Hoping Grey Goes Green: Air Pollution's Impact on Consumer Automobile Choices

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ABSTRACT

This paper examines to what extent, if any, natural environmental factors affect consumer purchase decisions regarding "green" products. We collect and combine several unique datasets to study the impact of air pollution on consumers' choices of passenger vehicles in China. Exploiting cross-city variation, we find that air pollution levels negatively affect the sales of fuel-inefficient cars on average. This relationship, though, is U-shaped over the observed air pollution levels, in that fuel-inefficient car purchases rise with air pollution beyond some threshold. Furthermore, a city's income level is a significant factor in this non-monotonic relationship, in the sense that consumers of higher-income cities are less likely to suffer this reversal. All these results are consistent with the literature's theoretical predictions of hope. The rich findings of our study yield important implications to both marketers and policy makers.

Keywords: Green marketing, hope, choice model, consumer behavior, environmental economics, applied industrial organization

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1. Introduction

Since Hardin (1968) resurrected and popularized Lloyd (1833), the tragedy of the commons has been a powerful framework for how self-interested agents overuse unregulated common resources such as public land and clean air. But what if the tragedy's conception of self-interest is too narrow to fully capture human behavior? A growing literature in marketing and economics explores how factors such as social norms can lead individuals to behave in ways that may mitigate the tragedy of the commons, perhaps by choosing "green" products.

The natural environmental condition that consumers face may intensify such factors and so affect behavior more broadly.[3] While this is an intuitive extension, there is not yet any direct test in the literature. We fill this gap by exploiting the disparate air quality of all Chinese cities and then linking this air pollution to the fuel-inefficiency of cars purchased. Study of the automobile market in China in this context is attractive for several reasons. First, China faces serious

[3] For example, as *The Wall Street Journal* (September 8, 2015) reported, many people in Beijing were so concerned about the negative impact of air pollution on their children that "they often wouldn't let their small children outside if the Air Quality Index (AQI) was more than 150." As "the median daily AQI in Beijing was 162," the air quality in the city could dramatically affect how consumers behave.

environmental challenges; 16 Chinese cities appear on the list of the world's top 20 most polluted places (Chen et al. 2013). For our purposes, it is especially useful that air pollution varies greatly across cities and that cities with similar incomes may be exposed to very different pollution levels. Second, cars are expensive durable goods that will have long-lasting environmental impacts. Consumers must consequently spend substantial resources to exercise any preference that is distinct from classically defined self-interest. Finally, the fuel-efficiency of a car is an easily observed and measurable "green" product characteristic. [4]

Because we lack information on individual consumers, we follow Berry (1994) to structurally estimate market-level demand. The model is specifically identified by the fact that air quality is largely driven by geographical and climatic factors, but identification is also supplemented by our ability to observe city-level income as a proxy for economic activity. This inclusion of city income not only controls for the potential correlation between air pollution and the city's economic development level, but also enables us to show that this correlation is working *against* our various hypotheses that the data support.

Our results indicate that air pollution is a significant contributor to a consumer's decision on which car to buy, in that consumers living in more heavily polluted cities tend to buy less fuel-

[4] In a concurrent survey study that we conduct to complement this research, 64% Chinese consumers agree that "Issues relating to the environment are very important;" 82% agree "Everyone is personally responsible for protecting the environment in their everyday life;" 81% believe "If all of us, individually, made a contribution to environmental protection, it would have a significant effect;" and 57% agree "Vehicles are a significant source of air pollution." The total sample size of the survey is 160. Detailed questionnaire is available from the authors upon request. In addition, a 2008 McKinsey & Company global survey of 7,751 consumers in eight world's major economies reveals that Chinese consumers are very "green", ranking No. 1 in the categories of "using energy-efficient appliances" and "driving less/using public transportation more" (Bonini et al. 2008).

inefficient cars. This average trend though masks a considerably *non-monotonic* relationship. While relatively clean-air cities see consumers shift to greener cars when air pollution worsens, this virtuous trend stops and reverses at some level of pollution. Furthermore, this reversal threshold is pushed outward for richer cities, the consumers of which are evidently more willing and able to make sacrifices for the common resource of less polluted air. These findings verify that consumer responses to the natural environmental condition can mitigate the tragedy of the commons. Furthermore, all the results are consistent with the psychological research on hope (e.g., MacInnis and de Mello 2005).

