DEMAND FUNCTION FOR MEAT IN BENGHAZI

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Introduction :

In an earlier paper, seasonal movement in the consumption of meat in Benghazi [1] was discussed. In this paper demand function for the three varieties of meat will be discussed. The three varieties of meat considered are of lamb, calf and camel. Use of demand function in market analysis is well known [2]. However, derivation of demand function from observed data presents some serious difficulties. Usually mutiple regression analysis is used for estimating the demand equation. The dependent variable being the quantity exchanged in the market, independent variables are the price, prices of related commodities and income. Price of the commodity and prices of related commodities are likely to be strongly correlated. This is called the problem of multicollinearity. Presence of multicollinearity may not, under other conditions on the residuals, discredit the estimated demand equation foı the purpose of prediction but it is likely to influence adversely the estimated regression coefficients by increasing the errors in the estimates. Fortunately, in the data the important determining variables namely, price of lamb meat, price of beef and price of camel meat do not show strong correlation. An interesting point arises here ; from the data it can be seen that the total correlation coefficient between price of lamb meat and beef or between price of

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(1) Mukerji Et - al. The Libyan Economic and Business Review, Vol. V no. 1 Spring 1969.

(2) O. Lange: Econometrics.

lamb meat and camel or between price of beef and camel meat individually is not small. But these correlations are large because each price series shows similar variation over the period of observation. Thus the apparent correlation is misleading and in fact the prices of the three varieties of meat are uncorrelated when the effect of time is held constant. This point will be further discussed later in the text.

The data gave the number of lambs, calves and camels each month butchered in the Benghazi municipal slaughtering house between the period July 1963 to June 1968. For lamb meat the market had two varieties, namely, local and imported. For beef and camel meat again two varieties of each were available, those from big animals and those from smaller animals. Price of each variety, each month, was quoted as interval. Mid. values of the interval was taken as the price of each month. For each type of meat a weighted average price per month was calculated. For the months of February, March and April each year, 50 per cent of the lambs butchered were assumed to be local, the remaining 50 per cent imported. For other months, each year, it was assumed that 75 percent of the lambs were imported variety and the remaining 25 per cent local lamb. For calves and camels it was assumed that each month 70 per cent of the animals butchered were big and the remaining 30 per cent were from smaller animals. These assumptions are based on the suggestions made by the authorities in the slaughtering house and the people actually doing the work. Table 1 shows the number of animals of each variety and the weighted average price of meat per kilogram.

Methodology :

Demand equation of a commodity is usually taken as $q = a - bp + c_s p_s + dI$, where q is the quantity, p the price of the commodity, p_s the price or prices of related commodity and I the income of the consumers. Unfortunately the distribution of household income in Benghazi is not known. Without a detailed family budget survey it is not possible to get an accurate measure of the regression coefficient of income in the above equation, as an approximation time was taken as one of the independent variables. Over time the income of the consumers has increased of course, the increase may not be linear. Thus a part of the contribution in the regression equation by the variable time will be due to changes in income. But, it is not possible to isolate from the contribution to the regression equation by the variables time the effect of income alone.

The demand equation for lamb meat was taken as

$$1)\ q_L = + BP_L + CP_B + DP_C + ET$$

Here. $P_{L,}$ $P_{B,}$ P_C stand for price of lamb meat, beef and camel meat respectively, A, B, C, D and E are the five parameters. Some of them may be zero, negative or positive. The normal equations for determining B, C, D and E are

$$BS_{22} + CS_{23} + DS_{24} + ES_{25} = S_{12}$$
$$BS_{23} + CS_{33} + DS_{34} + ES_{35} = S_{13}$$
$$BS_{24} + CS_{34} + DS_{44} + ES_{45} = S_{14}$$
$$BS_{25} + CS_{35} + DS_{45} + ES_{55} = S_{15}$$

Where S i j have the usual meaning.

