Investigating Consumer Preferences for Biofuels: The Effects of the Consideration of Future Consequences

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Abstract

The relationship between the consideration of future and immediate consequences (CFC) (Joireman et al., 2008; Strathman et al., 1994) and consumer preference for gasoline, cellulose-based and corn-based ethanol fuels was investigated using data from a representative panel of U.S. consumers (*N* = 300). Employing conjoint analysis, results showed that that the overall CFC score was positively associated with the choice for alternative transportation fuels. As the CFC score increases from its minimum to maximum, the predicted probability of choosing cellulose- and corn-based ethanol fuels increases from 14% to 61%, and 22% to 30%, respectively, and the probability of choosing gasoline drops from 64% to below 10%. Additional analyses showed that the CFC-Future and CFC-Immediate subscales were unique predictors of preference for biofuels. Implications for marketing of biofuels are discussed.

Keywords: consideration of future consequences, choice of biofuels, environmental behavior, conjoint analysis

1. Introduction

As the world struggles to cope with declining oil reserves, and the environmental consequences of fossil fuel powered vehicles, marketers and consumers alike are considering more fuel efficient cars and alternative means of fueling those cars. Two growing alternatives to traditional gasoline include corn-based ethanol and cellulose-based ethanol (Sissine, 2007; Tilman, Socolow, Foley, Hill, Larson, Lynd, Pacala, Reilly, Searchinger, Somerville, & Williams, 2009). Both alternatives offer lower emissions than traditional gasoline (Farrell, Plevin, Turner, Jones, O'Hare, & Kammen, 2006), but their limited availability and potential price premium may deter consumers from adopting these fuels. Because environmental emissions represent a long-term benefit, whereas service convenience and price represent more immediate costs, it is likely that consumers' willingness to use these alternative fuels will depend partly on the importance they attach to future vs. present outcomes. The present study tests this hypothesis by exploring whether the probability of selecting corn- and cellulose-based ethanol over traditional gasoline depends on individual differences in the consideration of future consequences (Strathman, Gleicher, Boninger & Edwards, 1994).

Strathman et al. (1994) defined CFC as "…*the extent to which people consider the potential distant outcomes of their current behaviors and the extent to which they are influenced by these potential outcomes*" (Strathman et al., 1994, p. 743; for a review, see Joireman, Strathman & Balliet, 2006). People scoring low in CFC assign great importance to the immediate consequences of behavior, and little importance to the delayed consequences of their behavior. Those high in CFC attach great importance to the future consequences of behavior, and little importance to the immediate consequences of behavior.

Previous research has established CFC as a predictor of environmental intentions and behaviors. For example, those scoring high (as opposed to low) in CFC show higher levels of recycling (Ebreo & Vining, 2001; Lindsay & Strathman, 1997; Strathman et al., 1994), cooperation in resource dilemmas (Kortenkamp & Moore, 2006; Joireman, Posey, Truelove, & Parks, 2009), proenvironmental political intentions and behavior (Joireman, Lasane, Bennett, Richards, & Solaimani, 2001), and preference for public transportation (Collins & Chambers, 2005; Joireman, Van Lange, & Van Vugt, 2004) (cf. Milfont & Gouveia, 2006). Those scoring high in CFC also are more supportive of plans for improving public transportation, if they are convinced the plan will reduce pollution (Joireman, Van Lange, Van Vugt, Wood, Vander Leest, & Lambert, 2001).

The preceding studies provide support for the relevance of CFC in the environmental arena. Nevertheless, several important gaps exist in our understanding of how CFC predicts environmental behavior. The present study addresses these gaps and advances prior work on CFC and environmental behavior in four ways. First, although previous research has connected CFC with a number of transportation-related outcomes (e.g., preference for public transit, support for transit initiatives), to our knowledge, no studies have explored whether CFC predicts preference for biofuels. Given their growing prevalence in the marketplace, their environmental benefits, and the theoretical connection between CFC and these benefits, this represents a significant gap in the literature. Second, whereas the bulk of past research in this area has utilized convenience samples of college students, or local residents (e.g., in Seattle), we recruit a representative panel of U.S. consumers. Third, whereas past CFC literature has typically relied on self-reported intentions and behaviors, we report a conjoint based study in which consumers make a series of choices between the three fuel options (gasoline, corn-based ethanol, and cellulose-based ethanol) designed to vary in terms of price, emissions, and service availability. The conjoint methodology used in the present study allows quantifying the relationship between CFC levels and product choice probability, which can have a number of theoretical and applied implications for research efforts linking temporal considerations to consumers' product choice behavior. Fourth, whereas previous research has treated CFC as a unitary construct, building on several recent studies (Joireman, Balliet, Sprott, Spangenberg, & Schultz, 2008; Petrocelli, 2003; Toepoel, 2010), we explore the value in distinguishing between two subscales on the CFC scale: one measuring *consideration of future consequences* (proper), the other measuring *consideration of immediate consequences* (proper). Below, we provide background on corn-based vs. cellulose-based ethanol, discuss the advantages of our conjoint methodology, consider the value of distinguishing between the two CFC subscales, and outline our hypotheses.

1.1 Background on Corn-Based vs. Cellulose-Based Ethanol

With increasing concerns of national energy security and dependence on imported transportation fuels, the U.S. Congress passed the Energy Independence and Security Act (EISA) of 2007, according to which the production of biofuels was required to progressively increase to 36 billion gallons by 2022, making biofuels about one fourth of the national transportation fuel mix. This mandate represents a significant increase from the earlier target of 7.5 billion gallons to be produced by 2012, as mandated by the Energy Policy Act of 2005 (Sissine, 2007). The demand for corn-based ethanol, a type of biofuel which uses corn as a primary feedstock, has become more prevalent as the gasoline additive methyl tertiary-butyl ether (MTBE) was phased out in 2006[1] (Energy Information Administration, 2006). The primary reasons for development

[1] Replacing lead as an octane enhancer in gasoline, MTBE was used in the U.S. as oxygenate since 1979. Later, MTBE was found to be a carcinogenic pollutant and after the Energy Policy Act of 2005 was banned in many states.

of corn-based ethanol are its environmental advantages—a renewable source of energy and potential to reduce greenhouse gas emissions (e.g., carbon dioxide emissions from gasoline) (Farrell et al., 2006). For example, recent corn-ethanol life cycle analyses showed 48-59% reduction in greenhouse gas emissions compared to gasoline (Liska, Yang, Bremer, Klopfenstein, Walters, Erickson, & Cassman, 2009). Unfortunately, increased demand for corn-based biofuel also contributes to increasing corn prices, with subsequent ripple effects on food prices. Production of corn-based ethanol products also carries potential environmental problems related to use of fertilizers for corn production, such as nitrogen runoff into water supplies.

Nevertheless, according to the EISA (2007) provisions, 21 billion gallons of the 36 billion-gallon renewable fuel target must be derived from cellulosic feedstocks, including hemicellulose, lignin, sugar, starch (excluding corn), agricultural and municipal waste, and biomass. Cellulosic feedstocks, by comparison, are abundant. As a result, production of cellulose-based ethanol does not interfere with food crops, and thus, does not contribute to the increasing food prices. In addition, the use of cellulosic feedstocks for ethanol processing helps avoid some of the environmental problems connected to corn production (e.g., there are no chemical fertilizer runoffs into groundwater sources). Considering different environmental impacts associated with gasoline (carbon dioxide emissions) and corn-based ethanol (nitrogen runoff and agricultural land conversion), it is reasonable to rank gasoline as the most harmful to the environment, followed by corn-based ethanol, followed by cellulose-based ethanol.

