A COMPARATIVE STUDY OF RESIDENTS' PERCEPTIONS OF ENVIRONMENTAL QUALITY IN THE TEXAS GOLDEN TRIANGLE AREA

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ABSTRACT

This study examines the attitudes of Golden Triangle area residents in Southeast Texas towards their quality of life. It focuses on residents' perceptions of the environmental effects of the petrochemical industry in the region, and their view of the level of environmental responsibility taken by local firms. The data for this study are from a survey conducted locally of 3,272 individuals. Statistical methods such as ANOVA and logistic regression are used to analyze and ascertain if there are significant relationships between the response variables and the set of independent variables. Variables tested include demographic and locational variables such as total household income, gender, age, ethnicity, level of education, and length of time in the area. Significant differences in perceptions towards the impacts and benefits of the petrochemical industry across cohorts were found.

INTRODUCTION

Since the discovery of oil at Spindletop near Beaumont, Texas in 1901, the Beaumont-Port Arthur-Orange Metropolitan Statistical Area (MSA) of Southeast Texas has grown as an important center of refining and manufacturing. The region acquired the nickname "Golden Triangle" due to the oil boom that occurred there after 1901. The majority of the largest employers in the Golden Triangle are manufacturers of petrochemicals. Without a commitment of sizeable resources to pollution abatement, the production of petrochemicals is capable of generating significant amounts of air, water, soil, and noise pollution.

Understandably, community leaders, industry, environmental groups, environmental activists, and local residents are concerned about the impact of these facilities and their operation on the public image of their city and community as a place to live, raise their families, and do business (Bowman, 2007). Industry is frequently blamed when residents of communities near petrochemical plants are diagnosed with cancer, chronic obstructive pulmonary disease (COPD), or any disease with possible environmental causes (Rappeleye & Stone, 2003; Cappiello, 2005).

The rise of greater environmental awareness in the 1960s was accompanied by the health effects of pollution becoming more widely known. These events caused Golden Triangle area citizens increased concern with the effects of local refinery activities on the quality of their lives, health, and property values. Local governments and civic leaders have recognized the tension

between concerns about the environment, attracting and keeping jobs locally, and the need to uphold the image of the area as a good place to live and work. This tension is reflected in news stories on local television stations and in newspapers about public health and the environment. Local news stories include news about the Texas Commission on Environmental Quality TCEQ and the Environmental Protection Agency (EPA) being challenged by environmental groups concerning pollution regulation and monitoring. Announcements by industry of new plants being built and old ones being upgraded are also featured (Rappleye, 2006; Wallach, 2003).

Perceptions about pollution and related issues may be quite different from reality. One way of comparing perceptions about pollution with reality is to compare scientific studies of health indicators in the area with public attitudes. Beaumont's Mobil Refinery, in operation since 1902, was the subject of a study of mortality rates of its workers (Collingwood, Raabe, & Wong, 1998). Workers studied worked at the refinery at least one year between the years of 1945 and 1987. Although there was some variation in mortality due to certain conditions, overall mortality was lower than comparable individuals in the U.S. general population.

Scholarly work on community attitudes toward air pollution and its sources has been ongoing since at least the early 1970s. A survey of public willingness to act against air pollution due to pressure inversions in Salt Lake City, Utah was conducted to find guidance for policymakers as they set up pollution-prevention programs and public education programs (Geertsen, Gray, & Kasteler, 1973). Other attempts to assess public perceptions about air and water pollution include that of Bickerstaff and Walker (2001). In 2000, beach-going behavior and perceptions of residents of Los Angeles County, California was studied (Martin, Pendleton, & Webster, 2001). The findings of this study were that the majority of participants believed that the water quality of 14 area beaches was bad and was getting worse. Even though Heal the Bay, a local environmental advocacy group, had recently graded water quality at these beaches from "B" up to "A+," these perceptions persisted. In fact, evidence was provided that water quality in the area had either remained the same, or was improving slightly over the study period.

A study of health risk perceptions in an urban industrial neighborhood in Hamilton, Ontario concluded that when participants found black soot on windows and cars, or smelled annoying odors in the air, their perceptions of health risks were very significantly affected (Cole, et. al. 1999). Bartlett, et. al. (1995) found sharp differences in health risk perceptions between chemical industry experts and lay people. Based on the literature surveyed, it is highly likely that policy makers, local leaders, and industry in the Golden Triangle area would find survey data of Golden Triangle area residents' perceptions of the petrochemical industry's effect on their lives and community to be of considerable interest and usefulness.

DATA AND METHODOLOGY

The data for this study come from a second stage of the survey conducted by the authors in 2007 to collect information initially on Beaumont residents' perceptions of the role of petrochemical firms and their effect on the quality of life in the area. The results of the initial survey of Beaumont residents can be found in Aydin, El-Houbi, and Morefield (2008). A similar survey was then conducted on the residents of other parts of the Golden Triangle area including Port Arthur, Nederland, Groves, Neches, Orange and Vidor. Beaumont is the largest city in the three-county Beaumont-Port Arthur-Orange MSA and is considered to be the center of trade and commerce and home of the leading media outlets in the area. Survey questions were designed to cover respondents' perceptions of general quality of life issues, environmental justice issues, and

the costs and benefits to residents of living in such a major center of refining and petrochemical manufacturing.

