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EFFECT OF DEMOGRAPHIC FACTORS ON THE U.S. HOUSEHOLD CONSUMPTION OF SOME SELECTED FOODS USING QUADRATIC ALMOST IDEAL DEMAND SYSTEM (QUAIDS)

Babatunde Stephen Ojetunde[1]

Department of Economics Federal University Lokoja Nigeria[1]

ABSTRACT— This study estimated the effect of demographic factors on the US household consumption of some selected food using the Quadratic Almost Ideal Demand System (QUAIDDS). Quarterly Food-at-Home Price Database from 2004-2010 from the USDA site was used, containing information on prices, total expenditure, household size, divisions, and regions, respectively. Average household size was used because the data have different numbers of households across all divisions and regions. Demand for the selected food groups was estimated using Quadratic Almost Ideal Demand System (QUAIDS). The result of the QUAIDS model showed that all the expenditure elasticities were positive and statistically significant at the percent level, which implies that food items are normal goods. Furthermore, it was revealed that raw sugar (.96725022), ice cream/frozen desserts (.95327974), baked good mixes (.97466743), and bakery items ready to eat (.99237186) are necessities since their coefficients were less than one. Additionally, all own-price elasticities were negative, as expected in both compensated and uncompensated price elasticities estimated for food items. The result also revealed that baked good mixes were a substitute for raw sugar, bakery items ready to eat were substituted goods for non-carbonated calorie beverages, raw sugar and packaged sweets/baked goods was a substitute for good mixes, and non-carbonated calorie beverages was substitute for bakery items ready to eat which is an indication that foods were substitutes. In addition, Marshallian cross elasticities show that both baked goods mixes and packaged sweets/baked goods were substituted goods for raw sugar, and ice cream/frozen desserts were substituted goods for non-carbonated calorie beverages. Packaged sweets/baked goods and bakery ready to eat were substituted goods for ice cream/frozen desserts, and raw sugar and packaged sweets/baked goods were substituted goods for baked goods mixes. Also, raw sugar, ice cream, and frozen desserts, baked goods mixes were substituted for packaged sweets/baked goods. In contrast, non-carbonated calorie beverages and ice cream/frozen desserts were substitutes for bakery items ready to eat. Therefore it is recommended that economic policies be made to prevent fluctuations in food prices in the US.

KEYWORDS: Agricultural production food demand QUAIDS

1. INTRODUCTION

According to [16], the United States of America is one of the top food producers, has the second-largest fertile land suitable for agricultural production, and has the third-largest population in the world. Additionally, the US was among the top two exporters and specialized in importing and exporting agricultural products [9]. In addition, as a current major consumer of agricultural products, the United States also provides food for most of the world's nations [16]. [12] found that due to the strong demand for industrialization, habitation, and other activities, agricultural lands have become less available as the US population has expanded over time. There have been many debates over the years on how to raise food consumption and expenditure among developed, emerging, and underdeveloped nations of the world because it is well-recognized that the distribution of income influences expenditure patterns in several ways, including how much money is expended on food [1]. Given this, [1] said that we might claim that the consumer desire for food is one of the most significant and crucial aspects of the economic evaluation of farming policies and social welfare programs. Therefore, food organization and arrangement are essential to modify and estimate some food and agricultural policies.

Olorunfemi (2012) investigated the Ondo state of Nigeria's food demand. Multistage sampling methods were employed to gather data from 1,200 heads of households, and a quadratic, almost ideal demand system was used for analysis. For the main caloric sweeteners used in the United States from 1975 to 2013, Prithviraj et al. (2016) estimated the expenditure, price, and Engel parameters using the quadratic, almost ideal demand system. [6] applied QUAIDS modeling with sample selection adjustment to analyze the features of the demand structure and preferences for wild and farmed seafood in Germany. The study compared six frozen seafood products, in both farmed and wild fish, from 2006 to 2010 using household monthly scanner panel data for Germany. In order to explore how the Quadratic Almost Ideal Demand System (QUAIDS) Model was applied to the demand for domestic animal-sourced food in West Java, [10] used cross-section data from the National Socio-Economic Survey (SUSENAS) of West Java Province in 2017. [7] researched the changes in food expenditure over time in Egypt, focusing on the disparities between urban and rural sectors (WLS). It was shown that changes in the pattern of food expenditure over the five subsequent survey periods were indeed a consequence of economic developments.

Hameed et al. 2021 used the Quadratic Almost Ideal Demand System (QUAIDS) to examine Pakistan's food demands across 11 food groups using data from the 2015–16 household survey. Their findings show that staple foods like wheat, rice, lentils, milk, oil, and fat are widely available and essential. Compared to wheat, lentils, and vegetables, fruits, milk, and meat are complementary in Pakistan. The Quadratic, Almost Ideal Demand System will be used in this research to estimate US household consumption of fats and prepared foods. Consequently, the following questions will be addressed in this research.