To the best of our knowledge, this is the first study in the marketing literature to directly test and quantify the effects of natural environmental factors on consumer purchase behavior. In so doing, we effectively test the relevance of Kotler (2011) and its Marketing 3.0 emphasis on social responsibilities. The existing literature extensively studies how consumer choice is influenced by relatively micro factors (product features, advertising, and word of mouth, to name a few), assuming consumers face the same natural setting or “macro” environment. Our study, however, advocates the importance of recognizing the macro environment and tailoring marketing approaches accordingly. For instance, our results imply that firms’ marketing strategies should vary across markets as they differ in income and air pollution.

2. Theoretical background

Economists and marketing researchers have considered many forces that may drive consumers’ pro-environmental behaviors. First of all, it is intuitive that in many circumstances people make pro-environmental choices for their own good. This “selfish” gain, however, is likely to be minimal against the reality of many other people’s choices overwhelming the impact of any one individual. Second, the behavior could also be driven by functionally altruistic considerations. The various (not mutually exclusive) altruism theories include pure altruism (e.g., Fransson and Garling 1999), competitive altruism/conspicuous conservation (e.g., Griskevicius et al. 2010), and social norms (e.g., Goldstein et al. 2008).

When the environmental imperatives (e.g., substantial air pollution) become greater, research shows that any of these altruistic forces should be more easily triggered (e.g., Mazar and Zhong 2010). As a result, consumers are more likely to avoid environmentally unfriendly products, such as fuel-inefficient vehicles. This leads to our first hypothesis:

HYPOTHESIS 1. *Higher air pollution tends to decrease sales of fuel inefficient vehicles.*

Intuition suggests that the above hypothesis will be subject to diminishing returns, but at least one theory predicts actual reversal. In a recent advance of the marketing literature, *hope* is defined as the degree of yearning for a goal congruent future outcome appraised as uncertain but possible (MacInnis and de Mello 2005). All three types of “altruism” are predicated on “hope,” in which the goal congruent outcome could be an intrinsic care about the well-being of the planet (Pure Altruism), attaining desired social status (Conspicuous Conservation), or conforming to the social norm (Social Norms). As the literature (e.g., Lazarus 1991; Smith et al. 1993) points out, hope involves outcomes in which the actual occurrence is viewed as possible but uncertain. *Uncertainty* about the ultimate goal is thus central (MacInnis and Chun 2006). Therefore, consumers tend to choose more environmentally friendly vehicles when the environmental condition worsens

(Hypothesis 1), but they will give up their pro-environmental behaviors if they feel the cause is hopeless. As a result, consumers' response to worse environmental condition is first positive, and then negative after they despair. In summary,

HYPOTHESIS 2. *The relationship between air pollution and sales of fuel inefficient vehicles is a U-shape.*

In Hypothesis 2, we posit a non-monotonic relationship between the environmental condition and consumers' choices of less environmentally unfriendly vehicles. That, however, is an unconditional relationship. Will all the cities in our data exhibit the same non-monotonic relationship? We again leverage the theory on hope to generate a hypothesis on that matter.

According to the definition of hope, the more one yearns for an outcome, the greater hope for the outcome one experiences. *Yearning* is defined as the degree of longing for a goal congruent outcome. Two fundamental factors that affect yearning are (1) desire. (e.g., Lazarus 1991) and (2) importance of an outcome (e.g., Averill et al. 1990). With the improvement of disposable income, people tend to have a stronger desire for clean air and high-quality life. They are also likely to be more aware of and to more highly value the importance of better environmental condition on their health and longevity. Thus, we expect that consumers with higher income experience greater yearning and hence more intense hope for environmental friendly products. As a result, the threshold for them to lose hope is higher than that of lower income consumers. Thus,

HYPOTHESIS 3. *The reversal threshold in the U-shaped relationship in Hypothesis 2 increases with a city's income level.*

3. Data

To test these hypotheses, we collected and combined several unique datasets at the city level. The city is the proper level to analyze our question.[5] While there is substantial income dispersion across cities, there is much less dispersion within Chinese cities.[6]

City-Level Automobile Sales: Monthly automobile sales data in China at the city-level were obtained from the nation's central administration of motor vehicles. Though our dataset spans only four months (January – April 2010), the cross-sectional coverage is exhaustive, in terms of both cities (273) and vehicle models (257).[7] The 257 distinct models come from 63 brands and include virtually all gasoline-powered car models sold in China during the sample period. Moreover, we are able to observe the sales of not only distinct models, but also different transmissions (automatic vs. manual) within a model. Because the transmission type is a key determinant of a car's performance and fuel efficiency, the data from the 426 transmissions are used throughout the data analysis.

