

An Empirical Study of The Demand of Imported Ceylonese Tea

Kun Young Chung*

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I. INTRODUCTION

This paper is an empirical study to find the demand function of the most suitable model for forecasting of the demand in a business through economic theory and regression analysis.

This case study for imported Ceylonese tea demand from 1947 to 1968 in time series data, presents what is the most suitable model for relation between quantity of imported Ceylonese tea (dependent variable), and several other independent variables, like import price of Ceylonese tea (P_{CV}), import price of Brazilian coffee (P_{BZ}), U.S. disposable income (Y_D) and import price of Indian tea (P_1).

For the empirical test for the demand of the Ceylonese tea, the regression models are used which are linear models and log linear models in nature, so that we can search for the suitable and appropriate model for the explanation of the demand function.

II. THEORY

1. Description of the Variables.

Dependent variable

$C_2=C$: Demand of imported Ceylonese tea

* Lecturer, Kei Myung University

Independent variables

$C_3 = P_{CY}$: Import price of Ceylonese tea

$C_4 = P_{BZ}$: Import price of Brazilian coffee

$C_5 = Y_D$: U. S. disposable income (Billions \$)

$C_7 = P_I$: Import price of Indian tea

2. Hypothesis and Expected Signs in the Independent Variables

P_{CY} : In this study, economic theory suggests that there should be an inverse relation between the price of the Ceylonese tea and demand of the Ceylonese tea. Thus, the expected sign of P_{CY} is negative.

P_{BZ} : Brazilian coffee is substituted for the Ceylonese tea. So economic theory suggests that, there should be an existing relationship between the price of the Brazilian tea and the demand of the Ceylonese tea. Thus, the expected sign of the P_{BZ} is positive.

Y_D : Here, one could hypothesize that there should be an existing relationship between U. S. disposable income and the demand of the Ceylonese tea. Thus, expected sign of Y_D is positive.

P_I : One salient aspect of the demand for Ceylonese tea in U. S. is the strong competition from other tea growing countries of the world. In particular, Indian tea has influence on the demand for Ceylonese tea, as other close substitute. Thus, the expected sign is also positive.

Therefore, we have demand function

$$\text{Demand function: } C = f(P_{CY}, P_{BZ}, Y_D, P_I)$$

The volume of demand of Ceylonese tea (C) is a function of P_{CY} , P_{BZ} , Y_D and P_I . The model predicts that the volume of demand is negatively related P_{CY} and positively correlated with the P_{BZ} , Y_D , P_I .

3. Linear Model

$$C = 47.5690 - 138.236 P_{CY} + 15.9400 P_{BZ} + 0.0244732 Y_D + 95.3399 P_I$$

$$R^2 = .64813$$

T-statistic

$$C = 1.84351$$

$$P_{CY} = -1.63563$$

$$P_{BZ} = 1.16566$$

$$Y_D = 1.14713$$

$$P_I = 1.98269$$

Durbin-Watson statistic = 2.37359

4. Log Linear Model

$$\log C = 2.51037 - 1.49538 \log P_{CY} + 0.183262 \log P_{BZ} \\ + 1.23510 \log P_I + 0.203216 \log Y_D$$

$$R^2 = .63824$$

T-statistic

$$C = 2.51001$$

$$P_{CY} = -1.30624$$

$$P_{BZ} = 1.29879$$

$$Y_D = .957208$$

$$P_I = 1.72341$$

Durbin-Watson statistic = 2.41435

5. Selection of the Model

In comparing the linear model and log linear model, we choose linear model because of the following reasons. In linear model, $R^2 = .64813$ which is higher than $R^2 = .63824$ in log linear model. Also T-Statistic for explanatory variables in linear model is more preferable to T-Statistic in log linear. Our economic statistic suggests that higher R^2 and T-Statistic is more significant.

Furthermore, by comparing Durbin-Watson Statistic (D.W.), we visualize that D.W. for linear model is more acceptable. Hence, we are inclined to choose linear model rather than log linear model for the above cited reasons.