Table 2 shows the calculated values of S i j. Using these values the normal equations become.

$$5939B + 5847C + 1831D + 9028E = 18632$$
$$5847B + 10045C + 2433D + 11518E = 26787$$
$$1831B + 2433C + 1520D + 3307E = 8508$$
$$9028B + 11518C + 3307D + 17995E = 40953$$

Or in matrix notation

$$\begin{bmatrix} 5939 & 5847 & 1831 & 9028 \\ 5847 & 10045 & 2433 & 11518 \\ 1831 & 2433 & 1520 & 3307 \\ 9028 & 11518 & 3307 & 17995 \end{bmatrix} \begin{bmatrix} B \\ C \\ D \\ E \end{bmatrix} \begin{matrix} = \\ = \\ = \\ = \end{matrix} \begin{bmatrix} 18632 \\ 26787 \\ 8508 \\ 40953 \end{bmatrix}$$

And so

$$\begin{bmatrix} B \\ C \\ D \\ E \end{bmatrix} \begin{matrix} = \\ = \\ = \\ = \end{matrix} \begin{bmatrix} 0.000724 & -0.000002 & -0.000135 & -0.000337 \\ -0.000002 & -0.000390 & -0.000134 & -0.000224 \\ -0.000135 & -0.000134 & -0.001168 & -0.000060 \\ -0.000337 & -0.000224 & -0.000060 & 0.000379 \end{bmatrix} \begin{bmatrix} 18632 \\ 26787 \\ 8508 \end{bmatrix}$$

The 4×4 matrix on the right hand side called the variance coveriance matrix will be used for test of significance of the regression coefficients. We have

$$\begin{aligned} B &= -1.514 \\ C &= 0.096 \\ D &= 1.375 \\ E &= 2.731 \end{aligned}$$

The regression coefficient A is obtained from the consideration that the line of regression passes through the means. Thus

$$\bar{q}_L = A + B\bar{P}_L + C\bar{P}_B + D\bar{P}_C + E\bar{T}$$

The estimated regression equation turns out to be

2) $q_L = 112.468 - 1.514P_L + 0.096P_B + 1.375P_C + 2.731T.$

From equation (2) it can be seen that an increase in the price of lamb meat will lead to a fall in the quantity. Price of beef has very little effect on q_L Since the coefficient of P_C is positive it means that camel meat is a substitute for lamb meat. Coefficient of T shows that with time consumption of lamb meat will increase. For testing the goodness of fit we have

$$R^2 = \frac{-1.514\times18632+0.096\times26787+1.375\times8508+2.731\times40953}{1642945 - \frac{(9365)^2}{60}}$$

$$= 0.540$$

giving a value of R = 0.735. Statistically R is highly significant showing that the fit is good.

Since the coeficient of the price of beef is small, the regression equation may be improved by deleting the price of beef from the equation. Suppressing the variable P_B the new regression equation turns out to be

3) $q_L = 116.516 - 1.521P_L + 1.371P_C + 2.802T$

giving a value of $R^2 = 0.833$ or $R = 0.913$.

The coeficients of P_L and P_C in both equations (2) and (3) are statistically not significant from zero. However, it should be kept in mind that test of significance in the case of time series data is only approximate. Autocorrelation in the variables or autocorrelation in the residuals substantially change the available degrees of freedom. As an illustration of the presence of autocorrelation in the data let us test the hypothesis that the observed series of the quantity of lamb is unautocorrelated. We use the exact test of randomness given by Wald-Wolfowitz [3]. A circular definition is given to the variable, in this case as the sample size is large the circular definition is not a serious handicap. However, the number of lambs butchered shows an increasing trend over time, fortunately the trend is not very strong, so the replacement of $q^L_N \; q^L_{N+1}$ by $q^L_N \; q^L_1$ in the test function is not likely to distort the test very much. We define

(3) A. Wald and J. Wofowitz : An exact test for randomness in the nonparametric case based on serial correlation, Annals of Math. Statistics Vol. 14 (1943).

$$Sp = \Sigma_{t=1}^{60} (q_t^L)^P \qquad (P = 1, 2, 3, 4)$$

and the test function as

$$R = \Sigma_{t=1}^{59} q_t^L q_{t+1}^L + q_{60}^L q_1^L$$

Here, q_t^L denotes the number of lambs in hundreds butchered in the t^{th} month. The expected value of R and its variance are

$$E(R) = \frac{S_1^2 - S_2}{N-1}$$

and

$$\sigma_R^2 = \frac{S_2^2 - S_4}{N-1} + \frac{S_1^4 - 4S_1^2 S_2 + 4S_1 S_3 + S_2^2 - 2S_4}{(N-1)\ (N-2)}$$
$$- [\ E(R)\ ]^2$$