The complete survey instrument is included in the appendix. The instrument posed 19 questions to which scaled answers are: 1. Strongly disagree; 2. Disagree; 3. Neither agree nor disagree; 4. Agree; and 5. Strongly agree. Questions 1 through 3 are about the quality of life in general in Beaumont and the surrounding area as it relates to petrochemical firms. Questions 4 through 6 are about health concerns of the people in the area. Question 7 is about perceived effects on pollution on property values. Questions 8 through 10 are about perceptions of "environmental justice" in the siting of local plants and questions 11 and 12 are about corporate environmental responsibility. Finally, questions 13 and 14 are about the balance of economic costs imposed and benefits conferred by firms locating in the area.

Tables 1A, 1B and 1C present the summary statistics of the data with respect to gender, age, education, income level, industry affiliation and residency. Overall the survey data include 3,272 self-identified Golden Triangle area residents. Of the 3,695 people surveyed, 88.5% responded, giving a non-response rate of 11.5%. Respondents are 45.5% male and 54.5% female. Respondents' ethnicity is 30.3% African-American, 5.5% Asian, 8.8% Hispanic and 56.4% White. The population f the Golden Triangle appears to be relatively stable, in that 57.5% of the respondents have lived there more than 20 years, and 27.0% between 5 and 20 years. The remaining 15.5% are relative newcomers who have lived there less than 5 years. The proportion of respondents with education beyond high school is 49.1%. Respondents with annual household incomes under $25,000 were 20.3%, 51.3% were in the middle with incomes from $25,000 to $75,000, while 28.6% reported household incomes greater than $75,000. An overwhelming majority of respondents (97.8%) are not members of an environmental group, but respondents reported spending an average of 1.3 hours daily watching, listening to, or reading the news.

Ordinal logistic regression techniques are employed to analyze and ascertain if there are significant relationships between the response variables and set of independent variables such as gender, total household income, ethnicity, marital status, area in which respondents live, and highest level of education. Logistic regression is a powerful statistical technique (Hosmer & Lemeshow 2000) for modeling the relationship between a categorical outcome and set of independent variables such as gender, highest level of education, and total household income. Unlike linear regression that predicts the actual values of the response variables, logistic regression models the probability associated with each level of the response variable by finding a linear relationship between predictor variables and a link function of these probabilities. Different link functions offer different levels of "goodness of fit" for the data. The goal of the logistic regression model is to find the best fitting and most reasonable model to describe the relationship between the response variable and set of the explanatory variables. The multiple logistic regression model can be written as:

$$\ln(\text{odds ratio}) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki} + \varepsilon_i \quad (1)$$

In equation (1) *k* represents number of independent variables in the model, and εi represents the random error in observation *i*. A logistic regression is based on the odds ratio, which represents the probability of a success compared with the probability of failure

$$\text{Odds ratio} = \frac{\pi(x)}{1-\pi(x)} \quad (2)$$

The logistic regression model is based on the natural log of this odds ratio. The Logistic Regression Equation can be expressed as:

$$\ln(\text{estimated odds ratio}) = b_0 + b_1 X_{1i} + b_2 X_{2i} + \ldots + b_k X_{ki} \quad (3)$$

In the case of binary logistic regression model, y is constructed in terms of the logit of y =1 versus y =0. The method used for ordinal logistic regression known as the proportional odds model. The basic idea for the proportional odds model is re-state the categorical variable in terms of a number of binary variables based on internal cut-points in the ordinal scale. For instance, if the response variable is based on a 5-point Likert scale, the idea is extended for the ordinal logistic regression by taking y = 0 as the baseline outcome and to structure logits comparing y =1, y =2, y =3, and y =4 to the baseline. The proroptional odds model can be expressed as follows:

$$\ln(Y_i') = \ln\left(\frac{\pi_i(x)}{1-\pi_i(x)}\right) = \beta_{0i} + \left(\beta_1 X_1 + \beta_2 X_2 + \ldots \beta_p X_p\right) \quad (4)$$

For more details about the the proroptional odds model, see (McCullagh, 1989).

The maximum likelihood technique is used to obtain the estimates of the parameters in the logistic regression equation (1). The deviance can be used as a statistic to assess the model's goodness of fit. The model is generally considered reasonable if the deviance is not significantly large.

EMPIRICAL RESULTS

Table 1A compares male and female, white and nonwhite, and college degree/no degree results from participants. Comparing male and female responses, females clearly have a significantly higher concern for overall pollution and health related issues, while males are significantly more worried about the economic aspects and contributions of the industry. Given the mean values of Q9 and Q10 at around 3, it appears that neither gender thinks there is a great deal of environmental racism in the siting of petrochemical facilities locally.

The responses of whites compared with minorities (non-whites) paint a different picture. It is clear that minorities have significantly different perceptions than whites when it comes to environmental racism and social justice, as they have significantly higher means for Q8, Q9, and Q10. Minority populations also seem to be more worried about health issues related to pollution created by the industry. Whites are more concerned with the economic value of the industry for the region. It should be noted here that the proportion of people who earn over $50,000 [High Income] and have college degrees is significantly lower among minorities as compared to whites.

In comparing people with a college degree and those with no college degree, it appears that people with higher education, as expected, are more concerned about overall pollution and the resulting health problems in their community. However, the college-educated respondents tend to disagree with the hypothesis of environmental racism. Interestingly, both groups agree on the importance of the economic benefits and contributions of the industry to the region. College-educated respondents in the survey have higher incomes, and they are older as a group than the non-college educated.

