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AN EMPIRICAL ANALYSIS OF PREDICTORS OF INCOME DISTRIBUTION EFFECTS OF WATER QUALITY CONTROLS

by

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ABSTRACT

The imposition of water quality controls has been both criticized and praised for its distributional impacts in the popular literature. Few, if any, empirical measures of the distributional impact have been attempted. This research had two objectives: first, to analyze methodologies of measuring income distribution changes, and, second, to select appropriate methodology and empirically test for the impacts of water quality controls.

The lognormal, displaced lognormal, gamma, and beta distribution functions were considered as appropriate methodologies, since each allows a more unique measurement of income distribution than do the Gini, Pietra, and Theil Entropy indices. Income distribution data were collected from all Standard Metropolitan Statistical Areas in the United States, and parameters of each of the functions were estimated. The Gastwirth upper and lower bound test for Gini coefficients was applied as a "goodness of fit" measure and the beta function was clearly superior to the other forms.

Next, a simultaneous equation econometric model was constructed, using a factor-share approach for wage and price changes. Water quality controls were introduced in the model through effects on wages and mean family income, and the latter variables were included in equations estimating the two parameters of the beta distribution function. Water quality data were collected for all states, and indices of quality were estimated using analysis of variance techniques. These indices did not differ significantly between states, but did differ between the census years 1960 and 1970, so a first difference model was constructed. Since this model theoretically conformed with the derivatives of the initial conceptual model, no conceptual problem was encountered. Regressions were run for a total of 172 SMSA's, adjusted so that new SMSA's or combined SMSA's from the 1960 data in the 1970 data were deleted from the study.

Regression results were inconclusive. When water quality variables were significant in the price equation, the coefficients for industrial controls were positive while those of agricultural controls were negative. For the wage equation the coefficients had the opposite signs. The quality variable was not consistently significant in the wage equations; however, both price and wage variables were significant in most of the equations estimating the beta distribution parameters. Price variables appeared to have the effect of making income distribution more equal, while wage variables had the opposite effect.

In an attempt to account for the many variables which might be expected to effect income distribution, factor analysis was performed on the SMSA's. Two groups of SMSA's were identified, and the regressions were performed for these groups. Results were quite similar to the original regressions.

Any interpretation of the results with respect to water quality programs or policy prescriptions based on those interpretations, would be dubious. The data limitations and the problems with possible model misspecification, with respect to variables which may have drastically changed over all SMSA's, make the results suspect. Factor analysis, while it may eliminate some of the relevant data problems, does not account for the policy changes, such as the Vietnamese War or the tax and transfer payment changes. Clearly, the causality between water quality controls and income distribution has not been determined by this research. As a minimum, refinement of data for the cost of compliance and/or treatment costs is necessary. Further exploration of the appropriate models and expansion of the data base should, however, lead to fruitful results.

ACKNOWLEDGMENT

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

AN EMPIRICAL ANALYSIS OF PREDICTORS OF INCOME DISTRIBUTION EFFECTS OF WATER QUALITY CONTROLS

Introduction

The imposition of constraints on economic activity have two possible effects: changing resource allocations among production possibilities and changing the distribution of the benefits of production among members of society.[1] An overwhelming majority of recent economic analysis deals with the former question. Many of the standard economic tools are structured to analyze allocation effects. The study of distributional changes also has a rather long history, but only recently have tools with strong analytic capability been suggested in the literature. Tests of these tools using current policies provide two benefits: (1) the tools themselves can be examined for usefulness and effectiveness, and (2) the effects of policies can be analyzed. The following is a research report on such tests involving water quality controls.

The Problem

The research problem consisted of two separate areas: (1) the income distribution measures and suggested alternatives, and (2) the impact of water quality controls on income distribution. The first necessarily had to be explored before the policy questions could be addressed.

The Distribution Measures

The income distribution measures most often utilized in the analysis of policy effects have been the Gini, Pietra, or Theil Entropy coefficients. These measures relate the actual income distribution to an equal distribution of income by measuring, in various ways, the area between the two distributions. The actual income distribution is represented by a Lorenz curve, which relates percent of income received to percent of population. A shortcoming of the Gini, Pietra, and Theil index is that a given "area of inequality" may be circumscribed by an infinite number of Lorenz curves, so that one distribution may be "more equal" than another, in the sense that income is distributed more widely over the population, but have the same Gini, Pietra, or Theil indices (see for example Budd (1967), and Budd and Seiders (1971)).

Several authors have suggested alternative measuring methods based on probability density functions which have parameters which relate to both the mean and skewness of a density function (Champernowne, 1974). Metcalf (1972) utilized lognormal and displaced lognormal distributions to estimate the Lorenz curve. The latter function has the property that the distribution is not necessarily symmetric about the mean, which would be expected of a Lorenz curve. Two of the Pearson family of curves have also been suggested: the gamma density function and the beta density function (Metcalf, 1972, and Thurow, 1972). All these functions have two parameters which relate mean, variances, and skewness (that is, have estimation of the first, second, and third moments), allowing a more complete description of the Lorenz curve.

The lognormal density

The distribution of family income may be approximated by two parameter lognormal distribution function, or a three parameter displaced lognormal distribution function. Various measures of distributional equality from the two functions are obtainable.

The curve fitting procedures include the computation of mean income in each of the income groups. The midpoint is chosen as the mean income for the first income group; the mean income of the open ended interval is obtained by fitting a Pareto curve to the data.

Pareto's mathematical formulation is widely used as the basis for estimating the mean for the open-end of an income distribution. For a discussion of fitting a Pareto curve to the open-end interval see U.S. Bureau of the Census (1965). Due to assumed geometric nature of the income distribution, the mean income of each of the remainder of the groups is computed from the geometric mean of the lower and upper bounds.

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[1] There is also a question concerning the division of returns among factors of production, but this appears to be a more allocational than distributional kind of analysis.

The overall mean income of the population is estimated by:

$$\mu = \frac{\Sigma \mu_i f_i}{\Sigma f_i}$$

in which μ_i is the group mean income and f_i is the number of families in group i.

Income distribution appears to be positively skewed in that μ is greater than the median (see Figure 1). Thus, it is likely that income is more closely approximated by a lognormal curve than a normal curve.

The density function of the three parameter lognormal[2] is

$$f([X+C], M, V) = \frac{1}{(X+C)V\sqrt{2\Pi}} \mathrm{EXP} \cdot \left[\frac{\ln(X+C)\text{-}M}{2V}\right]$$

in which $0 < x < \infty, \beta > 0, C > -y > -\infty$.

The variable x is defined as the income and f(x) is the percentage of families having that income. The method of moments was used to estimate the two parameters, M and V, of the lognormal density function, and the method of quartiles was used to estimate the three parameters, M, V, and C, of the displaced lognormal density function.

The parameter M, which is the natural log of the geometric mean of x, should also equal the natural log of the median, if the actual distribution is the two parameter lognormal. Since the income distribution in the SMSA's is skewed, often dramatically, the three parameter lognormal may be a more desirable estimation. The third parameter of the lognormal may be a more desirable estimation. The third parameter of the lognormal distribution will indicate the extent to which the income must be shifted to "best" fit the lognormal distribution function.[2]

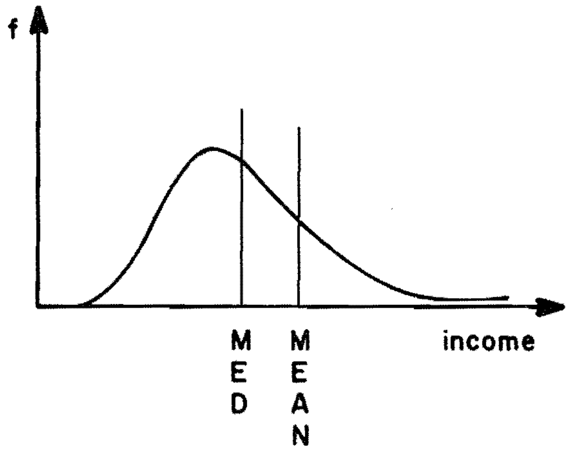

Figure 1. One type of income curve.

The gamma density

The gamma density is one of the functional forms suggested to describe changes in the distribution of income. Salem and Mount (1974) found that the two gamma parameters can be directly related to indicators of inequality and scale, and the two parameters are easy to estimate.

If income per family is represented by x, then the family income is distributed as the gamma density

$$f(x,\alpha,\beta) = \frac{\beta^{\alpha}}{\Gamma(\alpha)} x^{\alpha-1} e^{-\beta x} \qquad 0 < x < \infty$$

in which $\Sigma(\alpha)$

α and β are positive parameters, and

$$\Gamma(\alpha) = \int_0^{\infty} e^{-y} y^{\alpha-1} dy$$

is the gamma function. It is assumed that all the family incomes are multiplied by a constant k, namely Y = kx, as would happen under Gibrat's Law of proportionate growth. The density function of Y is g(Y), and the cumulative distribution function is G(Y), where

$$g(Y) = \frac{d}{dy} G(Y)$$

by definition.

G(Y) and g(Y) can be related to F(x) and f(x) in the following equations

$$\begin{aligned} G(Y) &= p\{Y \leqslant y\} \\ &= p\{kx \leqslant y\} \\ &= p\{x \leqslant (y/k)\} \\ &= \textstyle\int_0^{y/k} f(x)\,dx \\ &= F(y/k) - F(o) \\ &= F(y/k) \qquad \text{(assume } k > 0\text{)} \\ g(Y) &= \frac{d}{dY} G(Y) \\ &= \frac{d}{dY} F(y/k) \\ &= f(y/k)\ (dx/dY) \end{aligned}$$

---

[2] The two parameter lognormal is simply a special case of the three parameter, wherein the skewness, or third parameter "c," is zero.

$$= \frac{1}{k} f(y/k)$$

$$= \frac{1}{k} \cdot \frac{\beta^{a}}{\Gamma(a)} \left(\frac{y}{k}\right)^{a-1} e^{-\beta} \cdot \frac{y}{k}$$

$$= \frac{(\beta/k)^{a}}{r(a)} y^{a-1} e^{-(\beta/k)} y$$

$$= f\left(y; a, \frac{\beta}{k}\right)$$

It is clear that a is not directly related to the scale change in income, but is related to the skewness, kertosis, and variance.

It has been shown that Gini (Salem and Mount, 1974), Theil, and Pietra (McDonald and Jensen, 1976) indices are all functions of a alone. Thus, the non-uniqueness of these inequality measures is clear. McDonald and Jensen also indicate that maximum likelihood estimators have smaller sample biases than method of moments estimations in most cases.

The beta density

The final distribution form to be examined is the beta density function. The beta function has the form

$$f(x,\sigma,\rho) = \frac{\Gamma(\sigma+\rho)}{\Gamma(\sigma)\cdot\Gamma(\rho)} x^{\sigma-1} (1-x)^{\rho-1}$$

The relationship between the beta function and the three indices of inequality is currently under study. No specific relationship has been determined, nor has it been demonstrated that the maximum likelihood estimators have smaller sample biases than the method of moments. Since the maximum likelihood estimators are impossible to directly estimate at present, a Newton-Raphson approximation is used. However, since the beta and gamma functions are members of the same Pearson family of distributions, the use of maximum likelihood estimators appears warranted.

The empirical estimation of income distribution

The major problems of estimating the income distribution parameters for each of the chosen functions were: first, to choose the method of estimating the mean of the highest (unbounded) income class, and second, to estimate the parameters of each function corresponding to the income distribution data collected from the 1960 and 1970 census data for every Standard Metropolitan Statistical Area (SMSA) in the nation.

As discussed, the Pareto-Levy law was used by the U.S. Bureau of the Census (1965) to estimate the mean of the unbounded upper income group. This law states:

> ...The upper ranges of the income distribution could be described by a curve of the general type $Y = AX^{-V}$, where X is the income size and Y is the number of persons have that, or a larger, income.

The "weak" form of the Pareto-Levy law is used in this study. This weak law states that percentage of individuals with an income level U exceeded some number U_0 approximates $(U/U_0)^{-a}$ as U approaches infinity. While the law is difficult to use for lower income levels, it is a reasonable approximation of the higher income group. Because the only income group requiring estimation is the "open-intervalled" highest income group, the law probably applies reasonably well.

A related difficulty occurs when the beta function is used for income distribution estimation. Since the beta function is a finite distribution function of scaled incomes (that is, scaled between 0 and 1), it has a maximum income implicit in its estimation. The mean income of the open ended interval derived from the Pareto-Levy law is the mid-point of the interval. The formula used is:

$$UD = B + 2(X-b)$$

in which

UD = maximum income;
B = upper limit of the interval preceding the open ended interval; and
X = mean income of the open ended interval.

Incomes were divided by UD to satisfy the scale (0 to 1).

Distribution data were collected from the 1960 and 1970 census of population (U.S. Bureau of Census, 1963, 1973, 1974, 1975) and from data available in the 1972 County and City Data Book (1972). Since only grouped data of the family income of SMSA's are available, it was assumed that every member of the particular income group receives the same income, measured by the midpoint of that group. Thirteen income groups were used for 1960 and 1970 data to make comparisons possible. The 1960 data were restructured from original data tapes in order to make the groupings compatible with 1970 data.

Computer programs were developed to estimate the parameters of the displaced lognormal, gamma, and beta density functions from these data. The programs can be found in Appendices 1 and 2. The estimations of these parameters are given in Tables 1 and 2 for each SMSA.

Table 1. 1960 income parameters for each distribution function and Gastwirth bounds.

S.M.S.A. (60)	Gamma			Beta			Lognormal			Displaced Lognormal				Gastwirth	
	α	β	Gini	σ	ρ	Gini	M	V	Gini	C	M	V	Gini	GU	GL
Abilene, Tex	1.91	0.00031	0.27	1.59	13.48	0.39	8.42	0.634	0.43	15046.25	9.94	0.030	0.10	0.39	0.38
Akron, Ohio	2.59	0.00034	0.24	2.07	12.46	0.34	8.73	0.500	0.38	5793.73	9.45	0.096	0.17	0.32	0.32
Albany, Ga	1.68	0.00031	0.29	1.43	13.17	0.41	8.25	0.756	0.46	435973.30	13.00	0.000	0.00	0.41	0.40
Albany, NY	2.32	0.00033	0.25	1.88	11.51	0.36	8.62	0.557	0.40	4907.84	9.33	0.120	0.19	0.35	0.34
Albuquerque, NM	2.08	0.00028	0.26	1.68	10.36	0.37	8.64	0.617	0.42	3049.67	9.14	0.197	0.25	0.37	0.36
Allentown, NJ	2.44	0.00036	0.24	1.97	15.50	0.36	8.60	0.495	0.38	2645.49	9.05	0.160	0.22	0.34	0.33
Amarillo, Tex	2.02	0.00028	0.26	1.62	13.83	0.39	8.61	0.572	0.41	3395.37	9.17	0.160	0.22	0.38	0.37
Ann Arbor, Mich	2.16	0.00026	0.26	1.70	9.09	0.37	8.76	0.602	0.42	6381.78	9.52	0.106	0.18	0.36	0.35
Ashville, NC	1.58	0.00028	0.29	1.34	17.51	0.43	8.26	0.749	0.46	69607.93	11.22	0.002	0.02	0.43	0.42
Atlanta, Ga	1.77	0.00025	0.28	1.44	10.54	0.40	8.54	0.706	0.45	12081.93	9.84	0.054	0.13	0.40	0.40
Atlantic City, NJ	1.86	0.00030	0.27	1.55	13.20	0.40	8.43	0.671	0.44	3765.05	9.10	0.156	0.22	0.39	0.38
Austin, Tex	1.64	0.00025	0.29	1.35	12.34	0.42	8.43	0.722	0.45	10672.78	9.72	0.057	0.13	0.42	0.42
Bakersfield, Cal	2.05	0.00030	0.26	1.69	11.35	0.38	8.56	0.628	0.42	4331.86	9.24	0.150	0.22	0.37	0.36
Baltimore, Md	2.12	0.00029	0.26	1.71	11.24	0.37	8.64	0.603	0.42	5341.23	9.38	0.119	0.19	0.36	0.36
Baton Rouge, La	1.83	0.00027	0.28	1.51	10.32	0.39	8.53	0.707	0.45	26230.18	10.41	0.017	0.07	0.39	0.39
Bay City, Mich	2.55	0.00037	0.24	2.11	14.51	0.34	8.62	0.510	0.39	6787.51	9.47	0.079	0.16	0.32	0.32
Beaumont, Tex	1.90	0.00029	0.27	1.59	13.44	0.39	8.50	0.694	0.44	101891.40	11.59	0.001	0.02	0.37	0.37
Billings, Mont	2.40	0.00034	0.24	1.94	11.83	0.35	8.64	0.538	0.40	2919.45	9.11	0.173	0.23	0.34	0.33
Binghampton, NY	2.69	0.00037	0.23	2.15	12.55	0.34	8.69	0.470	0.37	2728.32	9.13	0.162	0.22	0.32	0.32
Birmingham, Ala	1.59	0.00026	0.29	1.34	11.85	0.42	8.38	0.802	0.47	22986.08	10.27	0.019	0.08	0.42	0.41
Boston, Mass	2.21	0.00027	0.25	1.72	10.44	0.37	8.75	0.553	0.40	1131.30	8.95	0.277	0.29	0.36	0.36
Bridgeport, Conn	2.56	0.00033	0.24	2.01	10.80	0.34	8.75	0.509	0.39	1333.11	8.98	0.239	0.27	0.33	0.32
Brockton, Mass	2.93	0.00043	0.22	2.37	15.80	0.32	8.65	0.428	0.36	1684.84	8.95	0.175	0.23	0.31	0.30
Buffalo, NY	2.51	0.00034	0.24	2.01	11.69	0.35	8.69	0.519	0.39	3619.00	9.22	0.147	0.21	0.33	0.32

Table 1. Continued.

S.M.S.A. (60)	Gamma			Beta			Lognormal			Displaced Lognormal				Gastwirth	
	α	β	Gini	σ	ρ	Gini	M	V	Gini	C	M	V	Gini	GU	GL
Canton, Ohio	2.46	0.00035	0.24	2.00	13.50	0.35	8.64	0.519	0.39	4314.13	9.27	0.122	0.19	0.33	0.33
Cedar Rapids, Iowa	2.17	0.00029	0.26	1.75	13.95	0.37	8.66	0.572	0.41	8911.42	9.65	0.063	0.14	0.35	0.35
Champaign, Ill	1.99	0.00028	0.27	1.61	11.66	0.39	8.57	0.613	0.42	1586.44	8.90	0.278	0.29	0.38	0.38
Charlotte, SC	1.48	0.00027	0.30	1.28	11.66	0.43	8.22	0.897	0.50	6196.04	9.28	0.104	0.18	0.43	0.42
Charleston, W Va	1.82	0.00028	0.28	1.53	10.75	0.39	8.48	0.751	0.46	8837.78	9.60	0.076	0.15	0.38	0.37
Charlotte, NC	1.68	0.00024	0.29	1.36	11.83	0.42	8.53	0.710	0.45	9005.45	9.64	0.074	0.15	0.42	0.41
Chicago, Ill	2.21	0.00025	0.25	1.72	9.17	0.37	8.82	0.586	0.41	4733.57	9.40	0.132	0.20	0.36	0.35
Cleveland, Ohio	2.19	0.00026	0.25	1.72	10.46	0.37	8.77	0.579	0.41	4503.90	9.35	0.136	0.21	0.36	0.35
Colo Springs, Colo	2.24	0.00035	0.25	1.84	13.44	0.36	8.52	0.556	0.40	4928.00	9.29	0.110	0.19	0.36	0.35
Columbia, SC	1.58	0.00028	0.29	1.35	12.86	0.42	8.27	0.805	0.47	4341.02	9.09	0.142	0.21	0.42	0.42
Columbus, Ohio	2.11	0.00028	0.26	1.69	11.72	0.38	8.67	0.598	0.42	5923.99	9.44	0.108	0.18	0.36	0.36
Corpus Christi, Tex	1.52	0.00025	0.30	1.29	12.68	0.43	8.33	0.834	0.48	5573.95	9.28	0.125	0.20	0.43	0.42
Dallas, Tex	1.70	0.00023	0.28	1.37	10.64	0.41	8.58	0.719	0.45	10122.59	9.73	0.069	0.15	0.41	0.41
Davenport, Ill	2.43	0.00033	0.24	1.97	12.44	0.35	8.68	0.541	0.40	4629.03	9.32	0.120	0.19	0.33	0.33
Dayton, Ohio	2.36	0.00031	0.25	1.90	11.46	0.35	8.70	0.559	0.40	7808.39	9.59	0.079	0.16	0.34	0.33
Decatur, Ill	2.29	0.00033	0.25	1.86	12.38	0.36	8.59	0.566	0.41	3787.33	9.18	0.145	0.21	0.34	0.34
Denver, Colo	2.22	0.00029	0.25	1.76	11.93	0.37	8.70	0.559	0.40	7045.42	9.54	0.088	0.17	0.36	0.35
Des Moines, Iowa	2.27	0.00030	0.25	1.80	12.21	0.37	8.69	0.546	0.40	5637.69	9.42	0.106	0.18	0.35	0.35
Detroit, Mich	1.92	0.00027	0.27	1.59	9.53	0.38	8.57	0.710	0.45	5608.80	9.37	0.133	0.20	0.37	0.37
Dubuque, Iowa	2.12	0.00031	0.26	1.75	11.57	0.37	8.56	0.638	0.43	14259.58	9.93	0.036	0.11	0.35	0.35
Duluth, Minn	2.40	0.00039	0.24	2.02	16.64	0.35	8.49	0.522	0.39	16704.51	10.01	0.020	0.08	0.34	0.33
El Paso, Tex	1.93	0.00031	0.27	1.60	12.39	0.39	8.46	0.635	0.43	1867.05	8.86	0.259	0.28	0.39	0.38
Erie, Pa	2.42	0.00037	0.24	1.99	13.80	0.35	8.55	0.531	0.39	4876.22	9.27	0.102	0.18	0.33	0.33
Eugene, Ore	2.40	0.00035	0.24	1.95	13.49	0.35	8.61	0.521	0.39	11287.62	9.78	0.044	0.12	0.34	0.33
Evansville, Ind	1.81	0.00030	0.28	1.52	14.48	0.40	8.41	0.690	0.44	68441.12	11.21	0.002	0.03	0.39	0.39
Fargo, ND	2.36	0.00035	0.25	1.92	14.41	0.36	8.58	0.518	0.39	3960.26	9.20	0.129	0.20	0.35	0.34

Table 1. Continued.