Car Characteristics: The sales data are supplemented with transmission characteristics from xcar.com.cn, one of the most authoritative and popular web portals on car information in China.

[5] A "city" in our data is more similar to the Metropolitan Statistical Area (MSA) than the concept of city/town in the United States.

[6] For example, unlike their U.S. counterparts, there are virtually no income differences across different postal codes within Chinese cities.

[7] There are four direct-controlled municipalities (Beijing, Tianjin, Shanghai, and Chongqing). The rest of its 269 cities belong to 22 provinces and 5 autonomous regions (Guangxi, Inner Mongolia, Ningxia, Tibet, and Xinjiang). Our data do not cover China's two special administrative regions (Hong Kong and Macau) and the territories governed by the Republic of China (R.O.C.), commonly known as Taiwan.

The collected characteristics are again fairly exhaustive. Among the collected characteristics, fuel consumption (L/100km) is the standard measurement of a transmission's fuel-inefficiency.[8]

City Characteristics: Our foremost city characteristic is air pollution. The decision to emphasize air pollution as our measure of environmental quality is driven in part by the existence of an objective measurement of air pollution – the Air Quality Index (AQI). In China, AQI is determined by six atmospheric pollutants: sulfur dioxide (SO_2), nitrogen dioxide (NO_2), suspended particulates smaller than 10μm in aerodynamic diameter (PM_{10}), suspended particulates smaller than 2.5μm in aerodynamic diameter ($MP_{2.5}$), carbon monoxide (CO), and ozone (O_3). While the measurement of each pollutant is scientifically sophisticated, the resulting AQI is a single number. A higher AQI number indicates worse air quality.

In China, local governments are required to post daily the current AQI on their websites.[9] Because some city governments do not make historical AQI information available, however, we were able to collect the historical AQI information of Jan – April 2010 from only 209 cities. These omitted cities were geographically dispersed, laying in 20 provinces/autonomous regions. We also collected information regarding city-level population, area of land, GDP, and average income level for all the cities for which we had sales information.[10] Chi-squared tests could not reject that the omitted cities had the same mean population, development, air pollution level, and auto sales as the included cities. Given these tests, we conclude that the 209 cities are representative of all

[8] A complete list of the characteristics that we collected is available from the authors upon request.

[9] In the survey study that we conduct to complement this paper, 85% of Chinese consumers understand the meaning of AQI and 77% of them pay attention to the AQI report and update.

[10] National Bureau of Statistics of the People's Republic of China 2010.

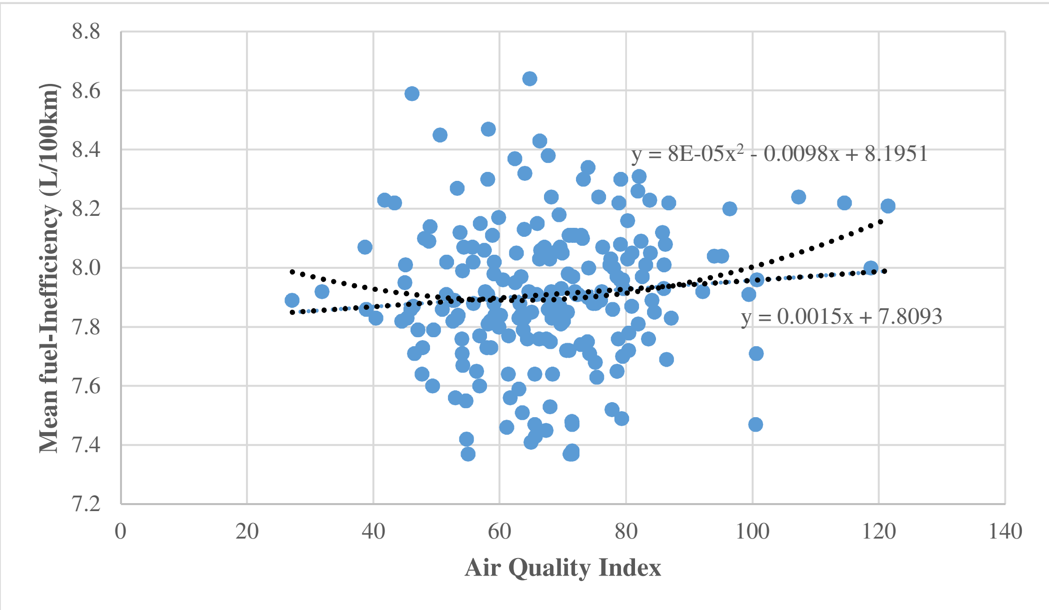
Chinese cities.

