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The process of public resource allocation may be analyzed in terms of a systems framework, comprising a set of input variables and a set of output variables, and the black box, which connects inputs with outputs. Two main subsets of inputs are taxes and charges, whereas public consumption and investment on the one hand and transfers on the other constitute the two main subsets of outputs. The black box contains the process through which inputs are transformed into outputs, covering the interactions and resource transactions between the political institutions making up the public sector; of course, the difference between outputs and inputs is the financial saving, which may be positive or negative. Diagram 1 portrays the system of political budgeting.

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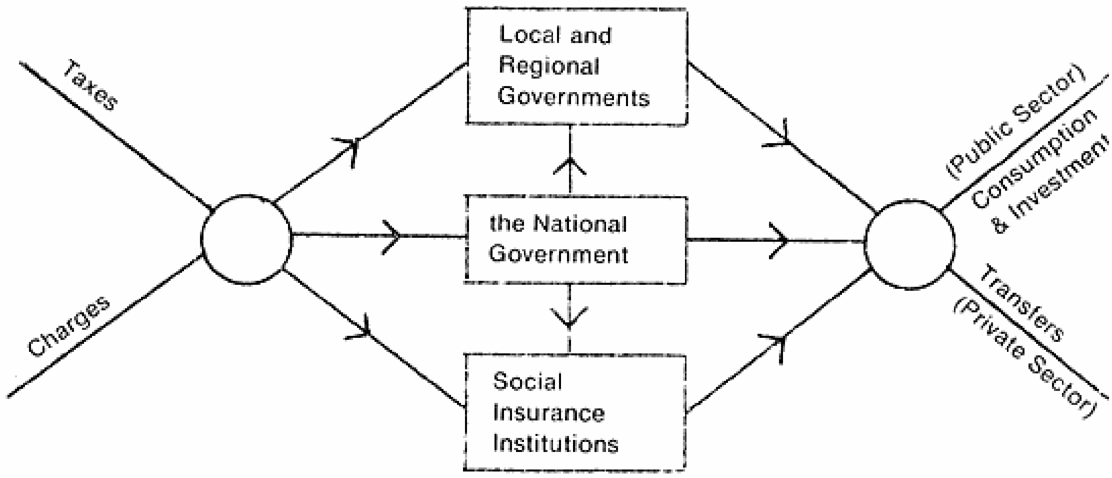
Diagram 1. The System of Political Budgeting.



The process of public resource allocation may be interpreted as a decision-making process; a distinction may be made between *income decisions*, i.e. decisions concerning taxes, charges, and borrowing, and *budget decisions*, i.e. decisions with regard to spending items and spending levels. Economists and political scientists have offered a number of suggestions as to what *principles* govern (should govern) the behavior in the black box; we focus upon one such theory of decision-making, the widely accepted theory of budget-making, *incrementalism*. Among political scientists it is generally believed that incrementalism is an adequate decision theory that explains budgetary decisions, in particular national budget making. From K. R. Popper we have learnt that a good scientific theory may be scrutinized by means of a severe test, that falsification is an inherent part of the scientific enterprise, and that an attempt at rejection of a theory by means of a severe test is actually what a good theory deserves (Popper, pp. 215–250). Thus, should we end up succeeding in our attempt at falsifying the theory of incrementalism, we still sense that we have only paid our tribute to that theory by worrying about what new theory offers a more promising route to a more adequate understanding of budgetary decision-making.

1. Incrementalism as a Decision Theory about Budget-Making

1.1. A general note on incrementalism

Incrementalism is a general theory about decision-making; its assumptions about the behavior of decision-makers were developed by J. G.

March & H. A. Simon in *Organizations* (1958) and D. Braybrooke & C. Lindblom in *A Strategy of Decision* (1963) as a critique of the rational model of decision-making or the synoptic conception of problem solving. The postulates of rational decision-making (see e.g. Lindgren 1971, White 1976, Tinbergen 1956), i.e. that

(a) decision-makers command comprehensive knowledge about the decision-making situation, enabling them to divide this situation into three mutually exclusive sets: alternative actions, outcomes, and environmental factors
(b) decision-makers command complete knowledge about the relationship between actions and outcomes
(c) decision-makers are fully familiar with the values that are relevant in relation to the alternatives, and decision-makers have complete and transitive preference functions over the outcomes
(d) the essence of decision-making is the rational calculation of the expected value of various alternatives and the choice of the alternative that maximizes the expected value in each single decision-making situation,

are according to the negative part of the incrementalist argument not true of organizational problem solving (March & Simon, pp. 137–169; Braybrooke & Lindblom, pp. 3–57). The positive part of the incrementalist argument comprises an alternative set of behavioral assumptions, by March and Simon identified as *Standard Operating Procedures* (SOP) and by Braybrooke and Lindblom as the principles of *disjointed incrementalism*. In his major work *The Politics of the Budgetary Process* (1964), A. Wildavsky developed the general theory of incremental decision behavior into a clear and specific theory of budgetary behavior. He accomplished two things, on the one hand adding to the general body of incremental decision theory and on the other stating the case for an analysis of budgetary behavior by means of Scientific Method. In order to establish what the incrementalist theory states about a set of public resource allocation decisions, budget making, we therefore turn only to two classic texts by A. Wildavsky: *The Politics of the Budgetary Process* and *Budgeting* (1975). Budget decisions consist of two kinds of decisions: *decisions on budget requests* and *decisions on appropriations*. According to Wildavsky decisions on budget requests and decisions on appropriations have the following properties:

(a′) *Simplification and specialization:* analyze programs in their various components, avoid comparisons between programs, adhere to a few indicators on program behavior and program outcomes.

(b′) *Testing based on experience:* let programs be in force for some time in order to accumulate a comprehensive and reliable material for evaluation, weigh different kinds of results against each other.

(c′) *Satisfying and fragmentation:* to suboptimize a certain goal function in relation to a program instead of aiming at maximizing.

(d′) *Marginal rate of change and a sequential process:* to frame decisions that in all essentials are a repetition of the decisions of the previous year with minor changes, to defend the base, and to arrive at an equitable share in the marginal change.

These properties have been considered most plausible and attractive, but the fundamental question is, of course, what evidence is provided in order that decisions on resource allocation in public finance satisfy the incremental decision theory. Firstly, it should be stated that when it is a matter of public resource allocation the theory has only been developed for budget decisions and only been used to describe the budgetary process. To what extent decisions on taxes and charges satisfy the decision theory has not been discussed. It is true that the knowledge of decision principles in taxation and other forms of public resource mobilization are in need of theoretical and empirical study. Secondly, the evidence in the analyses of incrementalism in budget decisions is of two different kinds: soft data studies of the budget procedure at national level and hard data studies of the budgetary process at various institutional levels within public finance. The soft data analyses have substantiated some notions in incrementalism concerning the strategic game around the process of public resource allocation, of the distribution of roles among different interested parties, of the interaction between politicians, administrators, and organized pressure groups. There are several penetrating soft data analyses of the budgetary process in the incrementalist tradition like H. Heclo's & A. Wildavsky's *The Private Government of Public Money* (1974), I. Sharkansky's *The Politics of Taxing and Spending* (1969), and T. Anton's *The Politics of State Expenditure in Illinois* (1966). However, the soft data analysis does not give decisive information about if, and to what extent, budget decisions satisfy the decision principles of the theory. The hard data studies give information on this very point.