(i) What is the expenditure pattern of foods in the US?
(ii) What are the elasticities of different foods consumed?
(iii) How does demographic factor affect food consumption in US?

In light of these issues, this research aims to enhance awareness and knowledge of food expenditure patterns. Therefore, the study's main objective is to estimate US household consumption of fats and prepared foods using the Quadratic Almost Ideal Demand System. The specific objectives of this study will be:
(i) To estimate the expenditure pattern in the US.
(ii) To estimate the demand elasticities of various foods consumed.
(iii) To know does demographic factor affect food consumption in US

This study will be based on Engel's law theoretical standpoint, which says that as income increases, then the ratio of income assigned for food decreases; that is, people use a small section of their entire income on food, and also Bennett's law says that how richer you determine how much you will spend on starchy staples.

This research will help contribute to the existing literature on food security, consumers' choices in food consumption, and the impact of prices and income on our expenditure patterns. Estimating ways of food consumption will also help us to know the needs of the populace as incomes and prices change. More so, we should know that even though the income increase in different households, that does not mean that a more significant portion of the income is devoted to only food, but instead, it might be devoted to other things due to way of life according to [15]. The paper will be organized as follows, the Quadratic, Almost Ideal Demand

System is defined, and its theoretical properties are discussed in the next section. Section three will contain (Expected) Data needs and Estimation, while section four will discuss the Preliminary/Expected Results and Discussions. Lastly, the final section will discuss the conclusions/Limitations/Next steps.

This research will be based on the theory of Engel's law, which asserts that as income rises, the proportion of income reserved for food decreases, meaning that people spend a smaller portion of their overall income on food. Bennett's law also states that one's degree of wealth defines how much money one would devote to starchy staples.

2. QUADRATIC ALMOST IDEAL DEMAND SYSTEM SPECIFICATION

The QUAIDS model was created as an expansion after [3] criticized the AIDS approach created by [8] for producing biased and inconsistent results. In order to determine income, own price and cross-price elasticities for this study, the QUAIDS forecasted by [4], [5] will be used to analyze the impact of demographic determinants on the US household consumption of several selected foods (such as oats, wheat, corn, and cowpea). Because the empirical research suggested by the Engel curves is not necessarily linear [11], Blundell et al. 1993, [5] incorporated a quadratic expenditure factor to the model, leading to the development of the QUAIDS.

The QUAIDS model enables you to fit either the quadratic AIDS model developed by Banks, Blundell, and Lewbel or the standard AIDS model developed by [8] in 1980. Additionally, the AIDS model made it difficult to integrate demographic factors, but the QUAIDS model addressed these shortcomings. Using Ray's (1983) technique, demographic characteristics can be defined and included. Using post-estimation procedures, you can compute expenditure elasticities and compensated and uncompensated price elasticities. Furthermore, the QUAIDS model fits the overall pattern of purchase behavior and is compatible with consumer theory [5].

This paper will follow the indirect utility function of [5] $lnV = \left\{\left[\frac{lnm - lna(p)}{b(p)}\right]^{-1} + \lambda(p)\right\}^{-1}$

Where

$Ina(p) = \propto_0 + \sum_{j=1}^{n} \propto_i In(P_i) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\gamma_{ij} InP_i InP_j \qquad \forall_i = 1, \dots\dots\dots, n$ .... (2)

$b(p) = \prod_{i=1}^{n} P_i^{B_i} > 0 \qquad \forall_i = 1, \dots\dots\dots, n$ .... (3)

$\lambda(p) = \sum_{i=1}^{n} \lambda_i In\, P_i$, where $\sum_{i=1}^{j} \lambda_i = 0 \qquad \forall_i = 1, \dots\dots\dots, n$ .... (4)

Applying Roy's identity next to the indirect function described above yields the expenditure share for good i which are typically provided by

$w_i = \frac{p_i q_i}{m}$

$\sum_i^N w_i = 1$ And by Roy's Identity the budget shares are given by;

$w_i = \frac{\partial lna(p)}{\partial lnP_i} + \frac{\partial lnb(p)}{\partial lnP_i}(lnx) + \frac{\partial \lambda_i}{\partial lnP_i}\frac{1}{b(p)}(lnx)^2$ ....$\forall_i = 1, \dots\dots\dots, n$ .... (5)

And the expenditure share equation is;

$In(P) = \propto_0 + \sum_{j=1}^{n} \propto_i In(P_i) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \propto_{ij} InP_i InP_j \qquad \forall_i \neq j, i, j = 1, \dots\dots\dots, n$ ..... (7)

$w_{it}^* = \propto_{it} + \sum_{j=1}^{n} \gamma_{ijt} In(P_{jt}) + B_{it} In\left(\frac{I}{P}\right) + \left[\frac{\lambda_i}{b(P)}\right]\left[In\left[\frac{I}{P}\right]\right]^2 + D_{kt} + \varepsilon_{it}$