For large value of N, in our case N=60, R is approximately normally distributed with mean E (R) and variance σ_R^2. In our case

$R = 1591787,\qquad E(R) = 1458648$

and $\sigma_R = 22465$

So $t = \dfrac{R - E(R)}{\sigma_R} = 5.9$ a value which is highly significant, showing that the series q_t^L [t = 1,2, ... 60] is not random. In fact, q_t^L may be expressed as a non stationary first order autoregressive scheme.

Writing

$$4)\quad q_t^L = aq_{t-1}^L + bt + C$$

the parameters a, b and c may be estimated by the usual least squares method. The estimated equation turns out to be

$$5)\quad q_t^L = 0.505 \quad q_{t-1}^L + 1.374\ t + 36.424.$$

The multiple correlation coefficient turned out to be R = 0.83, showing that the above equation expressing the number of lambs butchered in the tth month as a function of the number butchered in the earlier month and a linear time trend is feasible.

The demand equation for beef may be taken in the form

$$6)\quad q_B = F + GP_B + HP_L + JP_c + KT$$

F, G, H, J and K being the parameters, some of them may be negative, positive or zero. Solving the normal equations we have

$$\begin{bmatrix} G \\ H \\ J \\ K \end{bmatrix} = \begin{bmatrix} 0.0003903 & -0.0000026 & -0.0001348 & -0.0002238 \\ -0.0000026 & 0.0007261 & -0.0001359 & -0.0003377 \\ -0.0001348 & -0.0001359 & 0.0011685 & -0.0000603 \\ -0.0002238 & -0.0003377 & -0.0000603 & 0.0003792 \end{bmatrix} \begin{bmatrix} -16318 \\ 6701 \\ \cdot\ 6169 \\ -22321 \end{bmatrix}$$

Or G = —0.559 Substituting the mean values in (6) we have
H = 13.284 F = 64.432
J = —4.573
K = —6.703

Thus the demand equation for beef may be written as

$$7)\quad q_B = 64.432 - 0.559\ P_B + 13.284\ P_L - 4.537\ P_c - 6.703T.$$

From (7) it can be seen that increase in the price of beef will lead to fall in the demand for beef. The coefficient of P_L is positive and large. A small fall in the price of lamb meat will lead to a considerable decrease in the demand for beef. An increase in the price of camel meat will lead to a fall in q_B, also over time demand will fall. These points will be discussed later in the text. Equation (7) gives a value of R equal to 0.398. Test of significance shows that the fit is not bad. Test of significance for the regression coefficients shows that the coefficient for P_L is highly significant, those for P_c and T are also significant. Coefficient of P_B is not significant. Showing that price of beef has very little effect on the demand for beef. Prics of lamb meat and camel meat on the other hand has much more influence on the quantity of beef consumed.

The demand equation for camel meat was taken in the form

$$8)\quad q_c = L + MP_c + NP_L + QP_B + RT$$

where again some of the parameters L, M, N, Q and R may be negative, positive or zero. Solving the normal equations we have

$$\begin{bmatrix} M \\ N \\ Q \\ R \end{bmatrix} = \begin{bmatrix} 0.0011685 & -0.0001360 & -0.0001349 & -0.0000603 \\ -0.0001360 & 0.0007258 & -0.0000025 & -0.0003376 \\ -0.0001349 & -0.0000025 & 0.0003901 & -0.0002237 \\ -0.0000603 & -0.0003376 & -0.0002237 & 0.0003792 \end{bmatrix} \begin{bmatrix} \cdot 9529 \\ \cdot 67528 \\ \cdot 73814 \\ \cdot 99018 \end{bmatrix}$$