TABLE 1A
COMPARISON OF MEANS

	Male	Female	White	Non-White	College Degree	No College Degree
Question 1	3.95* (0.020)	4.18* (0.025)	4.07 (0.019)	4.11 (0.028)	4.13* (0.023)	4.04* (0.022)
Question 2	3.49* (0.025)	3.62* (0.028)	3.52* (0.023)	3.65* (0.030)	3.58 (0.027)	3.55 (0.025)
Question 3	3.48* (0.028)	3.55* (0.025)	3.53 (0.023)	3.50 (0.031)	3.58* (0.027)	3.47* (0.026)
Question 4	3.56* (0.025)	3.75* (0.022)	3.68 (0.021)	3.63 (0.028)	3.69 (0.025)	3.64 (0.023)
Question 5	3.33* (0.024)	3.41* (0.022)	3.34* (0.020)	3.44* (0.028)	3.39 (0.024)	3.36 (0.022)
Question 6	3.23* (0.025)	3.35* (0.022)	3.28 (0.021)	3.33 (0.029)	3.31 (0.025)	3.28 (0.023)
Question 7	2.95 (0.029)	2.99 (0.025)	2.89* (0.023)	3.13* (0.032)	2.99 (0.029)	2.96 (0.025)
Question 8	3.33 (0.032)	3.39 (0.027)	3.20* (0.025)	3.67* (0.034)	3.34 (0.031)	3.38 (0.028)
Question 9	3.00 (0.031)	3.07 (0.028)	2.81* (0.024)	3.48* (0.035)	2.99* (0.030)	3.08* (0.028)
Question 10	2.97* (0.030)	3.06* (0.027)	2.79* (0.024)	3.44* (0.034)	2.97* (0.029)	3.06* (0.027)
Question 11	2.91* (0.029)	3.16* (0.025)	2.88* (0.024)	3.37* (0.031)	2.95* (0.028)	3.13* (0.026)
Question 12	3.17* (0.028)	2.99* (0.024)	3.13* (0.023)	2.97* (0.031)	3.09 (0.027)	3.05 (0.025)
Question 13	3.42* (0.026)	3.27* (0.023)	3.37* (0.021)	3.29* (0.029)	3.35 (0.026)	3.33 (0.023)
Question 14	3.61* (0.026)	3.43* (0.024)	3.53 (0.022)	3.47 (0.030)	3.52 (0.026)	3.50 (0.023)
Age	33.80 (0.357)	34.58 (0.329)	35.68* (0.313)	31.45* (0.358)	36.21* (0.330)	32.51* (0.344)
Male	_____	_____	0.462 (0.010)	0.440 (0.015)	0.464 (0.013)	0.446 (0.012)
Minority	0.343 (0.012)	0.364 (0.011)	_____	_____	0.316* (0.012)	0.362* (0.012)
High Income	0.542* (0.013)	0.492* (0.012)	0.587* (0.011)	0.377* (0.014)	0.628* (0.012)	0.417* (0.012)
College Degree	0.473 (0.013)	0.455 (0.012)	0.483* (0.011)	0.422* (0.015)	_____	_____
Sample Size	1,488	1,784	1,846	1,426	1,515	1,757

Note: **Standard errors are in parentheses. Asterisk indicates that the mean difference is significant at 5% significance level using equal variance t-test.**

TABLE 1B
COMPARISON OF MEANS

	Family Member in Industry	Not Affiliated with Industry	High Income (over $50,000)	Low Income (below $50,000)
Question 1	4.00* (0.032)	4.11* (0.018)	4.09 (0.022)	4.07 (0.023)
Question 2	3.58 (0.034)	3.55 (0.022)	3.51* (0.026)	3.62* (0.026)
Question 3	3.48 (0.036)	3.53 (0.022)	3.53 (0.026)	3.51 (0.027)
Question 4	3.67 (0.032)	3.66 (0.020)	3.67 (0.024)	3.66 (0.024)
Question 5	3.42 (0.032)	3.36 (0.020)	3.34* (0.023)	3.42* (0.023)
Question 6	3.34 (0.033)	3.28 (0.020)	3.26* (0.023)	3.33* (0.025)
Question 7	2.96 (0.036)	2.98 (0.022)	2.89* (0.027)	3.06* (0.027)
Question 8	3.31 (0.040)	3.38 (0.024)	3.25* (0.030)	3.47* (0.028)
Question 9	3.04 (0.040)	3.04 (0.024)	2.88* (0.029)	3.21* (0.029)
Question 10	3.06 (0.039)	3.00 (0.023)	2.86* (0.028)	3.18* (0.028)
Question 11	2.94* (0.037)	3.09* (0.022)	2.86* (0.027)	3.25* (0.026)
Question 12	3.23* (0.035)	3.01* (0.021)	3.17* (0.026)	2.97* (0.026)
Question 13	3.39* (0.033)	3.31* (0.020)	3.38* (0.024)	3.29* (0.025)
Question 14	3.59* (0.034)	3.48* (0.021)	3.55* (0.024)	3.47* (0.025)
Age	34.71 (0.457)	34.02 (0.285)	37.09* (0.333)	31.18* (0.335)
Male	0.501* (0.016)	0.436* (0.010)	0.479* (0.012)	0.429* (0.012)
Minority	0.355 (0.016)	0.340 (0.010)	0.252* (0.011)	0.441* (0.012)
High Income	0.577* (0.016)	0.490* (0.010)	_____	_____
College Degree	0.535 (0.016)	0.532 (0.010)	0.435* (0.012)	0.645* (0.012)
Sample Size	938	2,334	1,684	1,588

