AN ECONOMETRIC MODELLING ANALYSIS:

THE CHESAPEAKE AND POTOMAC TELEPHONE COMPANY OF MARYLAND

A Study Of The Demand For

Local Coin Telephone Service

In Maryland

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I. INTRODUCTION

In August of 1984, the Chesapeake and Potomac (C&P) Telephone Company of Maryland presented testimony to the Federal Communications Commission (FCC) concerning a proposed public telephone rate increase. The purpose of this testimony was to present the econometric demand model developed by C&P to indicate the decrease in test period local coin usage which would have occurred as a result of the twenty-five cent rate proposed at that time. C&P's corporate strategy was that by illustrating that local coin telephone use would decrease as a result of a rate increase, thus, decreasing total revenues and rate of return from local coin use, that it may justifiably ask for compensation through rate increases in other corporate divisions such as Centrex, local service, customer assistance, etc. History has shown that the number of local coin telephone calls decreases after rate increases are implemented, as in both 1977 and 1983, when local rates increased from ten to fifteen cents, and from fifteen to twenty cents, respectively. C&P felt strongly that, as before, the proposed twenty-five cent local rate would decrease the number of local coin telephone calls.

C&P felt that the following factors affected the demand for local coin telephone service: 1) the price of a local coin call, 2) the prices of other goods and services, 3) the Gross State Product, and 4) seasonality. This report details the local coin econometric demand model used by C&P to present its case, and closely examines the statistical testing used to assess the validity of this model. Finally, recommendations are presented to improve the model.

II. DESCRIPTION

The Local Coin Telephone Service Model was constructed using quarterly data from the first quarter of 1968 through the first quarter of 1984 (n=65). The functional form of the model was multiplicative, however, by computing the natural logarithm of the demand equation, the estimated linear regression equation was developed as follows:

$$\ln(Q_t) = 16.202 - .41625 \ln(P/C)_t + .46903 \ln(G_t) - .15759\ 1Q80 - .037842\ S_{1t} + .0061563\ S_{2t} - .10878\ S_{3t}. \quad (k=7)$$

Where,

Q_t is the quantity demanded of Local Coin Telephone Service,

P_t is the nominal price of Local Coin Telephone Service,

C_t is the Gross National Product - Implicit Price Deflator Index,

1Q80 is a binary variable used to adjust for an inexplicable decline in revenue during the first quarter of 1980,

S_{1t}, S_{2t}, S_{3t} are binary variables used to account for seasonality in the data.

The variable, Q_t, was constructed by dividing local coin revenue by the price of a local coin call. For a given quarter t,

# of Local Coin Messages = (Revenue / Price).

Figures were based on Company reports of revenues and rates. P_t, the nominal price for local coin calls, was also obtained from Company records and rates. C_t, an index which measures broad price movement in the economy, was obtained from the U. S. Department Of Commerce. $(P/C)_t$, the real local coin price, was constructed by dividing local coin price (P) by the GNP deflator index (C). For a given quarter t,

Real Local Coin Price = $(P/C)_t$.

The variable, G_t, is an index of the real output of final goods and services produced in Maryland. This index was constructed by the C&P Corporate Economics staff. The binary variables, S_{1t}, S_{2t}, S_{3t} took on values of 1 during the first, second, and third quarters of the year, respectively. Otherwise, they took on values of 0.

The raw data used for regression analysis to compute the estimated coefficients of the demand model appears in Appendix A. The STATLAB software package was used to perform the regressions. Raw data representing Maryland Resident Population and Real Personal Income (Nominal Personal Income / Implicit Price Deflator) is used in the Analysis portion of this report.

