PRICE AND INCOME ELASTICITIES OF IMPORTS OF KUWAIT : A STATISTICAL ESTIMATION

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I — Introduction

This paper provides a statistical estimation of price and income elasticities of imports of Kuwait. The concepts of permanent income and permanent price will also be statistically measured and tested. In addition, a dynamic process which includes a lagged variable will be tested. This lagged variable will be the stock. Hence, this would call for a statistical measure of stock since data are not available.

The analysis is being carried out on quarterly basis over the period 1965 — 1974 (first quarter). The source of basic data is : «Monthly Statistical Bulletin, State of Kuwait, Planning Board C.S.O.».

The present article includes three main sections in addition to the introduction and the statistical appendix. Section (2) provides statistical mehodtology. Section (3) is devoted to statistical findings and conclusions. Section (4) contains a discussion as regards measuring variables.

II — Statistical Methodology

A) Additive and multiplicative forms of the function.

Writing (P) for price index, (y) for index of income in real terms, and (X) for the index of quantity of imports, two forms of the functional relationship may be suggested :

$$X = F \; (P + Y) \; ; \text{and,}$$
$$X = F \; (P.Y)$$

The last form is, of course, hyporbolic one, and the coefficients of (P) and (Y) (the exponents) are, by definition, the price and incom elasticities. These elasticities are constant for all points on the curve. Where the sum of these exponents equals unity, the function will be both linear and homogeneous. Generally, when the elasticities are calculated by this method, and least squares bias may result from a measurment errors or from shifts in the function. In case the errors in the measurment of the independent variables are random they may result in downward bias in the coefficients of the equation. In such a case the calculated elasticities will be underestimated.

On the other hand, in the case of the additive form, the elasticity is different for different points on the curve, and may be estimated, on the average, at the means.

B) The basic function.

In addition to the foregoing variables, we aefine :

Q_1 = 1 in the first quarter of any year,
= 0 in all other quarters.
Q_2 = 1 in the second quarter o fany year,
= 0 in all other quarters.
Q_3 = 1 in the third quarter of any year,
= 0 in all other quarters.

Hence, we may write our basic function as follows,

$$\text{Log}x_t = b_1 + b_2 \text{log} P_t + b_3 \text{Log} Y_t + b_4 Q1 + b_5 Q_2 + b \ Q_3 + e \quad (1)$$

This is a linear function in the logarithms of the real variables.

C) Simulaneous equation bias in ordinary least squares.

If, in a function, the causation is a two — way, it cannot be considered as a single equation. There will rather be a system of equations explaining the different relationships between all variables. In such a system of equations, each of the two-way causation variables appear as endogenous variable. Equation (1) above demostrates that (P) influences (X). But, if at the same time (P) is influenced by (X), the above single equation cannot be treated as a complete single — equation model. Fortunately, although this may be true in a local market, it may not be the case in the international market. Imports to Kuwait come from differen countries each of which exports to many other countries. Kuwait, may not influence the price of its imports through changing the level of imports. Thus, estimating equation (1) is not likely to arise simultaneous equation bias and hence the problem of indentifidation is not likely to appear.

D) The use of dummy variables Q.s

This refers to the variables Q_1 , Q_2 and Q_3 which allow for seasonal variations. We have prefered to include these dummy variables in the equation rather than measuring (X) , (P) and (Y) as deseasonalized series, since this would have introduced systematic variation built into them. The parameter estimates for the Q.s will give the seasonal effect for each of the three quarters, respectively. In the fourth quarter all the Q.s are Zeros and the costant term in the equation will provide the seasonal effect of the fourth quarter. This has been suggested by Klein (6) and Koutsoyiannis (11) , Thomas (7). Equation (1) does not include Q_4 in the same manner as other Q.s , since the determinant of the terms of sums of squares and sums of products would be Zero.

E) Corrected coefficient of determination.