Note: **Standard errors are in parentheses. Asterisk indicates that the mean difference is significant at 5% significance level using equal variance t-test.**

TABLE 1C
COMPARISON OF MEANS

	No Children	Have Children	Resident (over 20 years)	Resident (less than 20 years)
Question 1	4.03* (0.023)	4.12* (0.022)	4.09 (0.021)	4.07 (0.024)
Question 2	3.51* (0.026)	3.61* (0.025)	3.57 (0.024)	3.55 (0.028)
Question 3	3.53 (0.026)	3.51 (0.027)	3.50 (0.025)	3.55 (0.028)
Question 4	3.66 (0.023)	3.66 (0.024)	3.71* (0.022)	3.60* (0.025)
Question 5	3.36 (0.022)	3.39 (0.023)	3.35 (0.022)	3.41 (0.024)
Question 6	3.29 (0.023)	3.30 (0.024)	3.28 (0.023)	3.32 (0.025)
Question 7	3.06* (0.027)	2.89* (0.027)	2.84* (0.025)	3.15* (0.029)
Question 8	3.44* (0.029)	3.29* (0.029)	3.30* (0.028)	3.44* (0.031)
Question 9	3.12* (0.029)	2.97* (0.029)	2.93* (0.028)	3.19* (0.031)
Question 10	3.09* (0.029)	2.95* (0.028)	2.90* (0.027)	3.18* (0.030)
Question 11	3.14* (0.027)	2.96* (0.027)	2.91* (0.026)	3.23* (0.029)
Question 12	2.96* (0.026)	3.18* (0.025)	3.14* (0.024)	2.98* (0.028)
Question 13	3.29* (0.025)	3.38* (0.024)	3.41* (0.023)	3.25* (0.026)
Question 14	3.49 (0.025)	3.53 (0.024)	3.59* (0.023)	3.40* (0.026)
Age	25.42* (0.211)	42.38* (0.313)	37.89* (0.335)	29.27* (0.298)
Male	0.503* (0.013)	0.410* (0.012)	0.428* (0.011)	0.490* (0.013)
Minority	0.367* (0.012)	0.324* (0.011)	0.258* (0.010)	0.461* (0.013)
High Income	0.413* (0.012)	0.609* (0.012)	0.575* (0.011)	0.434* (0.013)
College Degree	0.593* (0.012)	0.485* (0.012)	0.526 (0.011)	0.551 (0.013)
Sample Size	1,574	1,698	1,881	1,391

Note: **Standard errors are in parentheses. Asterisk indicates that the mean difference is significant at 5% significance level using equal variance t-test.**

Table 1B compares people who work for one of the 6 largest petrochemical companies or have a family member working there with those who have no affiliation with those firms. Interestingly, the non-affiliated participants are significantly more worried about local pollution, although both groups have a high rate of concern. However, it is not clear if the people affiliated with the industry have lower concern than others because of their knowledge of the industry's practices, or their protective attitude towards their income and employment source. When these same people are asked in Q17 and Q19 "which company does the best to avoid pollution and spend the most," they tend to choose their affiliated companies. Again, it is unclear if their choice is based on loyalty or better information. As can be expected, the people who are affiliated with the industry have significantly higher income levels and register higher ratings for the economic value of the industry for the region.

The two right-hand columns of Table 1B compare high-income and low-income individuals. As with the earlier findings for minorities, low income earners are significantly more concerned about the pollution by industry and more worried about the health consequences of it. They also seem to rate the economic significance of the industry for the region lower, as they perceive that they are not directly receiving the economic benefits of the industry.

In Table 1C, people with children are more concerned about pollution and its health implications. They are significantly older than the people without children and earn significantly greater incomes. Therefore, they tend to emphasize the economic benefits of the industry even though they are at the same time concerned about the resulting pollution. They also do not seem to place much importance on the issue of environmental injustice/environmental racism in the siting of local plants. In the two right-hand columns of Table 1C, long-time area residents (over 20 years) are significantly more aware of the economic importance of the petrochemical industry for the region. But those residents do not share the concern of others about possible environmental injustice in the location decisions of local plants.

Table 2 presents the ordinal logistic regression results for each question asked the survey respondents. Due to space limitations in the table, only some of the explanatory variables are listed. (Variables not listed are: member of environmental organization, marital status, college degree and resident over 20 years.) In Table 2, age seems to be one of the important variables in the ratings of question, though it has a negative sign in questions 7 through 11. The results indicate that, the older a person, the more likely he/she is to give higher ratings to the question [agree with the statement more] of concerns about pollution created by the industry, the resulting health problems and higher health cost, shorter life expectancy associated with the pollution, and economic benefits of the industry for the area. However, at the same time the results suggest that, the older the person, the less likely he/she is to agree with the environmental injustice argument and the notion of lower property values due to pollution. Ordinal logistic regression results also confirm earlier findings that males are less worried about pollution and the resulting health problems as well as environmental racism compared to females. Males also tend to give higher ratings to the economic significance of the industry for the region. It also appears that the more people watch or listen to the news, the more they worry about local pollution and its impact.

