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Pain at the pump: Gasoline prices and subjective well-being

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ABSTRACT

In recent years, there has been growing interest in the health implications of rising gasoline prices. This paper considers the impact of gasoline prices on subjective well-being, as captured by survey questions on happiness and life satisfaction. Using rich data from the DDB Worldwide Communications Life Style™ survey, we document a negative relationship between gasoline prices and self-reported life satisfaction over the period 1985–2005. The estimated reduction in well-being, moreover, is found to be nearly twice as large among groups of likely car owners. Interestingly, although rising gasoline prices lead to an immediate deterioration in subjective well-being, analyses of lagged prices suggest that well-being almost fully rebounds 1 year later and changes very little each year thereafter. Our contemporaneous estimates imply that rising gasoline prices generate well-being losses comparable to faltering labor market conditions, and likely offset some of the physical health benefits found in previous research.

1. Introduction

In recent years, rising gasoline prices in the United States have captured the public's attention. Since 2000, the average price of gasoline increased 151%, from $1.56 per gallon (in March of 2000) to $3.91 (in March of 2012). Within the past 24 months alone, gasoline prices rose by nearly 40%. Such rapid changes in the cost of a good as essential as gasoline have led to deep concerns among the American public. According to a recent Gallup poll, 67% of respondents reported that high gasoline prices had resulted in financial hardship (Gallup, 2011). This figure is among the highest levels ever recorded by the measure, and is only slightly eclipsed by the record 72% when gasoline prices first reached $3.00 per gallon in 2005. The growing financial anxiety, moreover, appears to be coupled with signs of behavioral change. The same Gallup poll finds that 53% of Americans made "major changes in their personal lives," with many respondents claiming to stay home more, take fewer vacations, and engage in less leisure driving.

These data suggest that increases in gasoline prices may adversely affect perceptions regarding one's quality-of-life. Yet with the exception of a recent report by Graham et al. (2010) no study has undertaken a systematic examination of the relationship between gasoline prices and subjective well-being, as captured by survey questions on happiness and life satisfaction. The key contribution of this paper is to provide such an analysis. Although definitions of subjective well-being tend to focus on the cognitive dimensions of how people feel about their lives, the well-known connection between self-reported happiness and physical health suggests that results from this study are potentially germane to a variety of health outcomes (Diener and Seligman, 2004; Frey and Stutzer, 2002; Kahneman and Deaton, 2010). Furthermore, economists and public policy researchers are increasingly turning to these measures to understand the ways in which self-reported well-being is influenced by a range phenomena, including gross domestic product (Di Tella et al., 2003), labor market conditions (Herbst, 2011a), unemployment insurance benefits (Herbst, 2011a), and cigarette taxes (Gruber and Mullainathan, 2005). Our study makes a contribution to this broad literature.

This paper more directly complements the small but growing literature on the *physical health* effects of gasoline prices and taxes. The first strand of relevant literature examines the extent to which driving behavior and intensity influence rates of overweight and obesity (Frank et al., 2004; Li et al., 2009; Wen et al., 2006). This work consistently finds that increases in vehicle usage are associated with a significantly higher prevalence of weight problems. Another strand of research addresses directly the question of whether gasoline prices and taxes are related to health outcomes. For example, recent work by Courtemanche (2011) and Rashad et al. (2005) analyzes the relationship between gasoline prices and weight outcomes. This research finds that increased gasoline prices lead to reductions in BMI and declining rates of overweight and obesity. A final strand of research attempts to understand the mechanisms through which gasoline prices reduce obesity. Much of this work focuses on changes to health-related behaviors,

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including food consumption (Courtemanche, 2011) and physical activity (Courtemanche, 2011; Hou et al., 2011; Sen, 2011) patterns. These papers find that higher gasoline prices reduce the frequency of eating at restaurants while increasing the amount of physical activity from walking, housework, and yard work.

To empirically study the relationship between gasoline prices and subjective well-being, we rely on micro-data from the DDB Worldwide Communications Life Style™ survey, an extremely rich data archive that dates back to the mid-1970s, when the advertising agency DDB Worldwide Communications began inquiring about Americans' consumer preferences and habits. Importantly for the current study, the Life Style survey has consistently asked respondents a standard question about life satisfaction. The analyses rely on repeated cross-sections of Life Style surveys merged with real after-tax gasoline prices over the period 1985–2005. This data structure allows us to account for many hard-to-measure determinants of subjective well-being that are spuriously correlated with gasoline prices. In particular, our baseline model introduces state fixed effects to account for permanent differences across states that may simultaneously influence gasoline prices and subjective well-being, year effects to account for time-varying national determinants of well-being, and state-specific time trends to control for unobservables that are trending within states over time.

To further mitigate the influence of omitted variables, our expanded model exploits variation in states' population density to estimate the differential effect of gasoline prices across those with a higher propensity to own a car (low-population-density areas) and those with a lower propensity to own a car (high-population-density areas). Indeed, we provide evidence that car ownership rates are substantially higher in rural areas than in urban ones, and we use individuals residing in high-population-density areas as a comparison group to further account for unobserved social, political, and economic forces that shape gasoline prices. From a policy perspective, this approach is advantageous because it yields an estimate of gasoline prices for those most likely to be influenced by them: likely car owners.

We find that rising gasoline prices are associated with reductions in subjective well-being. Our full sample estimates suggest that a $1.00 increase in gasoline prices is associated with a 4.8% point decrease in the likelihood of being very satisfied with life, corresponding to a well-being reduction of 7.1%. Among likely car owners (i.e., rural residents), however, the adverse effect of gasoline prices is larger: our estimate implies a well-being reduction of 11.7%. On the other hand, increases in gasoline prices do not appear to influence life satisfaction among those living in increasingly urban areas. Interestingly, although rising gasoline prices lead to an immediate reduction in subjective well-being, these losses are offset by equal-sized well-being gains 1 year later and only minor well-being changes each year thereafter.

In the final section of the paper, we attempt to contextualize the regression estimates by calculating the income equivalence of the drop in life satisfaction due to an increase in gasoline prices. Our full sample estimates suggest that a $0.20 rise in gasoline prices is equivalent to losing approximately $260 in monthly household income. For individuals residing in the most rural areas, the monthly income loss amounts to nearly $400. These well-being reductions are comparable to those generated by a similar increase in the unemployment rate, and are likely to offset some of the physical health gains cited in Courtemanche's (2010) analysis of obesity.

The magnitude of such well-being losses is not surprising in light of the growing importance of car ownership and fuel consumption in American society. As of 2008, there were 208 million licensed drivers and 248 million vehicles on the road, an increase from 155 million and 165 million, respectively, in the mid-1980s (Federal Highway Administration, 2008). Furthermore, Americans travelled nearly twice as many miles on roads and highways in 2008 as compared to the mid-1980s. Currently, only 9% of households do not own a car, while nearly one-fifth own three or more cars.[1] The increased reliance on automobile travel has led to an explosion in expenditures on gasoline. The average household spent approximately $2700—or 4.3% of income—on fuel in 2008, compared to $1300—or 2.9% of income—in 2000. With gasoline prices on the rise, it is therefore not surprising that recent public opinion surveys find that Americans are deeply dissatisfied with current energy policy, cast widespread blame for the causes of growing prices, and express anxiety over the impact on household budgets.[2]

The remainder of the paper proceeds as follows. Section 2 provides an overview of the theoretical considerations in an analysis of gasoline prices. Section 3 introduces the DDB Needham Life Style survey, and Sections 4 and 5 describe the empirical strategy and results. We conclude with a discussion of policy implications in Section 6.

2. Theoretical considerations

A simple model of the demand for health can be a useful way to illustrate the potential impact of gasoline price fluctuations on subjective well-being (Grossman, 1972).[3] Assume that utility is expressed as a function of current health and well-being, non-market leisure time, the consumption of goods and services, and a set of demographic characteristics (e.g., age, race and ethnicity, and educational attainment). In this model, consumption can be health-promoting (e.g., medical care, physical activity, and healthy food) or health-degrading (e.g., sedentary activities and calorie-dense food). Environmental factors are also important to the production of health, which, for the purposes of this paper, include changes in gasoline prices. An insight from this framework is that rising gasoline price are predicted to have ambiguous effects on subjective well-being that operate through two channels. First, price-induced shocks to leisure time activities and consumption could lead to behavioral changes that affect health and subjective well-being. Second, the economic environment in which individuals operate could directly affect well-being without corresponding changes in individual behavior. We elaborate on these mechanisms below.

Insofar as people respond to an increase in gasoline prices by driving less, subjective well-being could be adversely affected by constraining access to and the consumption of happiness-enhancing goods and services. For example, since eating out at restaurants and taking road-trip vacations require the use of gasoline, individuals may respond to an increase in prices by shifting toward the home production of meals and engaging in "staycations" (i.e., stay-at-home vacations), both of which require little or no gasoline but which might generate less happiness than other activities. Such behavioral changes are referred to as substitution effects because, as gasoline prices rise, the relative cost of engaging in non-driving alternatives decreases, thereby encouraging a shift to these activities. In addition, increasing gasoline prices might induce an income effect that further reduces subjective well-being. If few substitute activities are accessible in the short-run, it is plausible that individuals will allocate more disposable income to gasoline expenses, leaving fewer resources to devote to the production of health and well-being.[4] For example, individuals may reduce the utilization of formal medical and mental health care, forgo expensive gym or

[1] The figures come from the authors' calculation of the 2005 American Community Survey.

[2] See this report from Gallup: http://www.gallup.com/poll/2167/energy.aspx.

[3] This discussion draws on a similar set of insights considered in Herbst (2011a).

[4] This proposition is bolstered by the finding that the short-run price elasticity of gasoline is substantially smaller than the long-run price elasticity (Brons et al., 2008; Espey, 1998).

health club memberships, and decrease participation in leisure activities (e.g., going to the movies, joining clubs, or dining at restaurants).

On the other hand, there are reasons to believe that rising gasoline prices might enhance subjective well-being vis-a-vis improvements in physical health. As gasoline prices increase, individuals would likely substitute away from driving and toward more physically demanding modes of transportation, including bicycling or walking. In addition, the income effects might induce a shift to less expensive but healthier forms of leisure-time activities (e.g., walking, jogging, or yard work), and, as previously stated, individuals could respond to rising gasoline prices by reducing the consumption of calorie-dense restaurant food and increasing the consumption of healthier home-cooked meals. Given the well-established link between physical and psychological health (e.g., Hilleras et al., 1998; Ostir et al., 2000), it is conceivable that gasoline-price-induced improvements in physical health create positive spillovers which increase happiness and life satisfaction.[5]

Finally, rising gasoline prices could adversely affect the subjective well-being of car owners and non-owners alike if individuals interpret such changes as evidence of faltering macro-economic conditions. If this is the case, periods of rising gasoline prices may increase the anxiety associated with losing one's job and the uncertainty about maintaining financial stability. This is consistent with the "economic stress" hypothesis introduced by Catalano and Dooley (1983). Given the strong link between economic downturns and impaired psychological health, including subjective well-being (e.g., Charles and DeCicca, 2008; Herbst, 2011a), it is therefore possible that the impact of gasoline prices could affect well-being indirectly through the perceived health of the macro-economy. Another possibility is that rising gasoline prices could lead to growing anger at and mistrust of economic and political institutions. This has manifested itself in recent years as public outrage at the federal government and petroleum companies compelled some US policymakers to consider a gas tax holiday and a windfall (profit) tax in order to mitigate the perception that the burden of rising gasoline prices is borne disproportionately by taxpayers.

