabla_{12}Z_t = (1-\theta_1 B-\theta_2 B^2-\theta_3 B^3)(1-\theta_4 B^{12})\,a_t$
Connecticut	$\nabla\nabla_{12}Z_t = \frac{(1-\theta B^{12})\,a_t}{(1-\phi_1 B-\phi_2 B^2)}$
Delaware	$\nabla\nabla_{12}Z_t = (1-\theta B^{12})a_t$
Washington, DC	$\nabla\nabla_{12}Z_t = \frac{(1-\theta B^{12})\,a_t}{(1-\phi B)}$
Florida	$\nabla\nabla_{12}Z_t = (1-\theta_1 B-\theta_2 B^2)(1-\theta_3 B^{12})\,a_t$
Georgia	$\nabla\nabla_{12}Z_t = (1-\theta B^{12})a_t$
Hawaii	$\nabla\nabla_{12}Z_t = (1-\theta B^{12})a_t$
Idaho	$\nabla\nabla_{12}Z_t = (1-\theta B^{12})a_t$
Illinois	$\nabla\nabla_{12}Z_t = \frac{(1-\theta B^{12})\,a_t}{(1-\phi B^2)}$
Indiana	$\nabla\nabla_{12}Z_t = \frac{(1-\theta B^{12})\,a_t}{(1-\phi B)}$
Iowa	$\nabla\nabla_{12}Z_t = (1-\theta B^{12})a_t$

Kansas	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Kentucky	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Louisiana	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Maine	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Maryland	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Massachusetts	$\nabla\nabla_{12}Z_t = \frac{(1 - \theta B^{12})\, a_t}{(1 - \emptyset_1 B - \emptyset_2 B^2 - \emptyset_3 B^3)}$
Michigan	$\nabla\nabla_{12}Z_t = \frac{(1 - \theta B^{12})\, a_t}{(1 - \emptyset_1 B - \emptyset_2 B^2)}$
Minnesota	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Mississippi	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Missouri	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Montana	$\nabla\nabla_{12}Z_t = (1 - \theta_1 B)(1 - \theta_2 B^{12})a_t$
Nebraska	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Nevada	$\nabla\nabla_{12}Z_t = \frac{(1 - \theta B^{12})\, a_t}{(1 - \emptyset_1 B^2 - \emptyset_2 B^3)}$
New Hampshire	$\nabla\nabla_{12}Z_t = \frac{(1 - \theta B^{12})\, a_t}{(1 - \emptyset_1 B - \emptyset_2 B^2)}$
New Jersey	$\nabla\nabla_{12}Z_t = (1 - \theta_1 B - \theta_2 B^2)(1 - \theta_3 B^{12})\, a_t$
New Mexico	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
New York	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
North Carolina	$\nabla\nabla_{12}Z_t = \frac{(1 - \theta B^{12})\, a_t}{(1 - \emptyset_1 B - \emptyset_2 B^2)}$
North Dakota	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Ohio	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$

Oklahoma	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Oregon	$\nabla\nabla_{12}Z_t = \frac{(1 - \theta B^{12})\, a_t}{(1 - \emptyset_1 B - \emptyset_2 B^2)}$
Pennsylvania	$\nabla\nabla_{12}Z_t = (1 - \theta_1 B - \theta_2 B^2)(1 - \theta_3 B^{12})a_t$
Rhode Island	$\nabla\nabla_{12}Z_t = \frac{(1 - \theta B^{12})\, a_t}{(1 - \emptyset_1 B - \emptyset_2 B^2 - \emptyset_3 B^3 - \emptyset_4 B^4)}$
South Carolina	$\nabla\nabla_{12}Z_t = (1 - \theta_1 B)(1 - \theta_2 B^{12})a_t$
South Dakota	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Tennessee	$\nabla\nabla_{12}Z_t = \frac{(1 - \theta_1 B^1)(1 - \theta_2 B^{12})\, a_t}{(1 - \emptyset_1 B)}$
Texas	$\nabla\nabla_{12}Z_t = \frac{(1 - \theta B^{12})\, a_t}{(1 - \emptyset_1 B)(1 - \emptyset_2 B^3)}$
Utah	$\nabla\nabla_{12}Z_t = \frac{(1 - \theta B^{12})\, a_t}{(1 - \emptyset_1 B - \emptyset_2 B^2)}$
Vermont	$\nabla\nabla_{12}Z_t = \frac{(1 - \theta B^{12})\, a_t}{(1 - \emptyset B)}$
Virginia	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Washington	$\nabla\nabla_{12}Z_t = (1 - \theta_1 B - \theta_2 B^2)(1 - \theta_3 B^{12})a_t$
West Virginia	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Wisconsin	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Wyoming	$\nabla\nabla_{12}Z_t = (1 - \theta B^{12})a_t$
Puerto Rico	$\nabla\nabla_{12}Z_t = \frac{(1 - \theta B^{12})\, a_t}{(1 - \emptyset_1 B)(1 - \emptyset_2 B^{12})}$

Appendix B. Observed and expected (from ARIMA models) values of unemployment rate for California, 1980-2009.



Appendix C. Number and percentage of pregnancies exposed to unexpected economic contraction in the first trimester by year.

Year	Exposure to economic contraction during first trimester
1982	86 (13.4)
1983	70 (11.3)
1984	4 (0.7)
1985	30 (4.8)
1986	51 (10.1)
1987	10 (1.9)
1988	2 (0.4)
1989	30 (5.2)
1990	25 (5.6)
1991	31 (8.3)
1992	18 (5.5)
1993	2 (0.8)
1994	0 (0)
1995	4 (2.5)
1996	9 (5.5)
1997	2 (1.2)
1998	0 (0)
1999	0 (0)

2000	0 (0)
2001	0 (0)
2002	2 (13.3)

Appendix D. Risk ratios (95% CI) maternal pregnancy behaviors comparing births exposed vs. unexposed to economic variables

	Risk ratios (95% CI)			
	Smoking (n=7,056)[a]	Alcohol use (n=7,064)[b]	Inadequate gestational weight gain (n=3,054)[c]	Excessive gestational weight gain (n=3,701)[c]
Exposure to economic contraction in first or second trimester	1.01 (0.93, 1.11)	1.06 (0.96, 1.17)	1.02 (0.92, 1.15)	0.98 (0.93, 1.02)
Exposure to economic expansion in first trimester	0.98 (0.88, 1.10)	1.06 (0.92, 1.20)	0.99 (0.86, 1.16)	0.99 (0.93, 1.05)
Individual-level maternal job loss during pregnancy	1.08 (0.97, 1.20)	1.04 (0.91, 1.18)	1.04 (0.90, 1.21)	1.02 (0.96, 1.08)
Robustness checks				
Restricted to first birth in dataset to each mother	(n = 3,970)	(n = 3,971)	(n = 1,713)	(n = 2,171)
	Did not converge	1.03 (0.88, 1.20)	0.96 (0.81, 1.13)	0.95 (0.87, 1.02)
Complete case analysis	(n=4,888)	(n=4,894)	(n=2,580)	(n=3,081)
	1.08 (0.96, 1.22)	0.97 (0.83, 1.13)	1.00 (0.87, 1.15)	0.96 (0.89, 1.02)

[a]Sample size reflects that 18 observations were missing data on maternal smoking

[b]Sample size reflects that 10 observations were missing data on maternal alcohol use

[c]Sample size reflects that analyses of gestational weight gain were restricted to full-term pregnancies (n=5,916), that 741 of those observations were missing data on weight gain, and that models of inadequate gain excluded excessive gainers and vice versa