1.2 Assessing Preference for Corn-Based vs. Cellulose-Based Ethanol

Given their increasing prevalence in the marketplace, it is useful to assess consumers' support for corn-based and cellulose-based ethanol, and identify factors that predict such support.

Ethanol replaced MTBE as an economically feasible gasoline additive as it contains 35% oxygen by weight, which is twice the oxygen content of MTBE (Energy Information Administration, 2006).

Unfortunately, while these fuels are becoming more prevalent, it is likely that many consumers may not have a great deal of experience with these fuels (especially cellulose-based ethanol). Corn-based ethanol production, for example, exceeded 13 billion gallons in 2010, whereas cellulose-based ethanol is currently not commercially available.[2] As a result, simply asking consumers about their likelihood of using these fuels may not be especially meaningful in the absence of relevant information and realistic scenarios. To address this problem, in the current study, we drew on conjoint analysis to evaluate consumers' preference for corn and cellulose-based ethanol (vs. gasoline) by presenting consumers with a range of fueling scenarios in which we varied the price, availability, and emissions of the three fuels. In each of the eight orthogonal fueling scenarios (see Appendix), formed from a factional factorial design (Kuhfeld, 2009), the two alternative fuels were either more or less expensive than gasoline (by .25/gallon; but on average, cost the same as gas), always offered lower emissions than gasoline (by 25%, on average), and were equally or less available than gasoline (i.e., whereas gasoline was available at every fueling station, the two alternative fuels were, on average, available at every other fueling station). In sum, the two alternative fuels were approximately the same price as gasoline, but offered lower emissions and somewhat limited availability relative to gasoline.

As briefly mentioned above, conjoint analysis is a survey-based methodology commonly used to evaluate consumer preferences and willingness-to-pay (WTP) for products or services (Louviere, Islam, Wasi, Street, & Burgess, 2008; Elrod, Louviere, & Davey, 1992; Green & Srinivasan, 1978; McFadden, 1974). Conjoint experiments are broadly used to analyze consumers' preference structure in a number of disciplines, including marketing, applied economics, operations research and transportation economics (McFadden, 2001; Small, et al.,

[2] Alternative Fuels & Advanced Vehicles Data Center. Department of Energy, Energy Efficiency & Renewable Energy. http://www.afdc.energy.gov/afdc/ethanol/production_cellulosic.html. Accessed November 22, 2011.

2005; Louviere, et al., 2008; Train & Wilson, 2008). This approach also allows investigating the preference for certain product attributes, as well as the relationship between choice behavior and socio-demographic variables.

Other survey-based methods to studying WTP or choice behavior include the contingent valuation method (Hanemann, 1994). Contingent valuation allows capturing uncertainty in consumer attitude and perception for a product or service. Despite the wide use of contingent valuation methods for investigating preferences for both public and private goods, a number of relatively recent studies (Murphy, Allen, Stevens, & Weatherhead, 2005; List & Gallet, 2001) indicated possibility of bias between WTP responses and actual real-world purchasing behaviors. It is natural, and is one the major limitations of the contingent valuation approach, that a survey participant will indicate a certain level of WTP for a service or product, but will deviate from her hypothetical commitment when an actual purchase decision is made.

As an alternative, the choice-based conjoint analysis method (Caparros, Oviedo, & Campos, 2008; Louviere et al., 2008; Hensher & Greene, 2003) that we use in this study mitigates the deviations from respondents' hypothetical commitments by offering a more realistic representation of the market situation (Adamowicz, Louviere, & Williams, 1994). The choice-based conjoint analysis allows decomposing product attributes and valuing the contribution of each of those attributes to choice decisions (Green & Srinivasan, 1978). The prevailing agreement is that the choice-based conjoint analysis provides improvement over the contingent valuation method for measuring preference structures (Adamowicz et al., 1998). As such, we adopted that methodology in the current study. Our primary interest was to determine whether, using that method, CFC would predict support for biofuels.

1.3 Formal Conjoint Model

In our model, consumers were faced with a set of fuel choice scenarios from which each selected a preferred option. Attributes of the fuel alternatives (i.e., per gallon prices, carbon dioxide emissions levels and service availability) vary for each of the eight choice scenarios. Gasoline is the reference category and its attributes do not vary across choice scenarios.

Consider an individual n who faces a choice among j fuel alternatives indexed as $j = 1, \dots, J$ (in our case gasoline, corn-based and cellulose-based ethanol). Assuming that individuals prefer choices that maximize their utility or level of satisfaction (U), individual n chooses alternative j if and only if $U_{ni} > U_{nj}$, for all $j \neq i$ By specifying the observed part of an individual's utility function to be linear in parameters, the utility (or level of satisfaction) of individual n obtained from consuming alternative i can be represented in the following equation:

$$\boldsymbol{U_{ni} = \beta' X_{ni} + \varepsilon_{ni}} \qquad (1)$$

where X_{ni} represents the vector of explanatory variables, including attributes for the i^{th} fuel alternative (among j alternatives, indexed as $j = 1, \dots, J$) and behavioral and/or socio-economic characteristics for individual n; β is the vector of parameters associated with explanatory variables. The ε_{ij} is the unobserved term, and is independently identically distributed Type I extreme value. McFadden (1974) showed that the probability of an individual i choosing alternative j from the choice set C_n can be presented as:

$$\boldsymbol{P(y_n = i) = \exp(\beta' X_{ni}) \,/\, \textstyle\sum_j \exp(\beta' X_{nj}), \;\; j \in C_n} \qquad (2)$$

where y_n represents the choice outcome selected by individual n. The effects of interactions between CFC and a number of socio-demographic variables on choice can also be estimated within the same model to understand moderation effects, but these interactions are out of the scope of this paper.

1.4 CFC and Environmental Research

In the present paper we focus how one dispositional factor relevant to environmental decision-making predicts willingness to purchase alternative biofuels. As reviewed earlier, a number of studies demonstrate that individuals high in CFC report higher proenvironmental intentions and behaviors across a range of domains (recycling, political action, transportation). Theoretically, the link between CFC and proenvironmental behavior makes sense, as the decision to engage in many proenvironmental actions can be viewed as a social dilemma in which short-term self-interests are at odds with long-term collective interests (cf. Joireman, 2005). Indeed, many actions that benefit the environment require some short-term sacrifice that ultimately provides long-term benefits to the decision-maker and society. As an example, in most cities, commuting by public transportation is less convenient than commuting by car, yet commuting by public transportation reduces pollution and a society's reliance on fossil fuels (cf. Joireman et al., 2004). Similarly, within the present context, opting for alternative fuels may require sacrificing convenience (as the fuels are not as easily available), but in the long-run, these alternative fuels can reduce pollution and a society's reliance on fossil fuels. Given the intertemporal nature of this decision, we hypothesized that preference for alternative fuels would be positively associated with a commuter's level of CFC (***Hypothesis 1***). More important, as we explain below, we advanced previous work on CFC and environmental decision-making by more closely examining how the two different dimensions underlying the CFC construct (concern with immediate consequences and concern with future consequences) relate to commuters' preference for these alternative fuels.