TABLE 1: SUMMARY STATISTICS

	Monthly Sales by City	Monthly Sales by Transmission	Car Fuel Inefficiency (L/100km)	City AQI	City Income (¥/yr)
# Obs	209	426	426	209	209
Mean	2878	1412	8.48	67.59	32695
S. D.	4656	1811	1.72	14.88	7720
Min	139	77	4.90	27.14	18604
Max	46857	13303	14.70	121.50	71875

We therefore use the combined data of the 209 cities in our empirical analysis. Table 1 reports the summary statistics of this sample on sales of car and car transmissions, and car fuel inefficiency, city monthly AQI, and city income. Figure 1 plots each city's mean fuel-inefficiency of cars purchased in the sample against that city's mean AQI with linear and quadratic trend lines. The figure offers some visual support for our hypothesis of a non-monotonic relationship, though it is statistically insignificant. Because the fuel-inefficiency is aggregated across all car models sold in a city, this plot ignores all the transmission-level variation in the data. Nevertheless, it is heartening that a primary prediction of our story finds some support even at this most aggregated level.

FIGURE 1: OBSERVED MEAN FUEL-INEFFICIENCIES VS. CITY AQI



4. Identification and Model

4.1 The Identification Strategy

Identifying the natural environment's causal impact on purchases is challenging. Our empirical strategy takes advantage of a unique feature of our data, i.e., the tremendous variation of air quality across cities. In our data, the average monthly city AQI during the sample period is 65, indicating an acceptable although not excellent air quality in China. The 10th and 90th percentiles are 52 and 86, so the range is substantial.[11]

Importantly, the cross-sectional variation of air quality is primarily caused by exogenous geographical and consequent climatic factors. China's vast size and especially its latitudinal breadth ensure substantial diversity on this margin. Relevant geographical features range from alluvial plains to grasslands to hills and mountain ranges. China also exhibits notable climate diversity, ranging from tropical in the far south to subarctic in the far north and alpine in the higher elevations of the Tibetan Plateau. All these factors interact to largely determine the air quality in a city.

A city's economic development may also affect its air quality. Fortunately, the variation in the economic development level across cities is substantial and largely orthogonal to geographical features. While areas along the coastline are generally richer than interior areas, both rich and poor cities are scattered across all of China. For example, Xinjiang, a northern inner autonomous region bordering Mongolia and Kazakhstan, has China's richest and poorest cities, Karamay and Hotan.

[11] As a matter of fact, these monthly averages mask the fact that air pollution varies within and across days and therefore understate a city's air pollution at its worst time on its worst day.

The 20 richest (poorest) cities belong to 7 (11) different provinces.

Furthermore, a city's economic development can derive from varying sources. Some cities rely heavily on "clean" production processes (e.g., the primary product of Ordos, one of China's richest cities, is wool). Other cities depend on natural resources with substantial negative environmental impact (e.g., Taiyuan, another of China's richest cities, is a center of coal production). The impact of economic development may also have varying impacts on cities that do not rely on natural resource extraction. Production expansions in Shanghai and Dongguan, China's respective financial and manufacturing capitals, naturally have very different implications for the environment.

Despite this arguably exogenous variation, an understandable concern is the potential endogeneity of air pollution and income, a concern that prompted our collection of city-level income data. The correlation of income with our city-level air pollution is $\rho = 0.2$, suggesting a modest endogeneity concern. Our explicit exclusion and then inclusion of income, therefore, should reveal the consequences of any potential correlation.[12]

4.2 Model Specification

Given the large number of cities and transmissions, our demand estimation could become parametrically cumbersome, and so we turn to the industrial organization literature with respect differentiated products. The now well-established logit framework popularized by Berry (1994) enables the analyst to concisely control for population and the depth of product offering.

[12] The fact that the Chinese government forbids the free movement of people across cities ensures that higher-income households moving to less polluted cities is not driving our results.