III. RESULTS

Unless noted, the null hypothesis of each test statistic was examined at the 95 percent assurance limit. Tests were constructed to check for autocorrelation, multicollinearity, and stability. The following table represents C&P's statistical results:

Coefficients and Summary Statistics

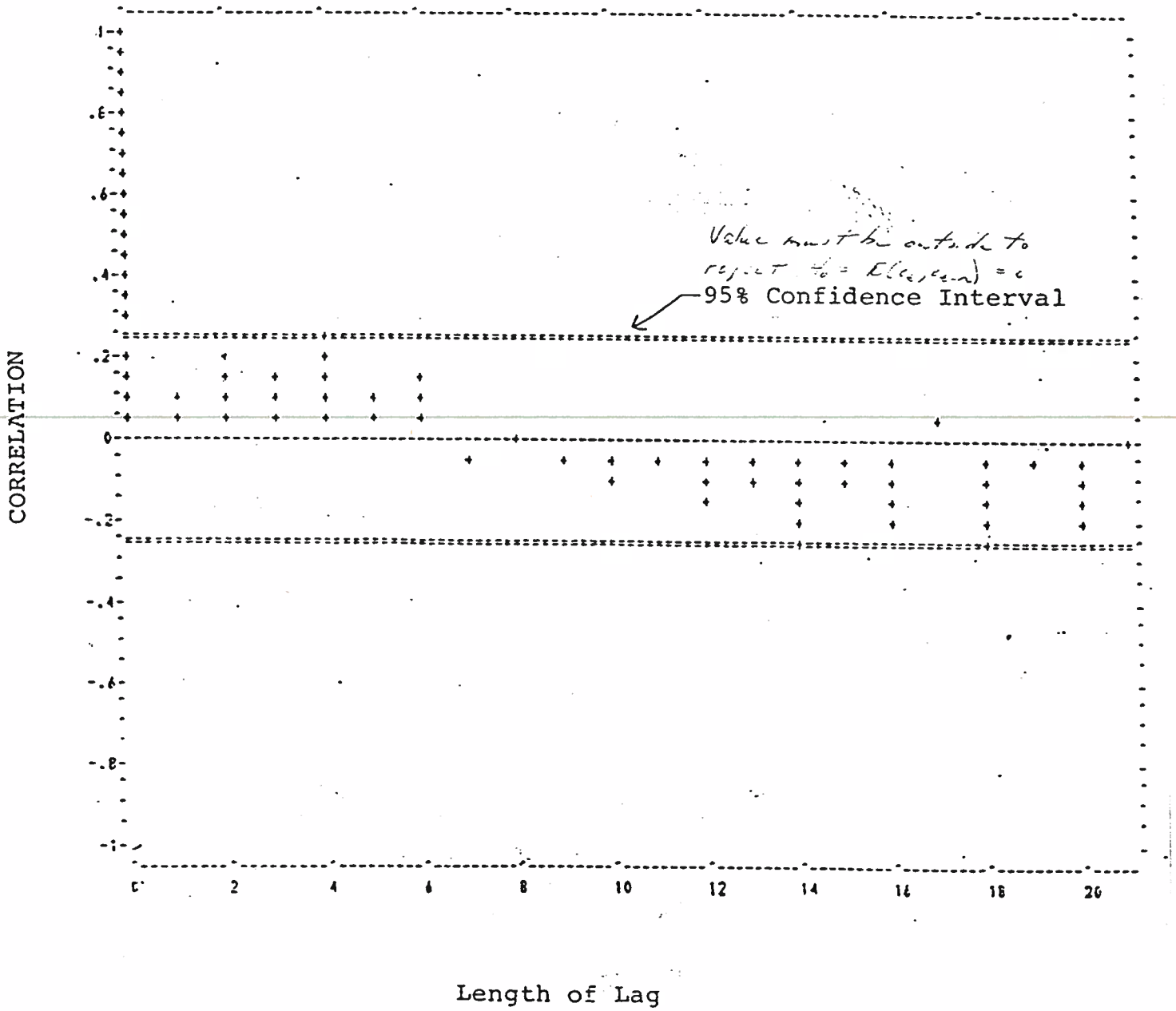
Variable	Coefficent	Standard Error	T-Statistic
Constant	16.202	.091687	176.7129
$\ln(P/C)_t$	-.41625	.042682	-9.7522
$\ln(G)_t$	.46903	.061463	7.6312
1Q80	-.15759	.038645	-4.0778
S_{1t}	-.037842	.013086	-2.8919
S_{2t}	.0061563	.013090	0.4703
S_{3t}	-.10878	.013083	-8.3151

R-Squared = 0.9150
Adjusted R-Squared = 0.9078
F Statistic (6,58) = 104.029
Incremental $F_{seasonality}$ (3,58) = 32.66
Standard Error of the Estimate = .036973

All of the T-statistics, except for S_{2t}, are significant, while the F statistic is much larger than the table value, suggesting a large statistical relationship between the demand for local coin usage and the independent variables used in the model.