3. Data

We use the DDB Worldwide Communications Life Style™ survey to examine the relationship between gasoline prices and subjective well-being.[6] Each year since 1975, the advertising agency DDB Worldwide Communications commissions Market Facts, a commercial polling firm, to conduct the survey on a sample of approximately 3500 Americans. The questionnaire covers a remarkably diverse set of topics, ranging from consumer behavior and product preferences to recreational activities and political attitudes. Importantly for the current study, the Life Style survey has consistently included a standard item on global life satisfaction in the questionnaire.[7]

It is important to mention several noteworthy characteristics of the Life Style survey. First, although the survey has been conducted annually since the mid-1970s, it included only married individuals between 1975 and 1984. To maintain consistency in the sampling frame, we begin the observation period in 1985.[8] Second, unlike the GSS data—which are collected through face-to-face interviews—the Life Style survey is administered through the mail, thus allowing DDB Worldwide Communications to inquire about sensitive issues while maintaining anonymity and reducing social desirability biases (Dillman et al., 1996; Visser et al., 1996). Finally, the Life Style survey is based on a form of quota sampling called the "mail panel." Briefly, the process for creating the sample begins when Market Facts invites (by mail) large, representative samples to express a willingness to participate in future mail inquires on consumer habits. From this pool of several hundred-thousand individuals, Market Facts then selects a demographically representative sample for the DDB Worldwide Communications Life Style™ survey. Approximately 5000 respondents are mailed a written questionnaire, for which the response rate is consistently between 70% and 80%. Mail panels in general, and the Life Style survey specifically, have been subjected to extensive validity tests (e.g., Groeneman, 1994; Herbst, 2011b; Heberlein and Baumgartner, 1978; Putnam and Yonish, 1999; Visser et al., 1996). Results from these tests indicate a striking similarity in the distribution of demographic characteristics for respondents in the Life Style survey and GSS; a close agreement in the trends of attitudinal variables common to both surveys; and a strong correspondence in the demographic correlates of those attitudinal variables.

Appendix A Table A.1 provides additional comparisons between the Life Style survey and GSS. We present summary statistics for a number of standard demographic variables found in both surveys. Summary statistics for the Life Style survey come from the period 1985 to 2005, while those for the GSS come from the period 1985 to 2004, as no GSS was implemented in 2005. With the exception of the percent married and never married, summary statistics in Life Style survey match closely those derived from the GSS. Consistent with Putnam and Yonish (1999), we find that the Life Style survey overcounts married individuals and undercounts never married individuals relative to the GSS. However, comparisons of other important background characteristics—including race and ethnicity, educational attainment, and employment status—show a close correspondence in the distribution of demographic characteristics across the Life Style survey and GSS.

The analysis sample is created by pooling cross-sections of Life Style surveys between 1985 and 2005 and retaining individuals ages 18 and over, regardless of their employment status, educational attainment, and place of residence. The main results are based on a sample of 75,609 respondents. The primary left-hand-side variable in this analysis is a measure of global life satisfaction. In particular, the questionnaire item is: "I am very satisfied with the way things are going in my life these days."[9] Respondents are asked to indicate the direction and intensity of their agreement with the statement on a scale of one ("definitely disagree") to six ("definitely agree").[10] For ease of interpretation, we construct a binary indicator that equals unity for individuals expressing any agreement with the life satisfaction statement ("moderately agree," "generally agree," or "definitely agree") and zero for those expressing any disagreement ("definitely disagree," "generally disagree," or "moderately disagree"). In robustness checks, we examine alternative parameteriza-

[5] It is important to point out the possibility that physical health could be harmed by rising gasoline prices through an income effect. A decrease in income (because of higher gasoline expenditures) could encourage individuals to shift toward the consumption of cheaper food alternatives, such as highly processed food, while reducing the consumption of more costly fresh fruits and vegetables. If physical and psychological health are correlated, then such behavioral changes imply a worsening of subjective well-being.

[6] We note that Courtemanche (2011) uses this data archive to explore the relationship between gasoline prices and eating and exercise habits. However, he did not provide a detailed introduction to these data, which we do here. Also, note that this discussion of the DDB Worldwide Communications Life Style™ survey is based on the data description provided in Herbst (2011b).

[7] Putnam and Yonish (1999) and Groeneman (1994) provide detailed introductions to the Life Style Survey. It is important to note that this is a proprietary data archive, although the 1975-1998 surveys are freely available on Putnam's *Bowling Alone* (2000) website.

[8] The item on life satisfaction was introduced into the survey in 1983, precluding an analysis throughout the 1970s. The survey underwent a dramatic redesign in 2006. Therefore, we end the observation period in 2005.

[9] The measure of life satisfaction used here is fairly close to other standard measures used in the happiness literature. For example, the Eurobarometer survey asks respondents: "On the whole, are you very satisfied, fairly satisfied, not very satisfied, and not at all satisfied with the life you lead?"

[10] The full set of responses is the following: 1 (definitely disagree), 2 (generally disagree), 3 (moderately disagree), 4 (moderately agree), 5 (generally agree), and 6 (definitely agree).

tions that leave intact the full distribution of ordered responses as well as binary indicators denoting the top ("definitely agree") and bottom ("definitely disagree") of the well-being distribution.

What do measures of "subjective well-being" capture, and are they likely to be valid? Survey reports of subjective well-being capture subjective evaluations about quality-of-life from an individual's point of view (Fischer, 2009). There is widespread scholarly agreement that measures of subjective well-being comprise both affective and cognitive components. Often referred to as emotional well-being, the former dimension captures instantaneous feelings of and momentary changes in happiness, sadness, and other affectations that indicate the degree of pleasantness or unpleasantness in one's short-run experiences. The latter refers to the rational or intellectual components of well-being. In particular, it reflects "remembered" well-being that stems from cognitive evaluations about one's life as a whole. In addition, these measures capture global evaluations of subjective well-being, as opposed to domain-specific well-being (e.g., work and marriage), and both reflect an assessment of average quality-of-life over substantial time horizons.

Measures of subjective well-being are gaining considerable traction in applied empirical research, especially in economics (e.g., Frey and Stutzer, 2002; Gruber and Mullainathan, 2005; Kahneman and Krueger, 2006). As such, these items have been exposed to extensive reliability and validity tests (e.g., Bertrand and Mullainathan, 2001; Krueger and Schkade, 2008).[11] Subjective well-being measures are highly correlated with one another and are strongly associated with other dimensions of well-being (Fordyce, 1988). For example, reports of global happiness and life satisfaction are highly correlated with such physical attributes as smiling, laughing, and verbal expressions of positive emotion (Frey and Stutzer, 2002; Layard, 2005). Indicators of physical health, including self-reported health status and sleep quality, also appear to be correlated with subjective well-being (Diener et al., 2006). Happy individuals are rated similarly happy by friends and family, tend to smile and display more positive affect during social interactions, and are less likely to commit suicide (Helliwell, 2006; Kahneman and Krueger, 2006). Reported happiness responds in predicable ways to changing life events, even though basic personality traits maintain the stability of reported happiness measures (Ehrhardt et al., 2000). Such evidence led Diener (1984) to conclude that subjective well-being measures contain "substantial amounts of valid variance" (p. 551).

We attach to the Life Style survey a measure of annual state-level gasoline prices, which are drawn from the U.S. Energy Information Agency (EIA). These data represent pre-tax retail prices across all grades (i.e., regular, mid-grade, and premium) and environmental formulations (i.e., conventional and reformulated). We adjust these gasoline prices for federal and state taxes using data from the Federal Highway Administration's (FHA) annual publication *Highway Statistics*. Finally, these post-tax prices are expressed in real 2005 dollars using the consumer price index (CPI) from the Bureau of Labor Statistics (BLS). It is important to note that the Life Style survey has been consistently administered in the first half of each calendar year—typically in late-spring or early-summer—while the measure of gasoline prices described above represents an average price over the entire calendar year. In a robustness check, we attempt to more accurately match the timing of the Life Style survey administration with the collection of gasoline price data. In particular, we construct an alternative gasoline price variable based on the average price in the second quarter of each calendar year. We then reestimate our main model—Eq. (2)—using this alternative gasoline price variable, and the results are very similar to those generated by the main measure.

Table 1 and Fig. 1 show summary statistics for the key variables used in the analysis. Over the period 1985–2005, approximately 68% of survey participants reported that they are very satisfied with life. Fully 16% are in the top well-being category (the most satisfied with life), while 8% are in the bottom category (the least satisfied with life). The average real gasoline price throughout this period is \$1.91 per gallon, with minimum price of \$1.38 and a maximum of \$2.58. A decomposition of the variation in gasoline prices shows that most of the variation comes from within-state changes over time as opposed to between-state differences. Indeed, the within-state standard deviation is \$0.20, while the between-state standard deviation is \$0.08.[12] We follow Courtemanche (2011) by including state and year fixed effects in the main model, but then estimate robustness checks in which the year effects are replaced by unrestricted linear and quadratic time trends. Doing so should mitigate the near-complete saturation of variation in gasoline prices, thereby increasing the efficiency of the estimates. Results from the time trend model are similar to those derived from the main model.

4. Empirical implementation

4.1. Basic model and results

Armed with individual-level survey data on subjective well-being and state-level gasoline prices over the period 1985–2005, we begin the empirical analysis by establishing the relationship between gasoline prices and self-reported life satisfaction. In particular, we estimate versions of the following standard reduced form regression model (e.g., Courtemanche, 2011; Gruber and Mullainathan, 2005; Herbst, 2011a):

$$Y^*_{ist} = \varphi_t + \gamma_1 G_{st} + \mathbf{X}'_{ist}\beta + \mathbf{S}'_{st}\beta + \eta_s + (\eta_s \times \text{trend}) + \varepsilon_{ist}, \quad (1)$$

where i indexes individuals, s indexes states, t indexes years, and Y^* is a continuous latent representation of the ith respondent's life satisfaction, Y. Given that the measure of life satisfaction is dichotomous, we estimate Eq. (1) using a linear probability model (OLS).[13] The G represents the state-specific gasoline price in each year, and the vector given by $\mathbf{X}'$ represents a number of observable demographic controls, including gender; age; race and ethnicity; marital status; the presence of children ages 0–17 in the household; educational attainment; and employment status. Note that we omit from (1) a control for household income, as this is likely to be endogenous. Inclusion of income would also complicate the interpretation gasoline prices, given that prices effects are expected to partially work through the impact on household income. Nevertheless, in a robustness check, we add household income to the basic analysis, and the results are qualitatively similar to those reported here.[14]

The model also includes a set of controls for the unobserved

[11] These measures are not without their criticisms, however (e.g., Bertrand and Mullainathan, 2001).