1.2 *The quantitative version of incrementalist theory*

In models of decisions on budget requests and of decisions on appropriations Wildavsky in collaboration with O. A. Davis and M. A. H. Dempster has specified key principles in the incremental decision theory:

(i) *The principle of marginalism:* decisions on budget requests always involve a marginal increase of the appropriations or the budget requests of the previous year; decisions on appropriations are always based on a marginal change in relation to the appropriations of the preceding year or the budget requests of the same year.

(ii) *The principle of an equitable share:* decisions on budget requests are always made on an assumption of a constant change in relation to the appropriations of the previous year; decisions on appropriations are based on a constant modification of the budget requests or the appropriations of the preceding year.

(iii) *The principle of the existence of the base:* decisions on budget requests and decisions on appropriations set out from the existence of a base identifiable over an interval of time.

And Wildavsky, Davis and Dempster (shortened below to (WDD)) took the step from a mere verbal theorizing about budgetary decision-making to presenting a set of formal models interpreting the decision principles (i), (ii), and (iii). The quantitative models which (WDD) have elaborated for an analysis of the national budgetary process in the USA are all simple, linear, stochastic models (Wildavsky et al. 1971, pp. 350–382). Depending on a hypothetical decision rule, they are either static or dynamic. (WDD)'s arguments for linearity are relatively convincing. However, the specification of the linear model can and should be tested empirically. Such an examination is normally based on a detailed analysis of the observed residual process. The simplicity characterizing (WDD)'s models – all of them are one-relation models with one or a few predetermined variables – is in itself attractive. Simplicity is generally an essential criterion of every process of model building. However, if there is interdependence between the two processes of budget requests and budget appropriations, this should be taken into consideration, particularly in connection with the estimation of parameters. Otherwise there are obvious risks of loss of precision and generally weakened reliability when parameters are estimated.

The behavior equations that are assumed to describe the procedure of budget requests are as follows:

$$r_t = \alpha_{11}\, a_{t-1} + \varepsilon_{1t} \qquad (1.1)$$

$$r_t = \alpha_{21} a_{t-1} + \alpha_{22} (a_{t-1} - r_{t-1}) + \varepsilon_{2t} \qquad (1.2)$$

or

$$r_t = \alpha_{31} r_{t-1} + \varepsilon_{3t} \qquad (1.3)$$

where r_t and a_t denote budget requests and appropriations respectively at the time t, α_{ij} denotes structure parameters and ε_{ij} a random term, representing actual shortcomings in the specification of the model, shortcomings of data etc. Model (1.1) thus corresponds to a budget request behavior where budget requests are dimensioned as a function of the immediately preceding appropriations. In model (1.2) the difference between previous budget requests and appropriations is also taken into account. In model (1.3) finally only preceding budget requests are considered, i.e. the size of the appropriations is assumed not to influence decisions on budget requests directly. In a similar way (WDD) formulate the following alternative, simple, linear behavior models for decisions about appropriations:

$$a_t = \beta_{11} r_t + \mu_{1t} \qquad (1.4)$$

$$a_t = \beta_{21} r_t + \beta_{22} (a_{t-1} - r_{t-1}) + \mu_{2t} \qquad (1.5)$$

and

$$a_t = \beta_{31} a_{t-1} + \mu_{3t} \qquad (1.6)$$

In the appropriation models (1.4–6), β_{ij} corresponds to structure parameters and μ_{it} to stochastic error terms. The hypotheses are in (1.4) that appropriations are determined mainly by budget requests, in (1.5) that decisions on appropriations made a certain year also pay regard to the difference of the preceding year between appropriations and budget requests, and in (1.6) finally that decisions on appropriations are related in the first place to the appropriations of the previous year. (Cf. the relations of the budget requests above).

What should the world look like described by means of the models (1.1–6) in order that it may be asserted that budget decisions are made in accordance with the principle of marginalism, the principle of an equitable share, and the principle of the existence of the base? The incremental decision theory is confirmed if an estimation of the parameters of the models results in:

(a) a marginal increase or decrease between two years
(b) a constant change over an interval of time
(c) the existence of an unchanged base over an interval of time

Inversely it applies that the incremental decision theory is falsified if the interpretation of the estimation of the parameters does not give these properties. Falsifiability, as Popper has clarified, is a property of a scientific theory; actually the more falsifiable a theory is, the more it says about the world. If (a) and (b) are to be true, the parameter estimation must result in constant or stable parameter estimates; if also (c) is to be true, the parameter estimates must be stable and positive. The assumption of a structural stability is indeed falsifiable.

1.3 *The evaluation of incrementalism*

The unknown structural parameters α_{ij} and β_{ij} of the models should be estimated on the basis of observed statistics of budget requests and appropriations. It is a self-evident criterion of adequacy that the specification of the models is as correct as possible. It is just as essential that the estimation of the parameters is carried out in a reliable way, i.e. that an appropriate method of estimation is used. This is of particular importance if the specification of the models and perhaps also the data available are impaired by shortcomings. The selection of a method of estimation inappropriate for relevant data can undoubtedly restrict or even eliminate the possibilities of utilizing the results of the quantitative analysis in a fruitful way. Different methods of estimation are based on different assumptions particularly with regard to the properties of the random terms; methods of estimation are also in a varying degree capable of resisting actual deviations from these assumptions. It is in view of such circumstances that (WDD)'s models of budget requests and appropriations should be examined more closely. The key hypotheses in (WDD)'s analysis are that the relations of budget requests and the relations of budget appropriations are constant periodically, i.e. that the structural parameters α_{ij} and β_{ij} are constant during a given period, after which a discrete change takes place, which is followed by the stability of one more period, etc. This assumption, that the structural parameters are time-varying, changes the specification of the models; of e.g. model (1.1) the following holds good:

$$r_t = \alpha_{11,t} a_{t-1} + \varepsilon_{1t} \qquad (1.7)$$

i.e. also the structural parameters are given a time indexing. This generalization in the specification of the models is in itself a step in the right direction. On the other hand, the way in which (WDD) test their hypothesis of step-by-step stability with a few discrete structural jumps is of doubtful value. By (WDD) the result of the empirical testing is regarded as satisfactory and this empirical testing is in reality the only empirical support there is of the incrementalist decision theory of public resource allocation, in particular budgeting. If the results of the testing of (WDD)'s equations can be called in question, this has definite consequences for the test of incrementalism.