1.5 CFC-Future vs. CFC-Immediate Sub-Scales of CFC

Most previous research has assumed that the CFC scale is a uni-dimensional scale, as proposed by Strathman et al. (1994). Several recent studies, however, suggest that the CFC scale is composed of *two* underlying factors (e.g., Joireman, Balliet, Sprott, Spangenberg, & Shultz, 2008; Petrocelli, 2003; Rappange et al., 2009; Toepoel, 2010). Joireman et al. referred to the two scales as the *CFC-Immediate* and *CFC-Future* subscales, respectively. A two-factor approach suggests that while individuals may hold a dominant temporal orientation, concern with future and concern with immediate consequences are not exact opposites; in other words, individuals may consider the future consequences of their actions, the immediate consequences of their actions, or both (cf. Shipp, Edwards, & Lambert, 2009; Zimbardo & Boyd, 1999).

A key advantage of a two factor solution is that it permits researchers to determine whether a given behavior (e.g., choice of alternative fuels) is motivated by a consideration of future consequences (proper) or a consideration of immediate consequences (proper). If a researcher adopts a one-factor solution, he/she reverse-codes the immediate items and averages them with the future items, resulting in a single CFC score. While this single CFC score may predict environmental behavior, appropriately interpreting the link between CFC and environmental behavior may not always be straightforward.

For example, imagine that the single CFC score is positively correlated with preference for alternative fuels. Using a one-factor approach, one would be tempted to conclude that *people who are concerned with the future consequences of their actions are more likely to prefer alternative fuels* (e.g., due to their long-term environmental benefits). This appears reasonable, but a closer look suggests an alternative interpretation: it is possible that the positive correlation between CFC and preference for alternative fuels is actually entirely a function the immediate items. In other words, the positive correlation between CFC and preference for alternative fuels may be due to the fact that *people who are concerned with the immediate consequences of their actions are less likely to prefer alternative fuels* (e.g., due to their relative inconvenience).

Given its ability to differentiate between these two interpretations, in the present study, we explored how preference for alternative fuels was related to concern with future consequences proper and concern with immediate consequences proper. We hypothesized that scores on the CFC-Future subscale would be positively associated with preference for biofuels (***Hypothesis 2***), whereas scores on the CFC-Immediate subscale would be negatively related to preference for biofuels (***Hypothesis 3***). An open question was whether the two CFC subfactors would be unique predictors of preference for biofuels, or whether one subfactor would emerge as the primary predictor.

2. Methods

2.1 Participants

The data were collected using the online survey provider Qualtrics.com. The survey was conducted in November 2009, and responses from 300 participants were collected from different regions within the U.S. The geographic distribution of the responses is shown in Figure 1 and demographic information is summarized in Table 1.

Insert Figure 1 and Table 1 about here

2.2 Fuel Survey

To determine whether participants perceived the fuel types as intended (gas cheaper and more available, but worse on emissions than the alternative fuels), participants first responded to nine questions measuring their perceptions of the relative price, emissions, and availability of gasoline, corn-based and cellulose-based ethanol. Each fuel type was paired with each other fuel type, with participants responding on 7-point Likert scales (e.g., 1 = gasoline is much better than corn-based ethanol on price, 7 = corn-based ethanol is much better than gasoline on price). As shown in Figure 2, participants believed gas was cheaper and more available, but also worse on emissions, when compared to the alternative fuels (as indicated by a significant deviation from the scale midpoint of 4, which represents equally…affordable, available, polluting).

Insert Figure 2 about here

To gauge participants' familiarity with the alternative fuels, participants rated how knowledgeable they were about corn-based and cellulose-based ethanol (1 = not knowledgeable, 7 = very knowledgeable). As anticipated, participants scored fairly low on their knowledge of the alternative fuels, with participants being less knowledgeable about cellulose-based ethanol (M = 2.24, SD = 1.50) than corn-based ethanol (M = 3.14, SD = 1.65), $t(298) = -14.81$, $p < .001$.

After rating their perceptions and knowledge of the fuels used in the present study, participants read a brief summary of corn-based and ethanol-based fuels (see Introduction to Cellulose-Based and Corn-Based Fuels in Appendix).[3] Next, participants received an example

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[3] In this paper, ethanol refers to E85 fuel, which is a blend of 85 percent ethanol and 15 percent gasoline.

fuel choice scenario (see Introduction to Fuel Choice Scenarios in Appendix). Once the fuel choice scenarios had been introduced, participants made a choice between the three fuel types in eight different fuel choice scenarios (with parameters varying in terms of price, emissions, and service availability, as summarized at the end of the Appendix).

In all scenarios, gasoline cost $2.75/gallon – based on 2007 – 2009 retail gasoline sales data from Energy Information Administration's (EIA) *Retail Gasoline Historical Prices* database (EIA, 2009) – and was available at every fueling station. In addition, gasoline was said to have an emission rating of 20, which corresponded to the estimated number of pounds of CO_2 emitted for one gallon of gasoline consumed. As noted in the table provided to participants, while one gallon of gasoline weighs only 6.3 pounds, according to U.S. Environmental Protection Agency (EPA) calculations (EPA, 2005), one gallon of gasoline can produce 20 pounds of carbon dioxide (most of the weight of the CO_2 doesn't come from the gasoline itself, but the from the oxygen in the air). This occurs because burned gasoline produces carbon and hydrogen, which after interacting with the oxygen in the air, increases its weight to 20 pounds of carbon dioxide (CO_2) per gallon. By comparison, cellulose-based and corn-based ethanol had an average emission rating of 15 (25% reduction), but was only available (on average) at every other fueling station. Also, while the cost of the alternative fuels varied (either greater than or less than gasoline by 0.25/gallon, the average cost of the alternative fuels was the same as gasoline (between $2.75 to $2.81/gallon).

2.3 Individual Differences and Demographics

After completing the fuel choice task, participants completed a 14-item CFC scale (cf. Joireman, Shaffer, Balliet, & Strathman, 2011) and provided demographics (age, gender, ethnicity, income, education, and political orientation from 1 = liberal to 7 = conservative). The

14-item CFC scale is composed of Strathman et al.'s (1994) original 12-item scale (containing 7 "immediate" items and 5 "future" items) along with 2 new "future" items written by Joireman et al. (2011). The two new items read: *(13) When I make a decision, I think about how it might affect me in the future. (14) My behavior is generally influenced by future consequences*. Joireman et al. have advocated use of the 14-item scale because it provides two balanced CFC subscales (both 7-item subscales), and improves upon the internal reliability of the original 5-item CFC-Future subscale (cf. Joireman et al., 2008) which tended, in past research, to be somewhat low. The internal reliability of the CFC-Immediate and CFC-Future subscales in the present study was acceptable (Cronbach's alphas = .78 and .76, respectively). For comparison with previous research, we also computed a total CFC score, which was also highly reliable in the current study (alpha = .80).

3. Results

3.1 Regression Results Interpretation

To evaluate our hypotheses, we conducted two multinomial logit models (MNLM), with the fuel choice as the dependent variable. In the first analysis, we used the overall CFC score and a variety of covariates (political orientation, knowledge of biofuels) as predictors. In the second analysis, we used the two CFC subscales (CFC-Future and CFC-Immediate) and the covariates as predictors.

The MNLM estimates $j - 1$ models, where j is the number of choice alternatives, with one choice option as the base or referent alternative (gasoline in our case). Therefore, the j^{th} equation is relative to the referent group. For a meaningful interpretation, the estimated coefficients are given in relative risk ratios, which are obtained by exponentiating the MNLM coefficients—the coefficients (βs) are represented in e^{β} rather than β form (Table 2). This means that for a unit change in the explanatory variable, the relative risk of a particular choice is anticipated to change by a factor of the respective coefficient (by holding the rest of the variables in the model constant).