Or $M = 13.977$ $\qquad$ $L = 1350.936$

$N = -14.103$ $\qquad$ The constant L has the value

$Q = -\ 5.190$

$R = 2.336$

Thus the demand equation will have the form

$$9)\quad q_c = 13.977\,P_c - 14.103\,P_L - 5.190\,P_B + 2.336T + 1350.936$$

Equation (9) has some extraordinary characteristics. The coefficient of P_c is large and positive. A positive coefficient of P_c is unusual for the demand equation. There can be two explanations for this peculiarity. First that the fit is not good, a fact which is supported by a fairly low value of $R^2 = 0.1104$. However, as has been pointed out earlier that the conventional statistical test of significance is not applicable to time series data. Thus on this ground we may not reject the estimated regression equation. The second explanation is that the estimated equation is not the demand equation. It may be the supply equation or a mixture of the demand and supply equations. In empirical estimation of the demand and supply equations from observed data on the quantity of a commodity exchanged in the market and its price, we sometimes face the above type of problem. In the terminology used in Economictrics studies, this is called the problem of identification. Identifibility means that we are in a position to identify the estimated regression equation with a given economic relationship between the variables. Certain mathematical conditions have been developed for identification of a given equation in a set of structural equations. [4] The structural equations express the relationship between the economic variables. A structural equation need not be a regression relationship. That is, it may not allow estimation of one of the variables as a function of the other variables in the system.

Coming back to the problem of estimation of the demand or supply equation from empirical data it may be pointed out that a simple regression of quantity on price is likely to give the demand equation if in the period of observation the demand remains more or less stable whereas supply fluctuates. On the other hand, if in the period of observation, supply remains more or less stable but the demand fluctuates, a regression of quantity on price will give the supply equation and not the demand equation. In real life both the demand and supply fluctuates, so a regression of quantity on price may not give either the demand or the supply equation. In the present analysis it is more likely that equation (9) is giving the supply equation of camel

(4) Tintner G. : Econometrics, (John Wiley and Sons), pp. 154.

meat and not the demand equation. From table 1 it can be seen tha quantity of caml has a lot of variability, the lowest value is 104 and the highest 1672. For calves the lowest and highest values are respectively 201 and 901, for lamb these two values are 68 and 281 Thus the variability in number of camel is very large compared to the other two types of meats. The supply of camel to Benghazi market is likely to be stable. Most of the animals are imported from outside and the number getting into the country and reaching Benghazi market dependent on transport and other facilities. If transport facility alone remains more or less stable the number coming to the market will be automatically controlled. Thus if supply is taken as relatively stable the fluctuations in the quantity is more due to fluctuations in demand and so a regression of quantity on price is likely to give the supply equation and not the demand equation.

On the assumption of relatively stable supply we may conclude that equation (9) is the supply equation. However, the coefficients of P_L and P_B especially the former brings in some doubt. Coefficients of P_c and P_L are nearly equal and of opposite sign. Increase in the price of lamb meat will on the basis of (9) lead to a fall in the supply of camel meat. If camel meat is a substitute for lamb meat, which is true as will be shown later, an increase in the price of lamb meat should lead to an increase in q_c So we come back to the original question namely, what is equation (9). At least on the basis of this analysis one cannot confidently name (9) as the demand or supply equation for camel meat. More empirical work using data for other parts of Libya and the country as a whole should be done. The best that can be done in the present case is to get a regression equation of q_c on P_c and T. This equation will give the supply function for q_c . Writing the supply equation as

$$10) \quad q_c = a + bP_c + dT$$

where q_c = the quantity of camel meat supplied

P_c = the price of camel meat per kilo

T = time, a, b, and d are the three parameters of the equation.

Using cross products from Table 2, the normal equations become

$$1520b + 3307d = -9529$$
$$3307b + 17995d = -99018$$

giving b = 9.25 and d = —7.15, the value of a turns out to be a = 579.93. Thus the supply equation becomes

$$11) \quad q_c = 579.93 + 9.25P_c - 7.15T$$

Equation (11) gives a value of R = 0.27. Omitting P_B and P_L from the supply equation has not improved the fit. In equation (9) the value of R^2 was 0.1104. The value of R = 0.27 is not significant at 5% level of significance. Equation (11) shows that an increase in the price of camel meat will lead to its increased supply, also over time the supply will decline. The decline over time can be attributed to the fact that over time income of the consumers goes up and the consumers switch from camel meat to lamb meat.