Denoting the coefficient of determination by (R^2) the corrected coefficient ($\bar{R}^2$), is given by ;

$$\bar{R}^2 = 1 - \text{Var (e)} / \text{Var (x)}$$

$$= 1 - \frac{\Sigma e^2 / (n - k - 1)}{\Sigma (x^2) / (n - 1)} \qquad (2)$$

But, Since,

$$R^2 = 1 - \frac{\Sigma e^2}{\Sigma (x^2)} \qquad (3)$$

Hence,

$$\bar{R}^2 = 1 - \frac{(n - 1)}{(n - k - 1)} (1 - R^2) \qquad (4)$$

Where (n) is the number of observations, (K) is the number of independent variables, and (x^2) is $\Sigma(x - \bar{x})$ For each equation edtimated, both (R^2) and ($\bar{R}^2$) will be given.

F) Testing the assumption of serial correlation.

Ordinary least squares method is based on the assumption that the successive values of the random variable in equation (1) are independent. Most economic variables are subject to a growth trend and tend to show cyclical patterns, hence autocorrelation is likely to be positive. When errors are autocorrelated, residuals are likely to underestimate thee true errors. Although parameters estimates of least squares, however, tend to be unbiased (i.e.their expected value is equal to the true parameters), their value in any single sample is not correct. Thus, the reliability of the estimates is overstated.

We utilize the Durbin/Watson test (d) For testing, for such a possibility. This test is suitable only for the first-order autoregressive modle. The exact distribution of the (d) is not known, but Durbin-Watson have established that it lies between a lower bound (dl) and an upper bound (du). In order to carry out the test for positive autocorrelation, we compare the calctlated value of (d) with (dU) and (dL) (with (n-k) degrees of freedom) : if (d) $\geq$ dU we accept the null hypothesis that there is no autocorrelation ; if (d) $\leq$ (dL) we reject the null hypotheses ; if (dL) $<$ d$<$ (dU) the test is inconclusive. This last decision has been a weakness in applying the test. Some statisticians have followed the procedure of rejecting the null hypothesis if (d) $<$ (dU) and accept it if (d) $>$ (dU).

G) A dynamic model.

Returning to equation (1), one may introduce a simple dynamic model where accumulated stock K of imports appear in the equation. Assuming that :

$$X = i ((K) - K) \qquad (5)$$

where (K) is an assumed level of stock of imports which is supposed to prevail during a unit of time ; and $0 < i < 1$, that is a fraction.

$$(K) = C_1 + C_2 P + C_3 Y \qquad (6)$$

Thus,

$$(X) = i (C_1 + C_2 P + C_3 Y - K) \qquad (7)$$

$$(X) = i \quad C_1 + i C_2 P + i C_3 Y - i K \qquad (8)$$

This last equation expresses (X) as a function of P, Y and K. Naturally, data on stock is not available and we shall estimate such series as shown later. We have decided t ointroduce K in period (t) in order to allow for enough time lag. Equation (8), if proves significant, would allow us to estimate the fraction (i) and hence C_1, C_2 and C_3 appearinb in (b) (note that data on (K) is neither available nor can be assumed). The dummy variable, Q.s, may appear in (8). This of course decreases the number of degrees of freedom but in our case the number of observations would be $n = 31$ for equation (8), while $n = 35$ for equation 1. In addition, we have estimated both Permanent income and Permanent price, as discussed later on the asstmption that it may not be ex-post income and price that are relevant as for as (X) is concerned, but rather permanent (P) and (Y).

III — Statistical Findings and Conclusions

Variables and definition :

log X	=	log. of the index of quantity of imports.
log P	=	log. of the index of imports.
Q.s	=	Dummy Variables as discussed before.
log y	=	log. of the index of income in real terms.
log K	=	log. of the index of estimated stock.
log Yex	=	log. of the index of estimated permanent income.
log Pex	=	log. of the index of esimated permanent price.
d	=	The Durbin/Watson Statistic.

The least — squares estimate for equation (1) is given as follows (n = 35) :

$$\log X = \underset{(0.300)}{1.690} - \underset{(0.190)}{0.463} \log P + \underset{(0.140)}{0.645} \log Y - \underset{(0.025)}{0.003} Q_1 + \underset{(0.026)}{0.001} Q_2 - \underset{(0.025)}{0.071} Q_3 \qquad (9)$$

$$R^2 = 0.523 \qquad R = 0.421 \qquad d = 0.83$$

The standard errors of the regression coefficients are given in parentheses below them. We note the statistical significance of the real variables P and Y. The sign of each is as expected *a proiri.* Quantity of imports is negatively correlated with price, while it is positively correlated with income. Both coefficients are more than tewice their standard errors. However, the coefficient of determination is rather low and the value of (d) is too small indicating a serial

correlation in the residuals.