The purpose of the present paper is to evaluate the principles of incrementalism, (i) – (iii) above, by applying the budgetary behavior relations (1.1–6), in a structural analysis of some Swedish public budgetary processes. Such an evaluation requires a general framework for this structural analysis, i.e. we will allow for potential structural instabilities. Our first task is then, of course, to test whether structural variability is or is not the most plausible characteristic of the Swedish budgetary processes to be analyzed. After a short description of structures and data actually used we will therefore in section 2 give a review of approaches possible to follow in order to judge statistically the extent of structural variability. In this special analysis we will select two test techniques, and a thorough description of these as well as the testing results obtained are then given. The pervading conclusion will be the rejection of all stability hypotheses. When estimating the structural budgetary relations we then have to choose a technique especially adapted to structurally varying systems. Such estimation techniques will often be recursive, and we are here applying a general recursive estimation technique, viz. Kalman filtering. Kalman filtering is introduced in section 3, where we also give the estimation results thus obtained, indicating the extent and time for structural variability. Finally, section 4 gives some conclusive comments on this evaluation of incrementalism within the framework of Swedish budgetary structures.

2. Analysis of Two Swedish Budgetary Structures

2.1 *Structures and data*

For the purpose of examining (WDD)'s models of budgetary behavior, the relations of budget requests and the relations of appropriations respectively, we have statistically tested hypotheses of structural stability against hypotheses of structural variability, and for structural estimation applied an approach designed to handle structurally varying systems. The interest is focused on a structural analysis in the model (1.7) and in structurally time-varying versions of (1.4) and (1.6). Data from the sphere of activity of the National Swedish Board of Universities and Colleges and of the National Swedish Board of Education have been used for the time 1946–1979. In order to arrive at comparability between data for different periods, data have been aggregated due to organizational changes.

2.2 *Testing for structural variability*

Econometric models are essential parts of the economic structural analysis. Generally, econometric modeling presupposes an assumption of structural stability, i.e. that the structural parameters are constant over time. Sometimes, this rather restrictive definition of the concept "structural stability" is relaxed by allowing for random variations (transitory variations) but rejecting permanent changes. When talking about structural variability it is convenient to distinguish between two sets of cases. In the first type, structural changes occur at a limited number of points in time, but the structure is stable between these points. In the second set of cases, the structural variability is assumed to be described by stochastic processes. The interest here is focused on problems connected with structural variability according to the second type.

Graphical representation of recursive estimates is generally not sufficient when testing stability against various alternatives of structural variability. Consequently, there is a strong need for stability significance tests. Such tests are partly based on recursive cumulated residuals, partly on various assumptions of parameter variation. Some tests are approximate, some are exact. Various inferential approaches, e.g. maximum likelihood, maximum invariance, etc., are used. However, all tests developed so far are designed for unirelational, multiple or simple, linear regression models.

Most stability tests will concern the linear regression model

$$y_t = x_t \beta_t + \varepsilon_t \; ; \; t = 1,T, \tag{2.1}$$

where x_t is a p-dimensional row vector of regressors, β_t is a parameter vector, and ε_t is a stochastic scalar, where

$$\varepsilon_t \sim N(O, \sigma_\varepsilon^2),$$

If $\varepsilon = (\varepsilon_1, \ldots, \varepsilon_T)'$, we have

$$\varepsilon \sim N(O, \sigma_\varepsilon^2 I_T).$$

For some tests we especially consider the simple regression model where $p = 1$.

As the present state of the art does not allow us to formulate explicit alternative hypotheses concerning structural variability, as a specific alternative to the characteristics of incrementalism, we will here restrict ourselves to the application of tests adapted for just general non-stability.

Recursive residuals will be of fundamental importance here. In order to define these, we introduce

$X'_t = (x'_1, \ldots, x'_t)$, of order (pxt),

and

$Y'_t = (y_1, \ldots y_t)$, of order (1xt),

where $p \leq t \leq T$.

If the parameters β_t in (2.1) are stable over time, the least-squares estimate based on t observations will be

$$b_t = (X'_t X_t)^{-1} X'_t Y_t,$$

with covariance as

$$\sigma_\varepsilon^2 (X'_t X_t)^{-1}.$$

The recursive residuals are then defined as

$$w_t = \frac{y_t - x_t b_{t-1}}{(1 + x_t(X'_{t-1} X_{t-1})^{-1} x'_t)^{1/2}}; \; t = p + 1, T. \qquad (2.2)$$

If the hypothesis of structural stability is true

$$w_t \sim N(O, \sigma_\varepsilon^2),$$

and w_t is a serially independent process.

The CUSUM test (see e.g. Brown et al., 1975) is based on the cumulative sums

$$W_{1t} = \sum_{t' = p + 1,}^{t} \omega_{t'}/\hat{\sigma}_{\varepsilon} \qquad (2.3)$$

where

$$\hat{\sigma}_{\varepsilon}^{2} = (Y_T - X_T b_T)' (Y_T - X_T b_T) / (T - p).$$

Under the structural stability hypothesis, i.e. if $\beta_1 = \ldots = \beta_T = \beta$

$$W_{1t} \overset{appr}{\sim} N(O, t-p).$$

The stability hypothesis is rejected, if

$$|W_{1t}| > (c\,(T-p)^{1/2} + 2c\,(t-p)\,(T-p)^{-1/2}),$$

for any t in [p + 1, T], and where c is a constant, the value of which determines the confidence level of the test:

c = 1.143 corresponds to .01 confidence level,
c = .948 corresponds to .05 confidence level.

The constants c are, however, only approximate.

An alternative to the CUSUM test is obtained if σ_{ε} in (2.3) is estimated by

$$\hat{\sigma}_{\varepsilon}^{2} = \Sigma(w_t - \bar{\omega})^2 / (T - p - 1), \qquad (2.4)$$

where $\bar{\omega} = \Sigma w_t / (T - p)$. Estimation of σ_{ε} by (2.4) does not change the distribution of W_{1t}, given the structural stability hypothesis. However, this modification is shown to increase power properties of the CUSUM test. See e.g. Garbade (1977) and Harvey and Phillips (1976) for robustness evaluations.

If W_{1t} is replaced by W_{2t}, where

$$W_{2t} = \sum_{t' = p + 1}^{t} \omega_{t'}^{2} \Big/ \sum_{t' = p + 1}^{T} \omega_{t'}^{2}; \quad t = p + 1, T, \qquad (2.5)$$

the CUSUMQ test is obtained. Obviously, w_{2t} is a monotonically increasing process with maximum $W_{2T} = 1$. From (2.5) it is found that

$$W_{2t}^{-1} - 1 = \sum_{t'=t+1}^{T} \omega_{t'}^2 / \sum_{t'=p+1}^{t} \omega_{t'}^2 \quad ,$$

