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The Application of a Time-Series Methodology to Federal Program Allocations

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ABSTRACT

Time-series analysis provides a useful tool in the evaluation of public policy outputs. It is shown that the general Box and Jenkins method, when extended to allow for multiple interrupts, enables researchers simultaneously to examine changes in drift and level of a series, and to select the best fit model for the series. As applied to urban renewal allocations, results show significant changes in the level of the series, corresponding to changes in party control of the Executive. No support is given to the "incrementalism" hypotheses as no significant changes in drift are found.

THE APPLICATION OF A TIME-SERIES METHODOLOGY TO FEDERAL PROGRAM ALLOCATIONS

Introduction

The technique of multiple nonstationary time-series analysis is becoming increasingly visible as a potential tool for analysis in public policy and evaluative research. Although a strong case has been made for its use in the analysis of public policy,[1] few comprehensive applications of the technique have been undertaken.

Box and Jenkins (1960, 1970), Box and Tiao, (1965), and Glass and Maguire (1968) have contributed to the interest in time-series applications through their development and operational use of the time-series integrated moving average model with deterministic drift. Under the assumption of random shocks to the series from the environment, their model enables the researcher simultaneously to examine the changes in level and slope of a series and to select the best fit model for analysis. As used here, the method has been extended to allow for the inclusion of multiple interrupts.[2] This application is cost-effective in that all parameters need not be examined for each series, and the best model selected need not necessarily be the most complex one.

The primary purpose of this brief study is to show the usefulness of the Box and Jenkins method for the analysis of public policy and evaluative research through the examination of appropriations for a single Federal program. Substantively, we wish to examine changes in appropriations which are associated with changes in party affiliation of the Executive, and to examine the assertion of incrementalism in Federal policy, through an empirical analysis of a single program. The

program chosen for this study is the Urban Renewal Program, whose effective life-span ranged from 1950 through 1972.

A Time-Series Model

The Box and Jenkins time-series model begins with a specification of the level of the series, given by

$$Z_t = L + \beta_t + \gamma \sum_{j=1}^{t-1} \beta_{t-j} \qquad t = 1,\ldots,n_1 \tag{1}$$

where

Z_t is the observed value at time t,

L is a fixed but unknown location parameter,

γ is a parameter descriptive of the degree of inter-dependence of the observations in the series and takes the value $0<\gamma<2$,

β_t is a normal random deviate with a mean μ, and a variance σ^2.

The model describes a series which is subjected to random shocks from the environment, β_t, a proportion of which, γ, is absorbed into the level of the series. The drift, or slope, of the series can be seen when β_t is expressed as the sum of its mean, μ, and a random variable, α_t, which has a mean zero and a variance σ^2. Substituting $\mu+\alpha_t$ for β_t in (1), we see that

$$Z_t = L + \mu\gamma\,(t-1) + \mu + \alpha_t + \gamma \sum_{j=1}^{t-1} \alpha_{t-j} \tag{2}$$

At time t, the expected drift may be expressed as $\mu\gamma t$. At the interruption of the time-series, changes in level and changes in drift

may occur. Denoting the change in level by δ and the change in drift by Δ, the series after the interrupt may be expressed as

$$Z_t = L + \mu\gamma(t-1) + \mu + \gamma\,\Delta(t-n_1-1) + \Delta + \delta + \alpha_t + \gamma \sum_{j=1}^{t-1} \alpha_{t-j} \qquad (3)$$

Where n represents the number of observations before the interruption. It should be noted that when no drift is present, μ approaches 0 and β takes on the value α, simplifying the model to the Box and Tiao integrated moving average model.

Data which are appropriate for the weighted moving average model are such that the graph of the series follows an "erratic, sometime random path with slight, but no systematic drifts, trends, or cycles" (Glass and Maguire, 1968:70). Data which do not conform to this assumption violate the assumption of a zero mean for random variable α.