These residuals are presented in chart (I). Since we are interes-

ted in estimating price and income elasticities, rather han providing a function explaining the variation in imports, we may introduce a dummy variable in the following manner :

M	=	—1	when	$e < -0.035$
M	=	1	when	$e > 0\ 0.035$
M	=	0	when	$0.035 > e > -0.035$

Re— estimating the equation after including (M) as an explanatory variable we get :

$$\log X = 1.923 - 0.552 \log P + 0.120 \log Y + 0.065\ M - 0.003\ Q_1 + 0.000\ Q_2 - 0.073\ Q_3 \quad (10)$$
$$(0.122)\ (0.076)\ (0.056)\ (0.005)\ (0.010)\ (0.010)\ (0.010)$$

$n = 35$ $R^2 = 0.926$ $\bar{R}^2 = 0.908$ $d = 2.13$

(The coefficient of Q_2 is 0.00001).

Ecuation (10) is much better than equaion (9). Both P and Y are both statistically significant and have the right signs. $\bar{R}^2$ is, of course, much higher. The variable (M) is of course both significant and has the right sign. This variable enables us to improve the equation and would allow us to give better estimates for both price and income elasticities under condiion of high coefficient of determination. The variable M is a proxy for other factors responsible for variations in X. To recall, we are not interested in explaining the variations in (X) but rather in esimating price and income elasticities. We also do not care about the insignificance of the dummy variables, as long as the real variables, P and Y, are statistically significant. The importance of equation (10) also lies in the fact that (d) is much higher than hat in equation (9). In fact (d) in equaion (10) is above (dU) at the 5% and hence we accept the null hypothesis of no positive serial correlation being present. Chart (II) represents both actual index of the quantity of imports and the anti-log. of estimated log X from equation (10). We note, of course the goodness of fit (the period is from the third quarter 1965 to the first quarter 1974 inclusive).

We have re-estimated the equation using different variables as follows ;

$$\log X = 2.128 - 0.797 \log P + 0.764 \log Yex + 0.051\ M - 0.011\ Q_1 + 0.003\ Q_2 - 0.067\ Q_3$$
$$(0.133)\ (0.097)\ (0.081)\ (0.006)\ (0.011)\ (0.011)\ (0.011)$$

$n = 32$ $R^2 = 0.895$ $\bar{R}^2 = 0.869$ $d = 1.70$ (11)

$$\log X = 2.094 - 0.697 \log Pex + 0.679 \log Y + 0.063\, M - 0.004\, Q_1 + 0.002\, Q_2 - 0.074\, Q_3 \quad (12)$$
$$(0.164) \quad (0.117) \quad (0.079) \quad (0.007) \quad (0.012) \quad (0.012) \quad (0.012)$$
$$n = 32 \quad R^2 = 0.876 \quad R^{-2} = 0.846 \quad d = 2.00$$

$$\log X = 2.199 - 0.829 \log Pex + 0.757 \log Yex + 0.051\, M + 0.008\, Q_1 + 0.015\, Q_2 - 0.0600\, Q_3 \quad (13)$$
$$(0.219) \quad (0.188) \quad (0.135) \quad (0.009) \quad (0.016) \quad (0.015) \quad (0.015)$$
$$n = 32 \quad R^2 = 0.783 \quad R^{-2} = 0.731 \quad d = 1.84$$