We assume that each consumer makes a relatively straightforward discrete choice among possible car transmissions, and we employ a nested logit model that permits segmentation between the option of buying no car and any car.[13] Formally, consumer *i* in city *c* selects the option that yields the greatest conditional indirect utility for buying car transmission *j* in month *m*. The no-purchase option is $j = 0$. Let Pop_c and q denote city *c*'s potential market size (i.e., the set of all households who might purchase a car)[14] and quantity sold. We define a transmission's purchase probability within a city as $s_{j,c,m} = \frac{q_{j,c,m}}{Pop_c}$ and the probability of no purchase as $s_{0,c,m} = \frac{\left(Pop_c - \sum_{i \in B_{c,m}} q_{i,c,m}\right)}{Pop_c}$.

The inside-outside segmentation is then operationalized by including information on a choice's city-month market share as traditionally defined $\left(sh_{j,c,m} = \frac{q_{j,c,m}}{\sum_{k \in B_{c,m}} q_{k,c,m}}\right)$. The parameter σ is the coefficient on $\ln(sh_{j,c,m})$ and its position on the unit interval reveals such segmentation's importance. If $\sigma = 0$, such segmentation is unimportant and the model reduces to the simple logit.

We use the above framework to specify mean consumer utility δ and the consequent equation to be taken to the data:

(1a) $$\delta_{j,c,m} = \theta_j + \phi_c + \mu_m + f(F_j, A_c, Y_c) + \xi_{j,c,m}$$

(1b) $$\ln(s_{j,c,m}) - \ln(s_{0,c,m}) = \sigma \ln(sh_{j,c,m}) + \delta_{j,c,m}$$

$$= \sigma \ln(sh_{j,c,m}) + \theta_j + \phi_c + \mu_m + f(F_j, A_c, Y_c) + \xi_{j,c,m}$$

In the above, $\theta_j, \phi_c,$ and μ_m represent sets of binary indicators for transmission, city, and month.

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[13] This form of segmentation mitigates mis-measurement of market size and has been useful in prior research (e.g., Berry and Waldfogel 1999, Einav 2007). The formal model is available from the authors upon request.

[14] We approximate a city's number of households as its population divided by three.

The variables A_c and Y_c denote city-level air pollution and income and are calculated as the mean of monthly averages of AQI and income over our four month sales period, and F_j denotes the transmission's fuel consumption (inefficiency). $F_j, A_c,$ and Y_c influence consumer i's utility through the function $f(\cdot)$. $\xi_{j,c,m}$ refers to the mean valuation of characteristics that all agents (consumers and marketers) in the market, but not the researcher, observe.

During our sample period, automobile manufacturers applied the universal pricing strategy in China. Thus, even though we lack these price data, consumer preferences regarding price will be absorbed by our transmission fixed effects. These same transmission fixed effects also absorb any uniform consumer preference regarding "green" characteristics, ensuring that our identification comes entirely from differences in sales across cities.

Mathematically, our hypotheses are focused on how marginal utility for fuel inefficiency changes with air pollution $\left(\frac{\partial^2 \delta_{j,c,m}}{\partial F_j \partial A_c}\right)$. We are also interested in how this second partial derivative changes with air pollution $\left(\frac{\partial^3 \delta_{j,c,m}}{\partial F_j \partial A_c^2}\right)$ and with city income $\left(\frac{\partial^3 \delta_{j,c,m}}{\partial F_j \partial A_c \partial Y_c}\right)$. These latter predictions can be addressed by including higher degree polynomial terms in $f(F_j, A_c, Y_c)$. Rather than specify an ad hoc collection of interaction terms, we employ full quadratic (2nd degree) and cubic (3rd degree) polynomials. Because we include transmission fixed effects and city fixed effects, mean utility with the employment of full 2nd and 3rd degree polynomials becomes:

(2a) $\delta_{j,c,m} = \theta_j + \phi_c + \mu_m + \alpha_1 F_j A_c + \alpha_2 F_j Y_c + \xi_{j,c,m}$

(2b) $\delta_{j,c,m} = \theta_j + \phi_c + \mu_m + \alpha_1 F_j A_c + \alpha_2 F_j Y_c +$

$$\beta_1 F_j A_c^2 + \beta_2 F_j^2 A_c + \beta_3 F_j^2 Y_c + \beta_4 F_j Y_c^2 + \beta_5 F_j A_c Y_c + \xi_{j,c,m}$$

The 2nd degree polynomial's estimates in (2a) will reveal the *average* impact of air pollution and city income on consumer preferences for fuel-inefficiency in cars, with Hypothesis 1 predicting $\alpha_1 < 0$. The 3rd degree polynomial's estimates in (2b) will reveal how those impacts change with air pollution and income, with Hypotheses 2 and 3 predicting $\beta_1 > 0$ and $\beta_5 < 0$, respectively.