An interesting question for policy makers, local leaders, and industry is that of how perceptions vary among residents of the 7 incorporated areas or cities shown on the survey instrument [Beaumont, Port Arthur, Nederland, Port Neches, Orange, Vidor, and Groves]. In Table 3 the analysis of variance (ANOVA) technique was used to ascertain if there are significant relationships between the response variables and several independent variables comparing different Golden Triangle cities. Based on the ANOVA, some of the important results

can be summarized as follows: There is no significant difference between cities of the level of concern about pollution in the area. Apparently residents' view is that they are equally affected in any of the 3 counties in the MSA. There is a statistically significant difference among cities in the level of concern about the health effects of pollution. There are also statistically significant differences in attitudes among cities about the number of cancer diagnoses and cancer related deaths related to pollution.

TABLE 2
LOGISTIC REGRESSION RESULTS

Dependent Variable	Age	Male	Minority	Children	High Income	News Hours	Industry Affiliated	*LR Chi²* Test
Question 1	0.021*	-0.457*	0.205*	-0.068*	0.011	0.134*	-0.173*	151.46
Question 2	0.012*	-0.208*	0.231*	0.018	-0.221*	0.068*	0.066	72.88
Question 3	0.006	-0.127*	-0.068	-0.054	0.009	-0.025	-0.050	24.89
Question 4	0.009*	-0.359*	-0.076	-0.069*	-0.033	0.062*	0.060	64.22
Question 5	0.009*	-0.154*	0.193*	-0.049	-0.154*	0.014	0.148*	37.53
Question 6	0.004	-0.196*	0.064	-0.002	-0.146*	0.015	0170*	32.92
Question 7	-0.010*	-0.075	0.270*	0.005	-0.169*	-0.036	0.044	122.58
Question 8	-0.010*	-0.059	0.675*	0.001	-0.140*	0.059*	-0.084	157.81
Question 9	-0.012*	-0.094	0.926*	0.047	-0.280*	0.054	0.028	293.40
Question 10	-0.013*	-0.128*	0.919*	0.049	-0.288*	0.059*	0.122	310.22
Question 11	-0.014*	-0.426*	0.633*	0.001	-0.354*	0.021	-0.192*	314.79
Question 12	0.020*	0.342*	-0.176*	0.017	0.171*	0.008	0.378*	176.03
Question 13	0.014*	0.312*	-0.081	0.006	0.044	-0.011	0.111	84.20
Question 14	0.005	0.378*	-0.043	0.000	0.056	0.055	0.137*	85.90

Note: **Asterisk indicates that the coefficient is significantly different than zero at 5% significance level using z-test. All LR Chi² test results are significant at 1% level.**

There are statistically significant differences in attitudes among cities in the answer to Question 8 about the siting of facilities related to neighborhood incomes and wealth. There are statistically significant differences in attitudes among cities in the answers to questions about levels of concern over pollution created by the petrochemical industry. Bartlett's test was used to check if the homogeneity of variances assumption is reasonable. Based on the results from the ANOVA, there was no statistically significant evidence that variances of responses are different across the areas. Table 4 presents the response percentages for Questions 15 through 19. (Question 15 identifies the company with which the person is affiliated). It should be noted that this table only presents the responses of people who indicated a choice of a company for that particular question. Any "No Idea" response was excluded from the count. Overall 1,077 participants responded to Question 16 (greatest concern), 726 responded to Question 17 (least concern), 780 people responded to Question 18 (spending most) and 539 people responded to Question 19 (spending least), excluding "No Idea" responses in each case. In addition, 938 people indicated an affiliation to one of the six companies presented in the survey. At first glance, it appears that there is rather high correlation between the proportion of people who indicated their affiliated company and their choice of most concerned company with the population. (The Chi-square goodness of fit test was able to reject the null hypothesis of equal proportions across the companies for all questions 15 through 19.) To test if these choices are

biased, the people who are affiliated with any of these companies were excluded and interestingly, as is also indicated in the same table, the proportions are almost identical to the previous ones. The goodness of fit test using the Chi-square test failed to reject the null hypothesis of similar proportions across the choices of people who were affiliated with the industry versus people who were not.

TABLE 3
ANOVA: COMPARISON OF MEAN RESPONSES BY REGIONS

Dependent Variable	F-test	P-value	Bartletts's Chi-square test	P-value
Question 1	1.75	0.093	12.13	0.096
Question 2	7.23*	0.000	7.83	0.348
Question 3	4.00*	0.000	5.89	0.553
Question 4	3.41*	0.001	9.43	0.223
Question 5	3.48*	0.001	5.37	0.615
Question 6	5.32*	0.000	2.94	0.891
Question 7	8.32*	0.000	17.42*	0.015
Question 8	11.92*	0.000	9.47	0.221
Question 9	23.04*	0.000	15.89*	0.026
Question 10	21.65*	0.000	11.76	0.109
Question 11	13.19*	0.000	3.89	0.793
Question 12	6.30*	0.000	1.98	0.961
Question 13	2.02*	0.049	9.48	0.220
Question 14	1.51	0.159	10.76	0.150

Note: **Asterisk indicates that the mean difference is significant at 5% significance level.**

TABLE 4
RESPONSES BY COMPANY FOR Q15 THROUGH Q19
(Joint Sample)

	Q15		Q16		Q17		Q18		Q19	
Companies	**Freq**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Chevron	86	9.2%	110	10.2%	66	9.1%	75	9.6%	63	11.7%
ExxonMobil	323	34.4%	365	33.9%	152	20.9%	293	37.6%	92	17.1%
Huntsman	128	13.7%	133	12.4%	119	16.4%	96	12.3%	83	15.4%
Motiva	142	15.1%	142	13.2%	115	15.8%	98	12.6%	80	14.8%
Valero	106	11.3%	161	15.0%	174	24.0%	104	13.3%	127	23.6%
DuPont	153	16.3%	166	15.4%	100	13.8%	114	14.6%	94	17.4%
Sample Size*	938		1,077		726		780		539	