III. INTERPRETATION OF THE RESULTS

$$C = 47.5690 - 138.236 P_{CY} + 15.9400 P_{BZ} + 0.0244732 Y_D + 95.3399 P_I \\ (25.8035) \quad (84.5155) \quad (13.6746) \quad (0.0213343) \quad (48.0860)$$

1. Multicollinearity

By looking at the correlation coefficient matrix (see appendix, computer printout #1), we can say that there are a multicollinearity between U.S. disposable income (C5=Y_D) and consumer price index of food commodities(=C6) because of $r_{c_5, c_6}=.970$, year(=C1) and C5 (=Y_D) because of $r_{c_1, c_5}=.976$, C1 and C6 because of $r_{c_1, c_6}=.957$. Therefore, we have dropped year (=C1) and consumer price index of food commodities (=C6) as a explanatory variable in the above model.

2. Autocorrelation

By Durbin-watson test we found that there is no autocorrelation because of the following tests.

Rule:

If $\left\{ \begin{array}{l} D \geq 1.80 = d_U, \text{ conclude } \rho = 0 \\ \qquad \qquad \qquad \text{means no autocorrelation.} \\ D \leq 0.96 = d_L, \text{ conclude } \rho > 0 \\ \qquad \qquad \qquad \text{means positively autocorrelated.} \\ d_L \leq D \leq d_U, \text{ at } \alpha = 0.05, \text{ the test is inconclusive.} \end{array} \right.$

* $\left\{ \begin{array}{l} n = 22 \quad d_U = 1.80 \\ p - 1 = 4 \quad d_L = 0.96 \end{array} \right\}$

D = 2.37359 from computer printout #2 (see appendix)

Thus, we conclude that $\rho = 0$, means no autocorrelation.

3. Verification of Signs

$\left. \begin{array}{l} P_{CY} = - \\ P_{BZ} = + \\ Y_D = + \\ P_I = + \end{array} \right\} \text{ from theory, } \left. \begin{array}{l} P_{CY} = - \\ P_{BZ} = + \\ Y_D = + \\ P_I = + \end{array} \right\} \text{ from results}$

Thus, we can say signs of explanatory variables are consistent.

* See John Neter and William Wasserman, Applied Linear Statistical Models, p.816 (tableA-6).

4. Test of Significance:

According to T-Statistic, we found the following.

$$\left. \begin{array}{l} H_0: \beta=0 \\ H_1: \beta \neq 0 \end{array} \right\} \alpha=0.1$$

Rule: if $|t^*| = \left| \frac{b-\beta}{s(b)} \right| \geq t(1-\frac{\alpha}{2}, n-p)$ reject H_0 , otherwise accept H_0 .

i) Test for $P_{CY} = |t^*| = 1.63563 \leq t(0.95, 17) = 1.740$ accept H_0 .

ii) Test for $P_{BZ} = |t^*| = 1.16566 \leq t = 1.740$ accept H_0 .

iii) Test for $Y_D = |t^*| = 1.14713 \leq t = 1.740$ accept H_0 .

iv) Test for $P_I = |t^*| = 1.98269 \geq t = 1.740$ reject H_0 .

Thus, we can say there is a significant relationship between dependent variable (C) and explanatory variable (P_I) at $\alpha=0.1$ significant level.

IV. CONCLUION

We observed that linear model is better than log linear model for estimation purposes. The result of imported Ceylonese tea equation showed that there is no multicollinearity, and autocorrelation. And the signs of coefficients are consistent as predicted by theory. Also one explanatory variable (P_I) is significant, others are not significant, which means the demand of imported Ceylonese tea is significantly related with the import price of Indian tea. Price of Indian tea significantly influences the demand of [the Ceylonese tea rather than the price of Brazilian coffee. This implies substitutes [of the same category will affect significantly the demand equation [rather than substitutes of the different category because Indian tea and Ceylonese tea fall under the same category as substitutes rather than Brazilian coffee.

In short, based on the results of this limited study of the demand of imported Ceylonese tea, we conclude the theory is empirically confirmed, and present the demand function of the most suitable model for forecasting of the demand.