4.3 Instruments

Given our application's lack of endogeneity bias from prices, the need for instrumental variables (IVs) is motivated by the correlation between the transmission's unobservable ξ and its $\ln(sh)$. Following the relevant literature introduced by Berry (1994), we leverage the assumption of exogenous product characteristics to construct instruments that capture the fierceness of a transmission's competitive environment. That is, we instrument for market share by using the product characteristics of rival transmissions in the market. Such IVs are made valid by their exclusion from the mean consumer utility, and their power comes from the fact that the competitive environment will directly affect a transmission's market share. The short length of our sample ensures that no firm has the opportunity to introduce a new product in response to a competing product that had especially favorable unobservable characteristics.

We use means of products' variables for car transmissions in the same city and month as our potential instrumental variables for the market share. We also recognize that many firm-brands are sold by the same ultimate manufacturer (group) and construct some IVs accordingly. Preliminary analysis indicated that IVs based on car weight, size (passenger capacity), and the ratio of horsepower to weight were especially powerful. We then used these variables to construct IVs that exploit potential portfolio effects so that "competing" transmissions are divided into other transmissions that are sold by the same firm and transmissions that are sold by other firms. We added to these two IVs a third IV based on other competing transmissions that shared the transmission's group. Overall, we use nine IVs, mean weight, mean size, and mean horsepower-to-weight ratio for each of the three IV types, to accommodate our inclusion of $\ln(sh)$ as a regressor.[15]

5. Results

We employ 2SLS to estimate our various nested logit specifications.[16] The results are reported in Table 2. Our key identification assumption is that the level of unobserved economic development of a city is orthogonal to its air quality. While we believe the assumption plausible, concerns may remain that air pollution is proxying for economic development and that it is this spurious correlation that drives our results. By comparing models without and with the inclusion of income, we are able to shed further light on any implications of our identifying assumption's violation.

Columns (1-2) displays estimates that omit income using the 2nd and 3rd degree polynomials. In Column (1), the estimated coefficient on the air*fuel interaction, i.e., α_1 in Equation (2a), denotes the average impact of increasing air pollution on the mean consumer's marginal utility for fuel inefficiency. Consistent with any of the altruism hypotheses, higher air pollution is associated with a lower preference for fuel-inefficient cars. While the null hypothesis of no impact can in both

[15] These instruments have sufficient power. Using $\ln(sh)$ as the dependent variable, a comparison of goodness-of-fit measures without and without the set of IVs yields an F-stat of 151.61, well above the 99% confidence threshold of 2.41.

[16] OLS estimates of the simple logit were qualitatively similar but less precise.

cases be rejected with 5% significance, the estimate is neither large nor precise, especially given the sample size. This suggests that the simple linear relationship is unable to adequately capture the underlying relationship. The inside-outside segmentation parameter σ, on the other hand, is estimated with extraordinary precision.

TABLE 2: 2SLS ESTIMATION RESULTS (N = 197240)

	Income Excluded		Income Included	
	(1) w/ 2nd Degree Polynomials	(2) w/ 3rd Degree Polynomials	(3) w/ 2nd Degree Polynomials	(4) w/ 3rd Degree Polynomials
Air_c*$Fuel_k$ (α_1)	-.74**	-8.94**	-1.56***	-12.07***
	(.26)	(2.44)	(.27)	(2.67)
$Fuel_k$*$Income_c$ (α_2)		-	.98***	8.03***
			(.07)	(.59)
Air_c^2*$Fuel_k$ (β_1)	-	10.82**	-	13.49***
		(1.07)		(1.16)
Air_c*$Fuel_k^2$ (β_2)	-	-42.86**	-	-1.49
		(11.12)		(11.54)
$Fuel_k^2$*$Income_c$ (β_3)	-	-	-	-37.96***
				(2.68)
$Fuel_k$*$Income_c^2$ (β_4)	-	-	-	.21***
				(.04)
$Income_c$* Air_c*$Fuel_k$ (β_5)	-	-	-	-2.57***
				(.39)
ln(sh_{kcm}) (σ)	.72**	.72**	.71***	.71***
	(.01)	(.01)	(.01)	(.01)

*/**/*** denote 90%/95%/99% confidence levels.