$\forall_i \neq j, i, j =$

$1 \dots\dots\dots, n$ ... (8)

Where w_i $is\ the\ share\ of\ group\ expenditure\ allocated\ to\ product\ i,$

$P_{it}\ is\ the\ price\ of\ product\ it$

$q_{it}\ is\ the\ quantity\ of\ product\ i$

$m\ is\ the\ per\ capita\ expenditure\ on\ all\ commodities$
t time series
Differentiate equation 8 with respect to lnm and lnP_j, respectively to obtain

$$\mu_i = \frac{\partial w_i^*}{\partial In\ m} = \beta_i + 2\frac{\lambda_i}{b(P)} In\left[\frac{m}{P}\right] \ldots\ldots\ldots\ldots\ldots\ldots \quad \forall_i \neq j, i, j = 1 \ldots, n \ldots\ldots (9)$$

$$\mu_{ij} = \frac{\partial w_i}{\partial InP_j} = \gamma_{ij} - \mu_i\left(\propto_j + \sum_{j=1}^{n} \gamma_{ij} In(P_j)\right) - \frac{\lambda_i\beta_i}{b(P)}\left[In\left[\frac{I}{P}\right]\right]^2 \quad \forall_i \neq j, i, j = 1 \ldots, n \ldots (10)$$

The budget elasticities are then given by $e_i = \frac{\mu_i}{w_i} + 1$ with a positive β and a negative λ_i

The uncompensated price elasticities are given by;

$$e_{ij}^{u} = \frac{\mu_{ij}}{w_i} - \delta_{ij} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \forall_i \neq j, i, j = 1 \ldots, n \ldots (11)$$

$$e_{ij}^{u} = \frac{1}{w_i}\gamma_{ij} - \mu_i\left(\propto_j + \sum_{j=1}^{n}\gamma_{ij} In(P_j)\right) - \frac{\lambda_i\beta_i}{b(P)}\left[In\left[\frac{I}{P}\right]\right]^2 - \delta_{ij} \ldots\forall_i \neq j, i, j = 1 \ldots, n \ldots (12)$$

Where δ_{ij} $is\ the\ kronecker\ delta$

The set of compensated elasticities e_{ij}^{c} can be calculated using the Slutsky equation, which is written as $e_{ij}^{c} = e_{ij}^{u} + e_i w_j$. The symmetry and negativity conditions can be determined by looking at the matrix containing the elements $w_i[e_{ij}^{c}]$, which normally should be symmetric and negative semi-definitely.

Concerning capturing income effects, the QUAIDS model mentioned in (8) was ranked third, displaying flexibility. The typical linear AIDS and translog models and this model share the same level of price flexibility. With the fewest additional parameters over the AIDS model as possible, it includes the linear AIDS model nested inside it as a particular case. Therefore the practical implementation requires that the necessary condition that leads to parameter restrictions of the functional specification must fulfill some assumptions such as Adding up, homogeneity and symmetry.

Homogeneity and symmetry restrictions help define the exact linear restrictions on the parameters of the QUAIDS share equations implied by the utility maximization objective. Referring to the notation in equation (8), they are expressed as;

(1) **Homogeneity;**

$$\sum_i^n B_i = 0,\ \sum_i^n \gamma_{ij} = 0$$

$$\sum_i^n \lambda_i = 0 \quad \sum_i^n \gamma_{ij} = 0 \qquad \forall_i = 1, \ldots\ldots\ldots, n \ \ldots\ldots\ldots\ldots (13)$$

(2) Symmetry;

$$\gamma_{ij} = \gamma_{ji}, \qquad \forall_i \neq j, i, j = 1, \ldots, n \ \ldots\ldots\ldots (14)$$

Provided equations (13), (14) and (15) hold, the estimated demand functions add up to the total expenditure (13), are homogenous degree of zero in prices and income (14) and also satisfy slutsky symmetry (15).

Therefore, Abdulahi (2015), in line with [4], [5] further stated that we choose to allow demographic effects to influence preferences through the intercept in equation (8)

$$\sum_i^n \propto_i = \rho_{i0} + \sum_j^K P_{ij} D_k$$

Where D_k is the j[th] demographic variable of which there are K. According to (Pollak and Wales 1978), this

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transforming approach is used to include the demographic variables.

3. DATA NEEDS AND ESTIMATION

The data used for this research was quarterly household consumption data on raw sugar, non-carbonated caloric beverages, ice cream, frozen desserts, packaged sweets/baked goods, and bakery items ready to eat, both in quantities and their respective prices. Secondary data was used and obtained from the USDA quarterly Food-at-Home Price database respectively. More so, time series data from 2004-2010 for US household consumption quarterly on the various foods selected was used, which is based on a market group, regions, and divisions. Nevertheless, since the household size of different foods selected for the researcher differs from each, the household average was used as part of the demographic variables estimated with region and division.