In particular, if the estimated coefficient is > 1, then for a one unit increase in the predictor variable, the relative risk of the fuel choice outcome falling in the comparison alternative (i.e., corn- or cellulose-based ethanol in this case) relative to the risk of the choice falling in the referent alternative (i.e., gasoline) is expected to *increase* by a factor of the respective parameter estimate, holding the other variables in the model constant (Long & Freese, 2006). For example, if the coefficient for CFC-Total in Model 1 (Table 2, under corn-based column) is estimated to be 1.54, this means that for a one unit increase in the CFC-Total score, the relative risk of a fuel choice falling in the corn-based ethanol will be expected to *increase* 1.54 times.

Likewise, a coefficient estimate that is < 1 indicates that for a one unit increase in the predictor variable, the relative risk of the choice falling in the comparison alternative (corn- or cellulose-based ethanol) relative to the risk of the choice falling in the referent alternative (gasoline) is expected to *decrease* by a factor of the respective parameter estimate, holding the rest of the predictors in the model constant. For example, if the coefficient called political orientation is 0.82 (Table 2, Model 1, corn-based column), we expect that for a one unit increase in the political orientation variable, the relative risk of a fuel choice falling in the corn-based ethanol will be expected to *decrease* by a factor of 0.82, i.e., corn-based ethanol is 0.82 times less likely to be chosen.

3.2 Testing for Independence of Irrelevant Alternatives Assumption

Multinomial logit models restrictively assume independence of irrelevant alternatives (IIA), according to which the ratio of the probabilities of any two alternative choices does not depend (null hypothesis) on the third alternative introduced in the choice set (Hausman & McFadden, 1984; Small & Hsiao, 1985). To rule out the IIA assumption violations, we tested our models with the Small-Hsiao (SH) test (Small & Hsiao, 1985). The results were not statistically significant ($\chi^2(11) = 15.8$, $p = 0.15$ for Model 1, and $\chi^2(12) = 8.13$, $p = 0.77$ for Model 2), confirming that IIA has not been violated. Therefore, for this specific choice experiment, the multinomial logit is the correct type from a family of logit regressions to use.

3.3 CFC-Total Score and Fuel Choice

In Model 1 (see Table 2), the primary focus is on the relationship between CFC-Total score and the choice between corn- and cellulose-based fuels, relative to the base choice option—gasoline. The coefficient for CFC-Total is estimated to be 1.54 for corn-based ($\beta_{CFC-Total-Corn}$ = 1.54, $p < .01$), and 1.92 for cellulose-based ethanol ($\beta_{CFC-Total-Cell}$ = 1.92, $p < .01$). Both of these results (with coefficients greater than 1) support Hypothesis 1 that individuals high in CFC total score will prefer corn- or cellulose-based fuels to gasoline, i.e., the preference for alternative fuels is positively associated with individuals' level of CFC. Increasing the CFC-Total score by one unit, will increase the relative risk of cellulose-based ethanol choice by a factor of 1.92, and by a factor of 1.54 for corn-based alternative.[4]

To provide further support for the hypotheses, next we discuss predicted choice probabilities with respect to the CFC-Total scale. The choice probabilities shown in Figure 3

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[4] Among socio-demographic variables included in the model, only two coefficients showed a statistically significant positive relationship with alternative fuel choice. The coefficient for *previously used ethanol* variable was estimated to be 1.94 ($p < .01$) for corn-based ethanol, and 1.77 ($p < .01$) for cellulose-based ethanol. The coefficient for *education level* variable was significant for only corn-based ethanol (1.28, $p < 0.05$).

are based on the Model 1 estimation results. In general, the positive relationship between CFC-Total and the probability of choosing cellulose-based ethanol (as the most environmentally cleaner alternative) combined with the inverse relationship between CFC-Total and gasoline option (as the least environmentally cleaner alternative) are in line with the results discussed above, both supporting Hypothesis 1 (Figure 3).

Insert Figure 3 about here

According to these choice probability results, as CFC-Total score increases from its minimum to maximum, the probability of choosing cellulose-based ethanol increases from 14% to 61%. In contrast, the probability of corn-based ethanol increases only marginally (from 22% to 30%). Hypothesis 1, stating that preference for alternative fuels would be positively associated with CFC score, is further supported by the results for gasoline option—as the CFC-Total score increases from minimum to maximum, the predicted probability of choosing gasoline drops from around 64% to 10% (Figure 3).

3.4 CFC-Future and Fuel Choice

In contrast to the unidimensional CFC construct used in Model 1, the primary focus in Model 2 is the relationship between choice for fuels and the CFC-F and CFC-I subscales. The coefficient for the CFC-F was found to be statistically significant, positive for both corn- and cellulose-based fuels ($\beta_{CFC-F-Corn}$ = 1.55, $p < .01$; $\beta_{CFC-F-Cell}$ = 1.71, $p < .01$). The coefficient estimates for the CFC-F subscale supports Hypothesis 2 that CFC-F subscale would be positively associated with preference for alternative fuels (e.g., the relative risk for this fuel to be selected increases by a factor of 1.71 as a result of a one unit increase in CFC-F). However, a unit increase in the CFC-F score increases the relative risk of choice for cellulose-based fuel by a much higher factor (1.71) than that of the corn-based alternative (1.55). In addition to the distinction between conventional (gasoline) and alternative fuels (ethanol), the disaggregation of the CFC scale into Future and Immediate orientations allows investigating choice behavior among different types of alternative fuels. The higher estimate of the CFC-F subscale for the environmentally cleaner fuel alternative (cellulose-based ethanol) is also consistent with the findings from previous literature linking the CFC scale to pro-environmental behavior.

The choice probabilities shown in Figure 4 are based on the Model 2 results and provide additional support for Hypothesis 2 that individuals high in CFC-F will prefer cellulose-based to gasoline. With increasing CFC-F score (from minimum to maximum), the probability for cellulose-based choice increases from 16% to 52%, while the probability of gasoline choice decreases from 66% to 13%. These results also provide further support for research advocating disaggregation of the CFC scale into Future and Immediate orientations. The increase in the probability for corn-based increases only from 18% to 35%, which is much less than the increase in the probability of the cellulose-based fuel choice (16% to 62%).

Insert Figure 4 about here

3.5 CFC-Immediate and Fuel Choice

The estimated coefficient for the CFC-I subscale revealed a reversed relationship compared to the CFC-F estimates ($\beta_{CFC-I-Corn}$ = 0.92, $p < .1$, for corn-based; $\beta_{CFC-I-Cell}$ = 0.82, $p < .01$, for cellulose-based), although the coefficient for the corn-based option is only marginally significant. A unit increase in the CFC-I subscale decreases the relative risk of the choice outcome for both corn- and cellulose-based fuels by a factor of 0.92 and 0.82, respectively (i.e., less likely to be chosen). According to these estimates, individuals scoring high in CFC-I tend to prefer gasoline to the alternative biofuels. This is consistent with the Hypothesis 3 that scores on the CFC-I subscale would be negatively related to preference for alternative fuels. Individuals giving more importance to the immediate consequences of their behavior tend to choose the least environmentally clean fuel—gasoline.