S.M.S.A. (60)	Gamma			Beta			Lognormal			Displaced Lognormal				Gastwirth	
	α	β	Gini	σ	ρ	Gini	M	V	Gini	C	M	V	Gini	GU	GL
Fitchburg, Mass	2.72	0.00041	0.23	2.21	14.79	0.33	8.60	0.456	0.37	2054.21	8.96	0.180	0.24	0.32	0.32
Ft Lauderdale, Fla	1.58	0.00024	0.29	1.29	12.08	0.43	8.42	0.737	0.46	8026.10	9.53	0.081	0.16	0.43	0.43
Ft Wayne, Ind	2.38	0.00031	0.25	1.91	12.21	0.36	8.70	0.543	0.40	5444.29	9.41	0.107	0.18	0.34	0.33
Ft Worth Tex	1.97	0.00030	0.27	1.63	13.60	0.39	8.51	0.641	0.43	17237.50	10.07	0.027	0.09	0.38	0.37
Fresno, Cal	1.80	0.00027	0.28	1.48	11.83	0.40	8.50	0.696	0.44	3825.89	9.15	0.176	0.23	0.40	0.39
Gary, Ind	2.64	0.00035	0.23	2.12	11.38	0.33	8.71	0.498	0.38	3194.27	9.20	0.151	0.22	0.32	0.31
Grand Rapids, Mich	2.31	0.00031	0.25	1.85	12.96	0.36	8.67	0.536	0.40	4781.14	9.33	0.119	0.19	0.35	0.34
Great Falls, Mont	2.40	0.00035	0.24	1.93	12.74	0.35	8.61	0.522	0.39	3470.33	9.16	0.146	0.21	0.34	0.34
Green Bay, Wis	2.42	0.00034	0.24	1.95	14.65	0.36	8.63	0.512	0.39	2361.46	9.03	0.173	0.23	0.34	0.33
Greensboro, NC	1.81	0.00027	0.28	1.47	14.03	0.41	8.50	0.642	0.43	16609.20	10.04	0.027	0.09	0.40	0.40
Greenville, SC	1.77	0.00031	0.28	1.49	15.43	0.41	8.33	0.692	0.44	5724.57	9.26	0.089	0.17	0.40	0.39
Hamilton, Ohio	2.43	0.00033	0.24	1.97	11.80	0.35	8.68	0.548	0.40	8673.08	9.65	0.067	0.15	0.33	0.33
Harrisburg, Pa	2.41	0.00035	0.24	1.97	14.50	0.35	8.60	0.519	0.39	2830.92	9.07	0.161	0.22	0.34	0.33
Hartford, Conn	2.50	0.00029	0.24	1.92	10.70	0.35	8.83	0.496	0.38	1181.52	9.01	0.235	0.27	0.34	0.33
Honolulu, Ha	2.05	0.00025	0.26	1.62	8.65	0.38	8.75	0.633	0.43	1267.18	8.98	0.286	0.29	0.37	0.36
Houston, Tex	1.75	0.00024	0.28	1.43	11.14	0.41	8.58	0.716	0.45	14064.25	9.95	0.044	0.12	0.40	0.39
Huntington, Ky	1.74	0.00030	0.28	1.49	13.29	0.40	8.33	0.753	0.46	208923.70	12.28	0.000	0.01	0.39	0.39
Indianapolis, Ind	2.18	0.00028	0.26	1.74	10.71	0.37	8.70	0.585	0.41	6211.11	9.48	0.103	0.18	0.36	0.35
Jackson, Mich	2.39	0.00033	0.24	1.93	12.84	0.35	8.67	0.532	0.39	7697.98	9.57	0.074	0.15	0.34	0.33
Jacksonville, Fla	1.84	0.00029	0.27	1.53	13.14	0.40	8.45	0.685	0.44	30247.55	10.50	0.011	0.06	0.39	0.38
Jersey City, NJ	2.68	0.00038	0.23	2.17	10.99	0.33	8.64	0.496	0.38	2652.82	9.08	0.172	0.23	0.32	0.31
Kalamazoo, Mich	2.34	0.00031	0.25	1.86	12.17	0.36	8.70	0.543	0.40	4525.55	9.32	0.127	0.20	0.34	0.34
Kansas City, Kan	2.11	0.00028	0.26	1.69	12.13	0.38	8.66	0.591	0.41	3536.91	9.20	0.165	0.23	0.36	0.36
Kenosha, Wis	2.78	0.00035	0.23	2.20	11.26	0.33	8.77	0.476	0.37	2620.96	9.15	0.170	0.23	0.31	0.30
Knoxville, Tenn	1.73	0.00030	0.28	1.49	12.98	0.40	8.33	0.758	0.46	6102.50	9.31	0.099	0.18	0.40	0.39

Table 1. Continued.

S.M.S.A. (60)	Gamma			Beta			Lognormal			Displaced Lognormal				Gastwirth	
	α	β	Gini	$\underline{\sigma}$	ρ	Gini	M	V	Gini	C	M	V	Gini	GU	GL
Lake Charles, La	1.95	0.00032	0.27	1.66	14.81	0.39	8.41	0.646	0.43	33730.61	10.59	0.008	0.05	0.38	0.37
Lancaster, Pa	2.29	0.00034	0.25	1.86	13.60	0.36	8.58	0.539	0.40	2848.40	9.07	0.166	0.23	0.35	0.34
Las Vegas, Nev	2.32	0.00029	0.25	1.83	9.82	0.36	8.76	0.561	0.40	4004.70	9.31	0.146	0.21	0.35	0.34
Lewiston, Me	2.69	0.00045	0.23	2.20	17.06	0.34	8.48	0.435	0.36	5667.53	9.30	0.066	0.14	0.33	0.32
Lawton, Ohio	2.03	0.00037	0.26	1.71	15.44	0.38	8.34	0.600	0.42	18418.65	10.07	0.017	0.07	0.37	0.37
Lexington, Ky	1.63	0.00024	0.29	1.35	12.98	0.42	8.46	0.741	0.46	12217.14	9.81	0.048	0.12	0.42	0.41
Lima, Ohio	2.16	0.00033	0.26	1.81	14.73	0.37	8.52	0.592	0.41	21807.26	10.24	0.017	0.07	0.35	0.35
Lincoln, Neb	2.39	0.00036	0.24	1.94	14.20	0.26	8.58	0.511	0.39	3159.93	9.10	0.151	0.22	0.34	0.34
Little Rock, Ark	1.77	0.00030	0.28	1.48	12.58	0.40	8.37	0.706	0.45	26746.12	10.39	0.012	0.06	0.40	0.39
Loraine, Ohio	2.70	0.00038	0.23	2.21	13.56	0.33	8.65	0.489	0.38	4906.99	9.33	0.102	0.18	0.31	0.31
Los Angeles, Cal	2.06	0.00024	0.26	1.62	9.42	0.38	8.77	0.622	0.32	4974.09	9.40	0.135	0.21	0.37	0.36
Lowell, Mass	2.87	0.00043	0.23	2.34	14.08	0.32	8.62	0.444	0.36	5540.58	9.36	0.083	0.16	0.31	0.30
Lubbock, Tex	1.74	0.00025	0.28	1.40	11.57	0.41	8.51	0.676	0.44	7056.92	9.49	0.095	0.17	0.41	0.41
Lynchburg, Va	1.75	0.00029	0.28	1.49	16.17	0.41	8.37	0.710	0.45	73611.93	11.28	0.002	0.02	0.40	0.39
Macon, Ga	1.78	0.00030	0.28	1.51	12.01	0.40	8.39	0.726	0.45	38411.58	10.70	0.008	0.05	0.39	0.39
Manchester, NH	2.57	0.00039	0.24	2.08	15.62	0.35	8.59	0.467	0.37	3958.44	9.19	0.109	0.18	0.33	0.33
Memphis, Tenn	1.56	0.00026	0.30	1.31	14.31	0.43	8.35	0.786	0.47	134181.50	11.85	0.001	0.01	0.43	0.42
Meriden, Conn	3.02	0.00041	0.22	2.41	12.93	0.32	8.73	0.429	0.36	1504.40	9.00	0.189	0.24	0.30	0.29
Miami, Fla	1.61	0.00024	0.29	1.32	11.56	0.42	8.46	0.757	0.46	18792.59	10.13	0.027	0.09	0.42	0.42
Midland, Tex	1.88	0.00022	0.27	1.47	9.47	0.40	8.77	0.644	0.43	10427.84	9.79	0.066	0.14	0.40	0.39
Milwaukee, Wis	2.59	0.00032	0.24	2.02	11.87	0.34	8.79	0.488	0.38	2246.87	9.13	0.182	0.24	0.33	0.32
Minneapolis, Minn	2.36	0.00032	0.25	1.89	11.73	0.36	8.67	0.538	0.40	3973.96	9.25	0.145	0.21	0.34	0.34
Mobile, Ala	1.78	0.00030	0.28	1.52	13.47	0.40	8.38	0.726	0.45	30420.38	10.50	0.011	0.06	0.39	0.39
Montgomery, Ala	1.48	0.00025	0.30	1.26	11.76	0.43	8.31	0.864	0.49	41881.26	10.78	0.007	0.05	0.44	0.43
Muncie, Ind	2.22	0.00033	0.25	1.84	13.70	0.36	8.55	0.582	0.41	11613.63	9.79	0.044	0.12	0.35	0.34

Table 1. Continued.

S.M.S.A (60)		Gamma			Beta			Lognormal			Displaced Lognormal			Gastwirth	
	α	β	Gini	σ	ρ	Gini	M	V	Gini	C	M	V	Gini	GU	GL
Muskegon, Mich	2.58	0.00038	0.24	2.15	15.62	0.34	8.60	0.514	0.39	20780.23	10.21	0.016	0.07	0.32	0.31
Nashville, Tenn	1.63	0.00025	0.29	1.35	12.11	0.42	8.45	0.738	0.46	3514.52	9.09	0.184	0.24	0.42	0.41
New Bedford, Mass	2.28	0.00039	0.25	1.92	18.04	0.36	8.44	0.536	0.40	28224.66	10.43	0.008	0.05	0.35	0.34
New Britain, Conn	3.08	0.00041	0.22	2.43	13.00	0.32	8.75	0.411	0.35	438.64	8.85	0.255	0.28	0.30	0.30
New Haven, Conn	2.15	0.00027	0.26	1.69	11.32	0.38	8.73	0.568	0.41	2078.03	9.07	0.220	0.26	0.36	0.36
New Orleans, La	1.63	0.00025	0.29	1.34	12.35	0.42	8.44	0.739	0.46	8498.00	9.57	0.077	0.16	0.42	0.42
New York, NY	1.92	0.00023	0.27	1.50	9.40	0.39	8.72	0.642	0.43	2819.63	9.16	0.212	0.26	0.39	0.38
Newark, NJ	2.06	0.00023	0.26	1.58	8.42	0.38	8.82	0.615	0.42	2268.12	9.15	0.220	0.26	0.37	0.37
Newport News, Va	2.20	0.00033	0.25	1.83	11.98	0.36	8.54	0.592	0.41	9029.87	9.64	0.064	0.14	0.36	0.35
Norfolk, Va	1.56	0.00027	0.30	1.35	11.95	0.42	8.32	0.871	0.49	191565.00	12.19	0.000	0.01	0.41	0.40
Odessa, Tex	2.35	0.00034	0.25	1.94	13.72	0.36	8.61	0.560	0.40	10811.13	9.76	0.047	0.12	0.34	0.33
Ogden, Ut	2.91	0.00041	0.22	2.38	13.49	0.32	8.67	0.453	0.37	3382.97	9.18	0.134	0.20	0.30	0.30
Oklahoma City, Okla	1.86	0.00027	0.27	1.53	13.37	0.40	8.53	0.653	0.43	8171.30	9.57	0.076	0.15	0.39	0.38
Orlando, Fla	1.71	0.00027	0.28	1.42	13.24	0.41	8.43	0.694	0.44	11699.62	9.78	0.049	0.12	0.41	0.41
Paterson, NJ	2.45	0.00028	0.24	1.86	8.93	0.35	8.86	0.519	0.39	2095.24	9.16	0.196	0.25	0.34	0.33
Peoria, Ill	2.34	0.00032	0.25	1.91	12.38	0.36	8.65	0.561	0.40	3961.90	9.24	0.141	0.21	0.34	0.33
Philadelphia, Pa	2.20	0.00039	0.25	1.75	10.74	0.37	8.68	0.579	0.41	2796.35	9.13	0.194	0.24	0.36	0.35
Phoenix, Ariz	1.91	0.00026	0.27	1.55	11.77	0.39	8.60	0.658	0.43	8321.27	9.60	0.079	0.16	0.38	0.38
Pittsburgh, Pa	2.22	0.00031	0.25	1.79	11.84	0.37	8.61	0.568	0.41	2359.60	9.03	0.211	0.25	0.35	0.35
Portland, Me	2.29	0.00034	0.25	1.87	16.38	0.37	8.56	0.516	0.39	−823.53	8.28	0.582	0.41	0.35	0.35
Portland, Ore	2.15	0.00029	0.26	1.74	12.85	0.37	8.65	0.582	0.41	13185.78	9.90	0.041	0.11	0.36	0.35
Provo, Ut	2.46	0.00040	0.24	2.05	12.78	0.34	8.50	0.528	0.39	5015.96	9.26	0.099	0.18	0.33	0.33
Raleigh, NC	1.56	0.00026	0.30	1.32	12.13	0.42	8.32	0.820	0.48	90587.25	11.48	0.002	0.02	0.42	0.42
Reno, Nev	2.14	0.00024	0.26	1.65	9.87	0.38	8.81	0.574	0.41	3242.89	9.25	0.170	0.23	0.37	0.36
Richmond, Va	1.88	0.00026	0.27	1.52	11.86	0.40	8.60	0.656	0.43	8665.64	9.63	0.075	0.15	0.39	0.38

Table 1. Continued.

S.M.S.A. (60)		Gamma			Beta			Lognormal		Displaced Lognormal				Gastwirth	
	α	β	Gini	σ	ρ	Gini	M	V	Gini	C	M	V	Gini	GU	GL
Roanoake, Va	1.80	0.00028	0.28	1.50	15.88	0.41	8.44	0.671	0.44	13443.85	9.96	0.028	0.09	0.39	0.39
Rochester, NY	2.47	0.00030	0.24	1.93	10.06	0.35	8.79	0.526	0.39	5050.57	9.42	0.116	0.19	0.34	0.33
Rockford, Ill	2.49	0.00033	0.24	2.00	12.12	0.35	8.71	0.528	0.39	5126.68	9.38	0.109	0-18	0.33	0.32
Sacramento, Cal	2.57	0.00032	0.24	2.02	10.42	0.34	8.79	0.507	0.39	3848.60	9.30	0.140	0.21	0.33	0.32
Saginow, Mich	2.27	0.00033	0.25	1.86	14.57	0.36	8.60	0.563	0.40	9580.66	9.67	0.055	0.13	0.34	0.34
St. Joseph, MO	2.15	0.00035	0.26	1.79	15.05	0.37	8.47	0.580	0.41	7578.46	9.47	0.065	0.14	0.36	0.35
St. Louis, Ill	2.02	0.00037	0.26	1.64	11.81	0.38	8.63	0.631	0.43	4635.49	9.30	0.139	0.21	0.37	0.36
Salt Lake City, Utah	2.40	0.00033	0.24	1.91	13.07	0.36	8.68	0.510	0.39	1827.64	9.00	0.213	0.26	0.34	0.34
San Anjelo, Tex.	1.54	0.00036	0.30	1.28	15.12	0.43	8.33	0.728	0.45	18457.28	10.08	0.021	0.08	0.44	0.43
San Antonio, Tex	1.66	0.00028	0.29	1.40	15.20	0.42	8.35	0.718	0.45	11712.40	9.75	0.043	0.12	0.42	0.41
San Bernadino, Cal	2.18	0.00032	0.26	1.80	11.51	0.36	8.56	0.594	0.41	3996.08	9.20	0.151	0.22	0.36	0.35
San Diego, Cal	2.03	0.00027	0.26	1.65	10.40	0.38	8.66	0.648	0.43	4966.45	9.35	0.136	0.21	0.37	0.36
San Francisco, Cal	2.13	0.00025	0.26	1.67	9.64	0.37	8.78	0.605	0.42	4779.83	9.38	0.136	0.21	0.36	0.36
San Jose, Cal	2.40	0.00028	0.24	1.87	9.12	0.35	8.82	0.553	0.40	5037.88	9.43	0.120	0.19	0.34	0.33
Santa Barbara, Cal	2.02	0.00024	0.26	1.59	9.93	0.38	8.75	0.615	0.42	3388.60	9.23	0.180	0.24	0.38	0.37
Savannah, Ga	1.82	0.00032	0.28	1.55	12.39	0.39	8.34	0.702	0.45	122743.50	11.76	0.001	0.02	0.39	0.39
Scranton, Pa	2.19	0.00039	0.25	1.85	16.05	0.37	8.38	0.568	0.41	5273.94	9.23	0.084	0.16	0.35	0.35
Seattle, Wash	2.38	0.00029	0.25	1.88	10.89	0.36	8.76	0.535	0.39	7254.95	9.58	0.084	0.16	0.34	0.34
Shreveport, La	1.54	0.00025	0.30	1.30	11.50	0.43	8.33	0.819	0.48	40041.95	10.74	0.007	0-05	0.43	0.43
Sioux, Iowa	1.92	0.00029	0.27	1.58	14.00	0.39	8.50	0.635	0.43	6611.72	9.42	0.087	0.17	0.38	0.38
Sioux Falls, SD	2.28	0.00036	0.25	1.89	13.09	0.36	8.52	0.563	0.40	5648.23	9.34	0.096	0.17	0.35	0.34
South Bend, Ind	2.55	0.00034	0.24	2.05	13.21	0.34	8.71	0.504	0.38	6387.18	9.49	0.086	0.16	0.33	0.32
Spokane, Wash	2.30	0.00033	0.25	1.87	12.97	0.36	8.62	0.541	0.40	4009.27	9.22	0.143	0.21	0.35	0.34
Springfield, Mo	1.90	0.00033	0.27	1.59	15.29	0.39	8.34	0.634	0.43	6556.65	9.34	0.073	0.15	0.39	0.38
Springfield, Ohio	2.36	0.00036	0.25	1.96	13.77	0.35	8.56	0.551	0.40	12157.49	9.82	0.039	0.11	0.34	0.33

Table 1. Continued.