Test for Presence of Autocorrelation

1. Durbin-Watson = 1.8
2. The correlogram of this model (shown below) indicates no evidence of autocorrelation.



Test for the Presence of Multicollinearity

1. The strength of the t-statistics shown in the Coefficients table indicates the absence of multicollinearity.

2. Correlation Matrix (Raw Data) :

	1	2	3	4	5	6
1. ln $(P/C)_t$	1.0					
2. ln $(G)_t$	-.71	1.0				
3. 1Q80	-.05	.14	1.0			
4. S_{1t}	-.01	-.01	.21	1.0		
5. S_{2t}	.04	.03	-.07	-.34	1.0	
6. S_{3t}	.01	.01	-.07	-.34	-.33	1.0

3. Correllation Matrix (Regression Coefficients) :

	1	2	3	4	5	6
1. ln $(P/C)_t$	1.0					
2. ln $(G)_t$	.7071	1.0				
3. 1Q80	-.0790	-.1588	1.0			
4. S_{1t}	-.0060	.0278	-.1751	1.0		
5. S_{2t}	-.0374	-.0006	-.0024	.5007	1.0	
6. S_{3t}	-.0361	-.0125	.0002	.5001	.5009	1.0

Test for Stability

1. The difference between the coefficients of each variable from the full time period and the coefficients from the reduced time periods are less than the standard errors of the coefficients. This indicates the stability of each variable's coefficient.

IV. Analysis

The econometric model described in section II was evaluated from the standpoint of both economic theory and statistical theory. This model is largely consistent with economic theory. However, there seems to be two important variables that were omitted from the model specification that should influence the demand for local coin telephone service. Another error that was identified concerned the measurement of the dependent variable; the number of local coin messages. These flaws are discussed below:

Omitted Variable Bias

Two variables -- population and the number of coin phone stations were excluded from the demand model. We feel these are theoretically important explanatory variables of the demand for local coin messages. The exclusion of population is inconsistent with the theoretical specification of a market demand curve. Since the market demand curve is simply the summation of the individual demand curves, this implies that the market demand for a good at a given price will also be sensitive to the number of consumers in the market. This exclusion ignores the fact that population is one of the key determinants of the quantity demanded of local coin calls.

Further, the number of coin stations serves as a proxy measure of access to, or availability of, coin stations. Theoretically, this variable would be expected to influence the number of local coin messages.

Dependent Variable Bias

In this model, local sent paid revenue was divided by the nominal price of a local call to derive the number of local coin messages. Local sent paid revenue includes overpayments by some callers who did not have correct change[1]. As such, this ratio overstates the actual number of local coin messages made at the nominal coin rate. This produces a bias estimate of the quantity of local coin messages. Bias in the dependent variable of an Ordinary Least Squares regression equation will result in biased estimates of the paramenters which describe the independent effect of each explanatory variable on the dependent variable[2]. Consequently, this leads to a bias estimated price elasticity of demand.

V. Alternative Specifications

In building and selecting the final econometric model, C&P Telephone considered several alternative models (see attachment I). These models were rejected for reasons such as variables with (1) statistically insignificant T- ratios; and coefficients with theoretically unexpected signs. Also the quality of the model was judged by the F- statistic and R squared statistic.

1 C+P Revenue Tracking Report

2 Managerial Economics Class Notes

Alternative I is a modification of the variable specification of the selected model, but also included is a lagged dependent variable. This variable was used to capture the effects of "Habit". Analysis of this model shows that habit is not a significant factor in local coin demand as evidenced by the low t- statistic.

Alternative II includes resident population in the demand equation. It appears that resident population adds nothing to the explanation of coin demand, as indicated by the F statistic of this model compared to the selected model. Additionally, it was noted that Resident Population is highly statistically related to Gross State Product.

Alternative III is a modification of the selected model's economic output variable. In this model, Real Personal Income was substituted for the Real Gross Product Index. While these results are similar to the selected model, it was rejected by the company based on a lower R squared and F statistics compared with the selected model.