Figure 5 shows fuel choice probabilities with respect to the CFC-I subscale. Providing additional evidence for the Hypothesis 3, the results show that as the CFC-I increases from minimum to maximum score, the probability of choosing gasoline increases from 19% to 34%. Also consistent with the CFC-F vs. CFC-I unidimensional discussion, the probability of choosing cellulose-based ethanol decreases from 51% to 31%. The predicted probability curve for corn-based alternative is slightly upward sloping. However, the results from Model 2 showed that the coefficient was only marginally significant ($\beta_{CFC-I-Corn}$ = 0.92, $p < .1$).

Insert Figure 5 about here

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4. Discussion

4.1 General Discussion

The present study investigated the relationship between the revised 14-item CFC scale and alternative transportation fuel choice behavior. The choice probability results in the present study are in line with previous research, which linked CFC to environmentally significant behavior. Results also strongly support disaggregating the CFC scale into Future and Immediate subscales. In contrast to the previous work investigating the CFC construct and problems involving intertemporal choice, the present study employed choice-based conjoint methodology to collect fuel choice responses from respondents through an online national survey. Among the three fuel alternatives (gasoline, corn-based ethanol, and cellulose-based ethanol), gasoline was considered as the base category, followed by corn-based ethanol as a better alternative in terms of its environmental impacts compared to gasoline, and cellulose-based ethanol was considered as the most environmentally cleaner alternative in the fuel choice set. The conjoint methodology helped reveal a new relationship between the CFC scales and choice behavior (i.e., choice probability estimates), and may prove useful in assessing preferences and willingness-to-pay in other choice problems involving intertemporal tradeoffs (e.g., health, self-control, or personal finance related decision-making).

4.2 Contributions to the CFC-Environmental Research Literature

Overall, the findings encourage the use of the balanced, 14-item CFC scale, and contribute to temporal considerations in decision making related research with some new insights. With respect to two-dimensionality, the new, 14-item CFC scale provided strong empirical support for both CFC-F and CFC-I subscales, previously found in both the 12- and 14-item versions (i.e., Joireman et al., 2008; Joireman, et al., 2011).

In particular, the new 14-item CFC-Total scale maintained the previous empirical evidence about the relationship between CFC and environmental behavior (Strathman, et al, 1994; Joireman, et al., 2004). The results of Model 1 revealed that higher CFC-Total scores were strongly associated with preference for alternative fuels, such as corn- or cellulose-based ethanol (Table 2, see also Figure 3). As the CFC-Total score increases from minimum to maximum, the probability of choosing cellulose-based fuel increased by 47% (14% to 61%), while the probability of gasoline option to be chosen dropped by more than 50% (64% to 10%).

The increase in corn-based ethanol probability with respect to increasing CFC-Total score was relatively moderate— 8% (22% to 30%). These results initiate questions about the directionality of CFC's influence on decision making discussed in Joireman et al. (2011). Is the positive relationship between the CFC-Total score and choice for (environmentally friendly) cellulose-based fuel attributable to individuals' concern about the future consequences? The disaggregated CFC-F and CFC-I subscales were used to explore this important question.

In particular, individuals high in CFC-F showed significantly higher preference for cellulose-based ethanol compared to gasoline option (Table 2 and Figure 4). When comparing coefficients for two ethanol options (both considered to be preferred alternatives to gasoline in terms of environmental impacts), those high in CFC-F showed relatively higher preferences for the most environmentally clean alternative—cellulose-based ethanol. This difference was also supported by predicted probability results, showing 36% (16% to 52%) increase in cellulose-based fuel vs. 17% (18% to 35%) increase in corn-based fuel choice, as the CFC-F increases from minimum to maximum. In contrast, those high in CFC-I showed significantly higher preference for gasoline, among the three alternatives (Table 2 and Figure 5). Both choice probabilities (Figure 5) and regression coefficient for the cellulose-based option (Table 2) supported our hypothesis that higher scores in CFC-I would be associated with the environmentally least attractive fuel—gasoline. These contrasting results between predicted probability results clearly underline the predictive advantage of the two-dimensional CFC scale.

4.3 Practical Implications

Because biofuels are becoming more available in the marketplace, it is imperative to understand how consumers perceive and support such fuels. The present results suggest that desire for biofuels is a function of both concern with future and concern with immediate consequences, suggesting marketers must take into account both types of consequences when marketing such fuels. For example, it is not enough to stress that biofuels can serve as an environmentally-friendly alternative to gasoline that maximizes the planet's long-term well-being. While certain consumers (who are concerned with future consequences) are likely to respond favorably to such messages, other consumers (who are concerned with immediate consequences) are more likely to base their evaluation of fuel alternatives on more immediate concerns. Future research could build on the present research by testing how different message frames appeal to these different types of consumers. For example, when they first validated their CFC scale, Strathman and colleagues (1994) showed that people high on CFC were more likely to support offshore oil drilling when the costs were immediate and the benefits delayed, while those low in CFC were more likely to support offshore drilling when the benefits were immediate and the costs were delayed. It would be useful to determine whether a similar "targeted message approach" might be effective with regard to biofuels. Two additional directions for future research are outlined below.

4.4 Strengths, Limitations and Future Directions

The current paper has at least two limitations that should be addressed in future research. First, due to the relative unavailability of biofuels to many in the market (especially cellulose-based fuels), we gave participants eight hypothetical fuel scenarios. It will be necessary to validate the current findings in more realistic settings when such fuels become more available. With that being said, the conjoint methodology we used has the advantage of offering a more realistic range of fueling scenarios than simply asking potential consumers if the support each form of biofuel, in general. Second, the correlational nature of the findings prevents firm conclusions about causality. Cross-lagged panel designs could be used to evaluate the presumed causal order of the constructs (from CFC to preference for biofuels).

Although the current study has some limitations, the current study also has some noteworthy strengths. First, rather than using self-reported preference for biofuels in the abstract, we provided respondents with eight more realistic fueling choice scenario. Second, whereas past CFC research has often used college student samples, the current study solicited responses from a panel of U.S. consumers varying substantially in age, income, region of residence, and employment status, enhancing the generalizability of the findings. Finally, whereas past CFC-environmental research has focused on the global CFC construct, the current study showed that separating out the two subscales can provide useful insights into the underlying reasons why the (global) CFC score predicts an outcome. In the present case, CFC-Future and CFC-Immediate subscales were unique predictors of preference for biofuels, suggesting a more nuanced understanding of why CFC-Total predicts preference for biofuels (for other examples, see Adams, in press; Joireman et al., 2008). In the end, the present results suggest that consumer preference for biofuels will depend not only on a concern with future consequences, but a concern with immediate consequences as well. Overlooking this subtle, but important, difference by focusing solely on the global CFC construct may lead researchers and practitioners alike to devote all of their attention to stressing the future benefits of biofuels without paying sufficient attention to the immediate barriers to adopting such fuels. The present results suggest that any campaign for promoting biofuels will be more successful if it takes into account the role of both future and immediate consequences in the decision-making process.

Appendix

Fueling Scenarios

Introduction to Cellulose-Based and Corn-Based Ethanol

On the next several slides, we will be asking you about your preference for three different forms of transportation fuels (gas, cellulose-based ethanol, and corn-based ethanol). Some of these fuels are widely available today, while others are less available or still under development.

In today's study, we will be asking you to imagine eight *future* "fuel-choice scenarios" and indicate your preference for the three types of fuels in these scenarios. Before presenting the scenarios, we would like to provide some background information on the two ethanol-based fuels. Please read this information carefully before moving on.