The QUAIDS Model, created in line with (Banks et al., 1997), will be used to evaluate how households will respond to shifts in income and price elasticity as well as changes in the own-price and cross-price of oat, wheat, corn, and cowpea. Quadratic functions of the total expenditure logarithm are used in QUAIDS' expenditure share formulae. According to (Mittal 2010), the model would be considered appropriate for this study because it considers the interdependence of various goods in consumers' budget decisions and generates demand estimates after considering income distribution and variability in demographic characteristics.

4. Results and Discussions

Table 1 below summarizes the budget shares, prices, total expenditure, household size, division, and region of various foods selected. The data used in this study was quarterly data on consumption expenditure from USDA, which contains 980 households across four regions, nine divisions, and 39 market groups in the United States. The research variables consist of each food's prices, expenditure (income), and total household expenditure.

Table 1: The summary of the budget shares, prices, total expenditure, household size, division and region of various foods selected

Variable	Obs	Mean	Std. Dev.	Min	Max
w1	980	.0462528	.0114412	.0233885	.0841961
w2	980	.1658929	.0327622	0816613	.2890071
w3	980	.1771663	.0219571	.1216208	.2543116
w4	980	.0550313	.0086236	.0293117	.0843697
w5	980	.3884852	.0489422	.2888987	.5603092
w6	980	.1671715	.0228815	.0836197	.2529442
p1	980	.2066394	.0426131	.108899	.3545688
p2	980	.1092708	.0133901	.0750475	.1658359
p3	980	.3438707	.0422154	.2124966	.4916034
p4	980	.661712	.112694	.4129417	1.309168
p5	980	.8915072	0997556	.6685782	1.271665
p6	980	.5678874	.0664656	.4133988	.7734204
totalexp	980	2.31e+08	9.87e+07	5.93e+07	4.69e+08
hhsize	980	1034.159	634.1602	112.6	3179.8
division	980	5.057143	2.597398	1	9
region	980	2.6	1.074925	1	4

Source: Author's survey 2022

Table 1 above presents the descriptive statistics of the variables used in the study. The number of households observed was 980, with six variables consisting of three groups of variables which include the variable portion of the expenditure, the prices of food items, and the total expenditure. The household expenditure studied consists of raw sugars, non-carbonated calorie beverages, ice-cream/frozen desserts, baked sweets/baked goods, and bakery items ready to eat.

The expenditure portion data for the individual commodity is expressed as a percent. As was revealed from the table above, the most significant expenditure was packaged sweet/baked goods, with about 38.8%, followed by ice cream/frozen desserts, with 17.7%. Furthermore, the other largest expenditure group is for ready-to-eat bakery items, followed by non-carbonated calorie beverages, baked goods mixes, and raw sugar.

In addition, from table 1, it was revealed that the average price for packaged sweets/baked goods was high at about 0.89, followed by baked goods mixes, bakery items ready to eat, ice cream/frozen desserts, raw sugar, and non-carbonated beverages, respectively. The table above revealed that the mean expenditure was 2.31e+08, household size was 10.34.159, the division was 5.057143, and the region was 2.6, respectively.

Table 2 below shows the estimated parameters of the QUAIDS model with demographic variables (household size, division, and regions) using Household consumption Quarterly data from USDA ranging from 2004-2010

Table 2: Estimated parameters of the QUAIDS Food Demand System with Demographic variables using Quarterly data on Foods from USDA for the year 2004-2010