S.M.S.A. (60)	Gamma			Beta			Lognormal			Displaced Lognormal				Gastwirth	
	α	β	Gini	σ	ρ	Gini	M	V	Gini	C	M	V	Gini	GU	GL
Steubenville, Ohio	2.51	0.00037	0.24	2.07	12.53	0.34	8.60	0.535	0.39	8892.25	9.63	0.057	0.13	0.32	0.32
Stockton, Cal	1.98	0.00029	0.27	1.63	11.75	0.38	8.55	0.646	0.43	4354.46	9.23	0.146	0.21	0.37	0.37
Syracuse, NY	2.35	0.00032	0.25	1.88	11.25	0.36	8.67	0.550	0.40	4473.08	9.31	0.131	0.20	0.34	0.34
Tacoma, Wash	2.22	0.00032	0.25	1.83	13.59	0.37	8.59	0.563	0.40	5028.39	9.32	0.119	0.19	0.35	0.35
Tampa, Fla	1.62	0.00028	0.29	1.36	14.87	0.42	8.30	0.719	0.45	592379.60	13.30	0.000	0.00	0.43	0.42
Topeka, Kan	2.24	0.00032	0.25	1.83	13.96	0.37	8.59	0.551	0.40	8465.74	9.60	0.066	0.14	0.35	0.35
Trenton, NJ	2.18	0.00027	0.26	1.71	10.04	0.37	8.74	0.578	0.41	2187.30	9.09	0.219	0.26	0.36	0.35
Tuscon, Ariz	1.98	0.00029	0.27	1.62	13.53	0.39	8.55	0.616	0.42	7282.62	9.51	0.082	0.16	0.38	0.37
Tulsa, Okla	1.72	0.00024	0.28	1.41	12.20	0.41	8.53	0.705	0.45	10399.80	9.72	0.062	0.14	0.41	0.40
Tusclaoosa, Ala	1.43	0.00028	0.31	1.24	12.08	0.44	8.15	0.913	0.50	1939.71	8.63	0.304	0.30	0.44	0.43
Tyler, Tex	1.48	0.00025	0.30	1.25	12.43	0.44	8.28	0.836	0.48	61567.61	11.12	0.003	0.03	0.44	0.44
Utica, NY	2.45	0.00036	0.24	2.00	11.75	0.35	8.60	0.538	0.40	5841.81	9.40	0.096	0.17	0.33	0.33
Washington, D.C.	2.21	0.00025	0.25	1.71	7.86	0.36	8.84	0.591	0.41	11170.88	9.86	0.058	0.13	0.36	0.35
Waterbury, Conn	2.83	0.00036	0.23	2.22	11.80	0.33	8.77	0.450	0.36	976.92	8.95	0.235	0.27	0.31	0.31
Waterloo, Iowa	2.50	0.00034	0.24	2.02	14.67	0.35	8.67	0.507	0.39	6032.08	9.44	0.088	0.17	0.33	0.32
W. Palm Beach, Fla	1.43	0.00022	0.31	1.19	14.00	0.45	8.36	0.786	0.47	18211.64	10.09	0.026	0.09	0.46	0.45
Wichita, Kan	2.24	0.00031	0.25	1.80	13.46	0.37	8.65	0.552	0.40	4330.08	9.28	0.129	0.20	0.35	0.35
Wilkesburg, Pa	2.09	0.00038	0.26	1.79	17.57	0.37	8.33	0.596	0.41	6693.85	9.34	0.065	0.14	0.36	0.36
Wilmington, Del	2.05	0.00025	0.26	1.60	9.43	0.38	8.74	0.614	0.42	5364.25	9.43	0.125	0.20	0.37	0.37
Worcester, Mass	2.47	0.00035	0.24	1.98	14.20	0.35	8.64	0.495	0.38	2205.62	9.02	0.187	0.24	0.34	0.33
Yorktown, Pa	2.42	0.00037	0.24	1.99	15.13	0.35	8.55	0.517	0.39	5852.38	9.35	0.077	0.16	0.34	0.33
Younston, Ohio	2.45	0.00034	0.24	1.99	12.47	0.35	8.65	0.530	0.39	2821.85	9.10	0.172	0.23	0.33	0.33

Table 2. 1970 income parameters for each distribution function and Gastwirth bounds.

S.M.S.A. (70)	Gamma			Beta			Lognormal			Displaced Lognormal				Gastwirth	
	∝	β	Gini	σ	ρ	Gini	M	V	Gini	C	M	V	Gini	GU	GL
Abiline, Tex	1.99	0.00022	0.27	1.53	7.14	0.38	8.83	0.644	0.43	1450.74	9.04	0.338	0.32	0.38	0.37
Akron, Ohio	2.53	0.00020	0.24	1.81	4.97	0.33	9.21	0.549	0.40	-1846.42	8.84	0.725	0.45	0.33	0.31
Albany, Ga	1.72	0.00018	0.28	1.34	5.48	0.40	8.82	0.817	0.48	738.81	8.92	0.559	0.40	0.40	0.39
Albany, NY	2.43	0.00020	0.24	1.75	5.05	0.34	9.18	0.561	0.40	-2951.78	8.46	1.220	0.57	0.34	0.32
Albuquerque, NM	1.90	0.00018	0.27	1.43	4.80	0.38	8.99	0.739	0.46	1836.50	9.25	0.390	0.34	0.38	0.37
Allentown, NJ	2.74	0.00024	0.23	1.96	5.93	0.33	9.15	0.486	0.38	-539.56	9.06	0.446	0.36	0.32	0.31
Amarillo, Tex	2.18	0.00021	0.26	1.63	5.86	0.36	9.00	0.616	0.42	-451.87	8.90	0.572	0.41	0.36	0.35
Ann Arbor, Mich	2.30	0.00016	0.25	1.62	4.18	0.35	9.33	0.603	0.42	9.33	0.60	3.481	0.00	0.35	0.33
Ashville, NC	1.97	0.00022	0.27	1.53	6.28	0.38	8.83	0.689	0.44	206.38	8.82	0.531	0.39	0.38	0.37
Atlanta, Ga	2.04	0.00016	0.26	1.49	4.51	0.37	9.16	0.690	0.44	-2340.97	8.50	1.259	0.57	0.37	0.35
Atlantic City, NJ	1.90	0.00018	0.27	1.43	5.57	0.38	8.98	0.697	0.45	-2782.05	7.55	3.061	0.78	0.39	0.38
Austin, Tex	1.87	0.00016	0.27	1.40	5.16	0.39	9.04	0.712	0.45	-1020.60	8.79	0.808	0.47	0.39	0.38
Bakersfield, Cal	2.00	0.00019	0.27	1.51	5.12	0.37	8.96	0.689	0.44	2814.40	9.34	0.305	0.30	0.38	0.36
Baltimore, Md	2.17	0.00018	0.26	1.59	4.70	0.36	9.15	0.655	0.43	-2199.38	8.59	1.076	0.54	0.36	0.34
Baton Rouge, La	1.85	0.00017	0.27	1.40	4.65	0.38	9.01	0.772	0.47	354.55	9.00	0.607	0.42	0.38	0.37
Bay City, Mich	2.58	0.00022	0.24	1.88	5.24	0.33	9.15	0.538	0.40	-939.72	8.94	0.590	0.41	0.33	0.31
Beaumont, Tex	2.05	0.00020	0.26	1.56	5.47	0.37	8.98	0.693	0.44	547.82	9.02	0.492	0.38	0.36	0.35
Billings, Mont	2.25	0.00021	0.25	1.68	5.90	0.36	9.01	0.593	0.41	159.16	9.01	0.484	0.38	0.36	0.34
Binghampton, NY	2.47	0.00022	0.24	1.80	5.21	0.34	9.10	0.552	0.40	-1928.07	8.61	0.947	0.51	0.34	0.32
Birmingham, Ala	1.76	0.00018	0.28	1.37	5.70	0.39	8.87	0.788	0.47	34.66	8.79	0.684	0.44	0.39	0.38
Boston, Mass	2.19	0.00016	0.25	1.56	4.50	0.36	9.27	0.617	0.42	-3426.44	8.30	1.627	0.63	0.37	0.34
Bridgeport, Conn	2.56	0.00019	0.24	1.79	4.63	0.33	9.30	0.536	0.40	-3572.31	8.49	1.212	0.56	0.34	0.31
Brockton, Mass	2.90	0.00024	0.22	2.07	5.32	0.31	9.21	0.482	0.38	-2118.40	8.84	0.656	0.43	0.31	0.29
Buffalo, NY	2.46	0.00021	0.24	1.79	5.27	0.34	9.15	0.559	0.40	-2748.01	8.40	1.276	0.58	0.34	0.32

Table 2. Continued.

S.M.S.A. (70)	Gamma			Beta			Lognormal			Displaced Lognormal				Gastwirth	
	α	β	Gini	σ	ρ	Gini	M	V	Gini	C	M	V	Gini	GU	GL
Canton, Ohio	2.72	0.00023	0.23	1.96	5.75	0.32	9.15	0.501	0.38	-2442.00	8.62	0.875	0.49	0.32	0.30
Cedar Rapids, Iowa	2.70	0.00023	0.23	1.95	5.37	0.32	9.17	0.510	0.39	1872.04	9.36	0.293	0.30	0.32	0.30
Champaign, Ill	2.10	0.00017	0.26	1.48	4.89	0.37	9.14	0.630	0.43	-152.81	9.09	0.530	0.39	0.37	0.36
Charlotte, SC	1.56	0.00017	0.30	1.25	4.94	0.41	8.76	0.975	0.51	2033.07	9.05	0.453	0.37	0.40	0.39
Charleston, W Va	1.96	0.00020	0.27	1.50	5.50	0.37	8.92	0.705	0.45	1105.93	9.06	0.459	0.37	0.37	0.36
Charlotte, NC	2.04	0.00018	0.26	1.51	5.17	0.37	9.09	0.663	0.44	-49.01	9.04	0.549	0.40	0.37	0.36
Chicago, Ill	2.26	0.00016	0.25	1.61	4.29	0.35	9.29	0.623	0.42	-2537.41	8.71	0.965	0.51	0.35	0.33
Cleveland, Ohio	2.23	0.00017	0.25	1.61	4.49	0.35	9.23	0.642	0.43	-2778.70	8.50	1.253	0.57	0.35	0.33
Colo Springs, Colo	2.15	0.00020	0.26	1.60	5.55	0.36	9.01	0.636	0.43	-88.89	8.99	0.521	0.39	0.36	0.35
Columbia, SC	1.86	0.00018	0.27	1.42	5.39	0.38	8.93	0.755	0.46	-950.49	8.62	0.920	0.50	0.39	0.37
Columbus, Ohio	2.28	0.00019	0.25	1.66	4.97	0.35	9.15	0.607	0.42	-1442.38	8.84	0.742	0.46	0.35	0.33
Corpus Christi, Tex	1.78	0.00018	0.28	1.38	5.47	0.39	8.85	0.780	0.47	2299.85	9.20	0.358	0.33	0.40	0.38
Dallas, Tex	2.02	0.00016	0.26	1.48	4.85	0.37	9.15	0.670	0.44	-495.43	9.02	0.605	0.42	0.38	0.36
Davenport, Ill	2.46	0.00021	0.24	1.80	5.28	0.34	9.14	0.567	0.41	1072.80	9.26	0.350	0.32	0.33	0.32
Dayton, Ohio	2.54	0.00020	0.24	1.81	4.71	0.33	9.23	0.552	0.40	-2935.95	8.56	1.079	0.54	0.33	0.31
Decatur, Ill	2.35	0.00020	0.25	1.72	5.37	0.35	9.14	0.583	0.41	-539.46	9.02	0.538	0.40	0.34	0.33
Denver, Colo	2.32	0.00019	0.25	1.67	4.91	0.35	9.19	0.586	0.41	-2527.79	8.59	1.059	0.53	0.35	0.33
Des Moines, Iowa	2.46	0.00020	0.24	1.76	5.13	0.34	9.18	0.539	0.40	-1413.92	8.88	0.696	0.44	0.34	0.33
Detroit, Mich	2.33	0.00017	0.25	1.66	4.18	0.34	9.29	0.614	0.42	-2528.08	8.71	0.970	0.51	0.34	0.32
Dubuque, Iowa	2.47	0.00022	0.24	1.81	5.66	0.34	9.12	0.547	0.40	1939.98	9.32	0.310	0.31	0.34	0.32
Duluth, Minn	2.52	0.00025	0.24	1.90	6.44	0.34	8.98	0.536	0.40	1216.51	9.10	0.326	0.31	0.33	0.32
El Paso, Tex	1.86	0.00020	0.27	1.43	5.69	0.39	8.85	0.732	0.45	895.94	9.01	0.468	0.37	0.39	0.38
Erie, Pa	2.55	0.00024	0.24	1.87	6.39	0.34	9.07	0.518	0.39	-1316.83	8.78	0.646	0.43	0.33	0.32
Eugene, Ore	2.29	0.00021	0.25	1.70	5.79	0.35	9.04	0.591	0.41	-73.55	8.98	0.513	0.39	0.35	0.34
Evansville, Ind	2.25	0.00022	0.25	1.69	5.79	0.35	8.99	0.604	0.42	36.81	8.95	0.519	0.39	0.35	0.34
Fargo, ND	2.32	0.00021	0.25	1.70	5.65	0.35	9.08	0.570	0.41	-205.93	9.02	0.515	0.39	0.35	0.34

Table 2. Continued.

S.M.S.A. (70)	Gamma			Beta			Lognormal			Displaced Lognormal				Gastwirth	
	α	β	Gini	δ	ρ	Gini	M	V	Gini	C	M	V	Gini	GU	GL
Fitchburg, Mass	2.47	0.00021	0.24	1.80	5.61	0.34	9.13	0.552	0.40	-1347.10	8.85	0.659	0.43	0.34	0.32
Ft Lauderdale, Fla	1.76	0.00014	0.28	1.31	5.15	0.40	9.09	0.731	0.45	-409.94	8.98	0.661	0.43	0.41	0.40
Ft Wayne, Ind	2.75	0.00022	0.23	1.94	5.33	0.32	9.22	0.492	0.38	-2199.12	8.83	0.703	0.45	0.32	0.30
Ft Worth, Tex	2.29	0.00020	0.25	1.67	5.12	0.35	9.11	0.601	0.42	-1239.32	8.84	0.717	0.45	0.35	0.33
Fresno, Cal	1.86	0.00018	0.27	1.41	5.29	0.39	8.94	0.721	0.45	55.90	8.91	0.624	0.42	0.39	0.38
Gary, Ind	2.60	0.00021	0.24	1.88	4.82	0.32	9.19	0.557	0.40	-1332.33	8.92	0.622	0.42	0.32	0.30
Grand Rapids, Mich	2.54	0.00021	0.24	1.82	5.40	0.34	9.18	0.532	0.39	-1981.61	8.77	0.778	0.47	0.33	0.31
Great Falls, Mont	2.27	0.00022	0.25	1.69	6.23	0.36	9.01	0.586	0.41	348.21	9.06	0.428	0.36	0.35	0.34
Green Bay, Wis	2.61	0.00022	0.24	1.89	6.18	0.33	9.16	0.515	0.39	-764.11	9.02	0.484	0.38	0.33	0.31
Greensboro, NC	2.06	0.00019	0.26	1.54	5.74	0.37	9.02	0.657	0.43	3739.92	9.46	0.245	0.27	0.37	0.36
Greenville, SC	2.10	0.00021	0.26	1.61	6.01	0.36	8.93	0.659	0.43	-911.94	8.66	0.749	0.46	0.36	0.35
Hamilton, Ohio	2.53	0.00022	0.24	1.85	5.14	0.33	9.14	0.555	0.40	-1371.93	8.86	0.659	0.43	0.33	0.31
Harrisburg, Pa	2.46	0.00021	0.24	1.79	5.56	0.34	9.12	0.555	0.40	-3537.70	7.96	2.006	0.68	0.34	0.32
Hartford, Conn	2.55	0.00018	0.24	1.77	4.45	0.33	9.34	0.541	0.40	-4467.28	8.01	2.130	0.70	0.34	0.31
Honolulu, Ha	2.04	0.00014	0.26	1.47	3.92	0.36	9.28	0.706	0.45	2791.15	9.53	0.280	0.29	0.37	0.35
Houston, Tex	2.04	0.00017	0.26	1.51	4.87	0.37	9.11	0.685	0.44	160.07	9.09	0.522	0.39	0.37	0.35
Huntington, Ky	1.94	0.00021	0.27	1.52	6.13	0.38	8.83	0.710	0.45	1717.90	9.05	0.354	0.33	0.38	0.36
Indianapolis, Ind	2.45	0.00020	0.24	1.76	5.02	0.34	9.18	0.559	0.40	4.97	9.16	0.441	0.36	0.34	0.32
Jackson, Mich	2.46	0.00020	0.24	1.77	5.05	0.34	9.18	0.560	0.40	-1911.66	8.76	0.821	0.48	0.34	0.32
Jacksonville, Fla	1.79	0.00017	0.28	1.38	5.22	0.39	8.92	0.806	0.47	1320.66	9.10	0.458	0.37	0.39	0.37
Jersey City, NJ	2.25	0.00020	0.25	1.68	4.97	0.35	9.05	0.636	0.43	-890.25	8.85	0.669	0.44	0.35	0.33
Kalamazoo, Mich	2.45	0.00019	0.24	1.75	4.94	0.34	9.22	0.554	0.40	-2725.35	8.60	1.046	0.53	0.34	0.32
Kansas City, Kan	2.32	0.00019	0.25	1.68	5.08	0.35	9.16	0.592	0.41	-2152.13	8.68	0.922	0.50	0.35	0.33
Kenosha, Wis	2.82	0.00024	0.23	2.04	5.52	0.32	9.15	0.490	0.38	-75.62	9.12	0.407	0.35	0.31	0.29
Knoxville, Tenn	1.84	0.00019	0.27	1.42	5.82	0.39	8.87	0.742	0.46	64.38	8.81	0.647	0.43	0.39	0.38

Table 2. Continued.

S.M.S.A. (70)		Gamma			Beta			Lognormal			Displaced Lognormal			Gastwirth	
	α	β	Gini	$\bar{\sigma}$	ρ	Gini	M	V	Gini	C	M	V	Gini	GU	GL
Lake Charles, La	1.88	0.00020	0.27	1.47	5.40	0.38	8.86	0.763	0.46	2204.91	9.16	0.359	0.33	0.38	0.36
Lancaster, Pa	2.55	0.00022	0.24	1.85	5.93	0.34	9.12	0.528	0.39	-3170.45	8.25	1.406	0.60	0.33	0.32
Las Vegas, Nev	2.31	0.00019	0.25	1.67	4.60	0.34	9.18	0.604	0.42	1756.66	9.38	0.323	0.31	0.35	0.33
Lewiston, Me	2.44	0.00025	0.24	1.84	8.30	0.35	8.95	0.503	0.38	-553.32	8.73	0.476	0.37	0.35	0.34
Lawton, Okla	1.94	0.00022	0.27	1.53	6.33	0.38	8.77	0.728	0.45	2440.38	9.13	0.256	0.28	0.37	0.36
Lexington, Ky	2.07	0.00018	0.26	1.54	5.14	0.37	9.06	0.651	0.43	-1318.17	8.73	0.860	0.49	0.37	0.36
Lima, Ohio	2.56	0.00023	0.24	1.88	5.62	0.33	9.08	0.536	0.40	-1172.69	8.83	0.639	0.43	0.33	0.31
Lincoln, Neb	2.48	0.00022	0.24	1.79	5.66	0.34	9.11	0.522	0.39	-791.46	8.95	0.576	0.41	0.34	0.33
Little Rock, Ark	1.94	0.00020	0.27	1.49	5.90	0.38	8.90	0.703	0.45	892.05	9.02	0.456	0.37	0.38	0.37
Loraine, Ohio	2.89	0.00024	0.22	2.07	5.35	0.31	9.20	0.487	0.38	-1379.85	8.97	0.528	0.39	0.31	0.29
Los Angeles, Cal	1.97	0.00015	0.27	1.44	4.37	0.37	9.19	0.704	0.45	-1288.77	8.87	0.797	0.47	0.38	0.36
Lowell, Mass	2.80	0.00023	0.23	2.01	4.89	0.31	9.19	0.514	0.39	-2855.50	8.55	1.008	0.52	0.31	0.29
Lubbock, Tex	1.81	0.00017	0.28	1.38	5.95	0.39	8.93	0.717	0.45	-269.96	8.88	0.633	0.43	0.40	0.39
Lynchburg, Va	2.17	0.00021	0.26	1.64	6.13	0.36	8.97	0.610	0.42	-17.06	8.92	0.522	0.39	0.36	0.35
Macon, Ga	1.89	0.00019	0.27	1.45	5.13	0.38	8.92	0.733	0.45	-293.97	8.79	0.730	0.45	0.38	0.37
Manchester, NH	2.54	0.00023	0.24	1.86	5.95	0.34	9.09	0.529	0.39	-1429.23	8.78	0.683	0.44	0.33	0.32
Memphis, Tenn	1.69	0.00017	0.29	1.31	5.30	0.40	8.89	0.828	0.48	1646.72	9.12	0.451	0.37	0.40	0.39
Meriden, Conn	2.92	0.00024	0.22	2.07	5.07	0.31	9.22	0.480	0.38	74.91	9.22	0.368	0.33	0.31	0.29
Miami, Fla	1.64	0.00014	0.29	1.24	4.96	0.41	9.03	0.816	0.48	-1964.99	8.35	1.531	0.62	0.42	0.41
Midland, Tex	1.96	0.00015	0.27	1.43	4.69	0.38	9.15	0.695	0.44	1430.80	9.32	0.386	0.34	0.38	0.37
Milwaukee, Wis	2.59	0.00020	0.24	1.83	4.94	0.33	9.24	0.531	0.39	-2076.31	8.82	0.757	0.46	0.33	0.31
Minneapolis, Minn	2.62	0.00019	0.24	1.83	4.85	0.33	9.29	0.514	0.39	-3795.06	8.30	1.527	0.62	0.33	0.31
Mobile, Ala	1.73	0.00019	0.28	1.37	5.89	0.40	8.79	0.819	0.48	2950.36	9.21	0.296	0.30	0.39	0.38
Montgomery, Ala	1.62	0.00017	0.29	1.27	5.27	0.41	8.82	0.857	0.49	1687.99	9.09	0.457	0.37	0.41	0.40
Muncie, Ind	2.40	0.00022	0.24	1.76	5.77	0.35	9.08	0.564	0.40	-1105.70	8.84	0.645	0.43	0.34	0.33

Table 2. Continued.