References

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 2. John Neter and William Wasserman; Applied Linear Statistical Models, Richard D. Irwin, Inc., 1974.
 3. Lawrence R. Klein; An Introduction to Econometrics, Prentice-Hall of India, Ltd., 1965.
 4. James R. Mcguigan and R. Charles Mayer; Managerial Economics, West Publishing Company, 1979.
 5. R. Charles Mayer, James R. Mcguigan and George W. Trivoli; Managerial Economics: Reading, Cases and Exercises. Westing Publishing Company, 1979.
- Data Source: U.S. Department of Commerce, United States Imports of Merchandise for Consumption, Commodity by Country of Origin, Bureau of the Census. Disposable income and price of food commodities are taken from the Economic Report of the President.

APPENDIX

Computer Printout #1 (used Minitab Language)

PRINT C1, C2, C3, C4, C5, C6, C7

COLUMN	C1	C2	C3	C4	C5	C6	C7
COUNT	22	22	22	22	22	22	22
ROW							
1	1947.00	19.8900	.453000	.225000	169,800	81,300	.389000
2	1948.00	45.0800	.514000	.230000	189,100	88,200	.528000
3	1949.00	31.7000	.522000	.254000	188,600	84,700	.514000
4	1950.00	44.5600	.484000	.450000	206,900	85,800	.490000
5	1951.00	31.1200	.480000	.494000	226,600	95,400	.491000
6	1952.00	41.3700	.444000	.501000	238,300	97,100	.420000
7	1953.00	45.9400	.473000	.529000	252,600	95,600	.424000
8	1954.00	39.8000	.576000	.648000	257,400	95,400	.565000
9	1955.00	38.8900	.580000	.478000	275,300	94,000	.678000
10	1956.00	41.9000	.523000	.461000	293,200	94,700	.532000
11	1957.00	46.0400	.492000	.449000	308,500	97,800	.556000
12	1958.00	39.4300	.480000	.412000	381,800	101,900	.517000
13	1959.00	43.5400	.496000	.322000	337,300	100,300	.536000
14	1960.00	48.3200	.513000	.326000	350,000	101,400	.563000
15	1961.00	44.3100	.507000	.322000	364,400	102,600	.575000
16	1962.00	51.5000	.471000	.301000	385,300	103,600	.547000
17	1963.00	53.4900	.463000	.297000	404,600	105,100	.553000
18	1964.00	58.9400	.455000	.396000	438,100	106,000	.542000
19	1965.00	53.2900	.468000	.399000	473,200	108,800	.543000
20	1966.00	53.5400	.450000	.368000	511,600	114,200	.530000
21	1967.00	56.0500	.439000	.347000	546,300	115,200	.510000
22	1968.00	49.9100	.417000	.336000	589,000	119,200	.471000

--CORELATION OF C1-C7

	C1	C2	C3	C4	C5	C6
C2	.794					
C3	-.422	-.327				
C4	-.116	-.009	.318			
C5	.976	.745	-.514	-.142		
C6	.957	.760	-.499	-.017	.970	
C7	.311	.317	.638	.078	.195	.184

Computer Printout #2 (used TSP Language)

UNIVERSITY OF WISCONSIN-UNIVAC 1110-VERSION 1.19.77 ★★TSP★★ DATE 06/25/80
INSTRUCTION 0

PROGRAM

★★

CARD INSTRUCTION

```

1      1      LOAD
2      2      YEAR 1947=1
3      3      SAMPLE YEAR 1947 1968
4      4      GENR C=1.0
5      5      GENR LTEA=LOG(TEA)
6      6      GENR LPCY=LOG(PCY)
7      7      GENR LPBZ=LOG(PBZ)
8      8      GENR LYD=LOG(YD)
9      9      GENR LPI=LOG(PI)
10     10     PRINT TEA PCY PBZ YD PI
11     11     SAMPLE YEAR 1947 1968
12     12     OLSQ TEA C PCY PBZ YD PI
13     13     OLSQ LTEA C LPCY LPBZ LYD LPI
14     14     END
    
```

UNIVERSITY OF WISCONSIN-UNIVAC 1110-VERSION 1.19.77 ★★TSP★★ DATE 06/25/80
INSTRUCTION)