VI Recommended Model Specification

We recommend that a new econometric model be developed to address the flaws identified in section IV. Although an attempt was made in Alternative Model II to include Resident Population in the demand equation, we feel an additional attempt should be made to obtain a per capita version of the selected model. Also, ideally, in this model there should be included a variable to measure the number of coin phone stations.

Additionally, this new model should have a correctly specified dependent variable. One method for properly calculating the number of local coin calls is to conduct a study of the amount of revenue collected from calls which were overpaid. Once that information is obtained, local sent paid revenue should be separated into its "overpaid" and "correctly paid" components. The former revenue figure should be divided by the average overpayment amount (currently 25¢), and the latter should be divided by the regular coin phone rate (currently 20¢). Adding the number of calls resulting from the two calculations would give a more accurate measure of the number of local coin messages that were made at the regular rate, including overpaid local calls.

ATTACHMENT I

Summary of Alternative Specifications

Alternative Model	Selected Model	I	II	III
Dependent Variable	Q_t	Q_t	Q_t	Q_t
Lagged Dependent Variable		.1255 (1.2480)		
$(P/C)_t$	-.4163 (9.7522)	-.3696 (-6.6535)	-.3550 (-7.2837)	-.4097 (-9.0997)
G_t	.4690 (7.6312)	.3914 (4.6774)	.0553 (0.2974)	
I_t= Real Personal Income				.3644 (7.2453)
P_t= Population			1.5285 (2.3456)	
1Q80	-.1576 (-4.0778)	-.1505 (-3.8458)	-.1385 (-3.6351)	-.1444 (-3.6645)
S_{1t}	-.0378 (-2.8919)	-.0505 (-2.8631)	-.0381 (-3.0205)	-.0371 (-2.7668)
S_{2t}	.0062 (0.4703)	-.0031 (-.2039)	.0062 (0.4946)	.0073 (0.5426)
S_{3t}	-.1088 (-8.3151)	-.1238 (-6.9918)	-.1091 (-8.6560)	-.1085 (-8.0883)
Constant	16.2020 (176.7129)	14.1760 (8.6845)	3.7322 (0.7019)	14.3800 (69.5106)
Summary Statistics	R^2=0.9150 F=104.029 DW=1.80	R^2=0.9119 F=82.758 DW=2.17	R^2=0.9225 F=96.874 DW=1.94	R^2=0.9106 F=98.414 DW=1.66
Functional Form	Multiplicative	Multiplicative	Multiplicative	Multiplicative
Sample Period	1968:1- 1984:1	1968:2- 1984:1	1968:1- 1984:1	1968:1- 1984:1

The numbers in each block are the coefficient and its corresponding t-statistic (in parentheses) below the coefficient. An empty block indicates the absence of that particular variable from the model.

APPENDIX A

Local Coin Revenue

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	247204.	260611.	285518.	292145.	300882.	317489.	327771.	329341.	355950.	393801.	502237.	478283.	443990.
2	256862.	272335.	292313.	298267.	312765.	337706.	342776.	360899.	365006.	454754.	491443.	534263.	521491.
3	253672.	261703.	240244.	274903.	276846.	284083.	304324.	305239.	340833.	444119.	457069.	494486.	471740.
4	270491.	272808.	287658.	307080.	323103.	330512.	343533.	374642.	375644.	492041.	503503.	508802.	535618.
SUM	1028229.	1067456.	1105733.	1172395.	1213595.	1269790.	1318403.	1370121.	1437433.	1784715.	1954251.	2015833.	1972839.

	1981	1982	1983	1984
1	500958.	522738.	577514.	687985.
2	559125.	576184.	730182.	
3	486289.	503276.	669463.	
4	561464.	593399.	742996.	
SUM	2107837.	2195598.	2720154.	687985.

Local Coin Messages

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	247204.	260610.	285518.	292145.	300881.	317489.	327771.	329341.	355950.	393800.	334824.	318855.	295993.
2	256862.	272335.	292312.	298267.	312765.	337705.	342776.	360899.	365005.	349811.	327629.	356175.	347661.
3	253672.	261703.	240244.	274903.	276846.	284083.	304323.	305239.	340833.	296080.	304713.	329657.	314493.
4	270491.	272808.	287657.	307079.	323103.	330512.	343533.	374642.	375644.	328028.	335668.	339201.	357079.
SUM	1028229.	1067456.	1105733.	1172395.	1213595.	1269790.	1318403.	1370121.	1437433.	1367718.	1302834.	1343888.	1315226.