*** Each sample only includes the number of observation with a response other than "No Idea" response**

TABLE 5
RESPONSES BY COMPANY FOR Q15 THROUGH Q19
(Not Affiliated with the Company)

	Q15		Q16		Q17		Q18		Q19	
Companies	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Chevron	0	-	67	10.7%	42	9.4%	47	10.9%	37	11.8%
ExxonMobil	0	-	210	33.4%	105	23.4%	173	40.0%	57	18.1%
Huntsman	0	-	77	12.3%	74	16.5%	45	10.4%	52	16.5%
Motiva	0	-	80	12.7%	69	15.4%	52	12.0%	47	14.9%
Valero	0	-	94	15.0%	94	20.9%	54	12.5%	74	23.5%
DuPont	0	-	100	15.9%	65	14.5%	62	14.3%	48	15.2%
Sample Size*	0		628		449		433		315	

*** Each sample only includes the number of observation with a response other than "No Idea" response.**

CONCLUSIONS

The results of the study clearly indicate that some respondents are greatly concerned about pollution created by the petrochemical industry in the Golden Triangle area. About 79% of the respondents indicated their concern about pollution created by the petrochemical industry in the region. In general, females showed greater concern about the health effects and quality-of-life effects of pollution. Nonwhite participants showed a greater willingness to think that that poor and minority neighborhoods were targeted in the locational decisions made by area firms. Fifty two percent of the people who took the survey agreed or strongly agreed that there is an increase in the number of cancer related deaths as a result of chemical toxins emitted by the petrochemical companies in the area. Only 8% of respondents strongly agree that petrochemical companies in the Golden Triangle as a group are very concerned about the environment.

As might be expected, respondents who work or have a family member working in the industry show slightly more faith in the idea that local firms are environmentally responsible, although the differences between affiliated and non-affiliated respondents are surprisingly small. High-income respondents also indicated a stronger belief that local firms are environmentally responsible. Although childless respondents were less likely than those with children to believe in local corporate environmental responsibility, the overall differences between these groups are relatively small. Long-term residents showed more confidence in local environmental responsibility, although there is a possibility of self-selection in this result. That is, individuals with little faith in local firms' concern about the community would be less likely to establish a permanent residence in the area.

The greater health concerns exhibited by older residents (Table 2) may be a result of the fact that individual concerns about health and health-related matters are directly related to age. Older area residents tend to agree with the notion of local corporate environmental responsibility and disagree with the idea of environmental injustice in the siting of local facilities. They also place greater weight on the economic benefits of the industry to the area.

These differences in perceptions between genders and among different demographic groups in the Golden Triangle Area should be of interest to local leaders as they engage in policy-making and other local initiatives affecting their communities. Management of local

firms, especially the six large firms that are the focus of the survey, should find these results of interest when making decisions concerning local facilities siting and upgrading, as well as how to deal with local opinions concerning the benefits conferred, and the costs imposed, by them on their host communities.

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APPENDIX
GOLDEN TRIANGLE AREA ENVIRONMENT SURVEY

Survey Number: _____

Gender: M F [circle one] **Age:** _____ Years **Zip Code:**_____
Ethnicity [circle one]: African-American Asian Hispanic White Other
Marital Status: Single Married **Number of children:** 0 1 2 3 4 or more
In which area do you live? [circle one]: Beaumont Port Arthur Nederland Port Neches Orange Vidor Groves
How long have you lived in Golden Triangle area: Less than 5 years 5-9 years 10-14 years 14-19 years 20 years or more I don't live here
Your highest level of education: Up to Grade 6 Grades 7 – 11 High School Associate's Degree Bachelors Degree or higher
Total household income: Less than $25,000 $25,000-$50,000 $50,001-$75,000 over $75,000
Do you belong to any environmental organization(s)? Yes No Organization Name_____
Do you watch, listen to, or read the News? Yes No Number of hours spent daily on this _____

For questions 1 through 14 below, use the following scale to indicate next to the question on the designated line your level of agreement or disagreement:

5 Strongly Agree
4 Agree
3 Neither Agree nor Disagree
2 Disagree
1 Strongly disagree

1. _____I am concerned about pollution created by the petrochemical industry in the Golden Triangle Area.

2. _____Air and water pollution in the Golden Triangle is affecting my health or my family's health.

3._____ It is less healthy to live in the Golden Triangle than in other parts of Texas or Louisiana.

4._____ There is an increase in the number of cancer diagnoses and cancer related deaths in the area as a result of chemical toxins emitted by the petrochemical companies in the area.

5._____ Health care costs in the Golden Triangle are higher because of pollution.

6._____ Residents of the Golden Triangle have shorter lives because of pollution.

7. _____ Property values are lower in the Golden Triangle because of pollution.

8. _____ Companies in the Golden Triangle are more likely to build heavily polluting facilities near poor neighborhoods than near middle-class or wealthy neighborhoods.

9. _____Companies in the Golden Triangle are more likely to build heavily polluting facilities near predominantly African-American neighborhoods than near predominantly white neighborhoods.

10. _____Companies in the Golden Triangle are more likely to build heavily polluting facilities near predominantly Hispanic neighborhoods than near predominantly white neighborhoods.