Parameters	**Coef**	**Std. Err**	**Z**	**P>/z/**	**[95% Conf. Interval]**	
alfa						
alpha_1	.0812483***	.0150694	5.39	0.000	.0517129	.1107838
alpha_2	-.066825***	.0233169	-2.87	0.004	-.1125254	-.0211246
alpha_3	.4149203***	.0248703	16.68	0.000	.3661755	.4636651
alpha_4	.0900556***	.0104548	8.61	0.000	.0695645	.1105467
alpha_5	.3162611	.	.	.	.	.
alpha_6	.1643396***	.0228355	7.20	0.000	.1195828	.2090964
beta						
beta_1	-.0071508***	.0018919	-3.78	0.000	-.0108589	-.0034427
beta_2	.0053954	.0037494	1.44	0.150	-.0019533	.0127441
beta_3	-.0314804	.0038562	-8.16	0.000	-.0390384	-.0239224
beta_4	-.0018627	.0013053	-1.43	0.154	-.004421	.0006956
beta_5	.0364365***	.0048929	7.45	0.000	.0268467	.0460264
beta_6	-.0013381	.0028436	-0.47	0.638	-.0069114	.0042353
gamma						
gamma_1_1	-.0289234***	.0020905	-13.84	0.000	-.0330207	-.0248261
gamma_2_1	.0093721***	.0030773	3.05	0.002	.0033408	.0154034
gamma_3_1	.0060504**	.0027616	2.19	0.028	.0006377	.011463
gamma_4_1	-.0153981***	.0012003	-12.83	0.000	-.0177506	-.0130455
gamma_5_1	-.0036993	.0046059	-0.80	0.422	-.0127267	.0053281
gamma_6_1	.0325983***	.002855	11.42	0.000	.0270027	.038194
gamma_2_2	-.0887002***	.0094745	-9.36	0.000	-.1072699	-.0701305
gamma_3_2	-.0023414	.0061982	-0.38	0.706	.0144897	- .0098069
gamma_4_2	.0147396***	.0025775	5.72	0.000	.0096878	.0197914
gamma_5_2	.0964958***	.0122367	7.89	0.000	.0725122	.1204794
gamma_6_2	-.0295659***	.0057061	-5.18	0.000	-.0407497	-.0183821
gamma_3_3	.0283167***	.0071124	3.98	0.000	.0143767	.0422567
gamma_4_3	.0074514***	.0021622	3.45	0.001	.0032134	.0116893
gamma_5_3	-.0254507***	.0099438	-2.56	0.010	-.0449403	-.0059612
gamma_6_3	-.0140263***	.0053785	-2.61	0.009	-.024568	-.0034846
gamma_4_4	.0094924***	.001317	7.21	0.000	.0069112	.0120736

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gamma_5_4	-.0216112***	.003602	-6.00	0.000	-.028671	-.0145514
gamma_6_4	.0053259**	.0023158	2.30	0.021	.0007871	.0098648
gamma_5_5	-.0628394***	.021249	-2.96	0.003	-.1044867	-.021192
gamma_6_5	.0171047*	.0089006	1.92	0.055	-.0003402	.0345496
gamma_6_5	-.0114368	.0077206	-1.48	0.139	-.0265689	.0036953
lambda						
lambda_1	.0002262***	.000059	3.84	0.000	.0001106	.0003418
lambda_2	-.0000536	.0001096	-0.49	0.625	-.0002683	.0001612
lambda_3	.0010232***	.0001382	7.40	0.000	.0007523	.001294
lambda_4	-.000028	.0000389	-0.72	0.473	-.0001043	.0000484
lambda_5	-.0012729***	.0001742	-7.31	0.000	-.0016144	-.0009314
lambda_6	.000105	.0000826	1.27	0.203	-.0000568	.0002668
eta						
eta_hhsize_1	1.33e-07***	4.10e-08	3.24	0.001	5.26e-08	2.13e-07
eta_hhsize_2	1.57e-07	1.25e-07	1.26	0.209	-8.76e-08	4.01e-07
eta_hhsize_3	2.47e-07***	8.95e-08	2.76	0.006	7.14e-08	4.22e-07
eta_hhsize_4	1.81e-08	3.23e-08	0.56	0.575	-4.52e-08	8.14e-08
eta_hhsize_5	-4.03e-07**	1.85e-07	-2.18	0.029	-7.66e-07	-4.02e-08
eta_hhsize_6	-1.52e-07**	7.19e-08	-2.11	0.035	-2.93e-07	-1.07e-08
eta_division_1	.0000385	.0000749	0.51	0.607	-.0001083	.0001853
eta_division_2	.0011383***	.0002343	4.86	0.000	.0006792	.0015975
eta_division_3	-.0001202	.0001518	-0.79	0.428	-.0004177	.0001773
eta_division_4	-.0003955***	.0000603	-6.56	0.000	-.0005137	-.0002773
eta_division_5	-.0002326	.000332	-0.70	0.484	-.0008833	.0004182
eta_division_6	-.0004286***	.000137	-3.13	0.002	-.0006971	-.00016
eta_region_1	.0001682	.0002051	0.82	0.412	-.0002338	.0005703
eta_region_2	-.0025675***	.0006261	-4.10	0.000	-.0037947	-.0013403
eta_region_3	.0005942	.0004106	1.45	0.148	-.0002105	.0013989
eta_region_4	.0011736***	.0001646	7.13	0.000	.0008511	.0014962
eta_region_5	.0005823	.0008819	0.66	0.509	-.0011463	.0023108
eta_region_6	.0000492	.0003742	0.13	0.895	-.0006843	.0007826
rho						
rho_hhsize	2.68e-08	2.35e-08	1.14	0.253	-1.92e-08	7.28e-08
rho_division	.2511978***	.0001958	1283.17	0.000	.2508141	.2515815
rho_region	-.7519946***	.0003328	-2259.77	0.000	-.7526468	-.7513424

Level of significant is ***1%, **5% and *10% respectively
Source: Author's survey 2022

Number of Obs.	= 980
Number of demographics	= 3
Alpha_0	= 10
Log-likehood	= 14199.065

Table 2 above represents the estimation of the Quadratic Almost Ideal Demand System (QUAIDS) for the US household consumption of food such as; raw sugar, non-carbonated calorie beverages, ice cream/frozen desserts, baked good mixes, packaged sweets/baked goods and bakery items ready to eat and the parameters estimated are, respectively. The data were analyzed using Stata commands, where is the intercept and is the coefficient.