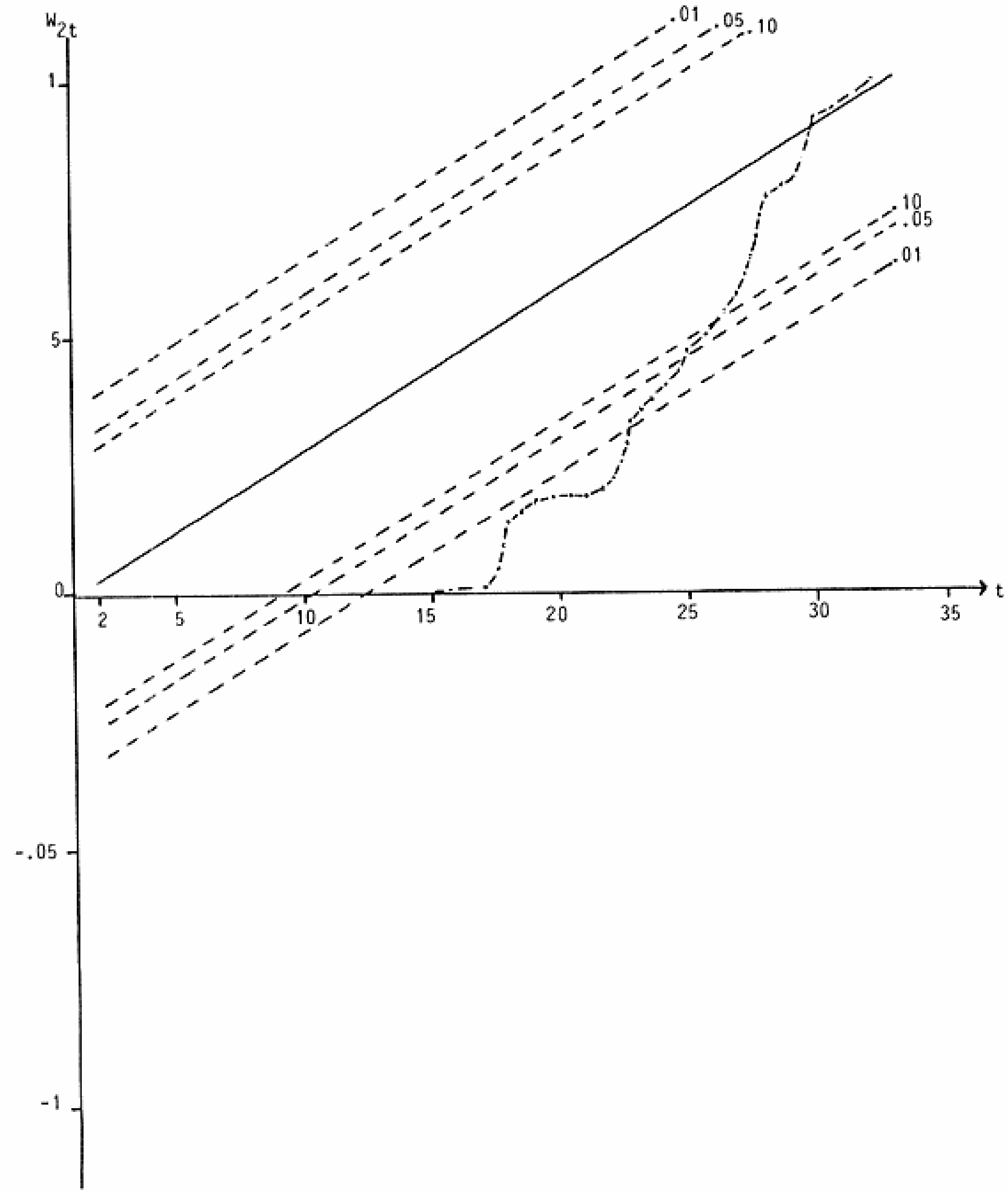


Figure 1. Testing for structural stability in the relation (1.6): appropriations as a function of last year's appropriations. The National Swedish Board of Universities and Colleges.

and then it may be shown that $1 - W_{2t}$ has a beta distribution with parameters $\alpha^* = -1 + (T - p)/2$, and $\beta^* = -1 + (t - p)/2$, i.e. the mean value of W_{2t} is $(t - p)/(T - p)$. For the stability testing procedure the following confidence interval for W_{2t} is to be used:

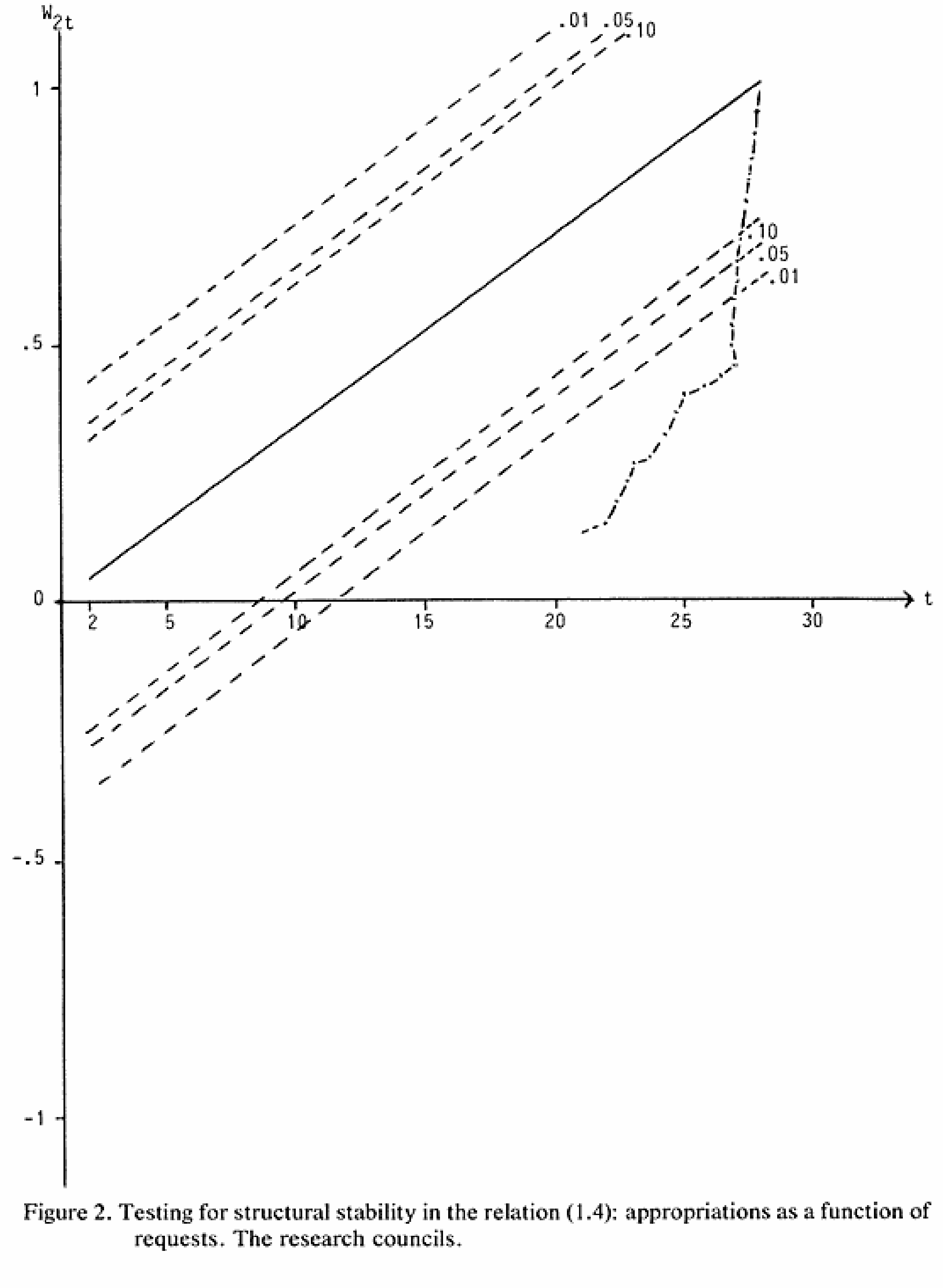


Figure 2. Testing for structural stability in the relation (1.4): appropriations as a function of requests. The research councils.