EXECUTION

★★

```

15     1      YEAR 1947=1
16     1      SAMPLE YEAR 1947 1968
        SAMPLE: 1. 22.
17     1      LOAD TEA
18     1      19.89 45.08 31.70 44.56 31.12 41.37 45.94 39.80 38.89 41.90 46.04 39.43 43.54
19     1      48.32 44.31 51.50 53.49 58.94 53.29 53.54 56.05 49.91
20     1      LOAD PCY
21     1      .453 .514 .522 .484 .480 .444 .473 .576 .580 .523 .492 .480 .496 .513 .507 .471
22     1      .463 .453 .468 .450 .439 .417
23     1      LOAD PBZ
24     1      .225 .230 .254 .450 .494 .501 .529 .648 .478 .461 .449 .412 .322 .326 .322 .301
25     1      .297 .396 .399 .368 .347 .336
26     1      LOAD YD
27     1      169.8 189.1 188.0 206.9 226.6 238.3 252.6 257.4 275.3 293.2 308.5 381.8 337.3
28     1      350.0 364.4 385.3 404.6 438.1 473.2 511.6 546.3 589.0
29     1      LOAD PI
30     1      .389 .528 .514 .490 .491 .420 .424 .565 .678 .532 .556 .517 .536 .563 .575 .547
31     1      .553 .542 .543 .530 .510 .471
32     1      END
    
```

SAMPLE: 1. 22.

	TEA	PCY	PBZ	YD	PI
1947	19.89000	.453000	.225000	169.8000	.389000
1948	45.08000	.514000	.230000	189.1000	.528000
1949	31.70000	.522000	.254000	188.6000	.514000
1950	44.56000	.484000	.450000	206.9000	.490000
1951	31.12000	.480000	.494000	226.6000	.491000
1952	41.37000	.444000	.501000	238.3000	.420000
1953	45.94000	.473000	.529000	252.6000	.424000
1954	39.80000	.576000	.648000	257.4000	.565000
1955	38.89000	.580000	.478000	275.3000	.678000
1956	41.90000	.523000	.461000	293.2000	.532000
1957	46.04000	.492000	.449000	308.5000	.556000
1958	39.43000	.480000	.412000	381.8000	.517000
1959	43.54000	.496000	.322000	337.3000	.536000
1960	48.32000	.513000	.326000	350.0000	.563000
1961	44.31000	.507000	.322000	364.4000	.575000
1962	51.50000	.471000	.301000	385.3000	.547000
1963	53.49000	.463000	.297000	404.6000	.553000
1964	58.94000	.453000	.396000	438.1000	.542000
1965	53.29000	.468000	.399000	473.2000	.543000
1966	53.54000	.450000	.368000	511.6000	.530000
1967	56.05000	.439000	.347000	546.3000	.510000
1968	49.91000	.417000	.336000	589.0000	.471000

UNIVERSITY OF WISCONSIN-UNVAC 1110-VERSION 1.19.77 ★★TSP★★ DATA 06/25/

80 INSTRUCTION 12

EQUATION 1.

★★★★★

ORDINARY LEAST SQUARES

DEPENDENT VARIABLE

TEA

RIGHT-HAND VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
C	47.5690	25.8035	18.4351
PCY	-138.236	84.5155	-1.63563
PBZ	15.9400	13.6746	1.16566
YD	.244732--01	.213343--01	1.14713
PI	95.3399	48.0860	1.98269

R-SQUARED=.64813

STANDARD ERROR OF THE REGRESSION=5.97474

MEAN VALUE OF DEPENDENT VARIABLE=44.4823

SUM OF RESIDUALS=.209808--04

SUM OF SQUARED RESIDUAS=606,857

DURBIN-WATSON STATISTIC(ADJ. FOR 0. GAPS)=2.37359

NUMBER OF OBSERVATIONS=22.

ESTIMATE OF VARIANCE-COVARIANCE MATRIX OF ESTIMATED COEFFICIENTS

	1	2	3	4	5
1	665.821	-1924.52	73.6072	-.437985	748.037
2	-1924.52	7142.86	-468.356	1.53787	-3611.16
3	73.6072	-468.356	186.995	-.784306--01	206.787
4	-.437985	1.53787	-.784306--01	.455152--03	-.828732
5	748.037	-3611.16	206.787	-.828732	2312.27

UNIVERSITY OF WISCONSIN-UNIVAC 1110-VERSION 1.19.77 ★★★TSP★★★ DATE 06/2

5/80 INSTRUCTION 13

EQUATION 2.