While we have estimated equation (8 after including the Q.s , as follows ;

$$\log X = 1.865 - 0.496 \log P + 0.438 \log Y + 0.164 \log K - 0.008\, Q_1 + 0.000\, Q_2 - 0.068\, Q_3 \quad (14)$$
$$(0.434) \quad (0.175) \quad (0.142) \quad (0.186) \quad (0.024) \quad (0.025) \quad (0.024)$$
$$n = 31 \quad R^2 = 0.487 \quad R^{-2} = 0.359 \quad d = 1.13$$

$$\log X = 1.962 - 0.562 \log P + 0.559 \log Y + 0.054\, M + 0.057 \log K - 0.008\, Q_1 - 0.006\, Q_2 - 0.088\, Q_3 \quad (15)$$
$$(0.296) \quad (0.119) \quad (0.099) \quad (0.010) \quad (0.128) \quad (0.016) \quad (0.017) \quad (0.017)$$
$$n = 31 \quad R^2 = 0.773 \quad R^{-2} = 0.704 \quad d = 1.63$$

$$\log X = 1.859 - 0.556 \log P + 0.577 \log Y + 0.059\, M + 0.082 \log K - 0.010\, Q_1 - 0.005\, Q_2 - 0.077\, Q_3 \quad (16)$$
$$(0.194) \quad (0.075) \quad (0.061) \quad (0.006) \quad (0.089) \quad (0.010) \quad (0.010) \quad (0.011)$$
$$n = 32 \quad R^2 = 0.909 \quad R^{-2} = 0.882 \quad d = 2.04$$

Generally, the coefficients of both P and Y are significant and have the right signs in all previous equations.

Equations (11) to (16) appear to be inferior to equation (10) on more than one ground :

R^2 is smaller, (d) is lower and the K variable does not seem to be significant no matter it may be lagged or not.

The estimated price and income elasticities are given as follows, (These estimates are in terms of log. P, log Y, and log X).

(1) Price elasticity (P.E) :

(a) Actual Price.

	Mean log P	Mean log X	Coefficient	(P.E)
Equation (10)	2.0438	2.0840	— 0.552	— 0.54
Equation (11)	2.0501	2.0956	— 0.797	— 0.78
Equation (14)	2.0517	2.0984	— 0.496	— 0.48
Equation (15)	2.0517	2.0984	— 0.562	— 0.55
Equation (16)	2.0501	2.0956	— 0.556	— 0.54

(b) Permanent Price.

	Mean log Pex	Mean log X	Coefficient	(P.E)
Equation (12)	2.0434	2.0956	— 0.697	— 0.68
Equation (13)	2.0434	2.0956	— 0.829	— 0.81

(2) Income elasticity (Y.E) :

(a) Actual income.

	Mean log Y	Mean log X	Coefficient	(Y.E)
Equation (10)	2.1075	2.0840	0.620	0.63
Equation (12)	2.1194	2.0956	0.679	0.69
Equation (14)	2.1236	2.0984	0.438	0.44
Equation (15)	2.1236	2.0984	0.559	0.57
Equation (16)	2.1194	2.0956	0.577	0.58

(b) Permanent income.

	Mean log Yex	Mean log X	Coefficient	(Y.E)
Equation (11)	2.1132	2.0956	0.764	0.77
Equation (13)	2.1132	2.0956	0.757	0.76

Thes elasticities are in terms of the logs of he variables as mentioned before. These are slightly different from the elasticities estimated in terms of the absolute variables.

Take for example equation (10). This equation implies that a (1%) increese in log income is associated with a (0.63%) increase in log quantity. That is to say if log (Y) increases from (1) to (1.01), log (X) increases from (1) to 1.0063). By taking the anti-logs, one may say hat if (Y) increases from (10.0) to (10.23), quantity increases from (10) to (10.15) other things being equal of course. This would imply a (1.5%) increase in quantity in response to a (2.3%) increase in income, and hence a (1%) increase in income would be associated with a (0.65%) increase in quantity (i.e. 1.5/2.3). This is slightly different from (0.63%).

Similarly, and as regards the same equation (10), a (1%) *fall* in log price is associated with an *expansion* of log quantity of (0.54%). That amounts to that : if (P) falls from (10.0) to (9.772) (a change of — 2.28%), (X) expands from (10.0) to (10.13) (an expansion of 1.3%). Therefore a (1%) fall in (P) would be associated with an expansion in (X) by (0.57%) (i.e. 1.3/2.28, and the result will be negative because of the opposite association between P and X).