S.M.S.A. (70)	Gamma			Beta			Lognormal			Displaced Lognormal				Gastwirth	
	α	β	Gini	σ	ρ	Gini	M	V	Gini	C	M	V	Gini	GU	GL
Muskegon, Mich	2.55	0.00023	0.24	1.88	5.67	0.33	9.08	0.544	0.40	-1313.88	8.77	0.689	0.44	0.33	0.31
Nashville, Tenn	1.96	0.00018	0.27	1.48	5.50	0.38	9.01	0.696	0.44	1341.57	9.18	0.408	0.35	0.38	0.37
New Bedford, Mass	2.22	0.00022	0.25	1.68	5.99	0.36	8.96	0.617	0.42	-1229.42	8.59	0.830	0.48	0.35	0.34
New Britain, Conn	2.85	0.00023	0.23	2.01	5.00	0.31	9.24	0.485	0.38	-1382.81	9.00	0.545	0.40	0.31	0.29
New Haven, Conn	2.09	0.00016	0.26	1.52	4.53	0.36	9.21	0.678	0.44	-2761.58	8.46	1.333	0.59	0.37	0.35
New Orleans, La	1.60	0.00015	0.29	1.25	5.04	0.41	8.90	0.892	0.50	-605.79	8.62	1.007	0.52	0.41	0.40
New York, NY	1.74	0.00013	0.28	1.29	4.19	0.39	9.18	0.805	0.47	-1150.26	8.86	0.852	0.49	0.40	0.39
Newark, NJ	2.02	0.00014	0.26	1.45	4.20	0.37	9.30	0.676	0.44	-3702.15	7.99	2.344	0.72	0.38	0.36
Newport News, Va	2.17	0.00020	0.26	1.63	4.84	0.35	9.03	0.674	0.44	978.74	9.17	0.408	0.35	0.35	0.33
Norfolk, Va	1.89	0.00019	0.27	1.46	5.12	0.38	8.92	0.776	0.47	-345.61	8.79	0.704	0.45	0.37	0.36
Odessa, Tex	2.38	0.00022	0.25	1.77	6.09	0.35	9.03	0.570	0.41	1978.97	9.28	0.287	0.30	0.34	0.33
Ogden, Ut	2.49	0.00022	0.24	1.81	5.03	0.33	9.12	0.552	0.40	-1902.35	8.69	0.855	0.49	0.34	0.32
Oklahoma City, Okla	2.07	0.00019	0.26	1.54	5.33	0.37	9.04	0.654	0.43	-919.25	8.81	0.734	0.46	0.37	0.36
Orlando, Fla	1.94	0.00018	0.27	1.46	5.21	0.38	8.98	0.703	0.45	-1620.64	8.51	1.107	0.54	0.38	0.37
Paterson, NJ	2.31	0.00015	0.25	1.60	4.23	0.35	9.39	0.578	0.41	-4738.25	7.90	2.487	0.74	0.36	0.34
Peoria, Ill	2.60	0.00021	0.24	1.86	5.34	0.33	9.19	0.521	0.39	-1103.20	8.98	0.567	0.41	0.33	0.31
Philadelphia, Pa	2.22	0.00018	0.25	1.61	4.76	0.35	9.18	0.627	0.42	583.96	9.23	0.422	0.35	0.35	0.34
Phoenix, Ariz	2.09	0.00018	0.26	1.54	5.05	0.37	9.09	0.652	0.43	555.54	9.14	0.467	0.37	0.37	0.35
Pittsburgh, Pa	2.34	0.00021	0.25	1.71	5.66	0.35	9.10	0.575	0.41	-2210.18	8.54	1.040	0.53	0.35	0.33
Portland, Me	2.42	0.00022	0.24	1.78	5.85	0.34	9.07	0.558	0.40	-2651.01	8.31	1.304	0.58	0.34	0.33
Portland, Ore	2.32	0.00019	0.25	1.68	5.16	0.35	9.15	0.587	0.41	-2144.92	8.61	1.002	0.52	0.35	0.33
Provo, Ut	2.24	0.00024	0.25	1.73	6.41	0.35	8.89	0.607	0.42	-297.72	8.73	0.540	0.40	0.35	0.34
Raleigh, NC	1.97	0.00017	0.27	1.47	4.95	0.37	9.04	0.706	0.45	1529.61	9.24	0.398	0.34	0.38	0.36
Reno, Nev	2.27	0.00017	0.25	1.61	4.68	0.35	9.23	0.590	0.41	-1243.89	8.96	0.666	0.44	0.36	0.34
Richmond, Va	2.18	0.00019	0.26	1.60	5.16	0.36	9.11	0.627	0.42	-2067.62	8.58	1.044	0.53	0.36	0.34

Table 2. Continued.

S.M.S.A. (70)		Gamma			Beta			Lognormal			Displaced Lognormal			Gastwirth	
	α	β	Gini	$\bar{\sigma}$	ρ	Gini	M	V	Gini	C	M	V	Gini	GU	GL
Roanoke, Va	2.28	0.00021	0.25	1.69	5.94	0.35	9.03	0.580	0.41	-1678.41	8.60	0.893	0.50	0.36	0.34
Rochester, NY	2.54	0.00019	0.24	1.78	4.43	0.33	9.29	0.546	0.40	-3241.36	8.53	1.171	0.56	0.33	0.31
Rockford, Ill	2.59	0.00021	0.24	1.87	5.12	0.33	9.20	0.542	0.40	327.77	9.21	0.393	0.34	0.32	0.30
Sacramento, Cal	2.17	0.00018	0.26	1.59	4.63	0.35	9.12	0.648	0.43	-1472.17	8.77	0.842	0.48	0.36	0.34
Saginow, Mich	2.40	0.00020	0.24	1.75	4.77	0.34	9.17	0.602	0.42	-776.44	8.98	0.593	0.41	0.33	0.31
St Joseph, Mo	2.27	0.00024	0.25	1.73	6.84	0.36	8.92	0.584	0.41	-493.35	8.74	0.560	0.40	0.35	0.34
St Louis, Mo	2.21	0.00018	0.25	1.62	4.94	0.35	9.14	0.634	0.43	1164.00	9.26	0.391	0.34	0.35	0.34
Salt Lake City, Ut	2.38	0.00020	0.25	1.73	5.59	0.35	9.12	0.569	0.41	-2752.74	8.39	1.259	0.57	0.35	0.33
San Angelo, Tex	1.82	0.00019	0.28	1.40	6.59	0.40	8.84	0.707	0.45	-293.73	8.74	0.659	0.43	0.40	0.39
San Antonio, Tex	1.79	0.00018	0.28	1.38	5.65	0.39	8.87	0.767	0.46	77.64	8.85	0.632	0.43	0.40	0.38
San Bernadino, Cal	1.99	0.00018	0.27	1.50	5.00	0.37	9.00	0.695	0.44	-852.44	8.77	0.785	0.47	0.37	0.36
San Diego, Cal	1.99	0.00017	0.27	1.48	4.63	0.37	9.09	0.721	0.45	-47.59	9.05	0.560	0.40	0.37	0.35
San Francisco, Cal	2.09	0.00015	0.26	1.51	4.14	0.36	9.26	0.682	0.44	-2522.07	8.60	1.151	0.55	0.37	0.34
San Jose, Cal	2.49	0.00018	0.24	1.74	4.20	0.33	9.33	0.564	0.40	1360.86	9.43	0.312	0.31	0.34	0.31
Santa Barbara, Cal	2.17	0.00018	0.26	1.58	4.60	0.36	9.14	0.631	0.43	-2261.46	8.54	1.163	0.55	0.36	0.34
Savannah, Ga	1.79	0.00018	0.28	1.39	5.46	0.39	8.86	0.780	0.47	-545.54	8.61	0.887	0.49	0.39	0.38
Scranton, Pa	2.47	0.00025	0.24	1.85	7.03	0.34	8.96	0.529	0.39	-1210.04	8.67	0.627	0.42	0.32	0.33
Seattle, Wash	2.51	0.00019	0.24	1.77	4.59	0.33	9.28	0.551	0.40	-2716.54	8.71	0.926	0.50	0.34	0.31
Shreveport, La	1.71	0.00018	0.28	1.34	5.54	0.40	8.83	0.810	0.48	1645.01	9.07	0.436	0.36	0.40	0.39
Sioux City, Iowa	2.16	0.00020	0.26	1.61	6.18	0.37	9.00	0.597	0.42	554.58	9.05	0.461	0.37	0.37	0.35
Sioux Falls, SD	2.41	0.00023	0.24	1.80	5.97	0.34	9.02	0.565	0.40	1483.28	9.19	0.335	0.32	0.34	0.32
South Bend, Ind	2.55	0.00022	0.24	1.84	5.64	0.34	9.15	0.526	0.39	-519.06	9.04	0.498	0.38	0.33	0.32
Spokane, Wash	2.19	0.00020	0.25	1.63	5.47	0.36	9.04	0.614	0.42	-1350.39	8.67	0.862	0.49	0.36	0.34
Springfield, Mo	2.37	0.00020	0.25	1.72	5.37	0.35	9.15	0.561	0.40	-1436.72	8.86	0.697	0.44	0.37	0.36
Springfield, Ohio	2.49	0.00022	0.24	1.83	5.36	0.33	9.10	0.561	0.40	-1508.73	8.76	0.736	0.46	0.33	0.31

Table 2. Continued.

S.M.S.A. (70)	Gamma			Beta			Lognormal			Displaced Lognormal				Gastwirth	
	α	β	Gini	ρ	σ	Gini	M	V	Gini	C	M	V	Gini	GU	GL
Steubenville, Ohio	2.53	0.00024	0.24	1.90	6.01	0.33	9.04	0.552	0.40	-83.49	8.96	0.464	0.37	0.33	0.31
Stockton, Cal	1.98	0.00018	0.27	1.49	5.11	0.37	9.02	0.706	0.45	-263.27	8.91	0.651	0.43	0.37	0.36
Syracuse, NY	2.35	0.00019	0.25	1.70	51.2	0.35	9.15	0.584	0.41	-2542.92	8.51	1.139	0.55	0.35	0.33
Tacoma, Wash	2.19	0.00019	0.25	1.62	5.18	0.36	9.08	0.631	0.43	-1184.22	8.80	0.755	0.46	0.36	0.34
Tampa, Fla	1.88	0.00019	0.27	1.43	6.17	0.39	8.88	0.687	0.44	-936.86	8.62	0.849	0.49	0.40	0.39
Topeka, Kan	2.38	0.00021	0.25	1.75	5.82	0.35	9.08	0.562	0.40	-732.25	8.93	0.567	0.41	0.35	0.33
Trenton, NJ	2.21	0.00017	0.25	1.58	4.75	0.36	9.24	0.609	0.42	-3405.14	8.26	1.663	0.64	0.36	0.34
Tuscon, Ariz	1.95	0.00018	0.27	1.46	5.37	0.38	8.99	0.692	0.44	-361.34	8.89	0.661	0.43	0.38	0.37
Tulsa, Okla	2.04	0.00019	0.26	1.53	5.52	0.37	9.03	0.659	0.43	1815.71	9.26	0.364	0.33	0.37	0.36
Tuscaloosa, Ala	1.61	0.00018	0.29	1.28	5.70	0.41	8.74	0.863	0.49	1067.56	8.90	0.523	0.39	0.41	0.40
Tyler, Tex	1.93	0.00020	0.27	1.48	6.03	0.38	8.89	0.692	0.44	2122.25	9.19	0.343	0.32	0.38	0.37
Utica, NY	2.48	0.00022	0.24	1.82	5.60	0.34	9.08	0.548	0.40	-2229.97	8.54	0.991	0.52	0.34	0.32
Washington, D.C.	2.02	0.00013	0.26	1.43	3.82	0.37	9.38	0.691	0.44	-3949.34	8.38	1.835	0.66	0.38	0.36
Waterbury, Conn	2.55	0.00020	0.24	1.81	4.86	0.33	9.24	0.545	0.40	-2185.53	8.84	0.734	0.46	0.33	0.31
Watterton, Iowa	2.45	0.00022	0.24	1.79	5.74	0.34	9.11	0.546	0.40	1532.28	9.26	0.339	0.32	0.34	0.32
W. Palm Beach, Fla	1.56	0.00013	0.30	1.18	5.02	0.42	9.04	0.819	0.48	-1722.43	8.50	1.318	0.58	0.44	0.43
Wichita, Kan	2.26	0.00021	0.25	1.68	5.65	0.35	9.05	0.609	0.42	-204.23	9.00	0.509	0.39	0.35	0.34
Wilkesburg, Pa	2.35	0.00025	0.25	1.79	7.30	0.35	8.92	0.566	0.41	2589.22	9.24	0.213	0.26	0.35	0.33
Wilmington, Del	2.30	0.00018	0.25	1.65	5.05	0.35	9.20	0.591	0.41	-3534.69	8.11	1.883	0.67	0.35	0.33
Worcester, Mass	2.65	0.00022	0.23	1.89	5.29	0.33	9.19	0.507	0.39	-2182.74	8.75	0.796	0.47	0.33	0.31
Yorktown, Pa	2.63	0.00023	0.23	1.91	6.25	0.33	9.12	0.497	0.38	-3198.49	8.20	1.452	0.61	0.33	0.31
Youngstown, Ohio	2.58	0.00022	0.24	1.88	5.28	0.33	9.15	0.542	0.40	-2032.52	8.70	0.836	0.48	0.33	0.31

One of the objectives of the research was to evaluate the different methodologies. The Gastwirth indices were used as the test. Gastwirth (1971, 1972, 1974) suggested a method of estimation of the Gini coefficient with group data that do not require any assumption about the functional form of income distribution. The method yields upper and lower bounds for the Gini coefficient. A "goodness of fit" test can be performed by relating the Gini coefficient generated by each of the estimation techniques to the Gastwirth bounds. This test is not a statistical test; rather it provides an alternative estimation of the upper and lower bounds of the Gini. The Gastwirth bounds are also indicated in Tables 1 and 2 for each SMSA.

Gastwirth (1975) found that the lognormal and displaced lognormal functions fail the test consistently. Metcalf (1972) indicates that logrithmic transformation over estimates the positive skewness of the data. The Gini coefficients generated by the lognormal and displaced lognormal functions fell outside the Gastwirth bounds in every SMSA, as can be seen in Tables 1 and 2. The gamma distribution function also consistently failed the Gastwirth test for each SMSA. The beta functions produced a Gini coefficient which frequently fell between the upper and lower Gastwirth bounds. When the beta-produced Gini is outside the bounds, the coefficient was substantially closer to one or the other of the bounds than any of the other functional forms. The Gastwirth test indicated that, for the purpose of this study, the beta was the appropriate estimation function.

Analysis of Water Quality Control Effects

Once the beta function was selected as the appropriate form for the test, an analysis of the effects of water quality controls was devised. This analysis consisted of three steps: first, an econometric model was conceptualized in order to generate test table hypotheses with respect to income distribution changes. Second, the data were accumulated for both water quality controls and for the other variables in the model. Finally, the hypotheses were tested for significance.

The conceptual basis

The conceptual model used in this study was drawn from models developed by Pitchford (1957, 1963), and a recent extension by Pitchford and Turnsovsky (1975) which examined the effect of inflation on tax incidence and income distribution. These models utilize a factor-share approach to distribution, in that labor and entrepreneurs are each assumed to attempt to avoid tax payments by passing these payments on through either higher wages or prices, respectively. This is, of course, not a profit maximizing model, but is rather a model of short-run wage and price adjustments. There is a similarity between the increasing costs due to taxes and those due to water quality controls based on effluent limitations, especially for entrepreneurs. Since these costs may have some effect on output, and the wage bill, the workers also may attempt to pass on treatment costs in the form of higher wages. The model assumes that wages and prices are determined partly by competitive demand and partly by the non-competitive environmental costs. The proportion of treatment costs which each will attempt to pass is defined as X_Π and X_w, where X_Π is the entrepreneurial proportion and X_w is the labor proportion. $X_\Pi + X_w$ must equal 1 and both proportions are greater than or equal to zero.

The price and wage adjustment equations can be written as

$$\frac{\Delta P}{P} = K_1 \left(\frac{Q - Q^t}{Q_t}\right) + K_2 \left(\frac{P^t - P}{P}\right) \quad . \; . \; . \quad (1)$$

$$\frac{\Delta W}{W} = K_3 \left(\frac{N - N^t}{N^t}\right) + K_4 \left(\frac{W^t - W}{W}\right) \quad . \; . \quad (2)$$

in which

P = price
ΔP = change in price
Π^t = target profit set by producers
Q = output
Q^t = target output set by producers
W = wage
ΔW = change in wage
W^t = target wage set by workers
N = employment
N^t = target employment set by workers

K_1, K_2, K_3, and K_4 are non-negative coefficients. Note that target employment and output are directly controllable by entrepreneurs and laborers, respectively, while prices and wages are not.

Following the Pitchford and Turnovsky derivation, target wage (W^t) and target profit (Π^t) are defined as:

$$W^t = \alpha p + X_w W_q \quad . \; . \; . \; . \; . \; . \quad (3)$$

and

$$\Pi^t = \beta W + X_\Pi W_q \quad . \; . \; . \; . \; . \; . \quad (4)$$

α and β are parameters and W_q stands for the treatment cost per unit of output. Thus, the entrepreneurs attempt to maintain a profit level proportional to wages and treatment costs, while laborers attempt to maintain a wage level proportional to prices and treatment cost which might be passed to them from producers in the form of lower wages. The target price then is:

$$\begin{aligned} p^t &= W^t + \Pi^t \\ &= \alpha P + \beta W + (X_w + X_\Pi)\, W_q \\ &= \alpha P + \beta W + W_q\,. \quad . \quad . \quad . \quad . \quad . \quad (5) \end{aligned}$$

It is further assumed that the factor share to labor, b is defined as

$$b = \frac{WN}{PQ} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

and we can select units of measurement such that

$$Q^t = N^t \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

In order to examine the possible effects of water quality controls on income distribution, the following mathematical manipulations are made.

$$0 = k_1 \left(\frac{Q - Q^t}{Q^t}\right) + k_2 \left[(\alpha - 1) + \beta \frac{W}{P} + \frac{W_g}{P}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

$$0 = k_3 \left(\frac{N - N^t}{N^t}\right) + k_4 \left[\alpha \frac{P}{W} + \frac{X_w W_q}{W} - 1\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Assuming that B is constant, Equation 6 can be rearranged as

$$\frac{N}{N^t} = \frac{Pb}{W} \left[1 - \frac{k_2}{k_1} \left(\alpha - 1 + \beta \frac{W}{P} + \frac{W_q}{P}\right)\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Substituting Equation 10 into Equation 9 and solving,

$$0 = \frac{k_3 Pb}{W} \left[1 - \frac{k_2}{k_1} \left(\alpha - 1 + \beta \frac{W}{P} + \frac{W_q}{P}\right)\right] - k_3 + k_4 \left[\alpha \frac{P}{W} + \frac{X_w W_q}{W} - 1\right]$$

After algebraic manipulation, the stationary real wage can be identified as

$$\frac{P}{W} = \frac{1}{k_2 k_3 b + k_1 k_3 + k_1 k_4} \left[k_1 k_3 b - k_2 k_3 b \left(\alpha - 1 + \frac{W_q}{P}\right) + k_1 k_4 \alpha + k_1 k_4 \frac{X_w W_q}{P}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

The impact of increased real water treatment costs on the real wage is determined by the derivative of Equation 10 with respect to W_q/P:

$$\frac{\partial\left(\frac{W}{P}\right)}{\partial\left(\frac{W_q}{P}\right)} = \frac{1}{k_2 k_3 b \beta + k_1 k_3 + k_1 k_4} \left[k_1 k_4 X_w - k_2 k_3 b\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Since all the coefficients k, β, and b are assumed to be smaller than infinity, $(\partial(W/P))/(\partial(W_q/P))$ is zero if and only if

$$k_1 k_4 X_w - k_2 k_3 b = 0$$

or

$$b = kX_w; \quad k = \frac{k_1 k_4}{k_2 k_3}$$

Since b represents the wage bill proportion of output and X_w the amount of treatment cost which labor can pass on (assumably to entrepreneurs in the bargaining process), then real wage changes as a result of water quality controls only if labor is not able to extract its costs in the form of higher wage bill proportions.