[12] Not surprisingly, a regression of real, post-tax gasoline prices that includes only state fixed effects yields an R-squared of 0.15. However, a model that includes only year fixed effects yields an R-squared of 0.74. Together, these state and year effects explain 89% of the variation in gasoline prices.

[13] We experiment with several other parameterizations of the life satisfaction variable. First, we estimate the model on the full distribution of ordered responses using an ordered probit. The results are qualitatively similar to those reported here. Second, we create separate binary indicators that equal unity for those "definitely agreeing" and "definitely disagreeing" with the life satisfaction statement. The outcomes are modeled using linear probability models. Although the gasoline price coefficient in these models takes the expected sign, they are small in magnitude and

[14] In this paper, we express income as real total family income, plus quadratic, cubic, and quartic polynomials in income. The raw income variable in the Life Style Survey is categorical. Therefore, we assign the mid-point of the income category into which each respondent falls and express that amount in constant 2005 dollars. Not surprisingly, a model with the income controls included causes the estimated effect of gasoline prices to decline somewhat. For example, the coefficient (and standard error) on gasoline prices in the full model without household income is −0.048 (0.028). In a model with income included, the coefficient on prices falls slightly to −0.044 (0.027).

Table 1
Summary statistics.

Variable	Mean	SD	Minimum	Maximum
Dependent variable				
Life satisfaction (%)	0.679	0.467	0	1
Gasoline price variable				
Real gasoline prices ($ per gallon, post-tax)	1.906	0.205	1.382	2.576
Demographic covariates				
Age (years)	47.163	16.004	18	99
Female (%)	0.551	0.497	0	1
White (%)	0.858	0.349	0	1
Black (%)	0.079	0.269	0	1
Other (%)	0.063	0.243	0	1
Married (%)	0.706	0.455	0	1
Single, never married (%)	0.113	0.316	0	1
Widowed (%)	0.075	0.264	0	1
Separated (%)	0.018	0.134	0	1
Divorced (%)	0.086	0.280	0	1
Children ages 0–17 (%)	0.381	0.486	0	1
Less than high school (%)	0.092	0.289	0	1
High school (%)	0.330	0.470	0	1
Some college (%)	0.303	0.460	0	1
Bachelor's degree (%)	0.274	0.446	0	1
Employed (%)	0.660	0.474	0	1
State-level covariates				
Population density (persons psm)	232.741	436.382	4.7	10140.35
Per capita income ($1000)	23.347	6.698	9.892	52.811

Notes: Calculations are based on the DDB Worldwide Communications Life Style™ survey for the period 1985–2005. The life satisfaction statement is the following: "I am very satisfied with the way things are going in my life these days." The responses categories are: 6 = definitely agree, 5 = generally agree, 4 = moderately agree, 3 = moderately disagree, 2 = generally disagree, and 1 = definitely disagree. These responses are collapsed to create a binary indicator of any agreement with the statement (6 = definitely agree, 5 = generally agree, 4 = moderately agree). Gasoline prices are expressed in 2005 dollars.

determinants of subjective well-being that might be spuriously correlated with gasoline prices. In particular, we introduce a vector of state fixed effects, η_s, to account for permanent differences across states that may simultaneously influence local gasoline prices and subjective well-being (e.g., access to public transportation). Second, we add year dummies, φ_t, to account for time-varying national determinants of prices and well-being (e.g., international political unrest or natural disasters). Third, we experiment with state-specific linear time trends to purge the estimates of unobservables that are trending at different rates within states over time (e.g., changing attitudes toward fuel efficient vehicles). Finally, the vector $\mathbf{S}'$ includes two additional state-level covariates—population density and per capita income—that control explicitly for cross-state differences in urbanicity and wealth that may determine gasoline prices and reported well-being.

The coefficient of interest in Eq. (1) is γ, which returns the percentage point change in the likelihood of being very satisfied with life given a one-dollar increase in real after-tax gasoline prices.[15,16] This coefficient represents the *average* effect of gasoline prices, that is, it reflects the expected response to an increase in prices across all respondents in the sample, irrespective of their income level or employment status and, importantly, their propensity to be a car owner. A forthcoming analysis will allow the impact of gasoline prices to vary across the distribution of population density (i.e., rural and urban areas) in order to capture the differential response of likely and unlikely car owners.

Results from Eq. (1) are reported in Table 2. Each column presents the coefficient and standard error (in parentheses) associated with gasoline prices from increasingly full specifications. Generally speaking, the coefficients imply that an increase in gasoline prices is associated with a reduction in self-reported life satisfaction. Adding controls causes the estimated effect of (and standard error on) gasoline prices to increase. Not surprisingly, the largest increase in both occurs when the state and year fixed effects are added [column (3)]. Although its standard error doubles in size, the coefficient on gasoline prices increases sixfold and becomes statistically significant when these controls are added. In contrast, incorporating the time trends [column (4)] and state-level covariates [column (5)] produces relatively minor changes in the estimate. Results in column (5), the richest specification, indicate that a $1.00 increase in gasoline prices is associated with a 4.8% point decrease in the likelihood of being very satisfied with life. Given that 67.9% of respondents report that they are very satisfied with life, this estimate corresponds to a well-being reduction of 7.1%.

4.2. Expanded model

Although the estimates in Table 2 suggest that rising gasoline prices lead to reductions in subjective well-being, there are at least two problems with the analysis. One concern is the continued presence of omitted variables that are spuriously correlated with gasoline prices. It is possible that the federal and state governments adjust gasoline taxes in response to changing economic or political conditions in ways that are not captured by the controls in Eq. (1). For example, state governments may provide individuals

[15] We experiment with a number of functional form changes to the gasoline price variable. First, we experiment with the natural logarithm of gasoline prices. The coefficient on the logged gasoline prices continues to indicate a negative relationship and statistically significant relationship with life satisfaction. Second, we enter a quadratic in gasoline prices. In this case, neither of the coefficients on the gasoline price variables are precisely estimated. Finally, we make several attempts to determine whether there are threshold effects of gasoline prices. For example, we test whether gasoline prices above the median for the sample period ($1.88) affect life satisfaction differentially from when prices are below the median. Interestingly, the magnitude of the effects are similar (−0.072 and −0.067) and both are nearly statistically significant at the 10% level.

[16] All regressions report robust standard errors, adjusted for state-year clustering. Estimating separate regressions that cluster the standard errors by state and by year does not substantially change the results. The Life Style Survey includes a weight, but there is insufficient documentation on how the weight is constructed. Therefore, we conduct the analyses using unweighted data. However, applying the weight does not change any of the results discussed in the text.

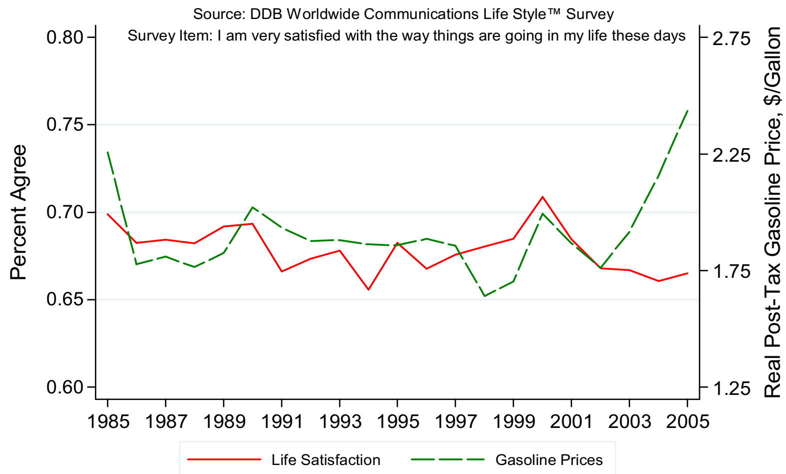

Fig. 1. Self-reported life satisfaction and real gasoline prices, 1985–2005.

Table 2
The impact of real gasoline prices on life satisfaction. Dependent variable: "I am very satisfied with the way things are going in my life these days".

Variable	(1)	(2)	(3)	(4)	(5)
Real gasoline prices	0.002	−0.007	−0.041*	−0.048*	−0.048*
	(0.009)	(0.009)	(0.021)	(0.028)	(0.028)
Demographic controls	No	Yes	Yes	Yes	Yes
State fixed effects	No	No	Yes	Yes	Yes
Period effects	No	No	Yes	Yes	Yes
State-specific linear time trends	No	No	No	Yes	Yes
State-level controls	No	No	No	No	Yes
Observations	75,609	75,609	75,609	75,609	75,609

Notes: Analyses are based on the DDB Worldwide Communications Life Style™ survey for the period 1985–2005. Standard errors, reported in parentheses, are adjusted for state-year clustering. The dependent variable is based on the statement: "I am very satisfied with the way things are going in my life these days." Responses categories are: 6 = definitely agree, 5 = generally agree, 4 = moderately agree, 3 = moderately disagree, 2 = generally disagree, and 1 = definitely disagree. These responses are collapsed to create a binary indicator of any agreement with the statement (6 = definitely agree, 5 = generally agree, 4 = moderately agree). Gasoline prices are expressed in 2005 dollars and incorporate state and federal taxes. Demographic controls include age, gender, race, the presence of children in the household, marital status, educational attainment, and employment status. State-level variables include per capita income and population density.

* Statistical significance at the 0.10 levels.

with a temporary gas tax "holiday" during economic downturns. Insofar as these unobserved economic and political factors are correlated with subjective well-being, the coefficient on gasoline prices will be biased. It is also possible that changes in gasoline taxes are enacted to fund other government initiatives that influence subjective well-being (e.g., infrastructure, education, and social services). Failure to control for these policy changes would also bias the effect of gasoline prices. The second problem with Eq. (1) is that it generates an *average* effect of gasoline prices over all individuals in the Life Style survey, many of whom do not own a car or do not drive extensively, and thus are less likely to be affected by an increase in prices. By averaging the impact of gasoline prices over car owners (or those with a high propensity to drive) and non-car-owners (or those with a low propensity to drive), estimates of γ in Eq. (1) are likely to understate the "true" effect of gasoline prices.

One solution is to stratify the sample by car ownership status and estimate Eq. (1) on the sub-set of car owners. Another strategy is to include in the model an explicit control for car ownership and interact it with the gasoline price variable. However, both options are problematic. Estimating the model on the sub-set of car owners would introduce a form of sample selection bias because decisions regarding car ownership and driving intensity are themselves a function of gasoline prices. If those who stop driving in response to a rise in gasoline prices have higher levels of subjective well-being (compared to those who continue driving), then splitting the sample by car ownership would bias the results toward a reduction in well-being among the remaining drivers as gasoline prices increase. Adding a control for car ownership is also problematic because it is likely to be endogenous in a model of subjective well-being. We are particularly concerned about the possibility of reverse causality between car ownership and subjective well-being. Another problem with these approaches is that a change in gasoline prices should influence the well-being of not only current car owners, but also potential owners and former owners. Although direct data on car ownership permits an analysis of the first group, it does not permit an analysis of the second and third groups, thereby precluding an estimate of the *overall* impact of gasoline prices on those with a propensity to own a car. In any case, we are not able to make use of these approaches because car ownership data are not available in the Life Style survey.