$$((t-p)/(T-p)) \pm c^*,$$

where c^* is determined subject to the desired significance level (see e.g. Durbin, 1969). Thus, the structural stability hypothesis is rejected, if

$$|W_{2t} - ((t-p)/(T-p))| > c^*, \text{ for } p + 1 \leq t \leq T.$$

2.3 *Empirical test results*

The CUSUM test, the alternative CUSUM test where σ_ε^2 is determined according to (2.4), and the CUSUMQ test have been applied in order to examine whether structural relations for budget requests and for appropriations formalized in (1.1–6) are structurally stable. From these tests it follows that we cannot reject stability hypotheses by CUSUM (and its variant), but that we will always reject the stability hypotheses by CUSUMQ. This difference in test conclusions depends mainly on differences in test power properties between CUSUM and CUSUMQ. The CUSUMQ test is generally characterized by clearly better power properties, i.e. the possibility to reject a false stability hypothesis is higher if using CUSUMQ instead of CUSUM tests. Consequently, we feel greater confidence in the testing procedures based on CUSUMQ and we will therefore reject the stability hypotheses. The results obtained with the CUSUMQ tests are illustrated in Figures 1–2. The dotted lines in Figures 1 and 2 describe the observed values of the CUSUMQ test statistic W_{2t} in (2.5). If the structural relations (1.4) and (1.6), respectively, in fact are structurally stable, the values of W_{2t} are expected to follow the diagonal curves, determined as $(t-p)/(T-p)$. The two sets of parallel diagonal lines describe the limits for non-rejection of the stability hypothesis for various test significance levels. Subject to a correct structural stability hypothesis these significance levels indicate the probability that the observed W_{2t} still will cross these limits. As is seen in Figures 1 and 2, both test situations illustrated here clearly indicate rejection of the stability hypothesis. It should be observed that these test charts can not be directly used to verify the time and extent of structural variability. Such information is better reached by the structural estimates given below.

3. Kalman Filtering for Structural Analysis

3.1 *The Kalman filter*

If the behavior models for the processes of budget requests and appropriations are characterized by some type of structural instability, it may be difficult or impossible to quantify this variation of structure in a reliable way by means of ordinary least-square estimation, which (WDD) do. (WDD) estimate the models of budget requests and appropriations with a statistical inference approach which is not particularly adapted to models with time-varying parameters. The incremental model for budgetary behavior based on (WDD)'s model analyses should be subjected to renewed examination on the basis of better methods of model estimation, before this theory can be assumed to be valid for the decision mechanism in public resource allocation. In structural analysis of data it is essential to use appropriate methods of estimation of parameters. In recent years the so-called Kalman filter method has been generally proposed as a suitable method for estimation of parameters in structurally time-varying models. The applicability of the method to the estimation of structurally time-var-

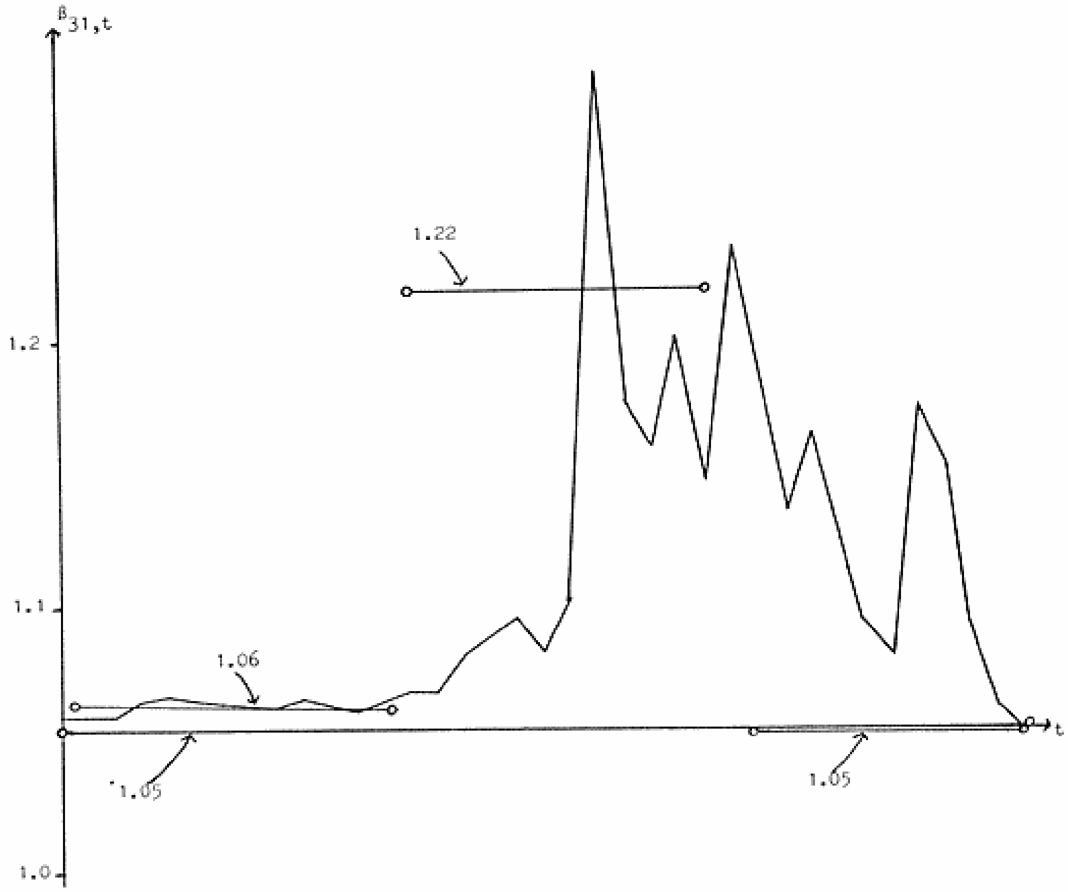


Figure 3. Structural parameters in the equation: appropriations as a function of last year's appropriations. The National Swedish Board of Universities and Colleges 1949–1979 (aggregation of bureaus).