It can further be assumed that:

$$\Pi = P - W \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

or

$$\frac{\Pi}{P} = 1 - \frac{W}{P}$$

Thus

$$\frac{\partial\left(\frac{\Pi}{P}\right)}{\partial\left(\frac{W}{P}\right)} = -1 < 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

The higher the real wage, the lower the real profit will be. Thus, if

$$\frac{\partial(W/P)}{\partial(W_q/P)} > 0,$$

then income will be redistributed from entrepreneur to labor; if

$$\frac{\partial(W/P)}{\partial(W_q/P)} < 0, \qquad \text{then}$$

income distribution changes will be in the opposite direction. If one assumes, as is probable, the entrepreneurs are in general in the higher income levels and wage earners are in general in the lower, then the shift in the Lorenz curve depends upon the relative changes in real wages and profits. Conceptually, water quality controls can have positive or negative distributional impacts; the argument is an empirical one.

In order to test the effects of these controls on distribution, two empirical models were constructed. The first model is based upon the mathematical models used for the conceptual model; the second is a modification of the first which intuitively appears relevant. Given the same assumptions and equations as before (Equations 1 through 6), we can derive an empirical model as follows:

Substituting Equation 5 into Equation 1 yields:

$$P^t - P = (\alpha - 1)\, P + \beta W + W_q \quad . \quad . \quad . \quad . \quad (15)$$

Substituting Equation 3 into Equation 2 yields:

$$W^t - W = \alpha p - W + X_w W_q \quad . \quad . \quad . \quad . \quad . \quad . (16)$$

Solving Equation 2 for N/N^t yields:

$$\frac{N}{N^t} = \frac{1}{k_3} \left[\frac{\Delta W}{W} + k_3 - k_4 \left(\frac{W^t - W}{W}\right)\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . (17)$$

Substituting Equation 16 into Equation 17

$$\frac{N}{N^t} = \frac{1}{k_3} \left[\frac{\Delta W}{W} + k_3 - k_4 \left(\frac{P - W + X_w W_q}{W}\right)\right]$$

or

$$\frac{WN}{bk_3} \left[\Delta W + k_3 W - k_4 (\alpha p - W + X_w W_q)\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . (18)$$

From Equation 1:

$$\Delta P = k_1 \left(\frac{PQ}{Q^t} - P\right) + k_2 (P^t - P)$$

Substituting Equations 15 into Equation 1,

$$\Delta P = k_1 \left(\frac{PQ}{N^t} - P\right) + k_2 \left[(\alpha - 1) P + \beta W + W_q\right]$$

or

$$= k_1 \left(\frac{WN}{bN^t} - P\right) + k_2 \left[(\alpha - 1) P + \beta W + W_q\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . (19)$$

Substituting Equation 18 into Equation 19; and solving:

$$\Delta P = \frac{k_1}{bk_3} \left[\Delta W + k_3 W - k_4 (\alpha P - W + X_w W_q) - bk_3 P\right] + k_2 \left[\quad \right]$$

$$\Delta P = \frac{k_1}{bk_3} \Delta W + \frac{k_1 k_3 + k_1 k_4}{bk_3} W - \frac{k_1 k_4 \alpha}{bk_3} P - \frac{k_1 k_4 X_w}{bk_3} W_q - k_1 P + k_2 (\alpha - 1) P + k_2 \Delta W + k_2 W_q$$

$$\Delta P = \left(\frac{k_1}{k_3}\right) \Delta W + \left(\frac{k_1 k_3 + k_1 k_4}{bk_3} + k_2 \beta\right) W + \left[k_2 (\alpha - 1) - k_1 - \frac{k_1 k_4 \alpha}{bk_3}\right] P + \left[k_2 - \frac{k_1 k_4 X_w}{bk_3}\right] W_q \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . (20)$$

The empirical model, then, is

$$\Delta P = f(\Delta W, W, P, W_q, b).$$

Solving Equation 1 for P yields;

$$\frac{\Delta P}{P} = k_1 \left(\frac{Q}{Q^t} - 1\right) + k_2 \left(\frac{P^t - P}{P}\right) \quad . \quad . \quad . (21)$$

or

$$\Delta P = k_1 \left(\frac{PQ}{Q^t} - P\right) + k_2 (P^t - P).$$

Solving for PQ/Q^t:

$$\frac{PQ}{Q^t} = \frac{1}{k_1} \left[\Delta P + k_1 P - k_2 (P^t - P)\right].$$

Multiplying by b gives:

$$\frac{bPQ}{Q^t} = \frac{b}{k_1} \left[\Delta P + k_1 P - k_2 (\alpha - 1) P + \beta W + W_q)\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . (22)$$

or

$$\frac{bPQ}{Q^t} = \frac{b}{k_1} \left[\Delta P + [k_1 - k_2 (\alpha - 1)] P + k\beta W + k_2 W_q\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . (23)$$

From Equation 2:

$$\Delta W = k_3 \left(\frac{WN}{N^t} - W\right) + k_4 (W^t - W) \quad . \quad . \quad . \quad . \quad . (24)$$

Substituting Equation 18 into Equation 24:

$$\Delta W = k_3 \left(\frac{bPQ}{Q^t} - W\right) + k_4 (\alpha P - W + X_w W_q) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . (25)$$

Substituting Equation 23 into Equation 25:

$$\Delta W = k_3 \left[\frac{b}{k_1} \{\Delta P + (k_1 - k_2 \alpha + k_2) P + (k_2 \beta - k_1) W + k_2 W_q\} + k_4 (\alpha P - W + X_w W_q)\right]$$

or

$$\Delta W = \frac{k_3 b}{k_1} (k_1 - k_2 \alpha + k_2 + k_1 k_4 \alpha) P + \frac{k_3 b}{k_1} (k_2 \beta - k_1 - k_1 k_4) W + \frac{k_3 b}{k_1} (k_2 + k_1 k_4 X_w) W_q + \frac{k_3 b}{k_1} \Delta P \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . (26)$$

The empirical model, then, is

$$\Delta W = g(\Delta P, P, W, W_q, b)$$

Note that b is a “shifter” for each of the equations, and is treated in the empirical model as such.

The final two equations of the empirical model relate the income distribution parameters to the wage and price changes. Since other factors may also have impacts on this distribution, a constant term is included in each equation. Further, since the two parameters are functionally related in the beta distribution, each parameter is included in the equation for the other. Thus:

$$\Delta\sigma = G(\Delta P, \Delta W, \Delta\rho, C_1), \text{ and} \quad \ldots \quad (26)$$

$$\Delta\rho = H(\Delta P, \Delta W, \Delta\sigma, C_2) \quad \ldots \quad (27)$$

The empirical model

Several empirical problems were encountered in the research effort. Data for important variables were missing so that surrogate variables consistent with the available data had to be selected for the model. The water quality data had a broad range of variables, so that indices had to be developed for each state. In addition, no cost data could be obtained to relate the water quality parameters to the wage and price equations. Therefore, the causality of the relationships which used the physical parameters is direct if and only if the cost of treatment is monotonically related to the level of quality constraint. Therefore, any statistical significance must be taken as a historical trend, rather than a causal relationship, unless the monotonic relationships are assumed.

Structural Equations

Structural equations were developed from the conceptual model and from the relationships between appropriate variables and the distribution parameters. Since agricultural wage and price data were not available for, nor particularly relevant to, SMSA's, only manufacturing sectors were analyzed. The variables for each SMSA are:

DB: Difference of the ratio of manufacturing payroll to total family income, 1960 and 1970. This variable is a proxy for the labor wages-output ratio for the manufacturing sector. The true ratio is probably underestimated, but the variable should be consistent between the two census years. Note that the change is used, rather than the absolute level, since wages and prices will change with changes in b.
WI: Index of water quality controls in industrial sector.
WA: Index of water quality controls in agricultural sectors.
DG: Rate of change of the first parameter (σ) of the beta function.
DH: Rate of change of the second parameter (ρ) of the beta function.
W: Industrial wage rate, 1960.
DW: Change in wages in the manufacturing sector 1960 to 1970.
P: Mean family income in 1960.
DP: Change in mean family income 1960 to 1970.

The first structural equations are:

$$DP = \phi\ (DW, WI, WA, P, W, DB) \quad \ldots \quad (28)$$

$$DW = \Omega\ (DP, WI, P, W, DB) \quad \ldots \quad (29)$$

$$DG = \Sigma\ (DP, DW, DH, C_1) \quad \ldots \quad (30)$$

$$DH = \psi\ (DP, DW, DG, C_2) \quad \ldots \quad (31)$$

WI, WA, DB, P, W are exogenous variables; DP, DW, DG, and DH are the endogenous variables.

The use of mean family income in Equations 28 and 29 results from a data problem; price indices are not available except for a few selected cities. Further, no close proxies for price exist. The best proxies for price are personal income measures, such as mean family income. However, using the change mean family income as a proxy for changes in prices requires the assumption that output, employment, and employees per household maintain a constant relationship between observations. The seriousness of the violation of this assumption is open to debate.

The model is assumed to be linear, so that the equation system is:

$$\begin{aligned} DP &= a_1 DW + a_3 WI + a_4 WA + a_5 P + a_6 W \\ &\quad + a_7 DB + e_1 \\ DW &= b_2 DP + b_3 WI + b_5 P + b_6 W + b_7 DB \\ DG &= g_1 DW + g_2 DP + g_8 DH + k_1 \\ DH &= h_1 DW + h_2 DP + h_8 DG + k_2 \end{aligned}$$

in which a_i b_i c_i, d_i stand for the parameters in the four equations; e_i stands for the disturbance term for four equations.

The empirical model uses water quality parameters in both industry and agriculture in the "price" equation, because the price index should be a function of water quality costs to all productive activities. On the other hand, industrial wages are logically a direct function only of water quality costs in the industrial sector.

A second empirical model was developed which included some variables thought to be important to income distribution changes but which were excluded from the conceptual model. Some of the original variables were retained, and some were not, on an intuitive basis only. This model was constructed as:

$$DP = (DW, WI, WA, DY) \quad \ldots \quad (32)$$

in which DY is the change in total family income between 1960 and 1970. This variable was a proxy for the rate of change of output in the economy of each SMSA. It was felt that total output would have an effect on prices in the economy. Price, wage, and factor share variables for 1960 were dropped from the equation.

$$DW = W(DE, DP, DB, WI) \quad . \; . \; . \; . \; . \; . \quad (33)$$

in which DE is the change in unemployment rate change from 1960 to 1970 for each SMSA. The effect of unemployment on the wage rate was thought to be an important factor in wage determination. Wage and price variables for 1960 were again dropped, but the labor wage-output ratio was retained. Since both wage changes and output were included in Equation 32, the variable for b was thought to be redundant. The equations for the distribution parameters remained the same as in the first empirical model.

This model was also assumed linear, so that the equation system was:

$$DP = a_1 DW + a_3 WI + a_4 WA + a_5 DY + e_1$$

$$DW = b_2 DP + b_3 WI + b_6 DE + b_7 DB + e_2$$

DG and DH are the same.

For the model WI, WA, DY, DE, and DB were exogenous variables, and DP, DW, DG, and DH were endogenous variables.

The Water Quality Indices

Water quality controls exist for five different classifications of uses: agricultural, industrial, recreational, fishery, and municipal. Each classification has specific controls or levels for 14 different criteria.[3] These classifications can be treated as a series of treatments in an analysis of variance, for which the experimental design is written mathematically as:

$$Y_{ij} = \mu + \alpha_i + e_{ij}$$

in which
i is the classification ($i = 1,...,5$)
j is the criteria ($j = 1,...,14$)
Y_{ij} is the jth criteria for the ith classification
μ = population mean
α_i = the adjustment for water quality for the ith classification
e_{ij} = disturbance term

The entire model in matrix form can be written:

$$\begin{bmatrix} Y_{11} \\ \vdots \\ Y_{1,14} \\ Y_{21} \\ \vdots \\ Y_{2,14} \\ Y_{31} \\ \vdots \\ Y_{3,14} \\ Y_{41} \\ \vdots \\ Y_{4,14} \\ Y_{51} \\ \vdots \\ Y_{5,14} \end{bmatrix} = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & 1 & 0 & \vdots & \vdots & \vdots \\ \vdots & 0 & 1 & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & 1 & 0 & \vdots & \vdots \\ \vdots & \vdots & 0 & 1 & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & 1 & 0 & \vdots \\ \vdots & \vdots & \vdots & 0 & 1 & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & 1 & 0 \\ \vdots & \vdots & \vdots & \vdots & 0 & 1 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} \mu \\ \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \end{bmatrix} + \begin{bmatrix} e_{11} \\ \vdots \\ e_{1,14} \\ e_{21} \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ e_{5,14} \end{bmatrix}$$

(70 X 1) (70 X 6) (6 X 1) (70 X 1)

The first equation, $Y_{11} = \mu + \alpha_1 + e_{11}$ can be interpreted as the temperature ($j=1$) of agricultural water ($i=1$), where the temperature cannot exceed μ_1, the mean water temperature, plus α_1, the adjustment for agricultural water quality control levels, and an observable disturbance term. Y_{11} is not an absolute term; rather, it is the ratio of the criterion divided by its mean among 50 states. The model is linear, and all X_{ij} equal one or zero.

Clearly, the rank of each matrix is

$$R(X) = 6, \quad \text{and} \quad R(X'X) < 6.$$

Hence (X'X) is a singular matrix. Regression analysis cannot be performed to estimate parameters. It is assumed that:

$$\mu_1 = \mu + \alpha_1$$

$$\mu_2 = \mu + \alpha_2$$

$$\mu_3 = \mu + \alpha_3$$

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[3] These criteria include: dissolved oxygen, fecal coliform bacteria, total coliform bacteria, upper bound of temperature, changes in temperature, lower bound of pH, upper bound of pH, state standards for disinfection, mercury and heavy metals, state standards for mixing zones, nitrates, phosphates, secondary treatment definition, turbidity.

$$\mu_4 = \mu + \alpha_4$$

$$\mu_5 = \mu + \alpha_5$$

The 6 parameters can be reduced to 5 by this linear combination. β can then be estimated since $R(X) = 5$. The following useful relations can be derived:

$$Y = X_\beta + e$$

$$E(Y) = E(X_\beta + e) = X_\beta + E(e) = X_\beta$$

Thus, Y is a linear unbiased estimate of X_β, in which

$$Y = X_{\hat{\beta}}.$$

$X'X_\beta$ is also an estimable function. The linear unbiased estimate of $X'X_\beta$ is $X'Y$.

$$X'Y = \begin{bmatrix} \sum_i \sum_j Y_{ij} \\ \sum_j Y_{ij} \\ \sum_j Y_{ij} \\ \sum_j Y_{ij} \\ \sum_j Y_{ij} \\ \sum_j Y_{ij} \end{bmatrix} = \begin{bmatrix} Y_{..} \\ Y_{1}. \\ Y_{2}. \\ Y_{3}. \\ Y_{4}. \\ Y_{5}. \end{bmatrix}$$

Furthermore,

$$\begin{aligned} E(Y_{1.}) &= E(Y_{11} + Y_{12} + \ldots + Y_{1D}) \\ &= 14(\mu + \alpha_1) \\ &= 14\mu_1 \\ E(Y_{2.}) &= E(Y_{21} + Y_{22} + \ldots + Y_{2D}) \\ &= 14(\mu + \alpha_2) \\ &= 14\mu_2 \\ E(Y_{3.}) &= E(Y_{31} + Y_{32} + \ldots + Y_{3D}) \\ &= 14(\mu + \alpha_3) \\ &= 14\mu_3 \\ E(Y_{4.}) &= E(Y_{41} + Y_{42} + \ldots + Y_{4D}) \\ &= 14(\mu + \alpha_4) \\ &= 14\mu_4 \\ E(Y_{5.}) &= E(Y_{51} + Y_{52} + \ldots + Y_{5D}) \\ &= 14(\mu + \alpha_5) \\ &= 14\mu_5 \end{aligned}$$

Thus,

$$\hat{\mu}_1 = \frac{\sum_j Y_{1j}}{14},$$

$$\hat{\mu}_2 = \frac{\sum_j Y_{2j}}{14},$$

$$\hat{\mu}_3 = \frac{\sum_j Y_{3j}}{14},$$

and

$$\hat{\mu}_4 = \frac{\sum_j Y_{4j}}{14},$$

$$\hat{\mu}_5 = \frac{\sum_j Y_{5j}}{14},$$

were chosen as the five indices of water quality for five different water uses. These are the simple arithmetic mean, derived from calculated observations. The empirical model used only $Y_1.$ and $Y_2.$ as variables.

Data Collection

Data were collected for all SMSA's from several sources. The data for the income distributions and the variables in the empirical model, exluding water quality parameters, were obtained from the 1960 and 1970 Census of Population (U.S. Bureau of the Census, 1963, 1973, 1974, 1975) and the 1970 City and County Data Book (Inter-University Consortium, 1972). Some data were not compatible between years, so that original data tapes were obtained from the Bureau of the Census and the data were reorganized in order that compatibility was achieved. For example, income distribution groupings were different from 1960 to 1970, and it was necessary to utilize the more precise groupings from 1960 data from the data tapes in order to construct a 13-group distribution for 1960 comparable to the 1970 data. The SMSA's were then grouped in order to compare 1960 and 1970 classification. One hundred seventy-two SMSA's were listed in both years with little or no change in spatial designations from 1960 to 1970. SMSA's were eliminated when either the SMSA's were created between 1960 and 1970, or 1960 SMSA's had been enlarged or combined in the 1970 data.

Data for water quality controls were collected from the regional offices of the Environmental Protection Agency.[4] Compilations of each state's quality requirements were available from most regions. The Central Region data were collected from each state's legal documents concerning water quality parameters. A final aggregation of water quality standards by state and use type was made and where only qualitative parameters existed for standards (criteria or classification) adjustments were made to reflect average or similar quantitative parameters for other states.

The enforcement of these water quality standards was not fully implemented by 1970. Not until 1972 and 1973 did water quality controls actually become widely applied. However, it is

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[4] References for each state are listed in the references section, but are too numerous for individual citation in the text.

assumed that industries and other producers reacted to these controls as if enforcement was extant in all cases. The expectation of enforcement was likely incorporated into industrial management plans, since the passage of PL 92-500 and its amendments were indicative of future requirements. As long as businesses acted as if these controls were a fact, the impact is identical. Not until the 1980 Census will a full test of the impact be possible, since annual data for income distribution for SMSA's is not available.

Initial Results

The initial results of the empirical test were taken from two stage least squares regression using the 172 SMSA's as the sample. Results were:

$$1)\quad \text{DP} = \underset{(0.554)}{0.4757\ \text{DW}} - \underset{(0.477)}{0.1019\ \text{W}} - \underset{(0.517)}{2.0951\ \text{P}} - \underset{(0.218)}{0.0428\ \text{WI}} - \underset{(0.325)}{0.0627\ \text{WA}} - \underset{(0.479)}{0.8274\ \text{DB}}$$

$$2)\quad \text{DW} = \underset{(0.660)}{2.4462\ \text{DP}} + \underset{(2.436)}{0.2014\ \text{W}} + \underset{(1.759)}{4.6878\ \text{P}} + \underset{(0.985)}{0.2141\ \text{WI}} + \underset{(1.460)}{1.6880\ \text{DB}}$$

$$3)\quad \text{DG} = \underset{(0.375)}{0.6436} + \underset{(1.119)}{28.8540\ \text{DP}} - \underset{(1.271)}{0.5973\ \text{DW}} + \underset{(0.890)}{4.8329\ \text{DH}}$$

$$4)\quad \text{DH} = \underset{(0.875)}{-0.1822} - \underset{(2.254)}{5.2485\ \text{DP}} + \underset{(2.393)}{0.1051\ \text{DW}} + \underset{(0.781)}{0.1182\ \text{DG}}$$

Numbers in parenthesis are the absolute values of the t-statistic. A statistical problem exists with regard to the interpretation of the t-statistic. Since the small sample properties of simultaneous equation systems are not known, except for the most simple cases (two equations, two or three unknowns), the large-sample asymptotic distribution is also not known for models of this size. It must be assumed that these distributions asymptotically approach a t-distribution. However, the distributions which have been generated for the simple cases are not distributed as a t. Thus, the significance of the t-statistics is in doubt. The common practice in the literature is to treat the results as if a Student's t was appropriate, which is the approach used in this report.

Two empirical problems were also evident in the initial regressions. First, the correlation between the two water quality parameters was very high (approximately 0.77). Thus, the DP equation was multicolinear. In response, the WA variable was dropped from Equation 1 and WI was used as a proxy variable for both quality parameters. A few significant differences in coefficients and significance levels are observed. Results were:

$$\text{DP} = \underset{(1.260)}{0.1323\ \text{DW}} - \underset{(0.641)}{0.0181\ \text{W}} - \underset{(1.011)}{0.7814\ \text{P}} + \underset{(0.494)}{0.0219\ \text{WI}} - \underset{(0.989)}{0.3699\ \text{DB}}$$

The DW, DG, and DH equations did not differ significantly from the initial results.