Data Analysis

Urban renewal appropriations form the data base for this analysis. Table 1 presents the dollar amounts of appropriations for the period 1950-1972. For the purposes of comparability all yearly appropriations have been calculated on the base of 1950 dollars, using a GNP deflator coefficient. This procedure not only corrects for general inflationary trends, but also helps control for the "mandatory needs" of the agency--those costs needed to keep the program operating at the same level as the previous year.[3] The program-project dichotomy is necessary due to the fact that commencing in 1965 other projects were added under the general umbrella of the Urban Renewal Program. Prior to 1965, the program included demolition projects (1965), code enforcement projects (1966),

Table 1. Urban Renewal Allocations
(dollars in thousands)

Year	Allocation[a] Project	Allocation[a] Program	GNP Deflator[b]	Allocation ($-1950) Project	Allocation ($-1950) Program
1950	198,774	198,774	1.00	198,774	198,774
1951	83,951	83,951	1.07	78,459	78,459
1952	46,504	46,504	1.09	42,251	42,251
1953	19,311	19,311	1.10	17,555	17,555
1954	28,631	28,631	1.12	25,563	25,563
1955	176,495	176,495	1.13	156,190	156,190
1956	273,019	273,019	1.17	233,350	233,350
1957	192,610	192,610	1.22	157,877	157,877
1958	304,878	304,878	1.25	243,902	243,902
1959	64,475	64,475	1.27	50,767	50,767
1960	477,512	477,512	1.29	370,164	370,164
1961	601,472	601,472	1.31	459,138	459,138
1962	546,632	546,632	1.32	414,153	414,153
1963	666,289	666,289	1.34	497,230	497,230
1964	598,893	598,893	1.36	440,362	440,362
1965	660,774	663,832	1.38	478,821	481,038
1966	727,270	766,173	1.42	512,162	539,558
1967	586,331	638,515	1.47	398,865	434,364
1968	784,788	936,938	1.53	512,933	612,378
1969	275,338	864,413	1.60	172,086	540,258
1970	521,587	1,047,219	1.69	308,631	619,656
1971	345,184	786,962	1.77	195,019	444,611
1972	797,826	1,386,018	1.82	438,366	761,548
Total:	8,978,594	11,069,566		6,402,618	8,819,146

[a]Source: 1972 HUD Statistical Yearbook, U.S. Government Printing Office, Washington, D.C., 1974, p. 52.

[b]Source: Economic Report of the President: Transmitted to the Congress, January 1973, U.S. Government Printing Office, Washington, D.C., 1973, p. 196.

neighborhood development projects (1968), certified area programs and interim assistance programs (1969), and fair program grants (1971). The program and project allocations expressed in terms of 1950 dollars are presented in graphical form in Figure 1.

Two interrupts were used in this analysis. The first, representing the Eisenhower-Kennedy transition, was 1960, and the second, representing the Johnson-Nixon transition, was 1968. Two propositions were examined. First, it was hypothesized that changes in party control of the Executive would lead to different levels of allocation for urban renewal--levels consistent with ideological positions regarding individualism, federalism, etc. Second, it was hypothesized that, once initial renewal allocations had been made for each change in party control of the executive, the allocation would increase incrementally each year with, possibly, different rates of incrementalism for each administration. In the language of time-series it was hypothesized that there would be (1) significant changes in level at each interrupt, (2) significant drift, and (3) significant changes in drift.[4]

Examining Figure 1, it is possible to imagine that all three of these hypotheses will be proven. There seem to be significant changes in levels for both the program and the project in 1969 and 1968, and while changes in slope are difficult to ascertain due to yearly fluctuations, there does seem to be a drift which may be significantly different from 0. Table 2 reports the time-series analysis for urban renewal project allocations.