ying social science models has been tested inter alia in Brännäs and Westlund (1980). The results of this testing are very promising. With Kalman filtering we make a structural analysis of data on the activities of two government agencies on the basis of (WDD)'s models for budget requests behavior and appropriations behavior. At the same time (WDD)'s approach to the estimation of parameters is applied with a view to making a comparative analysis of how the results of the two methods

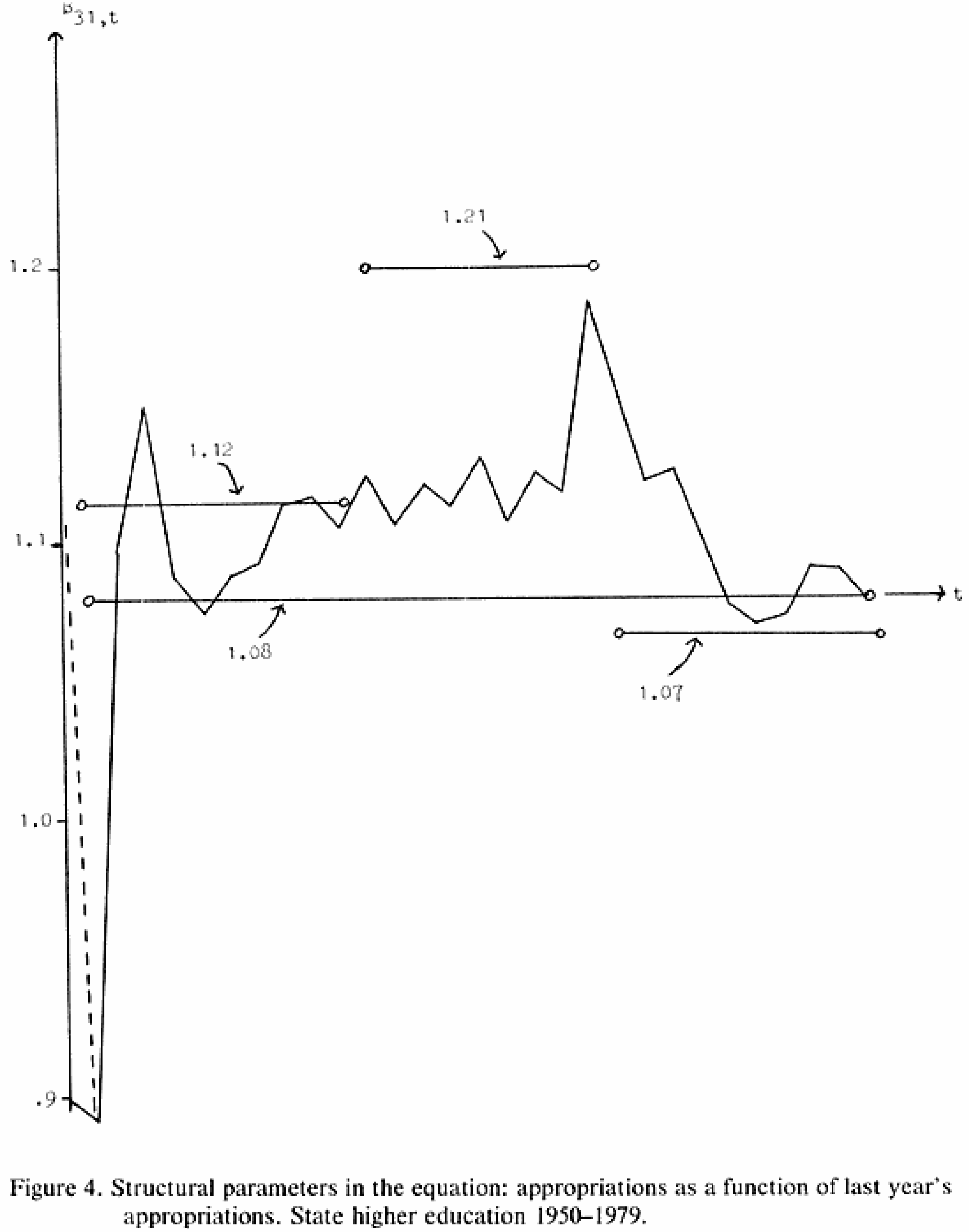


Figure 4. Structural parameters in the equation: appropriations as a function of last year's appropriations. State higher education 1950–1979.

differ and what consequences these differences have for the testing of incrementalism. First, however, a brief presentation of the Kalman filter method for the purpose of giving a picture of the fundamental function of the method.

Suppose that the structural model consists of a linear behavior relation:

$$y_t = x_t \alpha_t + \varepsilon_t \tag{3.1}$$

where y_t is a dependent variable, $x_t = (x_{1t}, x_{2t}, \ldots, x_{pt})$ denotes a sequence of p independent variables, (in the equation (1.1) is p = 1, in (1.2) p = 2, etc), $\alpha'_t = (\alpha_{1t}, \alpha_{2t}, \ldots, \alpha_{pt})$ is a vector with the p respective structural parameters, and ε_t denotes a random remainder. The remainder ε_t is supposed to be normally distributed with the anticipated value $E\varepsilon_t = 0$