Our approach therefore consists of exploiting a source of variation in car ownership that can be used to compare the impact of gasoline prices across those with a high propensity to own a car and those with a low propensity to own a car. In particular, we take advantage of the notion that gasoline prices should disproportionately affect the subjective well-being of current and potential car owners, and we attempt to confirm this by comparing the estimated price effect to a group with a low propensity to own a car. To implement this strategy, we exploit the cross-state and temporal variation in *population density* to generate variation in car ownership rates. There is robust evidence that rates of private vehicle ownership are substantially higher in rural areas than urban areas (e.g., U.S. Department of Transportation, 2001; Raphael and Rice, 2002; Schimek, 1996; Pucher and Renne, 2005), and our analysis of state-level data on population density and motor vehicle registrations overwhelmingly confirms this.[17] Insofar as population density produces meaningful variation in the propensity to own a car, and assuming that likely car owners are disproportionately affected by rising gas prices, then we expect the effect of gasoline prices on subjective well-being to be concentrated among individuals residing in low-population-density areas.

To test this proposition, we estimate the following regression model:

$$Y^*_{ist} = \varphi_t + \gamma_1(G_{st} \times P_{<26th}) + \gamma_2(G_{st} \times P_{26th-50th}) + \gamma_3(G_{st} \times P_{51st-75th}) + \gamma_4(G_{st} \times P_{>75th}) + \mathbf{X}'_{ist}\beta + \mathbf{S}'_{st}\beta + \eta_s + (\eta_s \times \text{trend}) + \varepsilon_{ist}, \text{where} \tag{2}$$

G once again represents the state-specific gasoline price in each year, the *P* is a set of dummy variables that indicate each quartile of the population density distribution, and all other variables are defined in the same manner as Eq. (1). To implement this approach, we first create quartile dummy variables by averaging state-level population density over the period 1985 to 2005, and producing breaks at the 25th percentile ($P_{<26th}$), between the 26th and 50th percentiles ($P_{26th-50th}$), between the 51st and 75th percentiles ($P_{51st-75th}$), and at the 76th percentile ($P_{>75th}$) of the population density distribution. We then interact the quartile dummy variables with gasoline prices (*G*), and include these interactions along with the quartile dummies in the regression. Suppressed from the model is the "main effect" associated with gasoline prices, so that the coefficient on the interactions (γ_1–γ_4) can be interpreted as the impact of gasoline prices at each quartile of the population density distribution. This parameterization allows for a test of whether the effect of gasoline prices on subjective well-being is concentrated among those most likely to own a vehicle or to drive intensively: individuals residing in areas at the bottom end of the population density distribution.

Creating quartile distribution breaks in this manner has several advantages. It ensures a large number of observations in each cell, and allows states to fluctuate between population density quartiles. In addition, there is considerable variation in population density *across* the distribution breaks, which provides a test of the impact of gasoline prices across a diverse continuum of urbanicity. But it also reduces the *within* quartile variation in population density, thereby capturing gasoline price impacts in fairly specific environments. Another advantage of the dummy variable approach is that it mitigates the multicollinearity problem that arises when interacting gasoline prices with the continuously measured population density and including all three variables in the model.[18]

Our identifying assumption is that the unobserved determinants of subjective well-being influence individuals in rural and urban areas in the same manner (Gruber and Mullainathan, 2005). One concern with this assumption is that population density is likely to be a proxy for states' wealth and labor market conditions, political environment, and cultural values, all of which might affect subjective well-being in different ways across rural and urban areas. For example, it is possible that the availability and impact of government-provided goods and services (e.g., welfare, unemployment insurance, and health care) varies systematically across rural and urban areas. Similarly, the presence and structure of states' other excise taxes (e.g., cigarette and sales taxes) may enhance or reduce well-being more in some areas than others. Finally, tastes for redistribution as well as attitudes toward driving and substitute forms of transportation are likely to differ dramatically across rural and urban areas. In each case, the presence of such unobservables would make it difficult to disentangle the effect of gasoline prices from the effect of these confounding factors. To ensure the validity of this identifying assumption, we introduce a number of robustness and falsification tests. First, it should be noted that all models include state fixed effects, year dummies, and state-specific time trends. These variables account for omitted time invariant factors specific to each state, time varying factors specific to each year, and factors following a linear trend with each state that influence the well-being of individuals in rural and urban areas. Second, we include in the model detailed controls for state-level per capita income; the unemployment rate; cigarette, beer, and sales taxes; and the political party affiliation of the governor. These observable controls account explicitly for economic and political factors which are highly likely to be correlated with population density. Further checks interact each of these controls with the population density quartile dummies to determine whether the differential effect of gasoline prices is confounded by other factors that vary across rural and urban areas.

Finally, we conduct an explicit check on the adequacy of using individuals in rural and urban areas to create groups of likely and unlikely car owners, respectively. In particular, we follow the approach in Gruber and Mullainathan (2005) and conduct a series of falsification tests that replace the interactions between gasoline prices and population density with interactions between various excise taxes (cigarette, beer, and sales taxes) and population density. If the estimates on the gasoline price–population density interactions reflect more general price or tax differences across rural and urban areas, then one might expect the excise tax–population density interactions to reveal a similar pattern, that is, to disproportionately influence the subjective well-being of individuals in rural areas. Such a pattern of results would invalidate the use of population density to generate variation in car ownership rates. However, if the gasoline price–population density interactions reflect well-being differences specific to likely and unlikely car owners, then the estimates on the excise tax–population density interactions should not be statistically significant, or at least should not reveal the same pattern as the gasoline price–population density interactions.

Table 3 presents the main results from Eq. (2). Columns (1) and

[17] In particular, we collected detailed data on state-level population density and motor vehicle registrations (per 1000 individuals) over the period 1985–2005. We performed a number of analyses on these data to confirm the relationship between the two. First, the raw correlation is very strong: −0.44. In a simple regression of the motor vehicle registration rate on population density, the R-squared is 0.20, suggesting that population density alone explains about one-fifth of the variation in vehicle ownership. Second, in both 1985 and 2005, we compared the motor vehicle registration rate across the five least population-dense states and the five most population-dense states, and in both years, we found that the vehicle ownership rate in the former far exceeds that in the latter. In 1985, there were approximately 826 vehicles per 1000 individuals in the five most rural states (Alaska, Wyoming, Montana, Nevada, and South Dakota). In contrast, there were 637 vehicles per 1000 individuals in the five most urban states (Connecticut, Massachusetts, Rhode Island, New Jersey, and the District of Columbia). As of 2005, the figures were 1107 vehicles per 1000 individuals (Alaska, Wyoming, Montana, North Dakota, and South Dakota) and 721 vehicles per 1000 individuals (Connecticut, Massachusetts, Rhode Island, New Jersey, and the District of Columbia), respectively. Finally, comparing the vehicle registration rate at various points in the population density distribution over the period 1985–2005, we found a rate of 1004 at the 10th percentile and a rate of 675 at the 90th percentile of the distribution.

[18] Quartile distribution breaks is admittedly ad hoc, so we experiment with quintile and decile breaks as well. Results based on these are qualitatively similar to those reported here. We also experiment with creating distribution breaks based on each year's average population (as opposed to the 1985–2005 average). Again, the results are quite similar to those discussed here.

Table 3
Impact of real gasoline prices on life satisfaction, by population density quartile. Dependent variable: "I am very satisfied with the way things are going in my life these days".

Variable	Regression model results		Household vehicle ownership rate		
	(1)	(2)	0–1 Vehicles (%)	2 Vehicles (%)	3 + Vehicles (%)
Real gasoline prices					
×Population density quartile 1	−0.079***	−0.080***	30	40	29
	(0.030)	(0.029)			
×Population density quartile 2	−0.040	−0.036	36	42	22
	(0.030)	(0.030)			
×Population density quartile 3	−0.044	−0.043	36	41	24
	(0.034)	(0.034)			
×Population density quartile 4	−0.038	−0.037	44	38	18
	(0.035)	(0.035)			
Demographic controls	Yes	Yes			
State fixed effects	Yes	Yes			
Period effects	Yes	Yes			
State-specific linear time trends	Yes	Yes			
State-level controls	No	Yes			
Specification test: *F*-statistic (*p*-value)	–	4.42 (0.036)			
Observations	75,609	75,609			

Notes: Analyses are based on the DDB Worldwide Communications Life Style™ survey for the period 1985–2005. Standard errors, reported in parentheses, are adjusted for state-year clustering. The dependent variable is based on the statement: "I am very satisfied with the way things are going in my life these days". Responses categories are: 6 = definitely agree, 5 = generally agree, 4 = moderately agree, 3 = moderately disagree, 2 = generally disagree, and 1 = definitely disagree. These responses are collapsed to create a binary indicator of any agreement with the statement (6 = definitely agree, 5 = generally agree, 4 = moderately agree). Gasoline prices are expressed in 2005 dollars and incorporate state and federal taxes. Demographic controls include age, gender, race, the presence of children in the household, marital status, educational attainment, and employment status. State-level variables include per capita income. The *F*-statistic and *p*-value are from a test of the null hypothesis of the equality of the gas price effect at the first population density quartile and the (average) impact across the second, third, and fourth quartiles.
*** Statistical significance at the 0.01 levels.

(2) show the coefficient and standard error associated with the impact of gasoline prices at each quartile of the population density distribution. Given that differences in wealth and labor market conditions are likely to be among the most important confounders of the differential effect of gasoline prices across rural and urban areas, we present results from separate models with and without a control for state-level per capita income. Column (1) omits this control, while column (2) adds it. It is clear that the gasoline price–population density interactions are robust to the inclusion of per capita income. In a further specification check, we add to the model an explicit control for household income to better capture income differences between individuals residing in rural and urban areas. Our results are robust to the inclusion of this control, thus providing additional evidence that our gasoline price effects are not likely to be confounded by differences in wealth. The estimates in column (2) strongly support the supposition that likely car owners—or those residing in low-population-density areas—are disproportionately influenced by rising gasoline prices. Indeed, the estimated effect of gasoline prices on subjective well-being at the bottom population density quartile is twice as large as the price effect in the other quartiles, and is significantly larger than the average effects presented in Table 2. This is corroborated by a formal test of the null hypothesis of equal gasoline price effects in the bottom population density quartile and the average across the remaining quartiles. The null is rejected at better than the 5% level (*F*-statistic: 4.42; *p*-value: 0.036), providing strong evidence of a differential gasoline price response across individuals with different propensities to own a car.