Cellulose-based ethanol is processed from cellulose, which is extracted from such sources as forest biomass, wood chips, agricultural crop residue, animal manure, or municipal solid waste.

Corn-based ethanol is processed from corn.

After production, the pure ethanol is blended with gasoline to create different grades of motor fuels. In this study, both cellulose-based and corn-based ethanol fuels refer to E85 grade (a blend of 85% ethanol and 15% gasoline).

Both cellulose-based and corn-based biofuels contribute to U.S. oil independence.

Introduction to the Fuel Choice Scenarios

In this part of the survey, we would like you to imagine that you are at a service station and you have a choice between the three types of fuels shown below.

1. Gasoline
2. Cellulose-based ethanol
3. Corn-based ethanol

On each of the following eight pages, we will present a fuel-choice scenario. In each scenario, you will find a table listing the price, environmental emissions and service availability for each type of fuel.

Each table contains a different combination of price, emissions and service availability for cellulose-based and corn-based ethanol fuels. The emissions and service availability for gasoline are the same in every table.

Please read each table carefully before selecting your preferred fuel type.

Here is an example. In this fuel-choice scenario, we would like you to imagine:

- Gas costs $2.75/gallon, while cellulose-based and corn-based ethanol cost $2.50/gallon.
- Gas has an emissions rating of 20 (lbs. per gallon)a, while cellulose-based ethanol has an emissions rating of 16, and corn-based ethanol has an emissions-rating of 14.
- Gas is available at every fueling station; cellulose-based and corn-based ethanol are available at every third fueling station.

This is an example. On the following eight pages, we would like you to select your preferred fueling option after carefully reviewing the information provided in the table on that page. Please note that the information in each table will change from page to page.

Example Fueling Scenario Provided to Participants

	GASOLINE	**CELLULOSE-BASED ETHANOL**	**CORN-BASED ETHANOL**
PRICE/GALLON	2.75	2.50	2.50
EMISSIONS (IN LBS/GALLON)	20[a]	16	14
SERVICE AVAILABILITY	every fueling station	every 3rd fueling station	every 3rd fueling station

[a] One gallon of gasoline weighs only 6.3 pounds. However, according to U.S. Department of Energy calculations, 1 gallon of gasoline can produce 20 pounds of carbon dioxide (most of the weight of the CO_2 doesn't come from the gasoline itself, but the from the oxygen in the air). This occurs because burned gasoline produces carbon and hydrogen, which after interacting with the oxygen in the air, increases its weight to 20 pounds of carbon dioxide (CO_2) per gallon.

Parameters Used in the Eight Fueling Scenarios[a]

	Price Per Gallon		Emissions		Availability	
Scenario	Cellulose	Corn	Cellulose	Corn	Cellulose	Corn
1	3.00	2.50	16	16	3	3
2	2.50	3.00	16	16	1	1
3	3.00	2.50	16	14	1	1
4	3.00	3.00	14	16	3	1
5	2.50	3.00	16	14	3	3
6	3.00	3.00	14	14	1	3
7	2.50	2.50	14	14	3	1
8	2.50	3.00	14	16	1	3
Averages	2.75	2.81	15	15	2	2

[a] Gasoline always cost 2.75; its emissions were listed as 20 (see previous section for an explanation provided to participants); and it was always available at every fueling station. Availability refers to whether the noted fuel is available at every station (1), every other station (2), or every third station (3).

Carbon dioxide (CO_2) emission statistics are available from the EPA Office of Transportation and Air Quality (http://www.epa.gov/oms/climate/420f05001.pdf)

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Table 1. Summary of Online Survey Respondents' Socio-demographic Characteristics

Variable	Freq. (%)	Mean	St. Dev.	Variable	Freq. (%)	Mean	St. Dev.
Gender		0.50	0.5	**Education**		3.9	1.4
Male = 0	50.1			1=Less than High School	1.0		
Female = 1	49.9			2=High School	15.7		
Age		2.9	0.81	3=Some College	30.1		
1=Under 25 years	3.5			4=2-year College	14.1		
2=25 to 44 years	26.9			5=4-year College	26.1		
3=45 to 59 years	44.9			6=Master's Degree	11.4		
4=60 to 78 years	24.6			7=Doctoral Degree	1.0		
Annual Income		4.4	2.6	8=Professional Degree	0.7		
1=Below $20,000	15.7			**Marital Status**		2.16	1.3
2=$20,000 - $29,999	14.7			1=Married with children	47.8		
3=$30,000 - 39,999	12.0			2=Married without child	14.7		
4=$40,000 - $49,000	12.0			3=Divorced	15.1		
5=$50,000 - $59,999	10.0			4=Single	18.4		
6=$60,000 - $69,999	9.7			5=Widowed	4.0		
7=$70,000 - $79,999	5.4			**Race**		2.9	0.3
8=$80,000 - $89,999	14.7			1=African American	1.0		
9=$90,000 and more	5.7			2=Asian American	2.7		
Occupation		3.1	2.0	3=Caucasian	93.8		
1=Full-time employed	34.7			4=Hispanic	2.1		
2=Part-time employed	12.3			5=Pacific Islander	0.0		
3=Self employed	9.0			6=Other	0.3		
4=Unemployed	18.3			**Regional Distribution**		2.4	1.1
5=Student	2.3			1=West	22.7		
6=Retired	20.3			2=South	32.3		
7=Other	3.0			3=Midwest	21.7		
				4=Northeast	23.3		

Table 2. Multinomial Logit Regression Coefficients Predicting Fuel Choice

Variables	Model 1		Model 2	
	Corn-based	Cellulose-based	Corn-based	Cellulose-based
CFC Constructs				
CFC-Total	1.54***	1.92***	-	-
CFC-Future	-	-	1.55***	1.71***
CFC-Immediate	-	-	0.92*	0.82***
Demographics				
Education level	1.28**	1.15	1.29**	1.15
Income level	1.02	1.04	1.01	1.03
Political orientation	0.82***	0.77***	0.83***	0.78***
Use ethanol now	1.94***	1.77***	1.86***	1.70***
Knowl. Corn-Ethanol	0.95	0.96	0.95	0.96
Knowl. Cell-Ethanol	0.95	1.03	0.94	1.03
Regional differences				
South	0.83	0.68**	0.83	0.68**
Midwest	0.87	0.76*	0.87	0.76**
Northeast	0.93	0.81*	0.94	0.83
Log-likelihood	-2340.3		-2331.3	
LR χ^2 (20)	237.4		LR χ^2(22)	255.4
Prob > χ^2	0.00		0.00	
N	2267		2267	

*** p < .01, ** p < .05, * p < .1. Fuel choice is the dependent variable. Knowl = knowledge of the denoted fuel. Political orientation (high values reflect a more conservative orientation). Positive coefficients indicate that the predictor increases the likelihood of selecting the alternative fuel noted (corn, cellulose based ethanol) over gasoline.