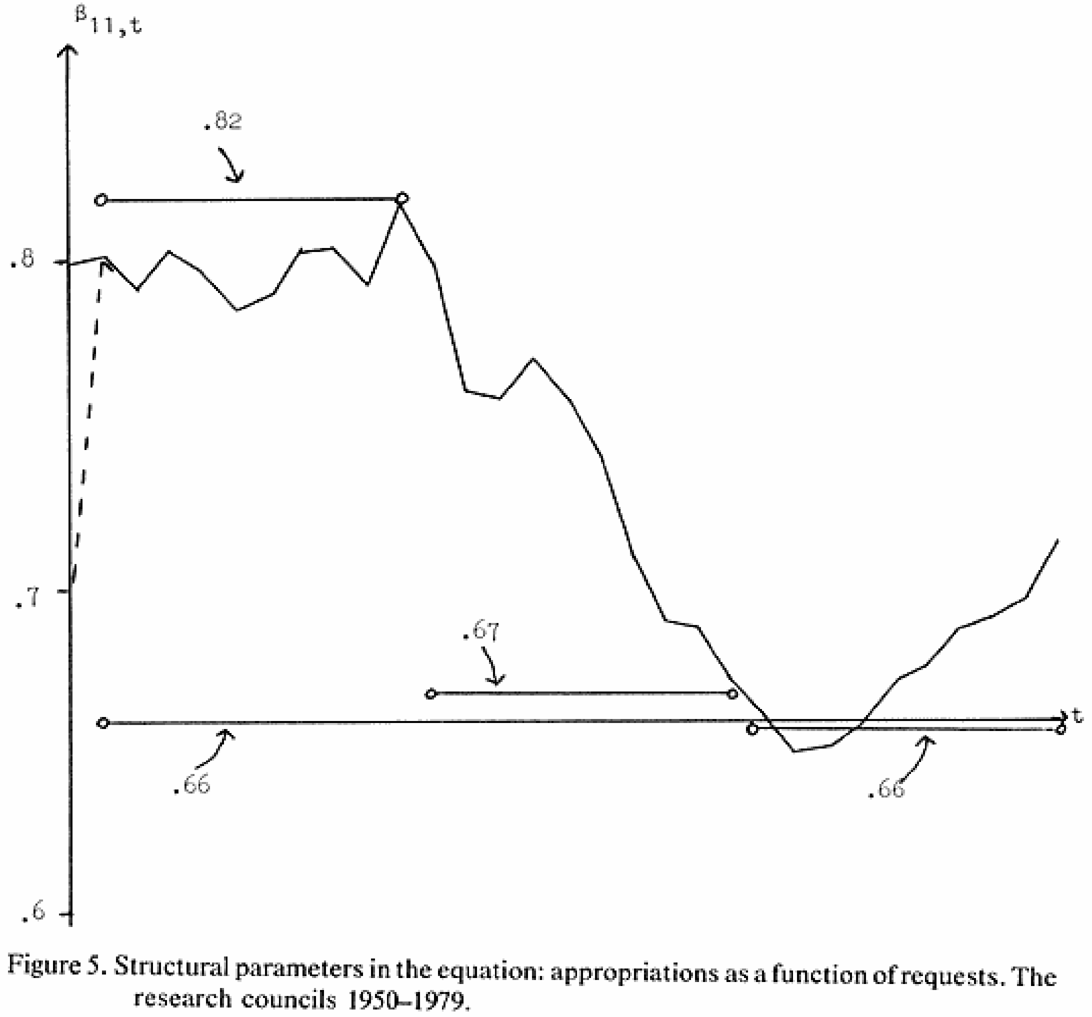


Figure 5. Structural parameters in the equation: appropriations as a function of requests. The research councils 1950–1979.

and constant, finite variance, Var $\varepsilon_t = \sigma_\varepsilon^2$. The structural parameters are thus assumed to vary with the time. A relatively general assumption concerning this variability in time can be summed up in a simplified way in the following parameter model:

$$\alpha_t + 1 = \Gamma_t \alpha_t + v_t \qquad (3.2)$$

The model (3.2) thus represents a system of p relations, where every parameter $\alpha_{i,t+1}$ is supposed to vary stochastically (v_t), and through some systematic change dependent on an earlier actual parameter value ($\Gamma_t\alpha_t$). The so-called transition matrix Γ_t of the order (p x p) is often supposed to be time-invariant (i.e. $\Gamma_t = \Gamma$ for all t), and often identical with or approximatively equal to the identity matrix. The remainder vector v_t is normally assumed to be p-dimensionally normally distributed, with expected values $Ev_t = 0$ (zero vector), and with variance – covariance matrix Q. If the p stochastical error terms in (3.2) are assumed to be independent, the matrix Q is diagonal, where the diagonal elements correspond to the variances for v_{it} (i = 1,2, ..., p). Finally ε_t and every element in the vector v_t are supposed to be independent. Models (3.1) and (3.2) form together the starting-point for application of the Kalman filter for structural analysis and the following estimating equation is obtained.

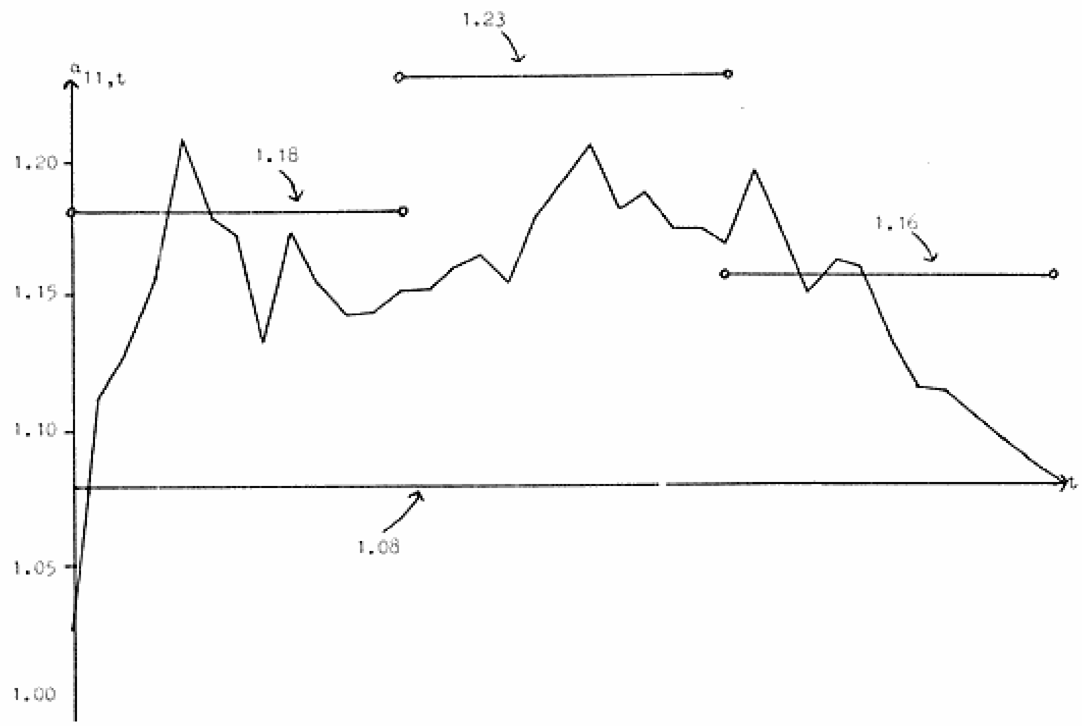


Figure 6. Structural parameters in the equation: requests as a function of last year's appropriations. The Swedish Board of Education 1946–1979.

$$\alpha_{t+1/t+1} = \alpha_{t+1/t} + G_{t+1}\{y_{t+1} - X'_{t+1} \quad \alpha_{t+1/t}\} \tag{3.3}$$

where

$$\alpha_{t+1/t} = \Gamma_t \alpha_{t/t} \tag{3.4}$$

By $\alpha_{k/l}$ is meant Kalman estimation of α_k at the time k based on information up to and including time 1. The term $(y_{t+1} - X'_{t+1}\alpha_{t+1/t})$ therefore corresponds to an actual error in forecasting at the time t + 1, i.e. every new estimation $\alpha_{t+1/t+1}$ is given recursively by a process of weighting together the preceding estimation $\alpha_{t/t}$ and the present error in forecasting. The process of weighting together depends on G_{t+1}, (the so-called filter gain) which is arrived at according to:

$$G_{t+1} = \Sigma_{t+1/t+1}X_{t+1}\left[X'_{t+1}\Sigma_{t+1/t}X_{t+1} + \sigma_\varepsilon^2\right] \tag{3.5}$$