Partial correlations :

Earlier it was mentioned that in a multiple regression equation if some of the determining variables are strongly correlated the result is that the standard error of the regression coefficients increase. In other words, the regression coefficients become unreliable. In econometric analysis a regression equation has two important applications, namely, best possible prediction of the dependent variable for given values of the independent variables and secondly in economic policy formation or decisions. For successful use of regression equation in economic decision making it is necessary that the estimated regression coefficients be reliable. In equations (2) to (7) the independent variables are P_L P_B P_c and T, Of these variables the first three are of importance to an economist. We try to test if P_L P_B and P_c are strongly correlated. Table 3 shows the total and partial correlations between the prices. Partial correlation means the correlation between two variables when the effect of other variables are held constant. Thus $r_{LB.T}$ is a first order partial correlation coefficient showing the correlation between P_L and P_B when the effect of time is held constant. From table three it can be seen that the total correlation coefficient between price of lamb meat and price of beef is $r_{LB} = 0.7570$. Similarly, the correlations between lamb meat price and camel meat price and between the prices of camel meat and beaf are respectively 0.6095 & 0.6226. All three correlation coefficients are high showing strong correlation between the three prices. This is rather unusual for Benghazi market. This would be true only if there was strong competition between the retailers. In Benghazi market prices are fixed with the intention of higher profit and as such tend to be arbitrarily fixed on the higher side. Further over time prices are increasing without any strong relationship to demand. To test this, correlations between time and the price of lamb meat, price of beef and price of camel meat were calculated. The three correlations are $r_{LT} = 0.8733$, $r_{BT} = 0.8567$, $r_{LT} = 0.6322$ showing that as time increases prices also increase. The partial correlation between the prices of lamb meat and beef when the effect of time is held constant is $r_{LB.T}$, where

$$r_{LB.T} = \frac{r_{LB} - r_{LT}\, r_{BT}}{\sqrt{(1-r^2_{LT})\ (1-r^2_{BT})}} = \frac{0.7570 - 0.8733 \times 0.6322}{\sqrt{(1-0.7626)\ (1-0.3998)}}$$

$$= 0.0000036$$

Similarly, $r_{LC.T} = 0.0000152$, $r_{CB.T} = 0.0000202$

The values of $r_{LB.T}$, $r_{LC.T}$ and $r_{CB.T}$ are very small, as good as zero. Showing that the correlations between the three types of meats are purely due to the fact that all the prices are increasing over time. The value of r_{CT} is 0.6322. Thus in the supply equation (11) the two determining variables P_C and T are strongly correlated. The result of this will be that the regression coefficients 9.25 and —7.15 of P_C and T may not be very reliable. This does not of course, mean that equation (11) is useless for predicting supply for given values of P_C and T.

Elasticities :

Elasticities of demand with respect to price and other economic variables are very useful. Table 4 shows the elasticities and cross elasticities. All elasticities have been calculated at average values of the variables concerned. Meat is an essential item of consumption and lamb meat forms the bulk of consumption in Benghazi. However, the proportion of income spent by the households on meat in Benghazi is unfortunately not known. In Tripoli a family budget survey for low and middle income groups showed that in 1962, 10.32 per cent of the total food expenditure was for purchases of fresh meat. Purchase of fresh meat for group accounted for a little more than 6 per cent of the total household consumption expenditure. These figures are rather high perhaps due to the fact that the data is for the low and middle income group. In this group generally the bulk of expenditure is for food items. If all income groups are considered it is likely that the percentage of total consumption for the purchase of fresh meat will be lower than 6.

From the demand equation for lamb meat, that is, equation (3) the price elasticity of lamb meat for the average price and quantities turn out to be

(5) Dajani, W. Sami : Family Budget survey in Tripoli town (1962).