Figure Captions

Figure 1. Online survey respondents' geographic distribution

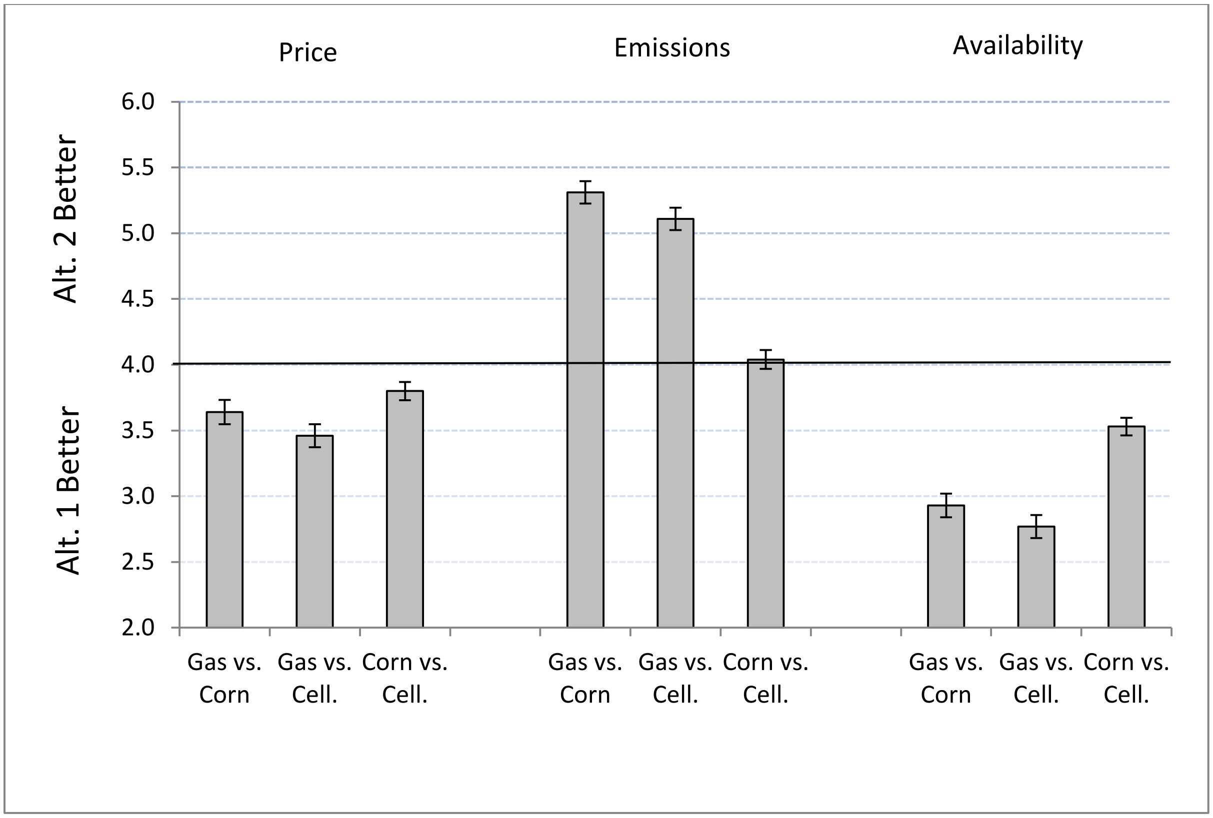
Figure 2. Perceptions of relative price, emissions, and availability of gas, cellulose-based ethanol, and corn-based ethanol.

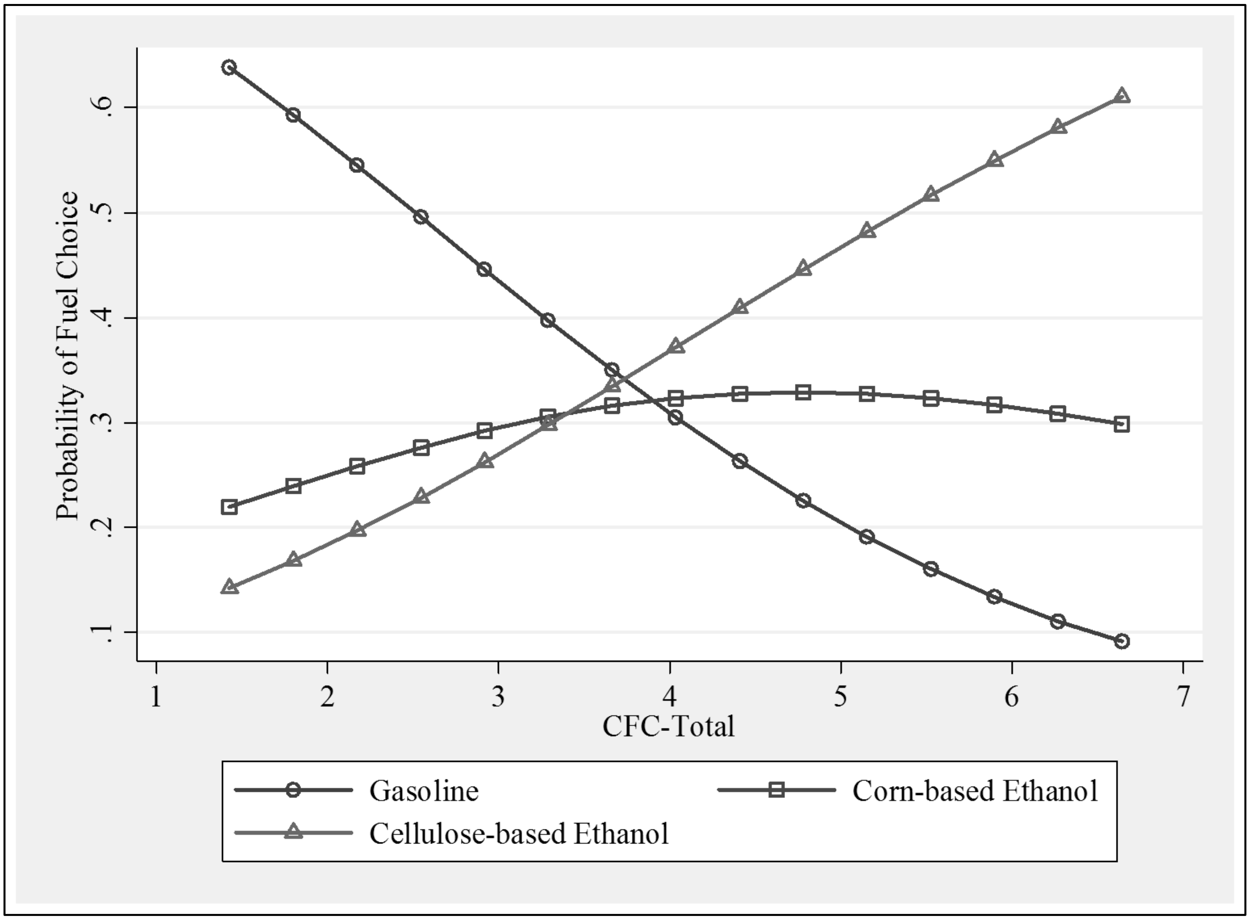
Figure 3. Relationship between fuel choice probability and CFC-Total scale