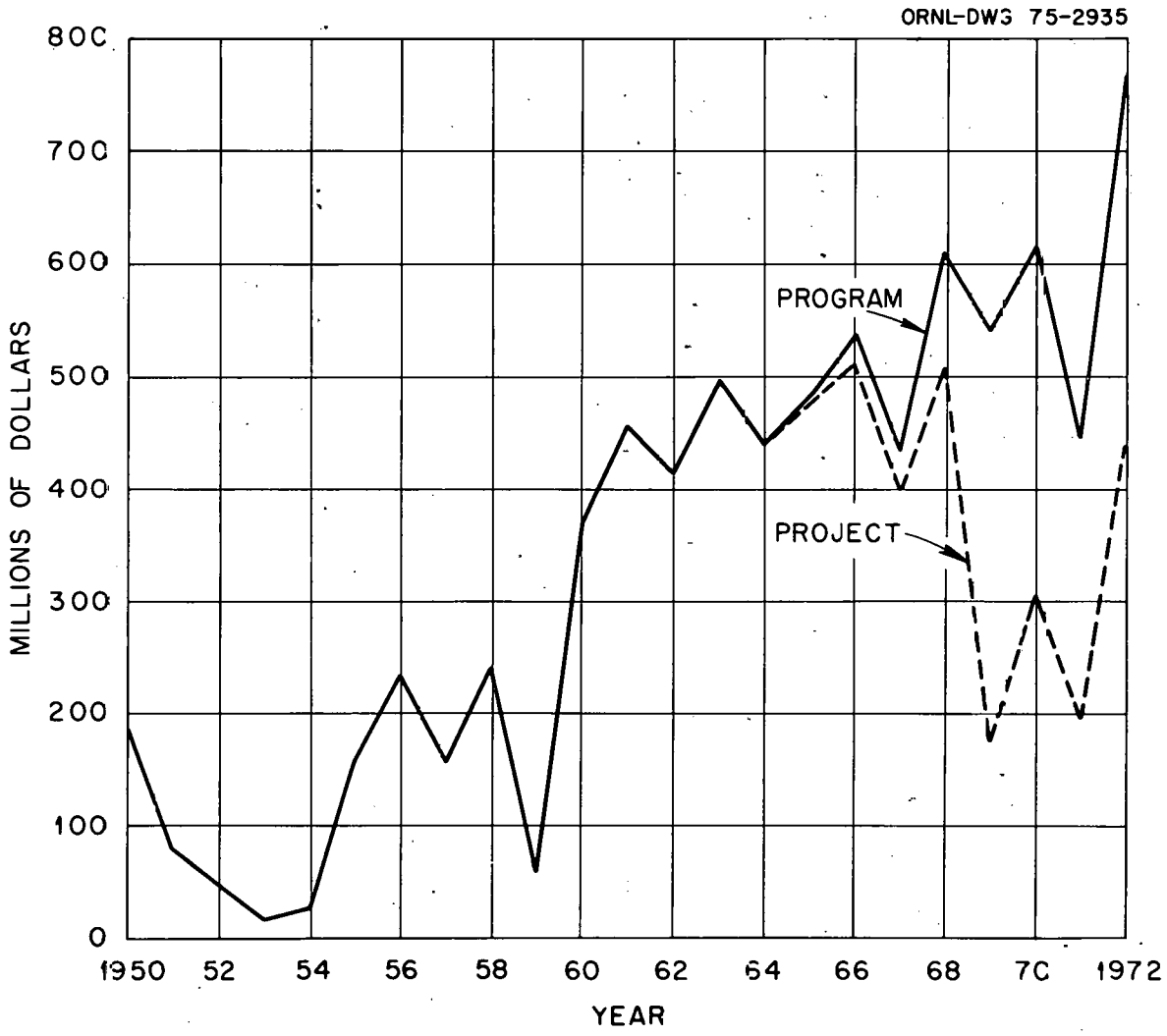

Figure 1. Urban Renewal Allocations ($ = 1950).

Table 2. Urban Renewal Project Allocations

"Extra sum of squares Analysis

	Parameter		
	Change in level	Drift	Change in Drift
Allocation	18.26[a]	0.37	0.18
df for F	2,17	2,17	2,17

Time-Series Analysis

Parameter	Value[b]	T[c]	P
Level	23.12<118.16<213.20	2.59	<0.02
Change in Level 1	216.19<320.29<424.39	6.42	<0.001
Change in Level 2	-238.41<-120.15<1.88	-2.12	<0.05

[a] $p<0.001$.