$$e_{L}^{PL} = -1.521 \times \frac{4081}{936500} = -0.00663$$

showing that a 10 per cent increase in the price of lamb meat will lead to a fall of about 0.07 per cent in the demand for this meat if other factors remain constant. Using the upper and lower fiducial limit of the regression coefficient —1.521 of P_L the maximum and minimum fall in the demand due to an increase in the price P_L can be computed. These limits are of importance for the government if price fixation is considered. For example, the 95% upper and lower limits for the coefficient of P_L are 0.513 and —3.555. Thus the maximum value for the price elasticity of lamb meat will be

$$e_{L\ \text{Max.}}^{PL} = -0.0155$$

Thus, a 10% increase in the price of lamb meat may lead to a maximum fall in the demand by about 0.2 per cent. In table 4 e_{L}^{PC} shows the cross price elasticity for lamb meat with respect to the price of camel meat. This cross elasticity has a positive sign showing that camel meat is a substitute for lamb meat, however, the degree of substitution is small. From table 4 it can be seen further that the elasticicies of demand for beef are much more than those for lamb meat. It means that lamb meat is essentially a necessary commodity. Beef, on the other hand, will show relativly larger variation for changes in the prices of lamb or camel meats.

Summary :

In this paper demand function for lamb meat, and beef has been derived. The data is for the town of Benghazi covering the period

July 1963 to June 1968. The two demand functions are

$$q_L = 116.516 - 1.521\ P_L + 1.371\ P_C + 2.802\ T$$

and

$$q_B = 64.432 - 0.559P_B + 13.284P_L - 4.537P_C - 6.703T$$

Supply equation for camel meat is shown to have the form

$$q_C = 579.93 + 9.25\ P_C - 7.15\ T$$

Some of the difficulties in applying the multiple regression analysis to economic variables have been indicated. The problems of multicollinearity, identification and autocorrelation have been discussed. Use of regression equation in economic decision making has been indicated, and some observations on the elasticities of demand have been made.

Acknowledgement

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TABLE No. 1

Number of animals butchered and weighted average price

Year	Month	No. of lambs in 100	Price of lamb meat per kilo in piasters	No. of calves	Price of beaf per kilo in piasters	No. of camels	Price of camel meat per kilo piasters
1963	July	118	48	547	35	680	35
	August	89	48	526	38	943	35
	September	88	55	546	38	1087	35
	October	82	55	587	40	1080	36
	November	76	55	519	40	838	36
	December	82	55	539	40	914	36
1964	January	105	58	696	45	1151	42
	February	122	58	680	45	872	42
	March	203	58	610	45	352	42
	April	200	63	576	52	104	37
	May	186	63	776	52	568	37
	June	154	63	776	52	856	37
	July	115	63	809	43	1132	38
	August	98	63	766	43	1082	38
	September	102	63	682	43	916	38
	October	109	63	553	50	754	35
	November	108	64	719	55	809	38
	December	100	63	773	53	744	38
1965	January	68	65	750	50	1224	43
	February	102	65	454	55	521	45
	March	177	63	444	45	557	40
	April	140	65	357	53	365	40
	May	156	65	462	60	500	44
	June	118	65	395	63	1126	44
	July	102	63	403	48	1377	40

TABLE 1 (Continued)

Year	Month	No. of lambs in 100	Price of lamb meat per kilo in piasters	No. of calves	Price of beaf per kilo in piasters	No. of camels	Price of camel meat per kilo piasters
	August	99	61	424	50	1227	40
	September	98	63	365	50	1144	40
	October	112	61	458	50	931	38
	November	128	64	428	50	733	43
	December	146	61	487	48	709	45
1966	January	166	58	504	45	653	37
	February	132	64	439	48	237	35
	March	209	64	453	60	146	35
	April	178	65	310	70	188	40
	May	174	67	400	58	836	48
	June	108	70	342	60	1672	45
	July	115	75	262	75	1655	45
	August	158	70	700	65	1279	45
	September	174	68	278	65	822	45
	October	203	65	262	80	560	48
	November	230	71	201	60	559	48
	December	233	78	538	63	708	48
1967	January	193	76	772	67	420	46
	February	109	85	762	75	326	50
	March	170	80	627	67	158	42
	April	182	86	516	75	154	50
	May	191	80	514	68	707	46
	June	146	81	474	75	1205	47
	July	175	74	394	73	1546	42
	August	213	75	320	61	1055	43
	September	226	76	601	65	799	46
	October	260	80	388	59	546	46
	November	235	80	586	68	385	57
	December	275	82	901	82	633	55
1968	January	171	89	892	64	362	39
	February	190	85	740	65	470	36
	March	183	88	504	91	216	46
	April	240	88	428	74	256	42
	May	262	75	857	70	526	43
	June	281	67	380	83	628	46