The result from the QUAIDS model estimation in table 2 above shows that all the intercepts are significant at 1% except for Alpha5. From the QUAIDS result, the Alphas represent the mean value of budget shares of food items when expenditure, household sizes, and prices effect are equal to zero. The result from the table revealed that in the absence of expenditure, household size, division, regions, and price effect, the budget share of raw sugar, ice cream /frozen desserts, baked good mixes, packaged sweets/baked goods, and bakery items ready to eat increase by 85, 41%, 9%, 31% and 16% while that of non-carbonated beverages decreases by 6% respectively. However, all the alphas were significant at 1%, respectively.

The expenditure terms on beta were statistically significant in three of the six expenditure share equations. It was discovered that raw sugar and packaged sweets/baked goods were negatively significant at 1%. In contrast, packaged sweets/baked goods were positively significant at 1%. Therefore, the coefficient for non-carbonated calorie beverages, baked goods mixes, and bakery items ready to eat does not affect the expenditure share. It is also good to know that the coefficients are less than 1. This result is consistent with that of Zhum et al. (2014), who revealed that most primary food products are necessities and price inelastic for an urban household in China. The result further showed that a 1% increase in income would lead to about 0.7%, 3%, 0.1%, and 0.1% decrease in raw sugar, ice cream/frozen desserts, baked goods mixes, and bakery ready to eat. This is because all the foods are inferior goods, while about a 1% increase in income will lead to about 0.5% and 0.3% in non-carbonated calorie beverages and packaged sweets/baked goods, respectively.

More so, gamma parameters captured the responsiveness of demand to variation in relative prices, including the own price of good i and the prices of other good j. However, the result shows that most price effects were statistically significant at a 1% level. In comparison, about two were significant at 5%, another two were significant at 10%, and about three were not statistically significant. This shows that there is much quantity response to movement in relative prices. Therefore a change in the price of raw sugar leads to a systemic change in the expenditure share of non-carbonated calorie beverages, ice cream/frozen dessert, baked good mixes, packaged sweets/baked goods, and bakery items ready to eat by 2%, 0.1%, 0.1%, 1%, 0.3%, and 3% respectively.

In addition, out of the six variables, two were negatively statistically significant at 1% in the quadratic expenditure regarding lambda. At the same time, one was positively significant at 1%, and the remaining were not. The lambdas help to regulate the effects of the second-order coefficient on the budget shares, thereby allowing for nonlinear Engel curves. While the beta parameters only regard expenditure and budget shares as a linear relation which affirms the importance of the quadratic term extension of the Linear Almost Ideal Demand System.

Also, the coefficient of household size, divisions, and regions (eta) is positively related to the expenditure share for individual food items, which implies that as household size, divisions, and regions increase, the expenditure share of foods increases. However, some of these demographic variables were insignificant in explaining the budget share of disaggregated food items except for raw sugar, ice cream/frozen desserts, and packaged sweets/baked goods, which are statistically significant for household size.

In addition, non-carbonated calorie beverages, baked goods mixes, and bakery ready to eat were significant at 15 for divisions. In contrast, non-carbonated calorie beverages and packaged sweets/baked foods were significant for the regions at 1%, respectively.

The results from table 3 below revealed the test for hypotheses for the QUAIDS model

Table 3: Wald test for QUAIDS model

Wald test	
Chi2(27)	3.0e+05
Prob > Chi2	0.0000

The level of significant were (***) 1%, (**) 5%, and (*) 10% respectively

The results from the Wald test show that the probability value was significant at 1%, which means that the coefficients are not equal to zero, and therefore we reject the null hypotheses.

5. PRICE ELASTICITIES

Table 4 below shows the compensated own and cross-price elasticities of raw sugar, non-carbonated calories beverages, ice cream/frozen desserts, baked goods mixes, packaged sweets/baked goods, and bakery items ready to eat foods among US households. It also indicated that all the commodities consumed had the expected negative own price elasticities. This suggests that a unit increase in the price of raw sugar, non-carbonated calories, ice cream, frozen desserts, mixed, baked goods, packaged sweets/baked goods, and bakery items ready to eat will result in a proportionate decrease in the consumption of the commodities by a unit of their respective elasticity values, ceteris paribus. This suggests that a unit increase in the price of raw sugar, non-carbonated calories, ice cream, frozen desserts, mixed, baked goods, packaged sweets/baked goods, and bakery items ready to eat will result in a proportionate decrease in the consumption of the commodities by a unit of their respective elasticity values, ceteris paribus. Moreover, the result further revealed that all the estimates were positive. Still, the cross-price elasticities of baked good mixes were negative for bakery items ready to eat on non-carbonated calorie beverages, packaged sweets/baked goods, and raw sugar on baked good mixes.