The estimates in column (2) suggest that, among those residing in extremely rural areas (i.e., the first quartile of population density), a $1.00 increase in gasoline prices is associated with an 8% point decrease in the likelihood of being very satisfied with life, a result which is highly statistically significant. Given that 68.1% of such respondents report that they are very satisfied with life, this estimate corresponds to a well-being reduction of 11.7%. In contrast, individuals residing in the remaining population density quartiles experience about a 4% point decline in life satisfaction, and in no case are the parameter estimates statistically significant. This marginal effect translates to a 5.9% well-being reduction for individuals in the top three population density quartiles.[19]

These findings indicate that there is a discontinuous drop in the gas price effect at population density quartiles above the first quartile. Does the pattern in car ownership rates over the population density distribution mimic that which is observed for the gas price effects? The last three columns in Table 3 address this question. Specifically, we draw on micro-data from the 2005 American Community Survey (ACS) to calculate household-level private vehicle ownership rates at each population density quartile. We calculate the fraction of households with zero or one vehicle, exactly two vehicles, and three or more vehicles.[20] Not surprisingly, we find that household ownership of zero or one vehicle is lowest in extremely rural areas, while the ownership of three or more vehicles is highest in extremely rural areas. Fully 30% of households in the bottom population density quartile own zero or one vehicle, compared to an average of 38% across the top three quartiles. Conversely, about 30% of households in the bottom quartile own three or more vehicles, compared to an average of 22% across the top three quartiles. In addition, we find that much of this variation is driven by the differential vehicle ownership rate in between the first and second population density quartiles: there is a 6% point gap at the zero or one ownership margin (30% versus 36%) and a 7% point gap at the three

[19] As previously mentioned, we reestimate Eq. (2) using average gasoline prices in the second quarter of each calendar year. Doing so produces only a slight change in the results. The marginal effect (and standard error) for gasoline prices at the bottom population density quartile is −0.073 (0.042) in this model, compared to −0.080 (0.029) in the model using average, annual gasoline prices.

[20] To produce the average vehicle ownership rate at each population density quartile, we ran separate regressions of each vehicle ownership category on dummy variables for the population density quartiles and (the demeaned) total household income. The regressions were estimated without a constant so that the coefficient on each quartile dummy could be interpreted as the average car ownership rate, conditional on family income. We conducted comparable analyses using the 2000 ACS as well as the 1990 U.S. Decennial Census, and the results are very similar to those discussed here.

or more ownership margin (29% versus 22%). These differential ownership rates are strikingly similar to those existing between the first and third population density quartiles, although the gaps jump again at the fourth quartile. Overall, the pattern of car ownership largely mirrors that of the gas price effects, thereby lending additional credibility to the estimates.

How big is the impact of gasoline prices on subjective well-being? One way to assess this is by comparing the gasoline price effects to other well-known happiness "shifters." Our comparison focuses on another macro determinant of subjective well-being: local labor market conditions, as measured by the state-level unemployment rate. To implement this comparison, we replace the gasoline price–population density interactions with an analogous set of interactions between the unemployment rate and population density. We then reestimate the model shown in column (2) of Table 3. Consistent with previous work (e.g., Herbst, 2011a; Di Tella et al., 2003), we find that worsening economic conditions lead to reductions in subjective well-being. In particular, for individuals residing in extremely rural areas (i.e., the first quartile of population density), a 1% point increase in the unemployment rate is associated with a 1% point decrease in the likelihood of being very satisfied with life. This corresponds to a 1.5% reduction in subjective well-being. Thus, within the population of likely car owners, it appears that rising gas prices erode life satisfaction substantially more than a faltering labor market. Tables 4 and 5 provide results from the robustness and falsification tests. Table 4 provides a check on whether the gasoline price–population density interactions are sensitive to explicit controls for a variety of political-economic factors, as well as whether there are omitted interactions that may explain the differential effects of gasoline prices across rural and urban areas. Column (1) presents for comparison purposes the basic results from the previous table. Column (2) adds a control for the state unemployment rate, and column (3) includes the excise taxes and a dummy variable indicating the political party affiliation of each state's governor. The addition of these controls does not substantially change the results, and the null hypothesis of equal gasoline prices effects is consistently rejected. Columns (4) through (6) add separate interactions between per capita income [column (4)], the unemployment rate [column (5)], and excise taxes/party affiliation [column (6)] and the population density quartile dummies. These interactions are intended to capture the differential effect of the political-economic environment on the well-being of individuals with different propensities to own a car (i.e., individuals residing in rural and urban areas). The gasoline price effects are robust to the inclusion of these interactions. In a final robustness check, which is not shown in the table, we add interactions between household income and population density in order to test whether the differential effect of income across rural and urban areas accounts for the pattern of gasoline price effects. Interestingly, the coefficients on the income–population density interactions are very similar in magnitude, implying that rural and urban individuals respond comparably to increases in household income. Once again, the gasoline price effects are robust to the inclusion of these interactions.

Table 5 presents the results from our falsification tests, replacing the gasoline price–population density interactions with state excise tax–population density interactions. The first set of results focus on cigarette taxes, followed by those for beer taxes and sales taxes, respectively. In all cases, we conduct the specification test of the null hypothesis of equal excise tax effects over the distribution of population density. It is clear that, unlike the results for gasoline prices, no discernible pattern exists for the interactions between excise taxes and population density. The interaction terms are not consistently negative and are rarely statistically significant. Most importantly, two of the three excise taxes in column (2) show a *positive* relationship with life satisfaction in the first population density quartile, and in no case are the interactions statistically significant. It is also noteworthy that the inclusion of these new

Table 4
Robustness checks. Dependent variable: "I am very satisfied with the way things are going in my life these days".

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Real gasoline prices						
×Population density quartile 1	−0.080***	−0.075**	−0.071**	−0.081***	−0.070**	−0.071**
	(0.029)	(0.029)	(0.030)	(0.029)	(0.029)	(0.030)
×Population density quartile 2	−0.036	−0.030	−0.029	−0.036	−0.037	−0.024
	(0.030)	(0.030)	(0.030)	(0.030)	(0.029)	(0.030)
×Population density quartile 3	−0.043	−0.036	−0.031	−0.057*	−0.032	−0.031
	(0.034)	(0.033)	(0.034)	(0.033)	(0.033)	(0.032)
×Population density quartile 4	−0.037	−0.032	−0.028	−0.042	−0.030	−0.039
	(0.035)	(0.035)	(0.036)	(0.035)	(0.034)	(0.038)
F-Statistic	4.42	4.48	4.17	3.29	3.42	3.78
p-Value	0.036	0.035	0.042	0.070	0.065	0.052
Per capita income	Yes	Yes	Yes	Yes	Yes	Yes
Unemployment rate	No	Yes	No	No	No	No
State taxes and governor party	No	No	Yes	No	No	No
Per capita income × pop dens	No	No	No	Yes	No	No
Unemployment rate × pop dens	No	No	No	No	Yes	No
State taxes and governor party × pop dens	No	No	No	No	No	Yes
Observations	75,609	75,609	73,600	75,609	75,609	73,600

Notes: Analyses are based on the DDB Worldwide Communications Life Style™ survey for the period 1985 to 2005. Standard errors, reported in parentheses, are adjusted for state-year clustering. The dependent variable is based on the statement: "I am very satisfied with the way things are going in my life these days." Responses categories are: 6 = definitely agree, 5 = generally agree, 4 = moderately agree, 3 = moderately disagree, 2 = generally disagree, and 1 = definitely disagree. These responses are then collapsed to create a binary indicator of any agreement with the statement (6 = definitely agree, 5 = generally agree, 4 = moderately agree). Real gasoline prices are expressed in 2005 dollars and incorporate state and federal taxes. Demographic controls include age, gender, race, the presence of children in the household, marital status, educational attainment, and employment status. The state taxes include cigarette taxes, beer taxes, and sales taxes. Cigarette taxes and beer taxes are reported as cents per 20 pack and cents per gallon, respectively, are adjusted to 2005 dollars, and are expressed in logarithmic form. Sales taxes are reported as percentages. The party of the state's governor is a binary indicator that equals unity for Republican governors. The *F*-statistic and *p*-value are from a test of the null hypothesis of the equality of the gas price effect at the first population density quartile and the (average) impact across the second, third, and fourth quartiles.

* Statistical significance at the 0.10 levels.

** Statistical significance at the 0.05 levels.

*** Statistical significance at the 0.01 levels.

Table 5
Impact of excise taxes on life satisfaction, by population density quartile. Dependent variable: "I am very satisfied with the way things are going in my life these days".

Variable	(1)	(2)	Specification test	
			F-Statistic	*p*-Value
Cigarette tax				
×Population density quartile 1	0.027	0.046		
	(0.289)	(0.287)		
×Population density quartile 2	1.318**	1.463***	2.31	0.129
	(0.539)	(0.542)		
×Population density quartile 3	0.034	−0.019		
	(0.244)	(0.228)		
×Population density quartile 4	0.231	0.249		
	(0.165)	(0.163)		
Beer tax				
×Population density quartile 1	−0.000	−0.088		
	(1.381)	(1.381)		
×Population density quartile 2	−1.617	−1.556	0.50	0.478
	(1.049)	(1.044)		
×Population density quartile 3	−1.115**	−0.961*		
	(0.564)	(0.558)		
×Population density quartile 4	−0.909*	−0.810		
	(0.530)	(0.526)		
Sales tax				
×Population density quartile 1	−0.130	0.016		
	(0.693)	(0.705)		
×Population density quartile 2	−1.696	−1.802	1.54	0.215
	(1.275)	(1.281)		
×Population density quartile 3	−2.409***	−2.270***		
	(0.685)	(0.678)		
×Population density quartile 4	0.549	0.680		
	(1.329)	(1.332)		
Demographic controls	Yes	Yes		
State fixed effects	Yes	Yes		
Period effects	Yes	Yes		
State-specific linear time trends	Yes	Yes		
State-level controls	No	Yes		
Observations	75,609	75,609		

Notes: Analyses are based on the DDB Worldwide Communications Life Style™ survey for the period 1985 to 2005. Standard errors, reported in parentheses, are adjusted for state-year clustering. The dependent variable is based on the statement: "I am very satisfied with the way things are going in my life these days." Responses categories are: 6 = definitely agree, 5 = generally agree, 4 = moderately agree, 3 = moderately disagree, 2 = generally disagree, and 1 = definitely disagree. These responses are collapsed to create a binary indicator of any agreement with the statement (6 = definitely agree, 5 = generally agree, 4 = moderately agree). Gasoline prices are expressed in 2005 dollars and incorporate state and federal taxes. Demographic controls include age, gender, race, the presence of children in the household, marital status, educational attainment, and employment status. State-level variable includes per capita income. The state taxes include cigarette taxes, beer taxes, and sales taxes. Cigarette taxes and beer taxes are reported as cents per 20 pack and cents per gallon, respectively, are adjusted to 2005 dollars, and are expressed in logarithmic form. Sales taxes are reported as percentages. The *F*-statistic and *p*-value are from a test of the null hypothesis of the equality of the gas price effect at the first population density quartile and the (average) impact across the second, third, and fourth quartiles.
* Statistical significance at the 0.10 levels.
** Statistical significance at the 0.05 levels.
*** Statistical significance at the 0.01 levels.

variables does not affect the estimates on the gasoline price–population density interactions. Increases in cigarette taxes appear to bolster well-being in the second population density quartile, while rising beer and sales taxes lower well-being in the third population density quartile. It is not immediately clear why excise taxes would influence well-being in these particular parts of the population density distribution. Together, these results provide little evidence that the gasoline price effects reflect more general price or tax differences between rural and urban areas. Thus, we can be reasonably confident that the pattern of results observed in Table 3 is due to the differential response of likely and unlikely car owners to changes in gasoline prices.