★★★★★

ORDINARY LEAST SQUARES

DEPENDENT VARIABLE...

LTEA

RIGHT-HAND VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
C	2.51037	1.00014	2.51001
LPCY	-1.49538	1.14480	-1.30624
LPBZ	.183262	.141102	1.29879
LYD	.203216	.212301	.957208
LPI	1.23510	.716659	1.72341

R-SQUARED=.63824

STANDARD ERROR OF THE REGRESSION=.160402

MEAN VALUE OF DEPENDENT VARIABLE=3.77075

SUM OF RESIDUALS=.214577-05

SUN OF SQUAREA RESIDUALS=.437389

DURBIN WATSON STATISTIC (ADJ. FOR 0. GAPs)=2.41435

NUMBER OF OBSERVATIONS=22.

ESTIMATE OF VVRIANCE COVARIANCE MATRIX OF ESTIMATED COEFFICIENTS

	1	2	3	4	5
1	1.00029	-.832097	.571774-01	-.201576	.586510
2	-.832097	1.31057	-.690647-01	.213310	-.739082
3	.571774-01	-.690647-01	.199099-01	-.112368-01	.349681-01
4	-.201576	.213310	-.112368-01	.450716-01	-.130288
5	.586510	-.739082	.349681-01	-.130288	.513600

<要約>

輸入 Ceylonese tea의 需要에 관한 實證的 研究

鄭 建 永

<啓明大學校·經營大學>

本稿의 目的은 企業의 需要 豫測을 위한 最適 model의 demand function을 經濟理論과 Regression Analysis에 의해서 發見하려는 것이다.

本 研究은 1947年에서 1968年에 걸친 輸入 Ceylonese tea의 需要에 관한 time series data를 Computer로 처리하여 얻은 몇 가지 model을 統計的 分析方法에 의하여 最適 model을 선택한 後 이를 分析 評價하였다.

Computer Printout #1(see appendix)에서 Correlation Coefficient matrix를 보면 媒介變數 C_1 (year)과 C_5 (=YD, U. S. disposable income), C_6 (Consumer price index of food Commodities) 그리고 C_5 와 C_6 가 multicollinearity를 이루고 있다. 그러므로 demand function에서 媒介變數 C_1 과 C_6 를 제외한 Regression model을 設定함으로써 multicollinearity를 제거하였다. Time series data에서 문제되는 autocorrelation은 Computer printout #2(see appendix)에서 얻은 linear model이 Durbin-Watson test에서 Autocorrelation되지 않았음을 증명하였다.

Demand function에서 經濟理論에 근거하여 設定한 媒介變數 豫想 signs이 hypothesis와 Consistence함도 實證的으로 증명하였다. 그리고 媒介變數의 significance test에서 hypothesis가 $\alpha=0.1$ significance level에서 t test를 통과한 것은 P_I (import price of Indian tea)가 유일하다. 따라서 輸入 Ceylonese tea의 需要는 輸入 Indian tea의 價格에 positive하게 영향을 받고 있음을 實證的으로 立證하고 需要 豫測을 위한 demand function이 P_{CY} 와 P_I 에 의하여 設定될 수 있음을 나타내었다. 그리고 price of Indian tea가 price of Bragilian Coffee보다 Ceylonese tea의 需要에 크게 영향을 미치고 있음을 나타내었다. 이것은 Indian tea가 Ceylonese tea가 同種代替財에 속한 반면 Bragilian Coffee와 Ceylonese tea가 異種代替財에 속하고 있기 때문에 同種代替財가 異種代替財보다 demand equation에 크게 영향을 미치고 있음을 의미한다. 以上の 輸入 Ceylonese tea의 需要에 관한 制限된 研究結果가 提示된 理論을 實證的으로 立證하고 需要 豫測을 위한 最適 model의 demand function 設定을 提示하였다.