11._____ In general, manufacturers and refiners in the Golden Triangle do not do much about pollution created by their plants.

12. _____ Petrochemical companies in Golden Triangle, as a group, are ***very*** concerned about the environment in the Golden Triangle.

13._____ The economic benefits brought by petrochemical companies to the Golden Triangle far outweigh the costs of their locating here.

14._____ The new plants being built by petrochemical companies such as Motiva and Valero in the Golden Triangle area are good news, as they create more jobs, even though it might harm the environment.

15. I or a member of my immediate family work for one of the following Golden Triangle area companies:

Chevron ExxonMobil Huntsman Motiva Valero DuPont None

16. In my opinion, of the 6 companies below, the one circled shows the ***greatest*** concern for the environment:

Chevron ExxonMobil Huntsman Motiva Valero DuPont None

17. In my opinion, the company circled below shows the ***least*** concern for the environment:

Chevron ExxonMobil Huntsman Motiva Valero DuPont None

18. In my opinion, the company circled below spends the ***most*** to reduce pollution:

Chevron ExxonMobil Huntsman Motiva Valero DuPont None

19. In my opinion, the company circled below spends the ***least*** to reduce pollution:

Chevron ExxonMobil Huntsman Motiva Valero DuPont None

production processes in the U.S. economy was clearly exhibited by the results of production function analysis in this study.

Chennareddy (2009) provides real gross domestic product, estimated gross domestic product, technical efficiency, marginal value product of labor, adjusted observed labor income per employee, marginal value product of real capital converted into marginal rate of return on real capital, and adjusted observed rate of return on real capital in selected years with 5 years apart during 1929-2004. The observed real gross domestic product and estimated real gross domestic product are very close to each other, and, therefore, the technical efficiency—if the real gross domestic product is greater than or equal to the estimated gross domestic product, which is the best output for the inputs used, based on the production parameters obtained from the data for 76-year period , 1929-2004, then the technical efficiency is equal to 1, otherwise the technical efficiency is less than 1— is either equal to 1 or slightly less than 1 (Chennareddy, 2009).

This indicates that the model is fairly accurate for prediction of output, if the inputs are accurately measured and used in the model proposed in this study. The marginal value product of labor in 2004 constant dollars increased from about $18.60 thousands in 1929 to about $57.13 thousands in 2004 with an exception in 1949. The adjusted observed labor income per employee in 2004 constant dollars increased form $16.05 in 1929 to $$56.39 in 2004, with exceptions in 1934, 1949, 1984. The marginal value product of capital converted into rate of return on capital increased from about 2.88-percent in 1929 to about 4.51-percent in 2004 with exceptions in 1934, 1949, 1969, 1974, 1994. The adjusted observed rate of return on real capital decreased from about 5.48-percent in 1929 to about 4.35-percent in 2004 with slight fluctuations during this period.

Chennareddy (2009) provides regression results in various regression models with a proxy measure of brainpower capacity as an independent variable. All the dependent variables (estimated technical economic and non-economic measures) are directly or indirectly the results of growth in the capacity of human brainpower, which is measured by a proxy measure—education inequality. All the coefficients in all the regression models are highly statistically significant even at 1-percent probability level of significance. The explanation powers of all these models are high—at least 70-percent but the majority of them have more than 84-percent. The marginal value products—in 2004 constant dollars—of labor, real capital, and brainpower capacity are positively associated with brainpower capacity, as expected because the brainpower capacity growth creates improved technology increases the quality of labor and real capital, and thus, their marginal value products increase. The marginal value product of brainpower capacity increases because the enhancement of human brainpower improves operational efficiency and creates new products, inventions, innovations, and most technically efficient and cost-reducing technology, which may lead to substantial reduction in real prices because of severe competition, which may bring about mass demand for such products and services, which may lead to the production of goods and services on mass scale, which in turn lead to economies to scale.

The elasticity of real gross domestic product with respect to labor decreased, while as such elasticity with respect to real capital increased with the increase in brainpower capacity growth. This may be a realistic situation because the effect of labor despite an increase in the quality of labor on real gross domestic product decreases because of the effect of more and more high-powered technology-based real capital, which has been substituting labor, and, therefore, which has been used less and less on a per unit of output basis. The elasticity of substitution is negatively associated with the increase in brainpower capacity growth.

This result is as expected because as brainpower capacity growth increased, sophisticated technology-based real capital has been replacing more and more labor and when less and less labor was used in the production of goods and services. When the ratio of labor to real capital decreased, the replacement of labor for real capital become harder and harder and the ratio of marginal value product of capital to the marginal value product of real capital increased. This situation led to decreased ratio of percentage change in the ratio of labor to real capital to the percentage change in the ratio of marginal value product of real capital to the marginal value product of labor, while as the brainpower capacity growth increased. This may be crystal clear in the case of high-powered technology-based production of specific products. In the aggregation of production of all products and services in the entire economy, this phenomenon may not be very clear. However, the elasticity of substitution , as provided in table 3 shows that it has been decreasing during 1929-2004 with an exception in 1934 and 1984, while as the brainpower capacity growth , as provided in Chennareddy (2009), has been increasing. Therefore, the negative relationship between the elasticity of substitution and the brainpower capacity growth, as shown in the regression model in Chennareddy (2009) is logical.