The second empirical problem was perhaps more critical. It is clear that the 1960-1970 decade was one in which broad public programs and defense expenditures increased enormously, and public policy changed in many ways which might have affected changes in income distribution more than water quality controls. These policies would include tax exchange and public expenditure shifts. In order to eliminate as many of these compounding factors as possible, the SMSA's were grouped, using factor analysis, into more or less homogenous factors. A Q-type analysis was required to group the SMSA's. This analysis uses a transposed matrix, so that the SMSA's become the factors which are grouped while the demographic variables, normally grouped in a factor analysis, become the independent observations or cases. Because the SMSA's exhibited a wide variation in the demographic characteristics, standardization for several of the demographic characteristics were required. Standardization was performed prior to transposing the matrix.

The number of demographic variables, or cases, on which the Q analysis was performed exceeded the number of SMSA's in both 1960 and 1970. One hundred and twenty-nine characteristics were identified as relevant to the factoring of SMSA's. In order to perform the statistical procedures, the number of cases must exceed the number of factors, similar to the conditions required for a solution to multiple equation systems. It was necessary, therefore, to divide the SMSA's into smaller groups. This was done on the basis of population. For 1960, a division was made between SMSA's over and under 250,000 population. For 1970, four divisions were made based on population: under 150,000; 150,001 to 250,000, 250,001 to 500,000, and over 500,000. Data for all the characteristics were taken from the Census of Populations for each year and from the City and County Data Book.

The groupings were picked from the Rotated Factor Matrix factors with an element greater than the absolute value of 0.50 with relatively low loadings on other factors. If an SMSA seemed to load on more than one factor it was eliminated from the analysis. The rotation was based on the verimax criterion, was orthogonal, and used the correlation matrix. The trace of that matrix was the squared multiple correlation coefficients. A listing of the results of the factor analysis for 1960 and 1970 may be found in

Appendix 3. Two non-orthogonal rotations were also attempted, and results were not different from the orthogonal approach.

SMSA's which remained in the same factor for both 1960 and 1970 were compiled. The results were not usable, because no more than seven to ten such SMSA's could be found in any one factor. Since the number of variables in the regression equations exceeded the number of observations or allowed only one or two degrees of freedom, a further consolidation of SMSA's was required. The consolidation was performed by eliminating some of the population breakdown for 1970, and combining the factors. The population groupings for both 1960 and 1970 were two: over 250,000 and under 250,000. Factor analysis in these two categories yielded two groups with 20 and 16 observations (SMSA's). Table 3 is a list of these SMSA's by population group.

Regressions were run on these groups for both the included and excluded WA in Equation 1. Results of these regressions are:

Group 1

$$\begin{array}{lllll} 1) & \mathrm{DP} = & 0.1404\ \mathrm{DW} & -\ 0.0243\ \mathrm{W} & -\ 0.7633\ \mathrm{P} \\ & & (1.277) & (0.751) & (1.015) \\ & & +\ 1.1113\ \mathrm{WI} & -\ 1.0903\ \mathrm{WA} & -\ 0.4475\ \mathrm{DB} \\ & & (1.078) & (1.047) & (1.038) \end{array}$$

$$\begin{array}{lllll} 2) & \mathrm{DW} = & 7.0120\ \mathrm{DP} & +\ 0.1443\ \mathrm{W} & +\ 5.9253\ \mathrm{P} \\ & & (1.173) & (1.160) & (1.868) \\ & & -\ 0.1439\ \mathrm{WI} & +\ 3.0209\ \mathrm{DB} & \\ & & (0.365) & (1.992) & \end{array}$$

$$\begin{array}{lllll} 3) & \mathrm{DG} = & -0.6500 & +\ 4.8530\ \mathrm{DP} & -\ 0.1546\ \mathrm{DW} \\ & & (0.988) & (0.947) & (1.168) \\ & & -\ 0.6776\ \mathrm{DH} & & \\ & & (0.621) & & \end{array}$$

$$\begin{array}{lllll} 4) & \mathrm{DH} = & -0.6054 & +\ 0.2877\ \mathrm{DP} & -\ 0.3275\ \mathrm{DW} \\ & & (2.893) & (0.087) & (0.035) \\ & & -\ 0.3056\ \mathrm{DG} & & \\ & & (0.818) & & \end{array}$$

Group 2

$$\begin{array}{lllll} 1) & \mathrm{DP} = & -\ 0.0543\ \mathrm{DW} & -\ 0.0103\ \mathrm{W} & +\ 0.0119\ \mathrm{P} \\ & & (0.793) & (0.344) & (0.029) \\ & & +\ 0.0952\ \mathrm{WI} & -\ 0.0382\ \mathrm{WA} & -\ 0.1479\ \mathrm{DB} \\ & & (1.129) & (0.560) & (0.420) \end{array}$$

$$\begin{array}{lllll} 2) & \mathrm{DW} = & 19.0096\ \mathrm{DP} & +\ 0.1212\ \mathrm{W} & +\ 2.5171\ \mathrm{P} \\ & & (0.819) & (0.366) & (0.371) \\ & & -\ 1.0845\ \mathrm{WI} & +\ 2.8815\ \mathrm{DB} & \\ & & (0.704) & (0.794) & \end{array}$$

$$\begin{array}{lllll} 3) & \mathrm{DG} = & -0.3851 & -\ 0.7101\ \mathrm{DP} & +\ 0.2718\ \mathrm{DW} \\ & & (0.438) & (0.134) & (0.187) \\ & & -\ 0.6633\ \mathrm{DH} & & \\ & & (0.322) & & \end{array}$$

$$\begin{array}{lllll} 4) & \mathrm{DH} = & -0.4129 & -\ 1.8463\ \mathrm{DP} & +\ 0.0249\ \mathrm{DW} \\ & & (6.809) & (2.066) & (0.753) \\ & & -\ 0.0202\ \mathrm{DG} & & \\ & & (0.231) & & \end{array}$$

Table 3. SMSA groupings from the factor analysis.

Group 1 Over 250,000	Group 2 Under 250,000
Birmingham, Alabama	Baton Rouge, La.
Chattanooga, Tennessee	Bay City, Michigan
Cleveland, Ohio	Cedar Rapids, Iowa
Columbia, S. C.	Charleston, S. C.
Davenport, Illinois	Columbus, Georgia
Detroit, Michigan	Corpus Christi, Texas
Houston, Texas	Decatur, Illinois
Huntington, W. V.	Jackson, Michigan
Jacksonville, Florida	Jackson, Mississippi
Knoxville, Tennessee	Kalamazoo, Michigan
Louisville, Kentucky	Kenosha, Wisconsin
Memphis, Tennessee	Lexington, Kentucky
Milwaukee, Wisconsin	Little Rock, Ark.
Minneapolis, Minn.	Macon, Georgia
Mobile, Alabama	Meriden, Conn.
New Orleans, La.	Montgomery, Ala.
Newark, N. J.	Muncie, Ind.
Norfolk, Va.	Savannah, Georgia
Paterson, N. J.	
Rochester, N. Y.	
San Antonio, Texas	
San Francisco, California	

When WA was excluded, the sign of WI remained the same, but the coefficient value and significance levels fell.

The interpretation of the results is somewhat unclear, even though some results do appear consistent among all regressions. Some of the conceptual model's implications appear to be corroborated. The proxies for the strength of bargaining power X_w as represented by the proportion of wages to total output (DB) are significant in determining the change in wages across SMSA's, at least at the 15 percent level, in almost every regression. The interrelation between the two parameters of the beta function is not clearly indicated. The price equation appears to indicate that none of the variables from the model are very significant in determining price changes, although the industrial water controls appear most significant (at about the 20 percent level) for the grouped data regressions.

As Thurow (1972) points out, increase in the first parameter of the beta distribution (σ or DG in this study) leads to a more dispersed, or more equal, distribution. Increases in the second parameter (ρ or

DH) leads to a less equal distribution, *ceterus paribus.*[5] Since change in price has a positive coefficient in the DG equation and negative in the DH, where coefficients are significant at more than the 0.15 level, increases in price appear to make income distribution more equal. The result is certainly counter-intuitive, although it agrees with Thurow's overall conclusions. The negative sign for price changes in the DH (ρ) equation agrees with Thurow's results, while the positive sign in the DG (σ) equation differs from his results.

The effect of industrial wages is exactly the opposite. Increases in wages result in decreases in DG (σ) and increases in DH (ρ) which indicates that the industrial wage increases lead to a less equal income distribution. Thurow did not include wages as a variable in his equations, so no comparison is possible.

The effects of the water quality parameters were also not clear cut. Coefficients for agricultural controls, where significant at the 0.20 level, were negative for the price estimation equation, which implies that these controls would affect a less equal distribution of income through the DP parameter. The industrial water quality controls, where significant in the price equation, had a positive sign indicating a more equal income distribution. Since the quality variable was consistently not significant in the wage equations, the industrial controls apparently have no effect on income distribution through wages. Moreover, the sign of the parameter is not consistent between equations.

Results from the Alternative Model

The results from the reformulation of the initial empirical are listed below. For 172 observations:

1) $\text{DP} = \underset{(0.560)}{-0.0141\ \text{WI}}\ \underset{(0.003)}{-0.0001\ \text{WA}}\ \underset{(7.193)}{+0.0656\ \text{DW}}\ \underset{(1.850)}{-3\text{X}10^{-12}\ \text{DY}}$

2) $\text{DW} = \underset{(0.554)}{0.0232\ \text{DE}}\ \underset{(7.300)}{+15.8358\ \text{DP}}\ \underset{(0.071)}{+0.0842\ \text{DB}}\ \underset{(0.961)}{+0.2160\ \text{WI}}$

3) $\text{DG} = \underset{(1.349)}{1.9296}\ \underset{(1.047)}{+18.7972\ \text{DP}}\ \underset{(1.471)}{-0.4135\ \text{DW}}\ \underset{(1.417)}{+5.7254\ \text{DH}}$

4) $\text{DH} = \underset{(1.892)}{-0.3250}\ \underset{(1.852)}{-3.3328\ \text{DP}}\ \underset{(1.809)}{+0.0684\ \text{DW}}\ \underset{(1.337)}{+0.1473\ \text{DG}}$

A second regression, eliminating WA was run. Results were not significantly different from the above equation.

For Group 1

1) $\text{DP} = \underset{(1.224)}{0.4315\ \text{WI}}\ \underset{(1.232)}{-0.4487\ \text{WA}}\ \underset{(3.053)}{+0.0654}\ \underset{(1.111)}{-4\text{X}10^{-12}}\ \text{DY}$

2) $\text{DW} = \underset{(0.190)}{-0.0197\ \text{DE}}\ \underset{(4.122)}{+18.6438\ \text{DP}}\ \underset{(0.873)}{+1.7907\ \text{DB}}\ \underset{(0.091)}{-0.046\ \text{WI}}$

3) $\text{DG} = \underset{(0.529)}{0.2612}\ \underset{(1.169)}{+4.5581\ \text{DP}}\ \underset{(1.250)}{-0.1541\ \text{DW}}\ \underset{(1.120)}{+0.8679\ \text{DH}}$

4) $\text{DH} = \underset{(4.025)}{-0.5217}\ \underset{(0.367)}{-0.8658\ \text{DP}}\ \underset{(0.374)}{+0.0283\ \text{DW}}\ \underset{(1.011)}{+0.2136\ \text{DG}}$

For Group 2

1) $\text{DP} = \underset{(1.713)}{0.0855\ \text{WI}}\ \underset{(0.747)}{-0.0303\ \text{WA}}\ \underset{(1.447)}{+0.0352\ \text{DW}}\ \underset{(0.403)}{-2\text{X}10^{11}\ \text{DY}}$

2) $\text{DW} = \underset{(1.735)}{-0.1815\ \text{DE}}\ \underset{(1.842)}{+19.7151\ \text{DP}}\ \underset{(0.727)}{+1.3600\ \text{DB}}\ \underset{(0.298)}{-0.3982\ \text{WI}}$

3) $\text{DG} = \underset{(0.819)}{1.5172}\ \underset{(0.430)}{+2.1454\ \text{DP}}\ \underset{(0.542)}{+0.1334\ \text{DW}}\ \underset{(0.826)}{+3.5823\ \text{DH}}$

4) $\text{DH} = \underset{(4.867)}{-0.4186}\ \underset{(0.897)}{-0.7239\ \text{DP}}\ \underset{(0.854)}{-0.0356\ \text{DW}}\ \underset{(0.526)}{+0.0674\ \text{DG}}$

These results are similar to those of the initial model, although change in total income, as a proxy for output, appears significant in the determination of price change and changes in wages and prices are very significantly intercorrelated. Increase in income has a negative coefficient for price, which indicates a less equal redistribution of wealth. This is, again, a counter-intuitive result.

Ordinary least squares regressions were run for the two beta distribution parameters. Results were:

$$\text{DG} = \underset{(2.040)}{0.0770}\ \underset{(9.501)}{-2.2069\ \text{P}}\ \underset{(3.479)}{-0.0592\ \text{WI}}\ \underset{(1.730)}{+0.0111\ \text{W}}$$

$$\underset{(4.572)}{+0.4425\ \text{DB}}\ \underset{(5.647)}{+1.4276\ \text{DP}}\ \underset{(0.203)}{+0.0013\ \text{DW}}$$

$$\text{DH} = \underset{(27.371)}{-0.4554}\ \underset{(5.770)}{+0.5903\ \text{P}}\ \underset{(2.587)}{-0.0194\ \text{WI}}\ \underset{(2.515)}{+0.0071\ \text{W}}$$

$$\underset{(4.269)}{+0.1820\ \text{DB}}\ \underset{(15.821)}{-1.7619\ \text{DP}}\ \underset{(0.004)}{+0.0001\ \text{DW}}$$

The change in price variable is highly significant, and the signs are the same as in the multiple equation model. The factor payment and water quality parameters are also significant, but have the same sign in both regressions. The overall effect of water quality control would be to decrease DG (σ) relative to DH (ρ), so that distribution would become more unequal. This result is different from the multi-equation estimation. Clearly, a multi-equation approach is warranted, due to the simultaneity of determination of the variables.

Given the reservations concerning both the empirical model's structure and the interpretation of the empirical results, policy prescriptions appear rather inappropriate. Clearly, there have been changes in the income distribution in SMSA's from 1960 to 1970, as indicated by the changes in the beta distribution func-

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[5] This is true only if the estimated Lorenz curve falls below. the 45 degree equal distribution line. If the curve lies above that line the opposite is true. The estimations for the beta parameters for the data indicate that the Lorenz curve is, in all cases, below the 45° line.

tions' parameters. Without a more correctly specified model and extensive data collection, the causality of these changes is not clear, even though water quality controls are significant variables in the regressions.

Summary and Conclusions

There were two main objectives of this research. The first was to test the various distribution functions in order to determine which was most appropriate for estimating income distribution changes. The second was to examine the impacts of water quality controls on income distribution using an empirical model relating the parameters of the chosen distribution function to variables which were expected to influence income distribution, including water quality controls. The beta distribution function was clearly the best estimator of distribution, based on the Gastwirth bounds as a test of goodness of fit. The parameters of the beta function were estimated using a conceptional model developed from an approach used by Pitchford and Turnovsky. Data were collected from the Bureau of the Census for 1960 and 1970, the City and County Data Book for 1972, and the Environmental Protection Agency.

Results of the water quality analysis were mixed and somewhat difficult to interpret. It appeared that water quality parameters may effect the price index, if these parameters were not surrogates for other excluded variables in the economic system. Bargaining power variables appeared to be the most significant in the wage change equation while total income had a negative effect on prices. Both price and wage changes were significant in many of the parameter equations but results were quite counter-intuitive. Some of these results did agree with those obtained by Thurow.

In order to reduce the probability that water quality controls were proxies for other variables, factor analysis was performed on the SMSA's and two groups of similar SMSA's were identified. The results of these regressions conformed rather closely, both in sign and significance levels, to the overall model. Additional regressions used to eliminate multicolinearity of the water quality controls were run with no significant changes in results. A test consisting of a single equation linear regression of the variables on the distribution parameters for all the SMSA's yielded somewhat different conclusions with respect to the effect of controls, but these results are suspect since the regression ignored the simultaneity of the determination of the variable values.

Conclusions with respect to distribution changes were difficult to draw because of the data problems. It appears that water quality controls may affect price changes, which in turn may cause a shift in income in the direction of less equal distribution for agricultural controls and more equal for industrial controls. However, better data are required for more complete and accurate analysis. The model should be broadly expanded to include other policy parameters, in order to draw more positive conclusions about specific impacts of water quality policy.