	1981	1982	1983	1984
1	333972.	348492.	330008.	343992.
2	372750.	384123.	365091.	
3	324193.	335518.	334731.	
4	374310.	395599.	371498.	
SUM	1405224.	1463732.	1401328.	343992.

Nominal Local Coin Price

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.150	0.150	0.150
2	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.130	0.150	0.150	0.150
3	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.150	0.150	0.150	0.150
4	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.150	0.150	0.150	0.150
SUM	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.530	0.600	0.600	0.600

	1981	1982	1983	1984
1	0.150	0.150	0.175	0.200
2	0.150	0.150	0.200	
3	0.150	0.150	0.200	
4	0.150	0.150	0.200	
SUM	0.600	0.600	0.775	0.200

Gross National Product - Implicit Price Deflator

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.8115	0.8497	0.8989	0.9440	0.9872	1.0295	1.1072	1.2288	1.3012	1.3680	1.4512	1.5860	1.7194
2	0.8214	0.8610	0.9107	0.9570	0.9942	1.0475	1.1348	1.2444	1.3130	1.3901	1.4889	1.6185	1.7646
3	0.8284	0.8749	0.9179	0.9652	1.0025	1.0653	1.1642	1.2668	1.3289	1.4103	1.5202	1.6512	1.8024
4	0.8399	0.8862	0.9303	0.9739	1.0154	1.0874	1.1979	1.2899	1.3499	1.4324	1.5538	1.6896	1.8513
SUM	3.3012	3.4718	3.6578	3.8401	3.9993	4.2297	4.6041	5.0299	5.2930	5.6008	6.0141	6.5363	7.1377

	1981	1982	1983	1984
1	1.8783	2.0335	2.1283	2.2060
2	1.9256	2.0815	2.1455	
3	1.9694	2.0803	2.1644	
4	2.0122	2.1600	2.1853	
SUM	7.8055	8.2753	8.6235	2.2060

Real Local Coin Price

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.12323	0.11769	0.11125	0.10593	0.10130	0.09713	0.09032	0.08138	0.07685	0.07310	0.10336	0.09458	0.08724
2	0.12174	0.11614	0.10981	0.10449	0.10058	0.09547	0.08812	0.08036	0.07616	0.09352	0.10075	0.09268	0.08501
3	0.12071	0.11430	0.10894	0.10361	0.09975	0.09387	0.08590	0.07894	0.07525	0.10636	0.09867	0.09084	0.08322
4	0.11906	0.11284	0.10749	0.10268	0.09848	0.09196	0.08348	0.07753	0.07408	0.10472	0.09654	0.08925	0.08102
SUM	0.48475	0.46097	0.43749	0.41671	0.40011	0.37843	0.34781	0.31820	0.30234	0.37770	0.39932	0.36735	0.33649

	1981	1982	1983	1984
1	0.07902	0.07376	0.08223	0.09066
2	0.07790	0.07276	0.09322	
3	0.07617	0.07210	0.09240	
4	0.07455	0.07143	0.09152	
SUM	0.30763	0.29006	0.35937	0.09066

Real Gross State Product Index

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	1.03200	1.09295	1.13310	1.13637	1.20085	1.28566	1.30467	1.28245	1.30780	1.34238	1.38211	1.44980	1.47118
2	1.03900	1.10813	1.12981	1.14670	1.21857	1.30626	1.29471	1.27586	1.32132	1.36749	1.40483	1.44967	1.44918
3	1.05791	1.11933	1.12780	1.16077	1.23308	1.31354	1.29417	1.28407	1.33991	1.37189	1.42827	1.44704	1.43102
4	1.06850	1.12616	1.12849	1.17497	1.25600	1.31420	1.29911	1.29208	1.33344	1.37942	1.44336	1.45378	1.44076
SUM	4.19740	4.44657	4.51920	4.61881	4.90851	5.21966	5.19266	5.13446	5.30247	5.46118	5.65857	5.80051	5.79212