We provide a final robustness check which is intended to confirm the usefulness of population density as a proxy for car ownership. Household-level vehicle ownership data was collected from the 1990 U.S. Decennial Census (5% sample) and the 2000 and 2005 waves of the American Community Survey (ACS). In each survey, a consistent question regarding vehicle ownership was posed to respondents: "How many automobiles, vans, and trucks of one-ton capacity or less are kept at home for use by members of your household?" We use this question to produce state-level estimates of the fraction of households owning three or more vehicles, which, in turn, is used to construct four dummy variables denoting the quartiles of the car ownership distribution over the period 1985–2005. This approach produces substantial variation in car ownership.[21] For example, in the 2005 ACS, the state-level average fraction of households owning three or more vehicles is approximately 22%, with a minimum of 5% and maximum of 35%. The mean ownership rate at the first quartile (the lowest ownership quartile) is 17%, compared to a mean of 27% at the fourth quartile (the highest ownership quartile). A regression model analogous to that in Table 3, column (2) is then estimated, substituting the gasoline price–pop-

[21] We examined several alternatives to the three or more vehicle ownership rate. For example, we produced state-level averages for zero vehicles, zero or one vehicles, and two or more vehicles. Each alternative categorization produced less cross-state variation in car ownership rates than the three or more ownership rate, despite the fact that the states included in each quartile was fairly consistent across each categorization. Ultimately, we decided to use the three or more vehicle ownership rate as the basis for creating the quartiles.

ulation density interactions with the gasoline price-car ownership interactions. The pattern of results is strikingly similar to the main results, with gasoline prices having the largest negative effect on life satisfaction among individuals residing in the highest car ownership quartile.[22]

5. Auxiliary analyses

5.1. Dynamics

Previous studies find that the long-run price elasticity of gasoline (generally in the range of −0.7 to −0.8) is substantially larger than the short-run elasticity (around −0.2) (Brons et al., 2008; Espey, 1998). Therefore, it is reasonable to suspect that as individuals adopt new behaviors by reducing the use of cars and increasing the use of alternative forms of transportation (e.g., bicycling and walking), rising gasoline prices could have different short- and long-term effects on a variety of health outcomes, including subjective well-being. The results in Courtemanche (2011) lend some credibility to this proposition. This paper finds that although changes in gasoline prices lead to immediate effects on adults' weight outcomes, there is fairly strong evidence that the effects are gradual, with rising gasoline prices having their largest impact on BMI and obesity rates over a 3-year period.

To investigate the timing of and potential changes in the impact of gasoline prices on life satisfaction, we incorporate 4-year lags into Eqs. (1) and (2).[23] Results from both equations are presented in Table 6. The estimates in column (1), which correspond to the overall impact of gasoline prices (Eq. (1)), show that although a contemporaneous increase in gasoline prices reduces life satisfaction, within 1 year the losses are more than offset by an *increase* in well-being. The marginal effect on contemporaneous gasoline prices is −0.056—implying an immediate reduction in subjective well-being—while the marginal effect on the 1-year lag in prices is 0.065—implying that a sustained increase in prices is associated with well-being gains 1 year later. Coefficients on the remaining lags are small in magnitude, are equally likely to point to positive and negative effects of gasoline prices, and are never statistically significant. Together, the lags suggest that after 5 years, a sustained $1.00 increase in gasoline prices leads to a 2.9% point decrease in the likelihood of being very satisfied with life, an estimate that is about 40% smaller (in absolute value) than that shown in column (5) of Table 2.

Column (2) shows the results of a model in which the contemporaneous and lagged gasoline prices are interacted with the population density quartile dummy variables, which correspond to Eq. (2). Once again, it appears that the contemporaneous and lagged effects of gasoline prices are concentrated among individuals most likely to own and intensively drive a car: those residing in highly rural areas. It also appears that the magnitude of the immediate reduction in subjective well-being among rural individuals is offset by an equal-sized improvement in well-being 1 year later. In addition, rural residents in years three through five are no longer responsive to gasoline price changes. These findings mirror the pattern emerging from the overall gasoline price effects in column (1). Consistent with our previous results, individuals residing in increasingly urban areas are not influenced by contemporaneous changes in gasoline prices, nor are they influenced by sustained changes in prices, as evidenced by the statistically insignificant coefficients in the second through fourth population density quartiles.

That gasoline prices are associated with an immediate reduction in life satisfaction, followed by a well-being "rebound" 1-year later, appears to be consistent with the larger long-run price elasticity of gasoline demand, as well as Courtmanche's (2011) finding that price-induced improvements in physical health unfold over the course of several years. Indeed, insofar as physical and mental health outcomes are inextricably linked, Courtmanche's (2011) results provide a plausible explanation for the longer-run improvement in life satisfaction. In particular, as individuals adopt healthier lifestyles and begin to reap the physical health benefits from the continued increase in gasoline prices, it is possible that psychological well-being—measured here by self-reported life satisfaction—begins to rebound over time. It is also important to note that such rebounds are frequently observed in studies of subjective well-being. This temporal pattern is known as the hedonic treadmill, in which a personal or environmental shock producing an immediate change in well-being reverts fairly quickly—through a process of adaption—to the pre-shock level of well-being (Kahneman and Krueger, 2006).

5.2. Sub-group analyses

The final set of results are based on sample stratifications by several demographic characteristics, including gender, age, marital status, and educational attainment. Such an exercise will enable us to assess whether there are heterogeneous effects of gasoline prices across urban and rural areas. Results from the sub-group analyses are presented in Table 7, and are based on the model estimated in column (2) of Table 3. All models include the state and year fixed effects, the state-specific time trends, and the control for per capita income. Also calculated for each sub-group is the test of the null hypothesis of equal gasoline price effects over the distribution of population density.

Generally speaking, the results in Table 7 continue to show that the largest reductions in subjective well-being occur among those most likely to own a car—individuals residing in low-population-density areas. Although women's well-being does not appear to be sensitive to gasoline prices, men residing in the first quartile of population density experience an 11.8% point decrease in life satisfaction for each $1 increase in prices, an effect that is substantially larger than that across the remaining quartiles. A recent paper by Herbst (2011a) finds that men's well-being is also more sensitive to labor market contractions. Therefore, it is possible that macro-economic indicators shape the well-being of men more so than women.

The results by employment status, educational attainment, and household income are striking. Among working individuals, only those residing in extremely rural areas appear to be affected by rising gasoline prices. However, the subjective well-being of non-workers declines in approximately equal measure throughout the distribution of population density. A similar pattern emerges for those with high and low levels of education. High-skilled individuals (defined as those with more than a high school degree) in the first quartile of population density witness a moderate reduction in well-being, while those in the remaining quartiles experience virtually no change. The well-being of the low-skilled (defined as those with no more than a high school degree), on the other hand, declines substantially throughout the most of the population density distribution. Finally, high-income individuals (defined as those with real household income above the median) experience no change in life satisfaction, while low-income individuals (defined as those with real household income below the median)—particularly those in extremely rural areas—witness large reductions in well-being. A potential explanation for these results is that the

[22] The coefficients (and standard errors are as follows): fourth car ownership quartile (highest car ownership): −0.078 (0.032); third car ownership quartile: −0.062 (0.031); second car ownership: −0.064 (0.032); and first car ownership quartile: −0.019 (0.030).

[23] We experiment with a variety of lag structures, up to a 10-year lag, and the results are always consistent with those discussed here.

Table 6
Impact of lagged real gasoline prices on life satisfaction. Dependent variable: ''I am very satisfied with the way things are going in my life these days''.

Variable	(1)	(2)
Real gasoline prices: contemporaneous	−0.056*	
	(0.032)	
Real gasoline prices: 1-year lag	0.065**	
	(0.033)	
Real gasoline prices: 2-year lag	0.003	
	(0.033)	
Real gasoline prices: 3-year lag	−0.029	
	(0.032)	
Real gasoline prices: 4-year lag	−0.012	
	(0.028)	
Real gasoline prices: contemporaneous		
×Population density quartile 1		−0.101***
		(0.037)
×Population density quartile 2		−0.037
		(0.035)
×Population density quartile 3		−0.048
		(0.048)
×Population density quartile 4		−0.044
		(0.045)
Real gasoline prices: 1-year lag		
×Population density quartile 1		0.106**
		(0.045)
×Population density quartile 2		0.046
		(0.045)
×Population density quartile 3		0.027
		(0.058)
×Population density quartile 4		0.026
		(0.043)
Real gasoline prices: 2-year lag		
×Population density quartile 1		0.000
		(0.041)
×Population density quartile 2		0.035
		(0.046)
×Population density quartile 3		−0.058
		(0.052)
×Population density quartile 4		−0.015
		(0.048)
Real gasoline prices: 3-year lag		
×Population density quartile 1		0.002
		(0.042)
×Population density quartile 2		−0.036
		(0.048)
×Population density quartile 3		−0.077
		(0.051)
×Population density quartile 4		−0.047
		(0.042)
Real gasoline prices: 4-year lag		
×Population density quartile 1		−0.016
		(0.033)
×Population density quartile 2		−0.034
		(0.035)
×Population density quartile 3		−0.016
		(0.036)
×Population density quartile 4		−0.015
		(0.034)
Demographic controls	Yes	Yes
State fixed effects	Yes	Yes
Period effects	Yes	Yes
State-specific linear time trends	Yes	Yes
State-level controls	Yes	Yes

Notes: Analyses are based on the DDB Worldwide Communications Life Style™ survey for the period 1985–2005. Standard errors, reported in parentheses, are adjusted for state-year clustering. The dependent variable is based on the statement: ''I am very satisfied with the way things are going in my life these days.'' Responses categories are: 6 = definitely agree, 5 = generally agree, 4 = moderately agree, 3 = moderately disagree, 2 = generally disagree, and 1 = definitely disagree. These responses are collapsed to create a binary indicator of any agreement with the statement (6 = definitely agree, 5 = generally agree, 4 = moderately agree). Gasoline prices are expressed in 2005 dollars and incorporate state and federal taxes and are lagged by 1–4 years. Demographic controls include age, gender, race, the presence of children in the household, marital status, educational attainment, and employment status. State-level variables include per capita income and population density (except in the interaction model).

* Statistical significance at the 0.10 levels.

** Statistical significance at the 0.05 levels.

*** Statistical significance at the 0.01 levels.

Table 7
Sub-group analyses. Dependent variable: "I am very satisfied with the way things are going in my life these days".