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Appendix 1

The following computer program was used to generate the gamma and beta distribution function parameters.

```
*WATFIV         J4409READING,TIME=300,PAGES=300
        SUBROUTINE DGTG(X,PHYY,PPHY)
        PHYY=ALOG(X)-1/(2*X)-1/(12*(X**2))+1/(120*(X**4))-1/(252*(X**6))+
       X1/(240*(X**8))
        PPHY=1/X+1/(2*(X**2))+1/(6*(X**3))-1/(30*(X**5))+1/(42*(X**7))-
       X1/(30*(X**9))
        RETURN
        END

        SUBROUTINE G(X,GAA)
        GAA=2.5066281*(X**(X+0.5))*EXP(-X)*(1+1/(12*X)+1/(288*(X**2))-
       X139/(51840*(X**3)))
        RETURN
        END

        DIMENSION THS(500),AHS(500),BHS(500),CHS(500),DHS(500),EHS(500),
       XFHS(500),GHS(500),HHS(500),OHS(500),PHS(500),QHS(500),RHS(500),
       XD(500),SHS(500),SSS(500 ),RRR(500 ),PPP(500),OOO(500)
        REAL M,LAHY,LBHY,LCHY,LDHY,LEHY,LFHY,LGHY, LHHY,LOHY,LPHY,LQHY,
       XLRHY,LX,LAHS,LBHS,LCHS,LDHS,LEHS,LFHS,LGHS,LHHS,LOHS,LPHS,LQHS,
       XLRHS,J
        DO 10 I=1,500
        READ(5,1,END=3)THS(I),AHS(I),BHS(I),CHS(I),DHS(I),EHS(I),FHS(I),
       XGHS(I),HHS(I),OHS(I),PHS(I),QHS(I),RHS(I),D(I),SHS(I),SSS(I),RRR(I
       X),PPP(I),OOO(I)
  1     FORMAT(9X,F8.0,8F7.0/9X,F8.0,4F7.0,14X,5A4)
        AHY=500
        BHY=1500
        CHY=2500
        DHY=3500
        EHY=4500
        FHY=5500
        GHY=6500
        HHY=7500
        OHY=8500
        PHY=9500
        QHY=12500
        RHY=20000
        LAHY=ALOG(AHY)
        LBHY=ALOG(BHY)
        LCHY=ALOG(CHY)
        LDHY=ALOG(DHY)
        LEHY=ALOG(EHY)
        LFHY=ALOG(FHY)
        LGHY=ALOG(GHY)
        LHHY=ALOG(HHY)
        LOHY=ALOG(OHY)
        LPHY=ALOG(PHY)
        LQHY=ALOG(QHY)
        LRHY=ALOG(RHY)
        A=15000
        B=25000
        XNLA=ALOG(A)
        XNLB=ALOG(B)
        C=RHS(I)+D(I)
        XNLC=ALOG(C)
        XNLD=ALOG(D(I))
        XV=(XNLC-XNLD)/(XNLB-XNLA)
        X=(B*XV)/(XV-1)
        LX=ALOG(X)
        M=(AHY*AHS(I)+BHY*BHS(I)+CHY*CHS(I)+DHY*DHS(I)+EHY*EHS(I)+
       XFHY*FHS(I)+GHY*GHS(I)+HHY*HHS(I)+OHY*OHS(I)+PHY*PHS(I)+QHY*QHS(I)
       X+RHY*RHS(I)+X*D(I))/THS(I)
        Y=M*THS(I)
        W=(   LAHY*AHS(I)+LBHY*BHS(I)+LCHY*CHS(I)+LDHY*DHS(I)+LEHY*EHS(I)+
       XLFHY*FHS(I)+LGHY*GHS(I)+LHHY*HHS(I)+LOHY*OHS(I)+LPHY*PHS(I)+
       XLQHY*QHS(I)+LRHY*RHS(I)+LX*D(I))/THS(I)
        CW=ALOG(M)-W
        EA=1/(2*CW)
 15     YEA=EA+10
        CALL DGTG(YEA,PHYY,PPHY)
        DG= PHYY-1/(EA+9)-1/(EA+8)-1/(EA+7)-1/(EA+6)-1/(EA+5)-1/(EA+4)-
       X1/(EA+3)-1/(EA+2)-1/(EA+1)-1/EA
```

```
      TG=PPHY+1/((EA+9)**2)+1/((EA+8)**2)+1/((EA+7)**2)+1/((EA+6)**2)+      46
     X1/((EA+5)**2)+1/((EA+4)**2)+1/((EA+3)**2)+1/((EA+2)**2)+
     X1/((EA+1)**2)+1/(EA**2)
    4 XNR=(ALOG(EA)-DG-CW)/(1/EA-TG)                                        47
      EA=EA-XNR                                                             48
      AXNR=ABS(XNR)                                                         49
      IF(AXNR.GE.0.0010)GO TO 16
      EB=EA/M                                                               51
      AEA=EA+1
      CALL G(AEA,GAA)                                                       53
      GAM=GAA/(AEA*EA)                                                      54
      BEA=AEA-0.5                                                           55
      CALL G(BEA,GAA)                                                       56
      GH=GAA/BEA                                                            57
      CEA=AEA+1                                                             58
      CALL G(CEA,GAA)                                                       59
      GG=GAA/(CEA*AEA)                                                      60
      AIND=0.3989423*GH/GG                                                  61
      FB=((EB**EA)/GAM)*(BHY**(EA-1))*EXP(-EB*BHY)*1000                     63
      FA=((EB**EA)/GAM)*(AHY**(EA-1))*EXP(-EB*AHY)*1000                     62
      FC=((EB**EA)/GAM)*(CHY**(EA-1))*EXP(-EB*CHY)*1000                     64
      FD=((EB**EA)/GAM)*(DHY**(EA-1))*EXP(-EB*DHY)*1000                     65
      FE=((EB**EA)/GAM)*(EHY**(EA-1))*EXP(-EB*EHY)*1000                     66
      FF=((EB**EA)/GAM)*(FHY**(EA-1))*EXP(-EB*FHY)*1000                     67
      FG=((EB**EA)/GAM)*(GHY**(EA-1))*EXP(-EB*GHY)*1000                     68
      FH=((EB**EA)/GAM)*(HHY**(EA-1))*EXP(-EB*HHY)*1000
      FO=((EB**EA)/GAM)*(OHY**(EA-1))*EXP(-EB*OHY)*1000
      FP=((EB**EA)/GAM)*(PHY**(EA-1))*EXP(-EB*PHY)*1000
      FQ=((EB**EA)/GAM)*(QHY**(EA-1))*EXP(-EB*QHY)*5000
      FR=((EB**EA)/GAM)*(RHY**(EA-1))*EXP(-EB*RHY)*10000
      FX=((EB**EA)/GAM)*(X**(EA-1))*EXP(-EB*X)*2*(X-25000)                  69
      SFA=LAHY*FA+LBHY*FB+LCHY*FC+LDHY*FD+LEHY*FE+LFHY*FF+LGHY*FG+LX*FX     70
     X+LHHY*FH+LOHY*FO+LPHY*FP+LQHY*FQ+LRHY*FR
      GM=EXP(SFA)                                                           71
      AMEN=EA/EB                                                            72
      AMOD=(EA-1)/EB                                                        73
      AMED=AMOD+2/(3*EB)                                                    74
      AVAR=EA/(EB**2)                                                       75
      ASKW=2/SQRT(EA)                                                       76
      AKUR=6/EA                                                             77
      ACOF=2*AMEN*AIND                                                      78
      R=AMEN/GM                                                             79
      UD=X+(X-25000)
      AHY=500/UD
      BHY=1500/UD
      CHY=2500/UD
      DHY=3500/UD
      EHY=4500/UD
      FHY=5500/UD
      GHY=6500/UD
      HHY=7500/UD
      OHY=8500/UD
      PHY=9500/UD
      QHY=12500/UD
      RHY=20000/UD
      X=X/UD
      M=(AHY*AHS(I)+BHY*BHS(I)+CHY*CHS(I)+DHY*DHS(I)+EHY*EHS(I)+            89
     XFHY*FHS(I)+GHY*GHS(I)+HHY*HHS(I)+OHY*OHS(I)+PHY*PHS(I)+QHY*QHS(I)
     X+RHY*RHS(I)+X*D(I))/THS(I)
      V=(((AHY-M)**2)*AHS(I)+((BHY-M)**2)*BHS(I)+((CHY-M)**2)*CHS(I)+       90
     X((DHY-M)**2)*DHS(I)+((EHY-M)**2)*EHS(I)+((FHY-M)**2)*FHS(I)+
     X((GHY-M)**2)*GHS(I)+((HHY-M)**2)*HHS(I)+((OHY-M)**2)*OHS(I)+((PHY-
     XM)**2)*PHS(I)+((QHY-M)**2)*QHS(I)+((RHY-M)**2)*RHS(I)+((X-M)**2)*    C90
     XD(I))/(THS(I)-1)
      P=((M**2)*(1-M)/V)-M                                                  91
      Q=(M*(1-M)/V-1)*(1-M)                                                 92
   34 YP=P+10                                                               93
      YQ=Q+10                                                               94
      CALLDGTG(YP,PHYY,PPHY)
      DGP=PHYY   -1/P-1/(P+1)-1/(P+2)-1/(P+3)-1/(P+4)-1/(P+5)-1/(P+6)-      96
     X1/(P+7)-1/(P+8)-1/(P+9)
      TGP=PPHY+1/(P**2)+1/((P+1)**2)+1/((P+2)**2)+1/((P+3)**2)+             97
     X1/((P+4)**2)+1/((P+5)**2)+1/((P+6)**2)+1/((P+7)**2)+
     X1/((P+8)**2)+1/((P+9)**2)
      CALL DGTG(YQ,PHYY,PPHY)
      DGQ=PHYY-1/Q-1/(Q+1)-1/(Q+2)-1/(Q+3)-1/(Q+4)-1/(Q+5)-1/(Q+6)-          9
     X1/(Q+7)-1/(Q+8)-1/(Q+9)
      TGQ=PPHY+1/(Q**2)+1/((Q+1)**2)+1/((Q+2)**2)+1/((Q+3)**2)+            100
     X1/((Q+4)**2)+1/((P+5)**2)+1/((Q+6)**2)+1/((Q+7)**2)+
     X1/((Q+8)**2)+1/((Q+9)**2)
      YPQ=P+Q+10                                                           101
      CALL DGTG(YPQ,PHYY,PPHY)                                              102
      DGPQ=PHYY-1/(P+Q)-1/(P+Q+1)-1/(P+Q+2)-1/(P+Q+3)-1/(P+Q+4)-1/(P+Q+5   103
     X)-1/(P+Q+6)-1/(P+Q+7)-1/(P+Q+8)-1/(P+Q+9)
      TGPQ=PPHY+1/((P+Q)**2)+1/((P+Q+1)**2)+1/((P+Q+2)**2)+                104
     X1/((P+Q+3)**2)+1/((P+Q+4)**2)+1/((P+Q+5)**2)+1/((P+Q+6)**2)+
     X1/((P+Q+7)**2)+1/((P+Q+8)**2)+1/((P+Q+9)**2)
      FP=TGP-TGPQ                                                          105
      FQ=-TGPQ                                                             106
      FFP=-TGPQ                                                            107
```

```
      FFQ=TGQ-TGPQ
      U= AHY**(AHS(I)/THS(I))* BHY**(BHS(I)/THS(I))* CHY**(CHS(I)/THS(I)
     X)* DHY**(DHS(I)/THS(I))* EHY**(EHS(I)/THS(I))* FHY**(FHS(I)/THS(I)
     X)* GHY**(GHS(I)/THS(I))* HHY**(HHS(I)/THS(I))* OHY**(OHS(I)/THS(I)
     X)* PHY**(PHS(I)/THS(I))* QHY**(QHS(I)/THS(I))* RHY**(RHS(I)/THS(I)
     X)* X**(D(I)/THS(I))
      W=((1-AHY)**(AHS(I)/THS(I)))*((1-BHY)**(BHS(I)/THS(I)))*
     X  ((1-CHY)**(CHS(I)/THS(I)))*((1-DHY)**(DHS(I)/THS(I)))*
     X  ((1-EHY)**(EHS(I)/THS(I)))*((1-FHY)**(FHS(I)/THS(I)))*
     X  ((1-GHY)**(GHS(I)/THS(I)))*((1-HHY)**(HHS(I)/THS(I)))*
     X  ((1-OHY)**(OHS(I)/THS(I)))*((1-PHY)**(PHS(I)/THS(I)))*
     X  ((1-QHY)**(QHS(I)/THS(I)))*((1-RHY)**(RHS(I)/THS(I)))*
     X((1-X)**(D(I)/THS(I)))
-XTENSION*  LIMIT OF 19 CONTINUATION CARDS EXCEEDED
      F=ALOG(U)
      FF=ALOG(W)
      F=DGP-DGPQ-F
      FF=DGQ-DGPQ-FF
      J=FP*FFQ-FQ*FFP
      DTP=(F*FFQ-FF*FQ)/J
      DTQ=(FP*FF-FFP*F)/J
      ADTP=ABS(DTP)
      ADTQ=ABS(DTQ)
      P=P-DTP
   99 Q=Q-DTQ
      IF(ADTP.GT.0.0010) GO TO 34
      IF(ADTQ.GT.0.0010) GO TO 34
      AP=P+1
      CALL G(AP,GAA)
      GAMPP=GAA/AP
      GAMP=GAMPP/P
      AQ=Q+1
       CALL G(AQ,GAA)
      GAMQ=GAA/(AQ*Q)
      BP=2*AP
      CALL G(BP,GAA)
      GAM2P=GAA/(BP*(2*P+1)*2*P)
      BQ=2*AQ
      CALL G(BQ,GAA)
      GAM2Q=GAA/(BQ*(2*Q+1)*2*Q)
      BPQ=2*AP+2*AQ
      CALL G(BPQ,GAA)
      GAM2PQ=GAA/(BPQ*(BPQ-1)*(BPQ-2)*(BPQ-3)*(BPQ-4))
      APQ=AP+AQ
      CALL G(APQ,GAA)
      GAMPQ=GAA/(APQ*(APQ-1)*(APQ-2))
      BIND=2*(GAMPQ**2)*GAM2P*GAM2Q/(GAMP*GAMPP*GAMQ*GAMQ*GAM2PQ)
      S=GAMPQ/(GAMP*GAMQ)
      FA=S*(AHY**(P-1))*((1-AHY)**(Q-1))*1000/UD
      FB=S*(BHY**(P-1))*((1-BHY)**(Q-1))*1000/UD
      FC=S*(CHY**(P-1))*((1-CHY)**(Q-1))*1000/UD
      FD=S*(DHY**(P-1))*((1-DHY)**(Q-1))*1000/UD
      FE=S*(EHY**(P-1))*((1-EHY)**(Q-1))*1000/UD
      FF=S*(FHY**(P-1))*((1-FHY)**(Q-1))*1000/UD
      FG=S*(GHY**(P-1))*((1-GHY)**(Q-1))*1000/UD
      FH=S*(HHY**(P-1))*((1-HHY)**(Q-1))*1000/UD
      FO=S*(OHY**(P-1))*((1-OHY)**(Q-1))*1000/UD
      FP=S*(PHY**(P-1))*((1-PHY)**(Q-1))*1000/UD
      FQ=S*(QHY**(P-1))*((1-QHY)**(Q-1))*5000/UD
      FR=S*(RHY**(P-1))*((1-RHY)**(Q-1))*10000/UD
      FX=S*(X**(P-1))*((1-X)**(Q-1))*2*(1-25000/UD)
      SFA=FA*ALOG(AHY)+FB*ALOG(BHY)+FC*ALOG(CHY)+FD*ALOG(DHY)+
     XFE*ALOG(EHY)+FF*ALOG(FHY)+FG*ALOG(GHY)+FX*ALOG(X)
     X+FH*ALOG(HHY)+FO*ALOG(OHY)+FP*ALOG(PHY)+FQ*ALOG(QHY)+FR*ALOG(RHY)
      GN=EXP(SFA)
      BMEN=P/(P+Q)
      BMOD=(P-1)/(P+Q-2)
      BMED=(3*(P-1)*(P+Q-2)+4*P+2*Q-6)/(3*(P+Q-2)*(P+Q))
      BVAR=(P*Q)/((P+Q)*(P+Q)*(P+Q+1))
      BSKW=(((P+Q+1)**(1/2))/(SQRT(P)*Q*SQRT(Q)))*((P+1)*(P+2)*(P+Q)*
     X(P+Q)/(P+Q+2)-3*P*(P+1)*(P+Q)+2*P*P*(P+Q+1))
      BKUU=(P+1)*(P+2)*(P+3)*((P+Q)**3)*(P+Q+1)/((P+Q+2)*(P+Q+3)*P)-
     X4*(P+1)*(P+2)*(P+Q)*(P+Q)*(P+Q+1)/(P+Q+2)+6*P*(P+1)*(P+Q)*(P+Q+1)-
     X3*P*P*(P+Q+1)*(P+Q+1)
      BKUR=BKUU/(Q*Q)-3
      BCOF=2*BMEN*BIND
      RR=BMEN/GN
```

```
      WRITE(6,21)SHS(I),SSS(I),RRR(I),PPP(I),ODD(I)
   21 FORMAT('1',5A4,/,' ',15('-'))
      WRITE(6,22)EA,P
   22 FORMAT('0','EA=',2X,F15.2,15X,'P=',3X,F15.2)
      WRITE(6,23)EB,Q
   23 FORMAT('0','EB=',2X,F15.2,15X,'Q=',3X,F15.2)
      WRITE(6,24)AIND,BIND
   24 FORMAT('0','AIND=',F15.2,15X,'BIND=',F15.2)
      WRITE(6,25)GM,GN
   25 FORMAT('0','GM=',2X,F15.2,15X,'GN=',2X,F15.2)
      WRITE(6,26)AMEN,BMEN
   26 FORMAT('0','AMEN=',F15.2,15X,'BMEN=',F15.2)
      WRITE(6,27)AMOD,BMOD
   27 FORMAT('0','AMOD=',F15.2,15X,'BMOD=',F15.2)
      WRITE(6,28)AMED,BMED
   28 FORMAT('0','AMED=',F15.2,15X,'BMED=',F15.2)
      WRITE(6,29)AVAR,BVAR
   29 FORMAT('0','AVAR=',F15.2,15X,'BVAR=',F15.2)
      WRITE(6,30)ASKW,BSKW
   30 FORMAT('0','ASKW=',F15.2,15X,'BSKW=',F15.2)
      WRITE(6,31)AKUR,BKUR
   31 FORMAT('0','AKUR=',F15.2,15X,'BKUR=',F15.2)
      WRITE(6,32)ACOF,BCOF
   32 FORMAT('0','ACOF=',F15.2,15X,'BCOF=',F15.2)
      WRITE(6,33)R,RR
   33 FORMAT('0','R=',3X,F15.2,15X,'RR=',2X,F15.2)
      WRITE(6,35) Y,M
   35 FORMAT('0','Y=',3X,F15.2/'0','M= ',F20.6)
      WRITE(7,240)EA,EB,AIND,ASKW,AKUR,R,SHS(I),SSS(I),RRR(I),PPP(I),
     XODD(I),P,Q,BIND,BSKW,BKUR,RR,Y,SHS(I),SSS(I),RRR(I),PPP(I),ODD(I)
  240 FORMAT(F4.2,1X,F7.5,1X,F4.2,1X,3F5.2,27X,5A4/6F5.2,2X,F15.2,13X,5A
     14)
   10 CONTINUE
    3 STOP
      END

  $EXEC
```