In addition, cross-price elasticity was negative for non-carbonated calorie beverages on bakery items ready to eat. More so, the values of the own price elasticities for raw sugar is (-1.5739747), non-carbonated calorie beverages (-1.3675785), ice cream/frozen desserts (-0.63229265), baked good mixed (-0.77216168), packaged sweets/baked goods (-0.75337249) and bakery items ready to eat is (-0.90076343) respectively.

It should also be noted that compensated price elasticities measure the strength of the pure substitution effects affecting the consumption of food items under consideration. It is assumed that the consumer has been compensated with income to keep the household utility constant. Therefore the economic interpretations of the compensated elasticities are also similar to that of the uncompensated elasticities, except that there are no income effects in the latter, which makes it smaller in absolute value. Also, the fact that the signs of compensated elasticities are different from the signs of uncompensated elasticities suggests that income effects are essential in consumer demand decisions [2].

Table 4: Compensated (Hicksian) Price Elasticity Matrix

Food items	**Raw sugar**	**Non-carbonated beverages**	**Ice cream/frozen desserts**	**Baked good mixed**	**Packaged sweets/baked goods**	**Bakery items ready to eat**
Raw sugar	-1.5739747	.36420386	.33254721	-.27694588	.27923298	.87493659
Non-carbonated beverages	.10161407	-1.3675785	.15745617	.1435482	.97673649	-.01177644

Ice cream/frozen desserts	.0867726	.14718396	-.63229265	.09830852	.20828226	.0917453
Baked good mixed	-.23286965	.43276863	.31607264	-.77216168	-.00825755	.26444761
Packaged sweets/baked goods	.03326091	.41723189	.09494814	-.00124052	-.75337249	.20917207
Bakery items ready to eat	.24205245	-.01168953	.09714003	.08705965	.48620084	-.90076343

Source: Author's survey 2022

The uncompensated own-price elasticity matrix is presented in Table 5 below. In line with consumer demand theory, all own-price elasticities are negative. Negative own price elasticity implies that an increase in the price of a commodity will result in a decrease in demand for that commodity. For example, when the cost of raw sugar increases by 1%, demand for raw sugar reduces by 1.6%, which is shown along the diagonal in table 5. Among the six food groups considered for this study, raw sugar, non-carbonated calorie beverages, packaged sweets/baked goods, and bakery items ready to eat are own price elastic. At the same time, ice cream/frozen desserts are own price inelastic. However, all the cross prices are inelastic because they are less than one, which means there is a weak response of the food group to changes in the price of the other food groups.

Table 5: Uncompensated (Marshallian) Price Elasticity Matrix

Food items	Raw sugar	Non-carbonated beverages	Ice cream/frozen desserts	Baked good mixed	Packaged sweets/baked goods	Bakery items ready to eat
Raw sugar	-1.6187128	.20374392	.16118303	-.33017487	-.09652942	.71323992
Non-carbonated beverages	.05438916	-1.5369579	-.02343365	.08736035	.58008653	-.18246137
Ice cream / frozen desserts	.04268073	-.01095838	-.80118173	.04584834	-.1620528	-.0676159
Baked good mixed	-.27795076	.27107823	.14339438	-.82579886	-.38690142	.101511
Packaged sweets/baked goods	-.01406044	.24750655	-.08631108	-.05754311	-1.1508324	.03813859
Bakery items ready to eat	.19615246	-.17631698	-.07867486	.03244818	.10067906	-1.0666597

Source: Author's survey 2022

Expenditure (Income) Elasticity

Table 6 above presents the income elasticity of six foods considered for this research. A commodity can be classified as luxury, necessity, inferior or superior goods depending on the degree of demand fluctuations with a change in income.

Table 6: Expenditure Elasticity for various Foods Consumed

Food items	Expenditure elasticities
Raw sugar	.96725022
Non-carbonated beverages	1.0210169

Ice cream / frozen desserts	.95327974
Baked good mixed	.97466743
Packaged sweets/baked goods	1.0231019
Bakery items ready to eat	.99237186

Source: Author's survey 2022

Expenditure (Income) elasticity measures the responsiveness of demand to a change in consumer income. It is affected by the period over which they are measured (that is, the shorter the period, the lower the income elasticity of demand) and the degree of necessity of the good (that is, the more necessary the good, the lower the income elasticity of demand) (Sloman and Norris 2002).