The sum of three elasticities—elasticity of real gross domestic product with respect to labor, real capital, and brainpower capacity growth—may provide some kind of indicator but not accurate measure of returns to scale (or economies to scale) similar to the measures provided in Chennareddy (2009), which are accurate according to the estimated model in this study. The relationship between the sum of the three elasticities and the brainpower capacity is positive, as expected, because brainpower capacity growth led to returns to scale (or economies to scale), as explained before. The relationship between average labor productivity and brainpower capacity growth is positive, as expected, because brainpower capacity growth led to creative technology, inventions, innovations etc., by which each employee, on an average, could produce more output. The relationship between the ratio of real capital to labor and the brainpower capacity growth is positive, as expected, because brainpower capacity growth produced advanced technology, which displaced more and more labor. The relationship between the elasticity of substitution and ratio of capital to labor is negative, as expected, because brainpower capacity growth led to increase in the ratio of real capital to labor but decreased the elasticity of substitution. This was clearly explained in the previous section.

Chennareddy (2009) provides the frequency distribution of annual production of real gross domestic product by technical efficiency level (see discussion in the previous section and in Chennareddy (2009) for definition of allocative efficiency level). An input is efficiently allocated (or used), if that input is used to the extent at which the marginal value product of that input is equal to the price of that input in a perfect competition situation. This is called optimum level of input or the level of input at which the allocative efficiency is optimum. .If that input is used at the level at which the marginal value product is greater than the price, then that input is less utilized. If that input is used at the level at which the marginal value product is less than the price, then that input is more utilized.

The optimum levels of labor and real capital in each year for 75 years were not derived because it is a system of two interdependent complex non linear equations and getting the solution may be difficult. Moreover, even if a solution can be obtained, it may not be very useful in the sense that the levels of inputs cannot be changed to produce optimum levels of output in each year in the past except knowing what would have been the optimum levels of inputs. In addition, mathematical optimum solutions might not show realistic, practical, and useable solutions given the fact that the production relates to the production of all products and services

ranging from paper clips to ships, and jet planes in the category of products and from restaurant services to hospital services and transportation services in the category of services.

Therefore, the discussion in this section is restricted to allocative efficiencies of actual levels of labor and real capital utilized if a level of one of the inputs is kept constant at the current level in each year. The allocative efficiencies of the current levels of inputs are not discussed in relation to the actual derived optimum level of output or at the levels of inputs at which the marginal value products of the inputs are made equal to prices of the inputs. However, the distribution of production situations in 76 years in terms of technical efficiency of production of real gross domestic product and the allocative efficiencies of labor and real capital may not be a distortion from a real situation based on mathematical solution in each year of the 76 years..

Twenty four annual production situations in 76 years were with technical efficiency of less than 1, more real capital utilized than it should be, and less labor utilized than it should be. Seventeen of the annual production situations were with technical efficiency equal to, more real capital utilized than it should be, and also more labor utilized than it should be. Approximately 50-percent of annual production situations (37 vs. 39) were with labor less utilized than it should be while as majority of the annual production situations (59 vs. 17) were with .real capital more utilized. A better situation, what it should have been in the past and it should be in the future is, in general, that a combination of more labor but less real capital was and will be more desirable for increasing national output.

Chennareddy (2009) provides first and second derivative, cross derivatives of production function, elasticities of capital and labor after adjustment for quality enhancement due to human growth and relative contribution quality-enhanced real capital and labor at an interval of five years, marginal value products and sum of elasticities in selected years with 15 years apart, assuming brainpower capacity level in 1929 and 2004, and average value product in selected years with 15 years apart, assuming brainpower capacity level in 1929 and 2004.

SUMMARY AND CONCLUSION

A new non-homogenous, non-homothetic, production function, allowing to exhibit the imbedded increasing returns to scale (or economies to scale) and a new measure of human-brainpower capacity are introduced in this study. The new production function, with the brainpower capacity, which was not used in previous studies, as one of the inputs, was estimated in this study for data, covering a long-term period, 1929-2004, of economic growth in the United States.

The model was estimated, using a nonlinear 3-stage least squares estimation procedure, utilizing SAS program of the SAS Institute, Cary, North Carolina. It explained 99.4-percent of the variance of the dependent variable. The estimated model appears to have exhibited the hidden features of the long-term economic growth. Thus, this new production function might be useful for future researchers for including sophisticated measures of currently used and additional inputs that might possibly developed and estimating it for deriving more useful public-policy ideas.

Chennareddy (author) is of the opinion that education is not only a seed and flower, as opinioned by Harbison & Myers (1965), but also a fantastic invisible catalyst and a strong nutrient of long-run economic growth. It stimulates thinking of and enables maximum utilization of human brainpower for successful fruition of innovative institutional, economic,

business operational, behavioral , administrative, legal, population, and policy changes , as well as, sophisticated technological breakthroughs for rapid progress of economic prosperity.

The overall and very general conclusion, based on the results in this study, is that less labor but more capital were utilized in the United States. This shows that real capital was over-invested but labor was less utilized. This leads to a conclusion that more labor, especially with high brainpower—if not enough available within the country, it should be brought into the country from abroad by providing incentives and reducing roadblocks in way of immigration of people with such brainpower—should be utilized and more real capital with imbedded high technology—investment of unproductive real capital should be reduced—should be invested by creating tax and interest rate incentives and offering subsidies for high priority advanced technology imbedded capital investment. This kind of future economic policy environment, if created by the action of U.S. policymakers, will stimulate accelerated future economic growth and prosperity in the United States.

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