Notes: (1) Heteroskedasticity-robust standard errors in parentheses. (2) In all the nested logit models, the dependent variable is $\ln(s_{j,c,m}) - \ln(s_{0,c,m})$ and IVs are used for ln(sh). City fixed effects (ϕ_c), month fixed effects (μ_m) and transmission fixed effects (θ_j) are included.

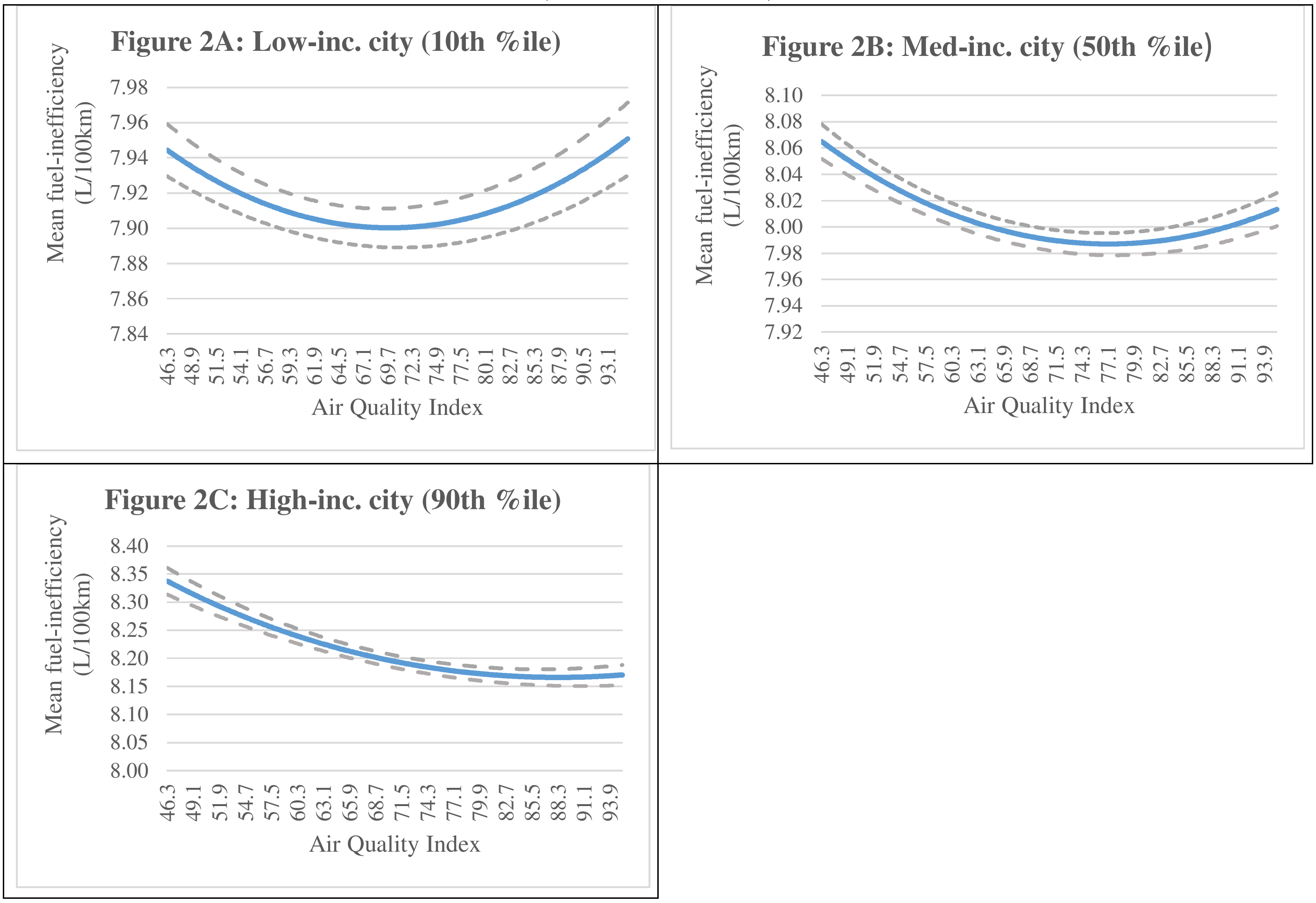
An important test of the hope hypothesis, however, involves not the average impact over all air qualities but rather the prediction of a non-monotonic relationship. Column (2) displays the 3rd degree polynomials. Here we see the predictions of our hope hypothesis borne out in a way that is highly statistically significant, as the estimated coefficient on A^2F (β_1 in Equation 2b) has a t-statistic of over 10. The level of air pollution affects consumers' preferences for fuel-inefficient cars in a way that, when faced with dirtier air, those in relatively clean cities shift toward greener cars but those in relatively dirty cities shift toward less green cars.