Table 6 above shows the expenditure elasticity of household consumption of various food items in the US. The elasticities are computed and presented at their mean levels. The result shows that all the expenditure elasticities for the food items were positive, consistent with a priori expectations. This means that raw sugar, non-carbonated beverages, ice cream/frozen desserts, baked goods mixed, packaged sweets/baked goods, and bakery items ready to eat were all normal goods.

In terms of degree, food with expenditure elasticity greater than one is considered a luxury. In this study, non-carbonated beverages and packaged sweets/baked goods are considered luxuries because their elasticities are greater than 1. In contrast, raw sugar, ice cream/frozen desserts, baked goods mixes, and bakery items ready to eat are considered to be necessities because their elasticities are less than 1. When computed at their mean level, the expenditure elasticity for raw sugar is 0.96735022, which means that a 1% increase in the income of the consumers is expected to increase the expenditure share devoted to raw sugar by 9.6%. This was consistent with Obayelu et al. (2022) assertion that while the expenditure elasticities for chicken, turkey, soy milk, pork, groundnuts, and milk were more significant than one, indicating that they were luxury goods, those for beans, eggs, beef, and goat meat were less than one, suggesting that they were necessities.

In addition, the same thing goes for non-carbonated calorie beverages, ice cream/frozen desserts, baked good mixes, packaged sweets/baked goods, and bakery items ready to eat with expenditure elasticities of 1.0210169, 0.95327974, 0.9466743, 1.0231019 and 0.99237186. A percent increase in household income will bring about a 100%, 95%, 97%, 100%, and 99% increase in the budget share of the household for the selected food items.

Table 7 below reveals the test of hypotheses concerning the validation of homogeneity and symmetry restrictions. It should also be good to remember that the tests for symmetry and homogeneity restrictions are the same for both QUAIDS and AIDS models. Therefore the restrictions imply that;

(1) **Homogeneity;**

$$\sum_i^n \gamma_{ij} = 0 \qquad \forall_i = 1, \dots \dots \dots, n \quad \dots\dots\dots\,..\,(14)$$

(2) Symmetry;

$$\gamma_{ij} = \gamma_{ji}, \qquad \forall_i \neq j, i, j = 1, \dots, n \quad \dots\dots..\,(15)$$

Table 7: Test for Symmetry and Homogeneity Restriction for QUAIDS

Restrictions	Parameters

Homogeneity	Alpha	Chi2(4) = 2851.78	Prob>Chi2 = 0.0000
	Beta	Chi2(5) = 101.56	Prob>Chi2 = 0.0000
	Gamma	Chi2(5) = 663.59	Prob>Chi2 = 0.0000
	Lambda	Chi2(5) = 72.93	Prob>Chi2 = 0.0000
Symmetry	Gamma	Chi2(1) = 41.17	Prob>Chi2 = 0.0000

Source: Author's survey 2022

The result from table 7 above shows that the Prob. value was significant at 1%, so table 7 revealed that the symmetry restrictions are valid, and we reject the null hypothesis. Table 7 above also shows that the homogeneity restrictions hold since the probability value was significant at 1%, and we reject the null hypothesis.

6. Summary, Conclusion and Recommendations

This study examined the effect of demographic factors on the household consumption of some selected foods in the US using the QUAIDS model by employing Household Quarterly data from 2004-2010 from the USDA. The specific objectives are to estimate the selected foods' consumption expenditure and elasticities of the chosen foods. The number of observations estimated was 980 and was analyzed using the Quadratic Almost Ideal Demand System (QUAIDS) model. The major findings were that all expenditure (income) elasticities were positive and significant from zero. It was also revealed that raw sugar, ice cream/frozen desserts, baked good mixes, and bakery items ready to eat are necessities with elasticities of less than one, which is an indication that those goods are stapled items that must be made available irrespective of the level of income and price. In contrast, non-carbonated and packaged sweets/baked goods are luxury goods since their coefficients are greater than 1.

Own price elasticities were negative for both the compensated and the uncompensated price elasticity estimates for the food items. The compensated cross-price elasticities revealed that some food items were substitutes, which also goes for the uncompensated elasticities. More so, the heterogeneous expenditure elasticities across different household sizes, regions, and divisions across the US suggest a change in consumer preferences as households' income changes.

Therefore, this study concluded that both price and income play a significant role in household purchasing power and hence recommended that policy be focused on measures to improve food production and distribution in the US to avoid abnormal increases in the price of food. In addition, household income should also be enhanced by creating jobs to meet the total household food requirements, as this will affect the expenditure pattern and improve their purchasing power. In addition, the government should try as much as possible to subsidize food prices so that it can be accessible to all.

Contribution to knowledge

Several studies have attempted to increase food consumption to reduce the poverty level in the country. Therefore, food sustainability must be maintained across all regions and division across United States. This paper's applicability to policy can be used to determine its significance.

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