The broad conclusion drawn is hat both price and income elastici ties are *less* than unity. Imports may be elastic to oher variables. Some of these variables may be bank loans and other financial facilities extended o the importers, liquid assets, consumer tastes, coditions in the markets for re-exposts ... etc. This is an interesting field of research and the present study should be followed by other investigations in order to answer questions the present paper is not devoted to them.

IV Construction of Statistical data

1. Quantity and price indices :

Data published provide information on he quantity of imports (Kg) classified under (9) classifications : Food & Live animals ; Beverages and tobacoo ; Crude materials inedible except fules ; Mineral Fuels ... etc. ; Animal & vegetable oils and fats ; Chemicals ; Manufactured goods classified chiefly by material ; Machinery and transport equipment ; and Miscellaneous manufactured articles. The value of the imports is also given. This is published monthly for the previous nine categories. Published data goes back as far as July 1965. We have collected series : quantity and value, on quarterly basis. By dividing value by quantity we obtained the average price of a unit of quantity. Denoting this average price by (P) and, average quantity by we have calculated the average (P) over all quarters of 1966 (as a base year) as well as the total quantity imported in 1966. This has been carried out for each of the nine categories. We have therefore expressed the quantity of imports in terms of the base year average price and sumed over the (9) categories, obtaining Similarly, we have expressed the avarage quantity in the base year in terms of the price of the compared period, and sumed over the (9) categories, obtaining $\Sigma P_1 q_0$. Since the total value of imports is $\Sigma P_1 q_0$, clearly we have been able to calculate the «Paesche» price and quantity indices, based on average 1966 = 100%. These indices are given, on quarterly basis, in the appendix.

2. Income index :

Data on «Net national product» is published in the yearly «Statisical abstract». Yearly net national product is given for year ending March 31. We have allocated yearly among quarters in the following manner.

(a) Data on total production of curde oil (the most important factor affecting national product in Kuwait) for he year ending March 31, have been collected. Such daa is also available on quarterly basis.

(b) Data on «Oil Receipts» for the year ending March 31, have also been collected.

(c) Dividing (b) / (a) we obtained the average receipt per unit of crude oil production (Barrel).

(d) By multiplying he quarterly production of crude oil by the average receipt per unit of production resulted in (c), we obtained quarterly estimates of oil receipts. The annual otal of these estimate, for the year ending March 31, was very near to the published figures on annual basis.

(e) We have found a correlation coefficient of 0.95 between quarterly «average» of net national product (i.e. net national product for year ending march 31 4) and quarterly «average» of oil receipts (i.e. dat in (b) above 4). The period considered covers the years 1962/63 to 1972/73 inclusive.

(f) We are now able to allocate the annual data as regards net national product among quarters of each year for the period from the second quarter 1965 o the first quarter 1974. For, on the basis of correlation found in (e) we have calculated a regression equation in which the quarterly «average» of net national product appears as the dependent variable while the quarterly «average» of oil receipts appears as the independent variable. By substituting the quarterly «estimates» of oil receipts (from (d) above) in regression, we obtained «estimates» of net national product on quarterly basis. As a last step, we adjusted the estimated series so as o add up to yearly net national product for year ending March 31, for each year for the period 1965/66 to 1973/74. Data for this final step is given in table (III). This table shows how accurae is the total annual estimate of net national product as compared with the published annual net national product, both series for the year ending March 31.

Income was deflated by (P) index so as to be expressed in real terms. Finally we expressed series as percenages based on average series for 1966 = 100 %.

3. Permanent income

We have estimated this series as a weighted moving average of quarterly series of income of the current quarter and income of the last three quarters. The weights are based on an arbitary weighting system. Starting from the current quarter, the weights decline exponentially. The formula is given as follows (in real erms) ;

$$Y_{tev} = Y_t^{0.4} \cdot Y_{t-1}^{0.2} \cdot Y_{t-2}^{0.2} \cdot Y_{t-1}^{0.2}$$

This series is given in table (II) for each (t), expressed as an index.

4. Permanent price.

Likewise, this series was calculated according to the formula

$$P_{tev} = P_t^{0.4} \cdot P_{t-2}^{0.2} \cdot P_{t-2}^{0.2} \cdot P_{t-3}^{0.1}$$

This series, expressed an index, is also given in table (II) for each (t).