	1981	1982	1983	1984
1	1.46469	1.43007	1.43900	1.52700
2	1.45711	1.42341	1.46100	
3	1.45292	1.41665	1.48100	
4	1.44272	1.42000	1.50000	
SUM	5.81744	5.69014	5.88100	1.52700

Maryland Resident Population

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	3829.50	3854.75	3921.25	4002.00	4066.50	4102.00	4127.00	4151.00	4168.25	4189.25	4207.75	4220.25	4224.50
2	3815.00	3868.00	3939.00	4023.00	4081.00	4109.00	4133.00	4157.00	4172.00	4195.00	4212.00	4223.00	4225.00
3	3828.25	3885.75	3960.00	4037.50	4068.00	4115.00	4139.00	4160.75	4177.75	4199.02	4214.75	4223.50	4233.50
4	3841.50	3903.50	3981.00	4052.00	4095.00	4121.00	4145.00	4164.50	4183.05	4203.50	4217.50	4224.00	4242.00
SUM	15314.25	15512.00	15801.25	16114.50	16330.50	16447.00	16544.00	16633.25	16701.05	16786.77	16852.00	16890.75	16925.00

	1981	1982	1983	1984
1	4250.50	4263.50	4294.25	4320.50
2	4256.00	4265.00	4304.00	
3	4260.50	4274.75	4309.50	
4	4262.00	4284.50	4315.00	
SUM	17032.00	17087.75	17222.75	4320.50

Nominal Personal Income

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	13386.	14874.	16408.	18014.	19609.	21662.	23768.	25804.	28298.	30486.	33792.	37905.	42389.
2	13875.	15328.	17126.	18310.	19864.	22127.	24352.	26199.	28800.	31188.	34900.	38558.	42987.
3	14195.	15798.	17203.	18545.	20399.	22753.	24978.	26901.	29453.	31947.	35969.	39941.	44271.
4	14559.	16192.	17345.	18760.	20988.	23282.	25628.	27679.	29947.	32783.	37157.	41032.	45867.
SUM	56015.	62192.	68082.	73629.	80860.	89824.	98726.	106583.	116498.	126604.	141818.	157436.	175514.

	1981	1982	1983	1984
1	47287.	50651.	53833.	59295.
2	48243.	51790.	55330.	
3	50169.	52569.	56817.	
4	50619.	53962.	57754.	
SUM	196318.	208972.	223734.	59295.

Implicit Price Deflator
for Personal Comsumption Expenditures

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	83.4	86.8	91.1	95.0	98.8	102.8	112.1	122.5	129.4	136.5	144.4	157.0	172.7
2	84.2	87.9	92.0	96.1	99.5	104.8	115.0	124.0	130.6	138.3	147.7	160.5	176.9
3	85.0	88.9	92.9	97.0	100.4	106.6	117.8	126.3	132.4	140.3	150.5	164.2	181.1
4	85.9	90.0	94.1	97.7	101.3	108.8	120.8	128.2	134.4	142.2	153.5	168.1	185.3
SUM	338.5	353.6	370.1	385.8	400.0	423.0	465.7	501.0	526.8	557.3	596.1	649.8	716.0

	1981	1982	1983	1984
1	189.1	201.7	210.1	218.1
2	192.3	203.6	212.5	
3	195.9	206.9	214.7	
4	199.2	209.0	216.1	
SUM	776.5	821.2	853.4	218.1

Real Personal Income

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	160.504	171.359	180.110	189.621	198.472	210.720	212.025	210.645	218.686	223.341	234.017	241.433	245.449
2	164.786	174.380	186.152	190.531	199.638	211.135	211.757	211.282	220.521	225.510	236.290	240.237	243.002
3	167.000	177.705	185.178	191.186	203.177	213.443	212.037	212.993	222.455	227.705	238.997	243.246	244.458
4	169.488	179.911	184.325	192.016	207.187	213.989	212.152	215.905	222.820	231.948	242.065	244.093	247.528
SUM	661.778	703.356	735.765	763.354	808.474	849.287	847.971	850.825	884.482	908.503	951.368	969.009	980.435

	1981	1982	1983	1984
1	250.063	251.120	256.226	271.871
2	250.874	254.371	260.376	
3	256.095	254.079	264.634	
4	254.111	258.191	267.256	
SUM	1011.143	1017.762	1048.492	271.871