Columns (3-4) display our results when we include city income. To the extent that our income measure proxies for economic development, estimates' changes from the previous columns reveal the robustness of our findings. While it is apparent from the 2nd degree polynomial results (Column 3) that there is indeed some correlation between air pollution and city income, we can now see that this correlation was working *against* our various hypotheses. One of our strongest results is that consumers in higher-income cities prefer more fuel-inefficient cars. This presumably arises because fuel-inefficiency is associated with many other favorable characteristics. With income included, the average negative impact of air pollution on the preference for fuel-inefficiency is also much larger, more than doubling in both cases.

Our 3rd degree polynomial estimates (Column 4) likewise reinforce our previous conclusions regarding the non-monotonic relationship between air pollution and preference for fuel-inefficiency. We can further conclude from the statistically negative coefficient on the triple interaction that the negative relationship between air pollution and preference for fuel inefficiency is more relevant for higher-income cities. That is, the reversal threshold occurs at higher AQI levels for richer cities.

The difficult interpretation of structural parameters such as the above is perhaps their greatest defect, and we turn to a counterfactual exercise to illustrate the real-world meaning of these estimates. Our estimates indicate that the average consumer's preferences regarding fuel-inefficiency are affected systematically by the level of air pollution and that this impact varies by a city's income. In our counterfactual exercise, we consider three cities that correspond to the observed 10th/50th/90th percentiles of income. Consumers in each city face the observed set of available transmissions of varying fuel-inefficiencies. We then solve for each city's equilibrium market shares of each transmission at various hypothetical AQI levels. From these market shares, we construct each city's mean fuel-inefficiency of cars purchased.

FIGURE 2: IMPLIED MEAN CITY-LEVEL FUEL-INEFFICIENCIES BY INCOME (WITH +/- 2 S.E.S)



These counterfactual city-level mean fuel-inefficiencies are plotted in Figure 2. The U-shape of the implied mean fuel inefficiencies is most obvious at the 10th percentile income-income, but it is also apparent at the 50th percentile income-city. At the 90th percentile income-city, though, the relationship between air pollution and fuel inefficiency never reverses. These figures illustrate one of our paper's key findings, namely that the purchase of "green" products requires an income sufficient to permit consumers the luxury of hope.

6. Conclusion

Understanding what influences consumer choice is one of the most important topics in marketing science. Marketing researchers and practitioners now have an extensive understanding of the effects of product features, display, promotion, etc., and they are now focusing on new media such as social networks and online word of mouth. Macro factors such as air pollution, however, have been largely ignored. Whether the quality of one's surrounding air has any impact on purchase decisions is the focus of this research.

We evaluate this by examining the Chinese consumers' choices of passenger vehicles. Consistent with various altruism theories, our estimation results show that air pollution is a significant contributor to consumers' decisions on which car to buy, in that consumers living in more heavily polluted cities tend to buy less fuel-inefficient cars. There are actionable managerial implications on the finding. For example, practitioners may capitalize on this finding by adjusting the marketing strategy according to natural environment. Just as popular items are heavily promoted during holiday seasons, the promotion of green products on dirty days may be especially impactful. As we discussed, reports have been released that Chinese consumers are very green, much greener than thought. Our research suggests that Chinese consumers' behavior may be driven by their surrounding dirty air rather than their ethics.

This average trend, though, masks a considerably *non-monotonic* relationship. While relatively clean-air cities see consumers shift to greener cars when air quality worsens, this virtuous trend stops and reverses at some level of air pollution. Furthermore, this reversal threshold is pushed outward for richer cities, the consumers of which are evidently more willing to make sacrifices for the common resource of less polluted air. This result suggests that different marketing schemes must be designed for and targeted at areas of different development stages. To the extent that environmental regulations require popular support, our results also suggest that policymakers might lean somewhat toward encouraging economic growth. Such growth, especially among the dirtiest cities, would then offer a complementary decentralized addition to centralized regulation, as fewer consumers despair and more consumers act on their hope for a cleaner future.

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