5. Stock index

We have made use of data on ΣP_1 and on ΣP_1 calculated in (1) above. For period (t), we have assumed that ;

$$(0.3)\, Q_{t-1} + (0.2)\, Q_{t-2} + (0.1)\, Q_{t-3}$$

remain in stock.

In order to express this in terms of index, we have applied this weighting system to both and for periods (t-1), (t-2) and (t-3), and we have calculated :

$$\sum_{t-1}^{t-3} \Sigma\, p\, Q \Bigg/ \sum_{t-1}^{t-3} \Sigma\, p\, Q$$

and expressed the result in percentage terms. This series is also given in table II.

Statistical Appendix

TABLE 1

		P	Y	X			P	Y	X
1965	iii	94.7	91.8	80.9	1970	i	119.3	106.9	108.0
	iv	95.6	96.4	91.1		ii	116.2	119.3	111.6
1966	i	94.1	99.0	102.9		iii	109.1	131.1	117.6
	ii	100.4	97.7	102.3		iv	121.6	111.5	122.3
	iii	101.5	99.0	90.2	1971	i	115.9	123.3	120.9
	iv	104.0	104.3	104.6		ii	103.5	173.1	134.0
1967	i	91.8	124.6	132.6		iii	116.3	150.8	99.9
	ii	91.5	111.5	157.5		iv	117.3	149.5	132.5
	iii	98.3	117.4	123.2	1972	i	125.2	147.5	121.2
	iv	93.6	131.1	142.4		ii	122.0	153.4	128.1
1968	i	102.1	110.8	135.0		iii	121.7	166.6	113.3
	ii	96.7	119.3	148.1		iv	121.9	167.9	146.0
	iii	110.4	114.8	105.0	1973	i	131.6	150.2	115.5
	iv	105.9	123.3	129.4		ii	135.0	171.1	133.7
1969	i	98.1	120.0	128.9		iii	138.8	198.7	120.3
	ii	101.2	128.5	143.2		iv	145.2	159.3	149.8
	iii	91.8	138.4	155.4	1974	i	162.2	144.9	134.7
	iv	117.7	114.8	116.6					

TABLE 2

		Pex	Yex	K			Pex	Yex	K
1966	ii	96.9	97.2	93.3	1971	i	116.2	120.4	116.9
	iii	99.1	98.3	98.9		ii	111.2	139.3	118.7
	iv	101.5	100.8	94.6		iii	112.7	146.4	125.0
1967	i	98.1	110.1	97.8		iv	114.0	151.4	111.5
	ii	95.0	112.4	113.0	1972	i	118.7	151.1	118.9
	iii	95.4	115.6	136.4		ii	121.4	150.5	118.9
	iv	94.4	122.2	132.9		iii	122.0	157.0	124.2
1968	i	97.6	118.0	135.6		iv	122.2	162.4	117.4
	ii	97.8	118.7	133.0	1973	i	125.6	158.9	129.5
	iii	102.8	116.9	139.9		ii	129.9	163.5	122.1
	iv	104.9	118.6	120.3		iii	134.5	176.6	126.7
1969	i	102.7	119.9	121.1		iv	139.8	171.7	121.5
	ii	102.1	123.5	122.4	1974	i	149.3	161.4	134.7
	iii	97.1	130.0	133.9					
	iv	104.1	124.7	144.0					
1970	i	110.9	117.1	129.4					
	ii	114.5	116.2	115.1					
	iii	114.0	120.7	109.2					
	iv	116.4	118.1	111.7					

TABLE 3

	65/66	66/67	67/68	68/69
ii	153	150	158	155
iii	145	153	178	170
iv	153	165	190	175
i	155	175	175	158
Total estimated net national Product (Million KD)	606	643	701	658
Published net national Product (Million KD.)	557	642	692	748

	69/70	70/71	71/72	72/73	73/74
ii	183	200	230	340	420
iii	195	190	230	343	353
iv	183	200	243	333	358
i	749	783	938	1331	1484
Total estimated net National Product.	188	193	235	315	353
Published net National Product.	792	854	1091	N.A.	N.A.

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