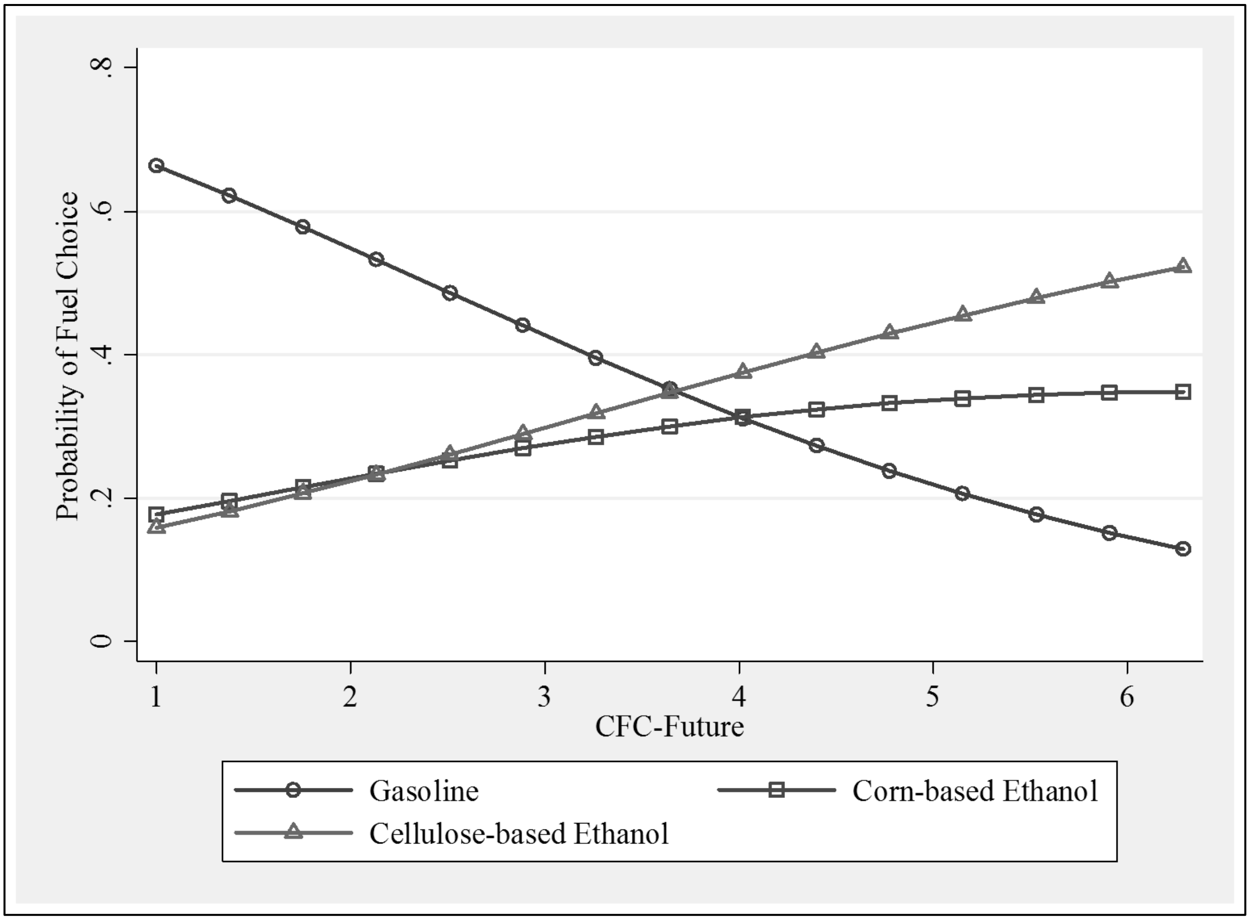
Figure 4. Relationship between fuel choice probability and CFC-Future subscale

Figure 5. Relationship between fuel choice probability and CFC-Immediate subscale

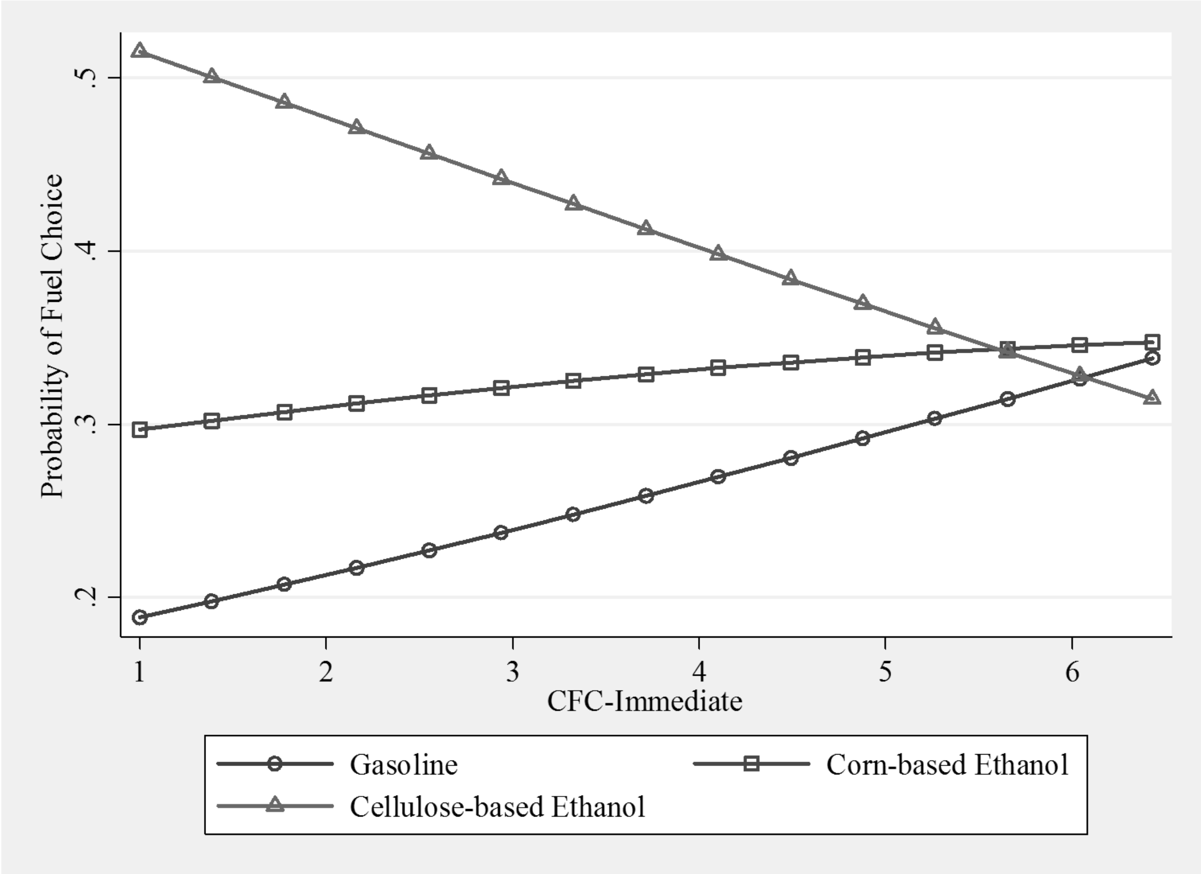

West
68
Midwest
65
Northeast
70
South
97


Price
Emissions
Availability
Alt. 2 Better
Alt. 1 Better
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
Gas vs. Corn
Gas vs. Cell.
Corn vs. Cell.
Gas vs. Corn
Gas vs. Cell.
Corn vs. Cell.
Gas vs. Corn
Gas vs. Cell.
Corn vs. Cell.


Probability of Fuel Choice
.1
.2
.3
.4
.5
.6
1
2
3
4
5
6
7
CFC-Total
Gasoline
Corn-based Ethanol
Cellulose-based Ethanol



Probability of Fuel Choice
0
.2
.4
.6
.8
1
2
3
4
5
6
CFC-Future
Gasoline
Corn-based Ethanol
Cellulose-based Ethanol



Probability of Fuel Choice
.2
.3
.4
.5
1
2
3
4
5
6
CFC-Immediate
Gasoline
Corn-based Ethanol
Cellulose-based Ethanol