Real gasoline prices × population density	Q1	Q2	Q3	Q4	Specification test	
					F-statistic	*p*-Value
Gender						
Female						
	−0.051	−0.049	−0.063	−0.041	0.00	0.989
	(0.039)	(0.038)	(0.040)	(0.045)		
Male						
	−0.118***	−0.018	−0.016	−0.033	10.18	0.002
	(0.045)	(0.044)	(0.047)	(0.050)		
Race						
White						
	−0.076**	−0.036	−0.036	−0.043	3.20	0.074
	(0.033)	(0.034)	(0.036)	(0.040)		
Non-white						
	−0.037	0.036	0.004	0.062	1.20	0.274
	(0.092)	(0.085)	(0.099)	(0.100)		
Employment Status						
Working						
	−0.064*	−0.012	−0.010	−0.002	5.18	0.023
	(0.036)	(0.037)	(0.037)	(0.042)		
Not working						
	−0.119**	−0.089*	−0.113**	−0.112*	0.18	0.671
	(0.053)	(0.051)	(0.055)	(0.057)		
Educational Attainment						
⩽High school						
	−0.112**	−0.083*	−0.115**	−0.073	4.34	0.038
	(0.050)	(0.050)	(0.055)	(0.057)		
>High school						
	−0.042	0.017	0.017	−0.002	0.49	0.483
	(0.036)	(0.035)	(0.037)	(0.041)		
Household Income						
⩽Median	−0.155***	−0.083*	−0.112**	−0.055		
	(0.042)	(0.045)	(0.050)	(0.044)	6.49	0.011
>Median	0.027	0.015	0.038	−0.007		
	(0.043)	(0.042)	(0.042)	(0.052)	0.16	0.686
Age						
Ages 18–34						
	−0.193***	−0.109*	−0.117*	−0.052	6.16	0.013
	(0.060)	(0.063)	(0.065)	(0.072)		
Ages 35–64						
	−0.030	0.020	0.009	−0.008	1.70	0.192
	(0.042)	(0.039)	(0.040)	(0.043)		
Ages 65+						
	−0.065	−0.079	−0.067	−0.058	0.00	0.949
	(0.073)	(0.069)	(0.077)	(0.080)		
Children in household						
Yes						
	−0.102**	−0.033	−0.018	0.024	7.10	0.008
	(0.046)	(0.048)	(0.048)	(0.052)		
No						
	−0.071*	−0.025	−0.060	−0.068	0.60	0.440
	(0.039)	(0.041)	(0.047)	(0.045)		
Marital status						
Married						
	−0.026	0.017	−0.010	0.004x	1.65	0.199
	(0.036)	(0.037)	(0.038)	(0.042)		
Not married						
	−0.184***	−0.130**	−0.083	−0.086	3.83	0.051
	(0.057)	(0.058)	(0.063)	(0.060)		

Notes: Analyses are based on the DDB Worldwide Communications Life Style™ survey for the period 1985 to 2005. Standard errors, reported in parentheses, are adjusted for state-year clustering. The dependent variable is based on the statement: "I am very satisfied with the way things are going in my life these days." Responses categories are: 6 = definitely agree, 5 = generally agree, 4 = moderately agree, 3 = moderately disagree, 2 = generally disagree, and 1 = definitely disagree. These responses are collapsed to create a binary indicator of any agreement with the statement (6 = definitely agree, 5 = generally agree, 4 = moderately agree). Gasoline prices are expressed in 2005 dollars and incorporate state and federal taxes. Demographic controls include age, gender, race, the presence of children in the household, marital status, educational attainment, and employment status. State-level variable includes per capita income. The *F*-statistic and *p*-value are from a test of the null hypothesis of the equality of the gas price effect at the first population density quartile and the (average) impact across the second, third, and fourth quartiles.

* Statistical significance at the 0.10 levels.

** Statistical significance at the 0.05 levels.

*** Statistical significance at the 0.01 levels.

Table 8
The income equivalence of rising gasoline prices.

	Overall	Population density quartile 1	Population density quartile 2	Population density quartile 3	Population density quartile 4
Increase in gasoline prices ($0.20)					
Monthly income equivalence	−$260	−$395	−$187	−$260	−$215
Percent of household income	0.065	0.106	0.049	0.060	0.048
Increase in unemployment rate (1.5 ppts)					
Monthly income equivalence	−$234	−$354	+$76	−$398	−$217
Percent of household income	0.059	0.096	0.020	0.091	0.048
Improved physical condition (15%)					
Monthly income equivalence	+$350	+$312	+$315	+$401	+$400
Percent of household income	0.088	0.084	0.083	0.092	0.089

Notes: The income equivalence for gasoline prices is based on a $0.20 increase in prices (the standard deviation during the analysis period). The income equivalence for the unemployment rate is based on a 1.5% point increase in the unemployment rate (the standard deviation during the analysis period). The income equivalence for physical health improvements is based on a 15% increase in health condition. To produce the calculations in the table, we first ran regressions comparable to those in column (5) of Table 2 and column (2) of Table 3, removing the gasoline price variable and replacing it with total household income and income-squared. We then calculated the change in life satisfaction due to a $1 increase in household income from the median (i.e., the marginal effect). The median household income for the sample overall is $47,770, while the median in the first though fourth population density quartiles is, respectively, $44,562, $45,371, $52,316, and $53,891. The marginal effects for household income were then compared to the marginal effects for gasoline prices for the overall model and the model by population density. For example, to produce the monthly income equivalent of a $0.20 increase in gasoline prices, the following was calculated: $0.20 \times (-0.048/0.000003081)/12) = -259.65$. The same procedures were followed to generate the income equivalence for the unemployment rate and physical health.

non-working and low-skilled have fewer financial resources to assist with paying for gasoline. Price shocks may therefore lower subjective well-being to a greater extent than is the case among their working and high-skilled counterparts, irrespective of where these individuals reside. It could also be the case that the non-working and low-skilled in high-population-density areas interpret rising gas prices as a signal of deteriorating economic conditions, which may have the effect of reducing well-being.

5.3. Economic significance of the gasoline price effects

The preceding analyses demonstrate that a $1.00 increase in gasoline prices leads to a 7% reduction in life satisfaction overall, and a 12% reduction among likely car owners. However, it remains to be seen whether and to what extent these well-being effects are economically important. One way to assess this is by calculating the income equivalence of the drop in life satisfaction due to an increase in gasoline prices. In other words, we ask: how much *income* would the median family need in order to fully offset the reduction in subjective well-being from rising gasoline prices? How does this amount compare to other macro-determinants of well-being?

We calculate the income equivalence of a $0.20 rise in gasoline prices using both the full sample estimate of gasoline prices (Table 2, column (5)) and the estimates by population density quartile (Table 3, column (2)). We use a $0.20 rise in prices because it is the sample standard deviation for the period 1985 to 2005. We then estimate regressions of life satisfaction on real household income and income-squared (and the full set of controls), and use the coefficients to calculate the change in well-being due to a $1.00 increase in household income from the sample median.[24] The marginal effects on household income are then compared to those on gasoline prices to produce a monetary valuation of the life satisfaction costs of rising gasoline prices. An analogous set of calculations are made for the state-level unemployment rate and an individual-level variable capturing overall physical health. Results from this exercise are shown in Table 8.[25]

Overall, a $0.20 increase in gasoline prices produces a reduction in life satisfaction equivalent to a loss of $260 in monthly household income. Not surprisingly, the well-being costs are substantially larger for individuals highly likely to own a car. Among those residing in extremely rural areas (the bottom population density quartile), the well-being loss amounts to $395, while those in increasingly urban areas (the top three population density quartiles) experience average losses of $187, $260, and $215, respectively.

There are a number of ways to assess the relative importance of these calculations. First, we compare the well-being equivalences to reported household income in the Life Style survey. The well-being loss for the full sample corresponds to 6.5% of monthly household income, while the loss among likely car owners corresponds to 10.6% of income. Another approach is to compare the well-being equivalences to household expenditures on vehicle fuel. US households in 2000 spent an average of $107 on gasoline each month, increasing to $226 per month in 2008 (Energy Information Administration, 2005; Cooper, 2011). These amounts correspond to 2.9% and 4.3% of household income, respectively. That the well-being costs of rising gasoline prices exceed what households actually spend is suggestive of several forces at work. The reduction in life satisfaction may not only reflect the financial impact of rising gasoline prices; it could also reflect a psychological or emotional response to the perceived causes of the price increases. It is also possible that individuals attach additional meaning to rising gasoline prices, for example international unrest or faltering macroeconomic conditions.

Still another approach is to compare the income equivalence of rising gasoline prices to that of other macro well-being "shifters," such as the unemployment rate. As shown in Table 8, we find that, for the full sample, a 1.5% point increase in the unemployment rate (the sample standard deviation) leads to a reduction in life satisfaction equivalent to a loss of $234 in monthly household income, or nearly 6% of income. Among those in extremely rural areas, such an increase in the unemployment rate reduces well-being by $354, which corresponds to approximately 10% of household income. These income losses are comparable to those generated by rising gasoline prices. Thus, a tentative conclusion is that shocks to gasoline prices may be as important to psychological health as a dampening of labor market conditions.

Finally, it might be useful to compare the monetized subjective well-being losses to the physical health gains cited in Courtmanche's (2011) analysis of obesity. Unfortunately, the Life Style survey does not contain objective health measures, including body mass index (BMI), so we rely on a measure of subjective physical

[24] Separate regressions are estimated for the full sample and by population density quartile, as household income has slightly different effects on subjective well-being across the population density distribution.

[25] The notes for Table 8 provide more details on the income equivalence calculations.

health based on responses to the statement "I am in very good physical condition." We calculate the income equivalence of a 15% increase (from the sample mean) in physical health. Doing so is analogous to increasing monthly household income by $350, which corresponds to nearly 9% of income and is approximately $100 higher than the well-being loss generated by rising gasoline prices. Such evidence, while extremely crude, indicates that the reduction in subjective well-being could be as important as the physical health improvements created by rising gasoline prices.

6. Conclusion

Using rich data from the DDB Worldwide Communications Life Style™ survey, this paper documents a negative relationship between gasoline prices and self-reported life satisfaction over the period 1985–2005. Rising gasoline prices decrease subjective well-being across a broad swath of the population, although the negative effects are substantially larger among likely car owners. These results are consistent with the implications of the simple conceptual framework discussed previously. The substitution and income effects associated with an increase in gasoline prices are likely to be more important for individuals in rural areas because car ownership rates are higher and alternative forms of transportation are less accessible. Therefore, it is not surprising that the impact of gasoline prices is larger in rural areas.

However, that these prices continue to influence well-being in a heterogeneous sample of likely *and* unlikely car owners suggests that individuals are affected in ways beyond the behavioral changes implied by the substitution and income effects. Although it is difficult to determine exactly how the subjective well-being of non-car-owners is influenced by rising gasoline prices, the conceptual framework provides a few possibilities. First, it is plausible that individuals interpret movements in gasoline prices as indicative of macro-economic conditions, the presence of international political unrest, or the impact of extreme weather events. Perceptions regarding each of these could, in turn, influence one's subjective well-being. Second, rising gasoline prices might inflame social and political unrest as individuals become mistrustful of the institutions perceived to be responsible for determining prices. Such unrest may also ultimately affect well-being.