Appendix 2

The following program was used to generate the parameters of the lognormal and displaced lognormal distribution:

```
$WATFIV          Q4409BANNERWATERQ,TIME=300,PAGES=300
          SUBROUTINE NDTR(Z,P,DD)
          AX=ABS(Z)
          T=1.0/(1.0+.2316419*AX)
          D=0.3989423*EXP(-Z*Z/2.0)
          P=1.0-D*T*((((1.330274*T-1.821256)*T+1.781478)*T-0.3565638)*T+
         10.3193815)
          IF(Z)1,2,2
      1   P=1.0-P
      2   RETURN
          END

          CHARACTER*20 OHS,XHS,UHS,VHS,WHS
          DIMENSION THS(500),AHS(500),BHS(500),CHS(500),DHS(500),EHS(500),
         XFHS(500),GHS(500),HHS(500),SHS(500),PHS(500),QHS(500),RHS(500),
         XD(500),XMED(500),MOD(500),OHS(500),XHS(500),UHS(500),VHS(500),
         XWHS(500)
          REAL M,LAHY,LBHY,LCHY,LDHY,LEHY,LFHY,LGHY,LX,LAHS,LBHS,LCHS,LDHS,
         1LEHS,LFHS,LGHS,LD,J,MOD,LHHY,LSHY,LPHY,LQHY,LRHY,LHHS,LSHS,LPHS,
         XLQHS,LRHS
          AHY=500
          BHY=1500
          CHY=2500
          DHY=3500
          EHY=4500
          FHY=5500
          GHY=6500
          HHY=7500
          SHY=8500
          PHY=9500
          QHY=12500
          RHY=20000
          A=15000
          Y=25000
          XNLA=ALOG(A)
          XNLB=ALOG(Y)
          W=0
          G=1.28
          DO 10 I=1,500
          READ(5,1,END=3)THS(I),AHS(I),BHS(I),CHS(I),DHS(I),EHS(I),FHS(I),
         XGHS(I),HHS(I),SHS(I),PHS(I),QHS(I),RHS(I),D(I),XMED(I),MOD(I),
         XOHS(I),XHS(I),UHS(I),VHS(I),WHS(I)
      1   FORMAT(9X,F8.0,8F7.0,/,9X,F8.0,6F7.0,5A4)
          C=RHS(I)+D(I)
          XNLC=ALOG(C)
          XNLD=ALOG(D(I))
          XV=(XNLC-XNLD)/(XNLB-XNLA)
          X=(Y*XV)/(XV-1)
          LAHS=500
          LBHS=1000
          LCHS=2000
          LDHS=3000
          LEHS=4000
          LFHS=5000
          LGHS=6000
          LHHS=7000
          LSHS=8000
          LPHS=9000
          LQHS=10000
          LRHS=15000
          LD=25000
          UAHS=999
          UBHS=1999
          UCHS=2999
          UDHS=3999
          UEHS=4999
          UFHS=5999
          UGHS=6999
          UHHS=7999
          USHS=8999
          UPHS=9999
          UQHS=14999
```

```
      URHS=24999
      UD=X+(X-25000)
      LAHY=ALOG(LAHS)
      LBHY=(ALOG(UBHS)+ALOG(LBHS))/2
      LCHY=(ALOG(UCHS)+ALOG(LCHS))/2
      LDHY=(ALOG(UDHS)+ALOG(LDHS))/2
      LEHY=(ALOG(UEHS)+ALOG(LEHS))/2
      LFHY=(ALOG(UFHS)+ALOG(LFHS))/2
      LGHY=(ALOG(UGHS)+ALOG(LGHS))/2
      LHHY=(ALOG(UHHS)+ALOG(LHHS))/2
      LSHY=(ALOG(USHS)+ALOG(LSHS))/2
      LPHY=(ALOG(UPHS)+ALOG(LPHS))/2
      LQHY=(ALOG(UQHS)+ALOG(LQHS))/2
      LRHY=(ALOG(URHS)+ALOG(LRHS))/2
      LX=ALOG(X)
      SLX=LX**2
      E=(LAHY*AHS(I))+(LBHY*BHS(I))+(LCHY*CHS(I))+(LDHY*DHS(I))+
     X(LEHY*EHS(I))+(LFHY*FHS(I))+(LGHY*GHS(I))+(LHHY*HHS(I))+
     X(LSHY*SHS(I))+(LPHY*PHS(I))+(LQHY*QHS(I))+(LPHY*RHS(I))+(LX*D(I))
      M=E/THS(I)
      V=(1/(THS(I)-1))*((AHS(I)*(LAHY-M)**2)+(BHS(I)*(LBHY-M)**2)+
     X(CHS(I)*(LCHY-M)**2)+(DHS(I)*(LDHY-M)**2)+(EHS(I)*(LEHY-M)**2)+
     X(FHS(I)*(LEHY-M)**2)+(GHS(I)*(LGHY-M)**2)+(HHS(I)*(LHHY-M)**2)+
     X(SHS(I)*(LSHY-M)**2)+(PHS(I)*(LPHY-M)**2)+(QHS(I)*(LQHY-M)**2)+
     X(RHS(I)*(LRHY-M)**2)+(D(I)*(LX-M)**2))
      AX=EXP((2*M)+V)
      AN=EXP(V)-1
      AMOD=EXP(M-V)
      AMED=EXP(M)
      AMEN=EXP(M+(V/2))
      AVAR=AX*AN
      AD=AMED-XMED(I)
      W=W+1
      ASKW=(AN**1.5)+(3*(AN**.5))
      AKUR=(AN**4)+(6*(AN**3))+(15*(AN**2))+(16*AN)
      F=(AHY*AHS(I))+(BHY*BHS(I))+(CHY*CHS(I))+(DHY*DHS(I))+(EHY*EHS(I))
     1+(FHY*FHS(I))+(GHY*GHS(I))+(HHY*HHS(I))+(SHY*SHS(I))+(PHY*PHS(I))+
     X(QHY*QHS(I))+(RHY*RHS(I))+(X*D(I))
      XMEN=F/THS(I)
      Z=(V**.5)/(2**.5)
      CALL NDTR(Z,P,DD)
      AIND=(2*P)-1
      ACOF=2*(AMEN)*AIND
      IF(AHS(I).GT.(THS(I)+1)/10)GO TO 20
      IF(AHS(I)+BHS(I).GT.(THS(I)+1)/10)GO TO 30
      IF(AHS(I)+BHS(I)+CHS(I).GT.(THS(I)+1)/10)GO TO 40
      IF(AHS(I)+BHS(I)+CHS(I)+DHS(I).GT.(THS(I)+1)/10)GO TO 50
      IF(AHS(I)+BHS(I)+CHS(I)+DHS(I)+EHS(I).GT.(THS(I)+1)/10)GO TO 60
      IF(AHS(I)+BHS(I)+CHS(I)+DHS(I)+EHS(I)+FHS(I).GT.(THS(I)+1)/10)
     1GO TO 70
      IF(AHS(I)+BHS(I)+CHS(I)+DHS(I)+EHS(I)+FHS(I)+GHS(I).GT.(THS(I)+1)
     1/10)GO TO 80
   20 DEC=0+(((THS(I)+1)/10-0)/AHS(I))*1000
      GO TO 16
   30 DEC=LBHS+(((THS(I)+1)/10-AHS(I))/BHS(I))*1000
      GO TO 16
   40 DEC=LCHS+(((THS(I)+1)/10-(AHS(I)+BHS(I)))/CHS(I))*1000
      GO TO 16
   50 DEC=LDHS+(((THS(I)+1)/10-(AHS(I)+BHS(I)+CHS(I)))/DHS(I))*1000
      GO TO 16
   60 DEC=LEHS+(((THS(I)+1)/10-(AHS(I)+BHS(I)+CHS(I)+DHS(I)))/EHS(I))
     1*1000
      GO TO 16
   70 DEC=LFHS+(((THS(I)+1)/10-(AHS(I)+BHS(I)+CHS(I)+DHS(I)+EHS(I)))/
     1FHS(I))*1000
      GO TO 16
   80 DEC=LGHS+(((THS(I)+1)/10-(AHS(I)+BHS(I)+CHS(I)+DHS(I)+EHS(I)+
     1FHS(I)))/GHS(I))*1000
   16 IF(.9*THS(I).GT.THS(I)-D(I))GO TO 100
      IF(.9*THS(I).GT.THS(I)-(D(I)+RHS(I)))GO TO 110
      IF(.9*THS(I).GT.THS(I)-(D(I)+RHS(I)+QHS(I)))GO TO 120
      IF(.9*THS(I).GT.THS(I)-(D(I)+RHS(I)+QHS(I)+PHS(I)))GO TO 130
  100 DEC9=LD+(((9*THS(I)+9)/10-(THS(I)-D(I)))/D(I))*(UD-LD)
      GO TO 29
  110 DEC9=LRHS+(((9*THS(I)+9)/10-(THS(I)-D(I)-RHS(I)))/RHS(I))*10000
      GO TO 29
  120 DEC9=LQHS+(((9*THS(I)+9)/10-(THS(I)-D(I)-RHS(I)-QHS(I)))/QHS(I))*
     X5000
      GO TO 29
  130 DEC9=LPHS+(((9*THS(I)+9)/10-(THS(I)-D(I)-RHS(I)-QHS(I)-PHS(I)))/
     XPHS(I))*1000
   29 H=DEC/XMED(I)
      J=DEC9/XMED(I)
      B=XMED(I)*((H*J-1)/(2-H-J))
      D1=ALOG((XMED(I)+B)/((H*XMED(I))+B))
      D9=ALOG(((J*XMED(I))+B)/(XMED(I)+B))
      BM=ALOG(XMED(I)+B)
      BV=(D1/G)**2
      BX=EXP((2*BM)+BV)
```

```
      BN=EXP(BV)-1
      BMOD=EXP(BM-BV)-B
      BMEN=EXP(BM+(.5*BV))-B
      BMED=EXP(BM)-B
      BVAR=BX*BN
      BSKW=(BN**1.5)+(3*(BN**.5))
      BKUR=(BN**4)+(6*(BN**3))+(15*(BN**2))+(16*BN)
      Z=(BV**.5)/(2**.5)
      CALL NDTR(Z,P,DD)
      BIND=(2*P)-1
      BCOF=2*BMEN*BIND
   17 WRITE(6,2)OHS(I),XHS(I),UHS(I),VHS(I),WHS(I)
    2 FORMAT('1',5A4;/,' ',20('-'))
      WRITE(6,4)X
    4 FORMAT('0','X=',3X,F15.2)
      WRITE(6,7)AD
    7 FORMAT('0','AD  =',F15.2)
      WRITE(6,8)XMED(I)
    8 FORMAT('0','XMED=',F15.2,15X)
      WRITE(6,9)XMEN
    9 FORMAT('0','XMEN=',F15.2)
      WRITE(6,5)M
    5 FORMAT('0','M=',3X,F15.4)
      WRITE(6,6)V
    6 FORMAT('0','V=',3X,F15.2)
      WRITE(6,47)AMOD
   47 FORMAT('0','AMOD=',F15.2)
      WRITE(6,48)AMED
   48 FORMAT('0','AMED=',F15.2)
      WRITE(6,49)AMEN
   49 FORMAT('0','AMEN=',F15.2)
      WRITE(6,51)AVAR
   51 FORMAT('0','AVAR=',F17.2)
      WRITE(6,12)ASKW
   12 FORMAT('0','ASKW=',F15.4)
      WRITE(6,13)AKUR
   13 FORMAT('0','AKUR=',F17.2)
      WRITE(6,14)AIND
   14 FORMAT('0','AIND=',F15.4)
      WRITE(6,15)ACOF
   15 FORMAT('0','ACOF=',F15.2)
      WRITE(6,18)DEC
   18 FORMAT('0','DEC=',1X,F15.2)
      WRITE(6,19)DEC9
   19 FORMAT('0','DEC9=',F15.2)
      WRITE(6,31)B
   31 FORMAT('0','B=',3X,F15.2)
      WRITE(6,32)BM
   32 FORMAT('0','BM=',2X,F15.4)
      WRITE(6,33)BV
   33 FORMAT('0','BV=',2X,F15.4)
      WRITE(6,34)BMOD
   34 FORMAT('0','BMOD=',F15.2)
      WRITE(6,35)BMED
   35 FORMAT('0','BMED=',F15.2)
      WRITE(6,36)BMEN
   36 FORMAT('0','BMEN=',F15.2)
      WRITE(6,37)BVAR
   37 FORMAT('0','BVAR=',F15.2)
      WRITE(6,38)BSKW
   38 FORMAT('0','BSKW=',F15.2)
      WRITE(6,39)BKUR
   39 FORMAT('0','BKUR=',F15.2)
      WRITE(6,42)BIND
   42 FORMAT('0','BIND=',F15.4)
      WRITE(6,41)BCOF
   41 FORMAT('0','BCOF=',F15.2)
      WRITE(7,240)M,V,ASKW,AKUR,AIND,OHS(I),XHS(I),UHS(I),VHS(I),WHS(I),
     XB,BM,BV,BSKW,BKUR,BIND,OHS(I),XHS(I),UHS(I),VHS(I),WHS(I)
  240 FORMAT (5F10.5,10X,5A4/F12.5,2F9.5,3F10.5,5A4)
   10 CONTINUE
    3 STOP
      END

$EXEC
```

Appendix 3

1960 and 1970 Factor Analysis for SMSA's

1960 SMSA's Over 250,000

Factor 1 (21)

Atlanta, Ga.
Beaumont, Tex.
Birmingham, Ala.
Buffalo, N.Y.
Charlotte, N.C.
Chattanooga, Tenn.
Cleveland, Ohio
Columbia, S.C.
Erie, Pa.
Jacksonville, Florida
Findervill, Tenn.
Memphis, Tenn.
Milwaukee, Wisc.
Mobile, Ala.
Nashville, Tenn.
Newark, N.J.
Norfolk, Va.
Patterson, N.J.
Rochester, N.Y.
San Antonio, Tex.
Shreveport, La.

Factor 2 (20)

Akron, Ohio
Canton, Ohio
Chicago, Ill.
Davenport, Iowa
Dayton, Ohio
Ft. Lauderdale, Fla.
Grand Rapids, Mich.
Greensboro, N.C.
Lansing, Mich.
Los Angeles, Calif.
Miami, Fla.
New York, N.Y.
Peoria, Ill.
New York, N.Y.
Salt Lake City, Ut.
San Francisco, Calif.
Syracuse, N.Y.
Toledo, Ohio
Wilmington, Del.
Youngstown, Ohio

Factor 3 (11)

Charleston, W.V.
Denver, Colo.
El Paso, Tex.
Flint, Mich.
Huntington, W.V.
Johnstown, Pa.
Sacramento, Calif.
San Jose, Calif.
Utica, N.Y.
Washington, D.C.
Wilkes-Barre, Pa.

Factor 5 (6)

Bridgeport, Conn.
Hartford, Conn.
New Haven, Conn.
Providence, R.I.
Springfield, Mass.
Worcester, Mass.

Factor 6 (5)

Baltimore, Md.
Portland, Oreg.
Seattle, Wash.
Spokane, Wash.
Tacoma, Wash.

Factor 7 (8)

Ft. Worth, Tex.
Miami, Fla.
Orlando, Fla.
Phoenix, Ariz.
San Bernandino, Calif.
San Diego, Calif.
Tampa, Fla.
Tucson, Ariz.

Factor 8 (6)

Albuquerque, N.M.
Allentown, Pa.
Erie, Pa.
Harrisburg, Pa.
Lancaster, Pa.
Reading, Pa.

Factor 9 (7)

Dallas, Tex.
Resno, Calif.
Houston, Tex.
Kansas City, Mo.
Oklahoma City, Ok.
Tulsa, Ok.
Wichita, Kan.

Factor 10 (4)

Jersey City, N.J.
Newark, N.J.
Paterson, N.J.
Trenton, N.J.

Factor 11 (4)

Bakersfield, Calif.
Columbus, Ohio
Gary, Ind.
Indianapolis, Ind.

Factor 12 (2)

Cincinnati, Ohio
Louisville, Ky.

No Cities

Factor 4, 13, 14

Cities Not Grouped (7)

Albany, N.Y.
Boston, Mass.
Des Moines, Iowa
Detroit, Mich.
Honolulu, Hawaii
New Orleans, Lo.
Omaha, Nebraska

1960 SMSA's Under 250,000

Factor 1 (22)

Austin, Tex.
Bay City, Mich.
Charleston, S.C.
Decatur, Ill.
Porham, N.C.
Hamilton, Ohio
Jackson, Mich.
Jackson, Mass.
Kenosha, Wisc.
Lima, Ohio
Little Rock, Ark.
Lorain, Ohio
Montgomery, Ala.
Muncie, Ind.
Muskegum, Mich.
Pueblo, Colo.
Racine, Wisc.
Raleigh, N.C.
Savannah, Ga.
Springfield, Ohio
Stevbenville, W.V.
Waterloo, Iowa

Factor 2 (17)

Albany, Ga.
Atlantic City, N.J.
Billings, Mont.
Evansville, Ind.
Fargo, N.D.
Great Falls, Mont.
Huntsville, Ala.
Lawton, Okla.
Midland, Tex.
Norwalk, Conn.
Odessa, Tex.
Ogden, Ut.
Scranton, Pa.
Sioux Falls, S.D.
Wheeling, W.V.
York,.Pa.

Factor 3 (14)

Altoona, Pa.
Cedar Rapids, Iowa
Ft. Smith, Ark.
Ft. Wayne, Ind.
Gadsden, Ala.
Lynchburg, Va.
Madison, Wisc.
Monroe, La.
Rockford, Ill.
San Angelo, Tex.
South Bend, Ind.
Texarkana, Tex.
Tuscaloosa, Ala.
Tyler, Tex.

Factor 4 (12)

Brokton, Mass.
Falls River, Mass.
Fitchburg, Mass.
Lawrence, Mass.
Lewiston, Maine
Lowell, Mass.
Manchester, N.H.
New Bedford, Mass.
New Britany, Conn.
Pittsfield, Mass.
Portland, Maine
Waterbury, Conn.

Factor 5 (4)

St. Joseph, Mo.
Sioux City, Iowa
Springfield, Mo.
Terre Haute, Ind.

Factor 6 (4)

Durham, N.C.
Greensboro, N.C.
Greenville, S.C.
Winston-Salem, N.C.

Factor 7 (2)

Lincoln, Nebr.
Topeka, Kan.

Factor 8 (2)

Macon, Ga.
Newport-News, Va.

Factor 9 (3)

Colorado Springs, Colo.
Las Vegas, Nev.
Reno, Nev.

Factor 10 (2)

Brownsville, Tex.
Stanford, Conn.

Factor 11 (2)

Ann Arbor, Mich.
Champaign, Ill.

Factor 12 (2)

Santa Barbara, Calif.
West Palm Beach, Fla.

Factor 13 (1)

Galveston, Tex.

Factor 14 (1)

Amarillo, Tex.

Factor 15 (3)

Abilene, Tex.
Amarillo, Tex.
Wichita Falls, Tex.

No Cities Factors 16 & 12

Cities Not Grouped

Ashville, N.C.
Augusta, Ga.
Baton Rouge, La.
Columbus, Ga.
Corpus Christi, Tex.
Eugene, Ore.
Green Bay, Wisc.
Kalamazoo, Mich.
Lake Charles, La.
Waco, Tex.
Loredo, Tex.
Lexington, Ky.
Lubbuck, Tex.
Mariden, Conn.
New London, Conn.
Pensecola, Fla.
Roanoke, Va.
Saginow, Mich.
Springfield, Ill.
Stockton, Calif.

SMSA's 1970 Between 150,000 & 250,000 (50)

Factor 1 (8)

Beoran, Mass.
Ft. Smith, Ark.
Lawrence, Mass.
Lowell, Mass.
Salem, Ore.
Springfield, Mo.
Terre Haute, Ind.
Waterbury, Conn.

Factor 2 (6)

Atlantic City, N.J.
Huntsville, Ala.
New Bedford, Mass.
Raleigh, N.C.
Scranton, Pa.
Wheeling, W.V.

Factor 3 (7)

Lexington, Ky.
Lima, Ohio
Muskegon, Mich.
Racine, Wisc.
Saginaw, Mich.
Springfield, Ohio
Steubenable, Ohio

Factor 4 (4)

Lincoln, Neb.
McAllen, Tex.
Springfield, Ill.
Topeka, Kan.

Factor 5 (3)

Modesto, Calif.
Santa Rosa, Calif.
Vallego, Calif.

Factor 6 (7)

Cedar Rapids, Iowa
Columbus, Ga.
Eugene, Ore.
Kalamazoo, Mich.
Macon, Ga.
Montgomery, Ala.
Savannah, Ga.

Factor 7 (1)

Evansville, Ind.

Factor 8 (3)

Colorado Springs, Colo.
Fayetteville, N.C.
Stamford, Conn.

Factor 9 (1)

Roanoke, Va.

Factor 10 (3)

Ann Arbor, Mich.
Champaign, Ill.
Durham, N.C.

Factor 11 (1)

Galveston, Tex.

Factor 12 (1)

Green Bay, Wisc.

Not Factored

Charleston, W.V.
Hamilton, Ohio
Lubbock, Tex.
New London, Conn.
Pensacola, Fla.

SMSA's 1970 Under 150,000

Factor 1 (12)

Anderson, Ind.
Bay City, Mich.
Bryan, Tex.
Decatur, Ill.
Jackson, Mich.
Kenosha, Wisc.
Laredo, Tex.
Mansfield, Ohio
Muncie, Ind.
New Britian, Conn.
San Angelo, Tex.
Vineland, N.J.

Factor 2 (6)

Bloomington, Ind.
Brownsville, Tex.
Columbia, Mo.
Gainsville, Fla.
Layfayette, Ind.
Tallahassee, Fla.

Factor 3 (3)

Dubque, Iowa
La Crosse, Wisc.
Sioux Falls, S.D.

Factor 4 (6)

Abilene, Tex.
Albany, Ga.
Altoona, Pa.
Bristof, Conn.
Danbury, Conn.
Nashua, N.H.

Factor 5 (7)

Fitchburg, Mass.
Layfayette, La.
Lake Charles, La.
Meriden, Conn.
Monroe, La.
Pittsfield, Mass.
Tuscalossa, Ala.

Factor 6 (6)

Fall Rider, R.I.
Lewiston, Maine
Manchester, N.H.
Midland, Tex.
Odessa, Tex.
Portland, Maine

Factor 7 (3)

St. Joseph, Mo.
Sioux City, Iowa
Waco, Tex.

Factor 8 (5)

Gadsen, Ala.
Owensburo, Ky.
Pine Bluff, Ark.
Texakana, Tex.
Tyler, Tex.

Factor 9 (3)

Norwalk, Conn.
Pueblo, Colo.
Reno, Nev.

Factor 10 (3)

Waterloo, Iowa
Wichita Falls, Tex.
Wilmington, N.C.

Factor 11 (1)

Amarillo, Tex.

Factor 12 (5)

Billings, Mont.
Boise, Id.
Fargo, N.D.
Great Falls, Mont.
Rochester, N.Y.

Factor 13 (2)

Lynchburg, Va.
Petersburg, Va.

Factor 14 (2)

Ogden, Utah
Sherman, Tex.

Not Factored

Ashville, N.C.
Biloxi, Miss.
Lawton, Ok.
Provo, Utah.

Appendix 4

SMSA's 1970 Over 500,000

SMSA's 1970 Over 500,000

Factor 1 (16)

Anaheim
Birmingham
Cleveland
Greensboro
Hartford
Jacksonville, Fla.
Memphis
Minneapolis
Nashville
New Orleans
Newark
Norfolk
Paterson
San Francisco
San Francisco
San Jose

Factor 2 (7)

Allentown, N.J.
Atlanta, Ga.
Buffalo
Pittsburgh
Providence
Springfield
Washington, D.C.

Factor 3 (7)

Boston
Dallas
Ft. Worth
Houston
Kansas City
Oklahoma City
Phoenix

Factor 4 (5)

Cincinnati
Honolulu
Indianapolis
Louisville
St. Louis

Factor 5 (12)

Arbor
Dayton
Ft. Lauderdale
Gary
Grand Rapids
Jersey City
Miami
Rochester
Syracuse
Tampa
Toledo
Youngstown

Factor 6 (2)

Portland, Ore.
Seattle

Factor 7 (2)

Baltimore
Richmond

Factor 8 (4)

Columbus, Ohio
Denver
Omaha
Salt Lake City

Factor 9 (5)

Chicago
Detroit
Los Angeles
New York
Philadelphia

Factor 10 (3)

San Bernardino
San Diego
Sacramento

Factor 11 (1)

Milwaukee

Factor 12 (0)

SMSA's 1970 Between 250,000 & 500,000 (60)

Factor 1 (20)

Augusta, Ga.
Baton Rouge, La.
Bridgeport, Conn.
Canton, Ohio
Charleston, S.C.
Columbia, S.C.
Corpus Christi, Tex.
Daven Port, Iowa
El Paso, Tex.
Jackson, Miss.
Knoxville, Tenn.
Little Rock, Ark.
Mobile, Ala.
New Haven, Conn.
Peoria, Ill.
Rockford, Ill.
Shreveport, La.
South Bend, Ind.
Trenton, N.J.
Worcester, Mass.

Factor 2 (16)

Albuquerque, N.M.
Austin, Tex.
Chattanooga, Tenn.
Greenville, S.C.
Huntington, W.V.
Johnstown, Pa.
Lancaster, Pa.
Las Vegas, Nev.
Madison, Wisc.
Oxnard, Calif.
Reading, Pa.
Salinas, Calif.
Santa Barbara, Calif.
Tucson, Arizona
Wilkes-Barre, Pa.
York, Pa.

Factor 3 (6)

Charlotte, N.C.
Harrisburg, Pa.
Lorain, Ohio
Orlando, Fla.
Tulsa, Okla.
West Palm Beach, Fla.

Factor 4 (3)

Duluth, Minn.
Stockton, Calif.
Utica, N.Y.

Factor 5 (4)

Bakersfield, Calif.
Beaumont, Tex.
Fresno, Calif.
Wichita, Kan.

Factor 6 (2)

Des Moines, Iowa
Flint, Mich.

Factor 7 (2)

Spokane, Wash.
Tacoma, Wash.

Factor 8 (0)

Factor 9 (0)

Factors 10-13 (0)

Not Factored (7)

Appleton, Wisc.
Binghampton, Pa.
Erie, Pa.
Fort Wayne, Ind.
Lansing, Mich.
New Port News, Va.
Wilmington, Del.

Factors 8-13 (0)