The size of the elements in G_{t+1} decreases if σ_ε^2 increases, i.e. increased uncertainty in model (3.1) leads to diminished credit in new data and therefore to a more conservative updating by means of (3.3). If on the other hand the elements in Q increase, also G_{t+1}, increases (see 3.7) below), i.e. observed variations in data affect the recursive parameter estimation more strongly. $\Sigma_{t+1/t+1}$ in (3.5) corresponds to the estimated variance – covariance matrix for $\alpha_{t+1/t+1}$, and is calculated recursively according to

$$\Sigma_{t+1/t} = \Sigma_{t+1/t} - G_{t+1}X'_{t+1}\Sigma_{t+1/t} \tag{3.6}$$

where

$$\Sigma_{t+1/t} = \Gamma_{t+1}\Sigma_{t/t}\Gamma_{t+1} + Q \tag{3.7}$$

Thus, the Kalman filter method has a recursive structure, which renders it attractive for practical application. Given the basic assumptions described above it is further characterized by good theoretical properties. However, when the method is applied, certain a priori specifications are required initially, namely (i) σ_ε^2, (ii) Q, (iii) $\Gamma_{.t}$, and (iv) $\alpha_{o/o}$. Of course, the theoretical properties of the method are influenced by the possibility of specifying these entities satisfactorily. There is, however, a manifest robustness vis-à-vis the specification of the variance elements σ_ε^2 and Q.

On the other hand the transitions in Γ_t and the initial parameters $\alpha_{o/o}$ should be specified with greater care. In most cases it is here appropriate to estimate these preliminary entities quantitatively on the basis of the data at hand concerning the process studies.

3.2 *Some results*

The results of the comparative analysis between the method used by (WDD) and the Kalman filter method are summed up in Figures 3–6. In every figure the broken curve illustrates the result of parameter estimation on application of Kalman filtering. In the figures are also given the results arrived at on application of conventional regression analysis, for the whole period as well as for parts of it. The figures show that the results of the regression analysis to some extent catch the structural variability that is estimated via Kalman filter. For the regression analyses in Figures 4 and 6 the results of the estimation seem unreliable. This is not surprising because inferior precision and deficient correctness of anticipated values in the regression analysis are to be expected, if the specified regression model is actually characterized by structural variability. The Kalman filtering adapted to such situations therefore appears as considerably more reliable. Furthermore, as a rule more information about structural variability is given on estimation with Kalman filter. This appears very clearly in Figures 3–6. In order to initiate the recursive Kalman filtering necessary, a priori specifications have been initiated by means of results obtained on regression analysis of the whole period of time. Of course, here is the cause of some uncertainty in the Kalman filtering. However, as has been stated earlier, the specifications of variance should hardly play any significant role. With regard to the initial parameter values several alternatives have normally been tested. Throughout we have then found great robustness vis-à-vis these a priori specifications, too. Already after a few points of time the alternative estimated parameter processes have connected on to each other (see e.g. Figures 4 and 5). Therefore we are of the opinion that potential uncertainty in the Kalman estimation in the first place can be associated with uncertainty in the initial transition assumptions that are made (see (3.2)). We intend later on to analyze the question of robustness which is closely connected with the problem of trying to find alternative decision rules that are valid for the description of decisions on appropriations and budget requests.

The question if the incremental decision theory is correct for budgetary decisions may vis-à-vis the data summed up in Figures 3–6 be specified into: to what degree do the data support that budget decisions satisfy the three key principles in Wildavsky's budget theory: the principle of marginalism, the principle of an equitable share, and the principle of the existence of a base.

(1) *Marginalism:* this principle says that decisions on budget requests and on appropriations involve a minor change in relation to the appropriations of the previous year and the budget requests of the previous year or of the same year. Data by no means confirm that this principle should be valid generally. On the contrary, both Figures 3 and 5 show changes that can hardly be interpreted as inconsiderable. The fact that budget decisions sometimes satisfy the principle of marginalism is no support for the principle being valid generally. Such a generalization involves disregard of the occurrence of a different decision principle not involving marginalism, and failure to clarify when the principle of marginalism applies and when it does not apply.

(2) *Equitable share:* this principle says that decisions on appropriations and on budget requests tend to show a constant change over an interval of time. There are intervals of time when data can be said to satisfy this property, but what is most salient in Figures 3 and 6 is that data indicate that an entirely different decision principle is applied. Nor can Figures 4 and 5 be taken as unambiguous support for the principle of an equitable share. It is obvious that this principle is sometimes satisfied by data, e.g. during the 1950's in Figure 3 and during the 1960's in Figure 5, but a generalization involves disregard of the fact that data indicate that other decision principles are applied during certain invervals of time.

(3) *Existence of a base:* this principle says that decisions on budget requests and on appropriations revolve around a base that is fixed over an interval of time. Can this base be identified in the data in the figures? It is evidently difficult, not to say impossible, to identify a base in Figure 3 for the time 1960–1979. The same applies to Figure 5 for the time from the late fifties onward. Figure 4 indicates that a base can be identified, but that it varies at different levels for different intervals of time, whereas Figure 6 indicates that submitters of budget requests have different ideas of what a base should be like at different times. Again: the principle misleads more than it enlightens. During certain intervals of time decisions on appropriations and on budget requests appear to revolve around a base; during other intervals of time no base is identifiable. It must be essential to clarify when this principle is applied and when some other principle is used.

4. Conclusions

When we subject the widely accepted decision theory within organizational theory and policy analysis, the so-called incrementalism, to an empirical examination through an analysis of a number of well-known budgetary models by Wildavsky and collaborators, we get a negative result: falsification. If data are described with a regression model which permits that the structural variability that characterizes data does not disappear in the model but is reproduced in the parameter estimation (via the so-called Kalman filter method), it can be shown that incrementalism does not agree with data. The three key principles of the incrementalist theory are too crude for the understanding of budget decisions. It should be strongly emphasized that the falsification of incrementalism has been made with incremental models on a set of data which, if these had been described with a conventional method for parameter estimation, would have confirmed incrementalism. Thus, it cannot be asserted that the incremental models suit US, but not Swedish, budget data.

In some innovative articles Wildavsky and Dempster have outlined an approach to the study of budget-making which explicitly recognizes the importance of structural changes. They write:

> 'Our hope in this paper is to give new meaning to the concept of incrementalism applied to budgetary processes. This new meaning is central to our previous work and can be operationally linked to it in precise terms. By identifying 'incremental' with the regular relationship between Congress and bureaux, as expressed in our equations, non-incremental becomes equivalent to a shift in these relations.' (Wildavsky & Dempster, p. 371)

We believe that it is necessary to take one further step: to seriously question the basic hypothesis in all incrementalist theory, the assumption about structural regularity or stability. We have exposed this hypothesis to a refined statistical test and the data do not corroborate the hypothesis. Our next step will be the attempt to construct a theory of budgetary decision-making which does not contain the Juggernaut of incrementalism, the assumption of structural stability. Of course, any extension of a theory of decision principles explaining budgetary behavior into the field of resource mobilization accounting for decisions on taxation and charges would constitute a significant improvement of the present state of knowledge.

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