Results in this study are consistent with Graham et al. (2010), which provides a look at contemporary gasoline prices, but stand in contrast to the body of evidence that rising gasoline prices render contemporaneous improvements in physical health and health behaviors (Courtemanche, 2011; Hou et al., 2011; Rashad et al., 2005; Sen, 2011). Indeed, whereas this study finds that increasing prices lead to immediate reductions in subjective well-being, the extant literature generally concludes that obesity and overweight rates tend to fall and lifestyles become healthier as gasoline prices rise. Interestingly, the pattern emerging from this body of work—that of positive effects in the physical health domain and negative effects in the psychological domain—has been replicated in other literatures. For example, there is substantial evidence that macro-economic downturns lead to improvements in a variety of physical health outcomes (e.g., Ruhm, 2000, 2003), while increasing depression- and anxiety-related symptoms as well as decreasing happiness and life satisfaction (Charles and DeCicca, 2008; Herbst, 2011a).

It is important to remember, however, that this study finds fairly different short- and longer-run impacts of gasoline prices. In the immediate term, rising gasoline prices reduce subjective well-being, but we also uncover evidence that 1 year later these losses are offset by an *increase* in well-being. These differences are likely due to the slowly unfolding behavioral changes that individuals undertake when gasoline prices experience a sustained increase. Individuals in the short-run probably experience difficulties (or show a reluctance to) altering their travel, eating, and leisure habits, which may explain the immediate slippage in life satisfaction. However, as new and presumably healthier behavior patterns emerge, subjective well-being appears to rebound quickly and almost fully, such that there are few noticeable changes in well-being after 3–5 years. Such temporal differences in the response to gasoline prices clearly need to be considered as well when conducting welfare calculations.

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Appendix A

See Table A1.

Table A1
Comparison of demographic characteristics for respondents in the DDB Needham Life Style survey and General Social Survey.

	Life style survey	GSS
	1985–2005	1985–2004
Female (%)	0.551	0.543
	(0.497)	(0.498)
Age (years)	47.11	44.30
	(15.98)	(16.96)
White (%)	0.859	0.823
	(0.348)	(0.382)
Black (%)	0.078	0.122
	(0.268)	(0.327)
Other race/ethnicity (%)	0.063	0.055
	(0.243)	(0.227)
Married (%)	0.707	0.590
	(0.455)	(0.492)
Widowed (%)	0.075	0.069
	(0.263)	(0.253)
Separated (%)	0.018	0.026
	(0.134)	(0.160)
Divorced (%)	0.086	0.101
	(0.280)	(0.302)
Never married (%)	0.115	0.213
	(0.319)	(0.410)
Children ages 0–17 (%)	0.382	0.392
	(0.486)	(0.488)
Less than high school (%)	0.092	0.198
	(0.289)	(0.399)
High school (%)	0.330	0.312
	(0.470)	(0.463)
Some college (%)	0.303	0.260
	(0.460)	(0.439)
BA+ (%)	0.275	0.230
	(0.447)	(0.421)
Employed (%)	0.661	0.644
	(0.474)	(0.479)

Notes: All calculations are based on respondents with non-missing information on a given demographic characteristic and with non-missing information on the relevant well-being outcome (GSS: happiness; Life Style survey: life satisfaction). All GSS figures are weighted using "wt," which is constructed by Stevenson and Wolfers (2008) (and based on the GSS weight "wtssall") to adjust for differences in the questionnaire placement of the happiness question throughout the survey period. See Stevenson and Wolfers (2008) for a detailed description of the process for constructing the revised weight.

References

Bertrand, M., Mullainathan, S., 2001. Do people mean what they say? Implications for subjective survey data. American Economic Review 91, 67–72.

Brons, M., Nijkamp, P., Pels, E., Rietveld, P., 2008. A meta-analysis of the price elasticity of gasoline demand. A SUR approach. Energy Economics 30 (5), 2105–2122.

Catalano, R., Dooley, D., 1983. Health effects of economic instability: a test of the economic stress hypothesis. Journal of Health and Social Behavior 24, 46–60.

Charles, K., DeCicca, P., 2008. Local labor market fluctuations and health: is there a connection and for whom? Journal of Health Economics 27, 1532–1550.

Cooper, M., 2011. Gasoline prices and expenditures in 2011: record high levels drive consumer concerns and increased support for a 60 miles per gallon fuel economy standard. Consumer Federation of America, Washington, DC.

Courtemanche, C., 2011. A silver lining? The connection between gasoline prices and obesity. Economic Inquiry 49, 935–957.

Di Tella, R., MacCulloch, R., Oswald, A., 2003. The macroeconomics of happiness. Review of Economics and Statistics 85, 809–827.

Diener, E., 1984. Subjective well-being. Psychological Bulletin 95, 542–575.

Diener, E., Seligman, M.E.P., 2004. Beyond money: toward an economy of well-being. Psychological Science in the Public Interest 5 (1), 1–31.

Diener, E., Lucas, R., Scollon, C., 2006. Beyond the hedonic treadmill: revising the adaption theory of well-being. American Psychologist 61, 305–314.

Dillman, D., Sangster, R., Tarnai, J., Rockwood, T., 1996. Understanding differences in people's answers to telephone and mail surveys. New Directions for Evaluation 70, 45–61.

Ehrhardt, J., Saris, W., Veehoven, R., 2000. Stability of life satisfaction over time. Journal of Happiness Studies 1, 177–205.

Energy Information Administration, 2005. Household Vehicles Energy use Latest Data and Trends. U.S. Department of Energy, Energy Information Administration, Washington, DC.

Espey, M., 1998. Gasoline demand revisited: an international meta-analysis of elasticities. Energy Economics 20, 273–295.

Federal Highway Administration, 2008. Highway Statistics, 2008. U.S. Department of Transportation, Federal Highway Administration, Washington, DC.

Fischer, J., 2009. Subjective Well-being as Welfare Measure: Concepts and Methodology. Munich Personal RePEc Archive, Working Paper No. 16619.

Fordyce, M., 1988. A review of research on happiness measures: a sixty-second index of happiness and mental health. Social Indicators Research 20, 355–381.

Frank, L.D., Andresen, M.A., Schmid, T.L., 2004. Obesity relationships with community design, physical activity, and time spent in cars. American Journal of Preventative Medicine, 1–13.

Frey, B., Stutzer, A., 2002. What can economists learn from happiness research? Journal of Economic Literature 40, 402–435.

Gallup, 2011. High gas prices cause lifestyle changes for many Americans (May 18).

Graham, C., Chattopadhyay, S., Coan, J., Medlock, K., III, Jaffe, A., 2010. (Un?)happiness and Gasoline Prices in the United States. Working Paper. Brookings Institution, Washington, DC.

Groeneman, S., 1994. Multi-purpose household panels and general samples: how similar and how different? In: Paper Presented at the Annual Meeting of the American Association for Public Opinion Research, Danvers, MA.

Grossman, M., 1972. On the concept of health capital and the demand for health. Journal of Political Economy 80, 223–255.

Gruber, J., Mullainathan, S., 2005. Do cigarette taxes make smokers happier. Advances in Economic Analysis and Policy 5 (Article 4).

Heberlein, T., Baumgartner, R., 1978. Factors affecting response rate to mailed questionnaires: a quantitative analysis of the published literature. American Sociological Review 43, 447–462.

Helliwell, J., 2006. Well-being and social capital: does suicide pose a puzzle? Social Indicators Research 81, 455–496.

Herbst, C.M., 2011a. I Guess That's Why They Call It the Blues: Macro-Economic Downturns and Subjective Well-being. Working Paper. Arizona State University School of Public Affairs.

Herbst, C.M., 2011b. "Paradoxical" decline? Another look at the relative reduction in female happiness. Journal of Economic Psychology 32 (5), 773–788.

Hilleras, P., Jorm, A., Herlitz, A., Winbald, B., 1998. Negative and positive affect among the very old: a survey on a sample age 90 years or older. Research on Aging 20, 593–610.

Hou, N., Popkin, B.M., Jacobs, J., Song, Y., Guilkey, D.K., He, K., Lewis, C.E., et al., 2011. Longitudinal trends in gasoline price and physical activity: the CARDIA study. Preventive Medicine 52 (5), 365–369.

Kahneman, D., Deaton, A., 2010. High income improves evaluation of life but not emotional well-being. In: Proceedings of the National Academy of Sciences of the United States of America.

Kahneman, D., Krueger, A., 2006. Developments in the measurement of subjective well-being. Journal of Economic Perspectives 20, 3–24.

Krueger, A., Schkade, D., 2008. The reliability of subjective well-being measures. Journal of Public Economics 92, 1833–1845.

Layard, R., 2005. Happiness: Lessons from a New Science. Penguin Press, London.

Li, S., Yanyan, L., Zhang, J., 2009. Lose Some, Save Some: Obesity, Automobile Demand, and Gasoline Consumption in the United States. Resources for the Future Discussion Paper, 9–33.

Ostir, G., Markides, K., Black, S., Goodwin, J., 2000. Emotional well-being predicts subsequent functional independence and survival. Journal of the American Geriatrics Society 48, 473–478.

Pucher, J., Renne, J.L., 2005. Rural mobility and mode choice: evidence from the 2001 National Household Travel Survey. Transportation 32 (2), 165–186.

Putnam, R., Yonish, S., 1999. How Important is Response Rate? An Evaluation of a "Mail Panel" Survey Archive. Working Paper. JFK School of Government, Harvard University, Cambridge, MA.

Raphael, S., Rice, L., 2002. Car ownership, employment, and earnings. Journal of Urban Economics 52 (1), 109–130.

Rashad, I., Grossman, M., Chou, S., 2005. The Supersize of America: An Economic Estimation of Body Mass Index and Obesity in Adults. NBER Working Paper No. W11584.

Ruhm, C., 2000. Are recessions good for your health? Quarterly Journal of Economics 115, 617–650.

Ruhm, C., 2003. Good times make you sick. Journal of Health Economics 22, 637–658.

Schimek, P., 1996. Household motor vehicle ownership and use: how much does residential density matter? Transportation Research Record: Journal of the Transportation Research Board 1552 (-1), 120–125.

Sen, B., 2011. Is There an Association Between Gasoline Prices & Physical Activity? Evidence from American Time Use Data. Working Paper: University of Alabama at Birmingham Department of Healthcare Organization & Policy.

Stevenson, B., Wolfers, J., 2008. Happiness inequality in the United States. Journal of Legal Studies 37, S33–S79.

U.S. Department of Transportation, 2001. National Household Travel Survey. Federal Highway Administration and Bureau of Transportation Statistics, Washington, DC.

Visser, P., Krosnick, J., Marquette, J., Curtin, M., 1996. Mail surveying for election forecasting: an evaluation of the Columbus Dispatch poll. Public Opinion Quarterly 60, 181–227.

Wen, L.M., Orr, N., Millett, C., Rissel, C., 2006. Driving to work and overweight and obesity: findings from the 2003 New South Wales Health Survey, Australia. International Journal of Obesity 30, 782–786.