[b] 95% confidence interval.

[c] Two-tailed.

Significance of regression: $F(3,20) = 21.85$, $p<0.001$, $\gamma = 0.1$.

Two facts are readily apparent from this first time-series analysis. First, as shown by the "extra sum of squares" analysis,[5] no drift or change in drift significantly different from 0 has been found, and the model automatically was reduced to the two-parameter integrated moving average model. Second, the time-series analysis itself shows significant changes in level for each interrupt.[5] The same results hold for the urban renewal program as a whole, including all other projects, as shown in Table 3.

Table 3. Urban Renewal Program Allocations

"Extra sum of squares" Analysis	Parameter		
	Change in level	Drift	Change in Drift
Allocation	39.18[a]	1.49	0.12
df for F	2,17	1,17	2,17

Time-Series Analysis

Parameter	Value[b]	T[c]	P
Level	32.54<118.16<203.78	2.88	<0.01
Change in Level 1	233.81<327.59<421.37	7.29	<0.001
Change in Level 2	32.08<138.62<245.16	2.71	<0.02

[a] $p<0.001$.

[b] 95% confidence interval. .

[c] Two-tailed.

Significance of regression: $f(3.20) = 40.70$, $p<0.001$, $\gamma = 0.1$.

For the entire urban renewal program, significant shifts in levels of allocation occurred with shifts in party control of the Executive. In both the case of the Eisenhower-Kennedy and Johnson-Nixon shifts, the level of appropriation was significantly higher in the post-interrupt period. This occurred in spite of the drain on the economy from the Viet Nam War, and in spite of the obvious differences in ideological position between administrations with regard to social programs and urban policies.

Conclusions

The examination of public policies through the mechanism of time-series analysis enables researchers, as well as decision makers, better able to assess long-term trends, and changes in trends, than through the use of less sensitive techniques. While "eyeballing" figures or numbers is effective in some cases, it obviously was not in this case. Similarly, other time-series techniques[7] examining only one aspect of the series (drift or level) might also have led to biased interpretations (although the combined use of various statistics may have achieved similar results). The possibilities of Type I or, more importantly, Type II errors in the analysis of more simplistic time-series analyses than the method used here is as great, if not greater, than with other statistical procedures commonly used in policy analysis and evaluative research. The extension to a more complete time-series analysis, as shown here, offers a more powerful tool for the researcher.

The time-series analysis of urban renewal allocations has also opened up some questions directed at the concept of incrementalism in public budgetary decision analysis. Perhaps incrementalism as a step-function is more applicable to this case. Time-series analysis can be an extremely useful tool when properly applied to one specific program. Comparative analysis among programs and agencies would be a next logical step. Social scientists engaged in policy analysis and evaluative research should be encouraged to take that step.

NOTES

1. See, for example, Wilson (1973) and Gray (1973).

2. The programming was developed in conjunction with an evaluation of a federal DOT program, as described in Vaught, Keil, and Bronfman (1973). The new Box and Jenkins programs will allow for multiple input transfer function time series.

3. This inquiry into components of incrementalism is presented in Wanat (1974).

4. It should be noted that an examination of the autocorrelation and partial autocorrelation coefficients for the first 20 lags showed the data to be well behaved. Second differences were used to accommodate biennial congressional elections.

5. The "extra sum of squares" principle is used to test whether it is worthwhile to include certain terms in a model. The procedure involves the examination of the portion of the regression sum of squares (or residual sum of squares) which is due to the inclusion of the term or terms. The mean square derived from this procedure can be compared to the estimate, s^2, of δ^2 through an F-test. If not significant, the term may be eliminated without sacrificing the overall power of the model. For the time-series analysis presented in this paper, the "extra sum of squares" principle is used to determine the appropriate combination of time-series parameters. This procedure determines whether the full model (weighted moving average with deterministic drift) or the simple model (weighted moving average) is used. For a detailed discussion of the "extra sum of squares" principle see Draper and Smith (1966: 67-72).

6. A significant T for "level" implies a significant difference from 0.

7. See Wilson (1973).

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