TABLE 2

Sum of squares and cross products for estimating the regression Equations

$\Sigma q_L = 9365,\ \Sigma P_L = 4081,\ \Sigma P_B = 3462,\ \Sigma P_C = 2518,\ \Sigma T =$

$\Sigma q_B = 32452 \quad \Sigma q_C = 45003$

$\Sigma q_L P_L - \frac{\Sigma q_L \Sigma P_L}{60} = 18632,\ \Sigma q_L P_B - \frac{\Sigma q_L \Sigma P_B}{60} =$

$\Sigma q_L P_C - \frac{\Sigma q_L \Sigma P_C}{60} = 8508,\ \Sigma q_L T - \frac{\Sigma q_L \Sigma T}{60} =$

$\Sigma q^2_L - \frac{(\Sigma q)^2}{60} = 181225,\ \Sigma {}^2_L - \frac{(\Sigma P_L)^2}{60} =$

$\Sigma P^2_B - \frac{(\Sigma P_B)^2}{60} = 10045.\ \Sigma P^2_C - \frac{(\Sigma P_C)^2}{60} =$

$\Sigma T^2 - \frac{(\Sigma T)^2}{60} = 17995,$

$\Sigma P_L P_B - \frac{\Sigma P_L \Sigma P_B}{60} = 5847,\ \Sigma P_L P_C - \frac{\Sigma P_L \Sigma P_C}{60} = 18$

$\Sigma P_L T - \frac{\Sigma P_L \Sigma T}{60} = 9028.\ \Sigma P_P P_C - \frac{\Sigma P_B \Sigma P_C}{60} = 24$

TABLE 2 (*continued*)

$$\Sigma P_B T - \frac{\Sigma P_B \ \Sigma T}{60} = 11518, \quad \Sigma P_P T - \frac{\Sigma P_C \ \Sigma T}{60} = -3307$$

$$\Sigma q_B P_B - \frac{\Sigma q_B \ \Sigma P_B}{60} = -16318, \quad \Sigma q_P P_L - \frac{\Sigma q_B \ \Sigma P_L}{60} = -6701$$

$$\Sigma q_B P_C - \frac{\Sigma q_B \ \Sigma P_C}{60} = -6169, \quad \Sigma q_B T - \frac{\Sigma q_B \ \Sigma T}{60} = -22321$$

$$\Sigma q_B^2 - \frac{(\Sigma q_B)^2}{60} = 1744356$$

$$\Sigma q_C P_C - \frac{\Sigma q_C \ \Sigma P_C}{60} = -9529, \quad \Sigma q_C P_L - \frac{\Sigma q_C \ \Sigma P_L}{60} = -67528$$

$$\Sigma q_C P_B - \frac{\Sigma q_C \ \Sigma P_B}{60} = -73814, \quad \Sigma q_C T - \frac{\Sigma q_C \ \Sigma T}{60} = -99018$$

$$\Sigma q_C^2 - \frac{(\Sigma q_C)^2}{60} = 8792463$$

TABLE 3

Total and partial correlation coefficients

$r_{LB} = 0.7570$, $r_{LC} = 0.6095$, $r_{CB} = 0.6226$

$r_{LT} = 0.8733$, $r_{BT} = 0.8567$, $r_{CT} = 0.6322$

$r_{LB.T} = 0.0000036$, $r_{LC.T} = 0.0000152$ $r_{CB.T} = 0.0000202$.

TABLE 4

Elasticities

$$e_{L}^{PL} = -1.521 \times \frac{4081}{936500} = -0.00663$$

$$e_{L}^{PC} = 1.371 \times \frac{2518}{936500} = 0.00369$$

$$e_{L}^{T} = 2.802 \times \frac{1830}{936500} = 0.00546$$

$$e_{B}^{PB} = -0.599 \times \frac{3462}{32452} = -0.064$$

$$e_{B}^{PL} = 13.284 \times \frac{4081}{32452} = 0.167$$

$$e_{B}^{PC} = -4.537 \times \frac{2518}{32452} = -0.352$$

$$e_{B}^{T} = -6.703 \times \frac{1830}{32452} = -0.378$$