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Keskusteluaiheita
Discussion papers

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SOME COMMENTS ON FINE-TUNING MACRO-MODEL FORECASTS

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1. INTRODUCTION

This paper deals with fine-tuning or adjusting econometric models in actual forecasting situations. Fine-tuning consists of those modifications of the model which rest on "outside" information, not present in the standard structure of the model, and which are performed after final estimation, evaluation of exogenous variables and often also after calculation of a preliminary forecast.

The idea of fine-tuning turns up every now and then in the literature, cf. Haitovsky & Treyz (1972), several papers in Hickmann (1972), Hirsch, Grimm & Narasimham (1974), Vartia (1974), Intriligator (1978), Klein & Young (1980) and Young (1982). Fair (1974) can be regarded as the standard critical reference. However, in this literature attention is almost exclusively focused on various more or less mechanical adjustment rules for the residuals of the model. This also holds true for more practically oriented fine-tuning papers like Surrey & Ormerod (1977), Hujer, Cremer & Knepel (1979), Blazejczak (1980) and Corker (1982), although in these papers also alternative manipulation methods and general organizational aspects of forecasting are briefly discussed.

In the following our interest centres around the connections between alternative manipulation techniques and their interpretations and applications in actual forecasting situations. A case study (Section 4) is included suggesting that fine-tuning can result in major improvements in forecasting accuracy.

2. AN ECONOMETRIC MODEL AS A FORECASTING TOOL

2.1. Structure and solution of a model

We write the structural form of an econometric model as

$$(1) \qquad y = F(y,z,u)$$

where the vectors y,z and u stand for the endogenous variables, predetermined variables and residuals of the model, respectively. Whether the model is dynamic or static is not important in the following considerations. The values of all lagged variables are assumed to be known in any particular solution period and hence time subscripts have been dropped. In our notation F includes not only the functional form of the model but also the estimated parameter values.

The basic solution of (1), corresponding to a given choice z^0,u^0, is a vector y^0 which satisfies (1),

$$(2) \qquad y^0 = F(y^0,z^0,u^0).$$

In the following we will always assume that a unique solution exists. Then we can, in principle, consider the solution as a function G of z and u,

$$(3) \qquad y = G(z,u)$$

which, for the choice z^0,u^0, yields

(4) $y^0 = G(z^0,u^0)$.

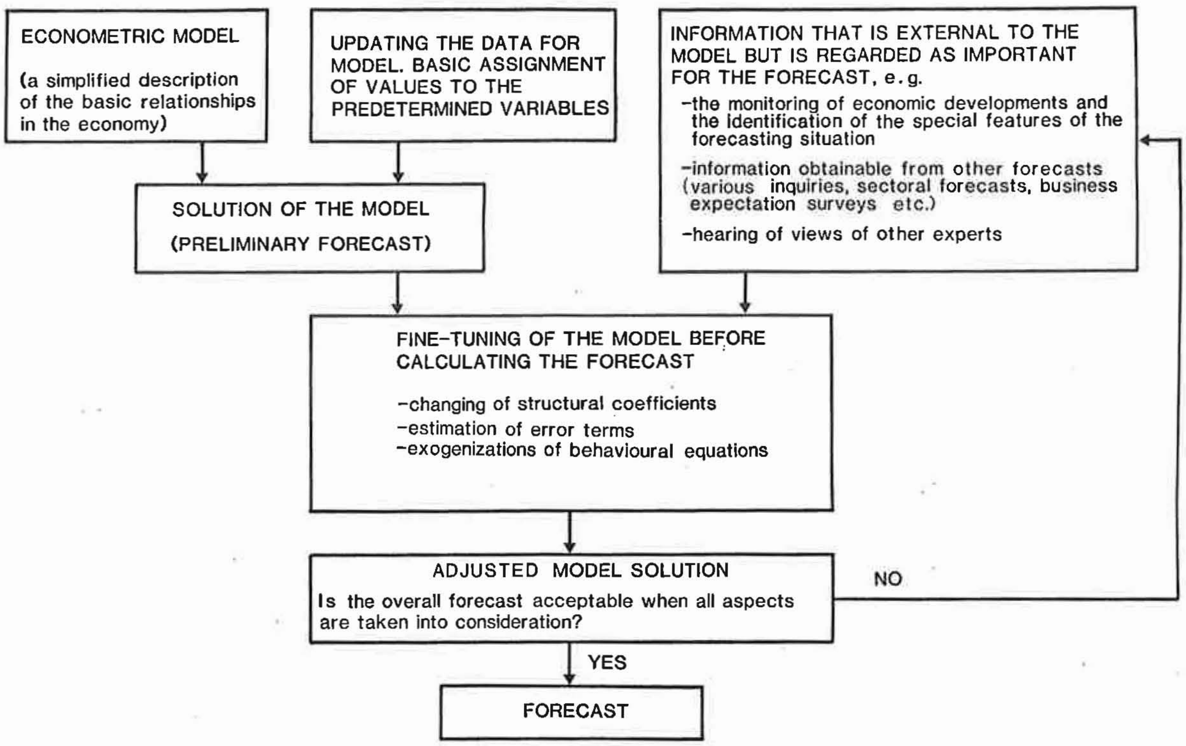
In practice, the function G in the reduced form (3) is often so complicated that it cannot be given in a closed form. Therefore, the solution of the equation system (1) is usually obtained by means of numerical methods.

Model (1) is a stochastic equation system when u is a vector of stochastic disturbances. However, the solution was obtained by solving a deterministic system with u fixed at a value u^0. This is a generally adopted procedure when producing model forecasts. In the following sections we will discuss various alternatives for fixing u.

2.2. A model as a tool for organizing available information

The status of an econometric model in an actual forecasting process can be as described in Figure 1. Our starting point here has been that generally a model is not good enough to allow mechanizing of the forecast making process. At some final stage somebody must either accept or reject the forecast suggested by the computer and this ultimate decision cannot be delegated to a machine. Model based forecasting can thus be seen as a process where the preliminary model forecast is supplemented and modified by relevant external information. In this process knowledge of the structural form of the model with its identities and behavioural equations based on historical data is essential in organizing also new external information.

Figure 1: Use of the model in forecasting



The three boxes in the north-west corner of the diagram show how the basic solution of the model is computed and the first preliminary forecast is obtained. The box in the north-east corner lists examples of relevant forecasting information not included in the model. The box in the middle pools the various information flows in order to produce adjusted model solutions the last of which is accepted as the final forecast.

The block of external information in Figure 1 covers "the rest of the world" and is as such unmanageably large. What kind of information is considered as relevant is a non-trivial question which depends on circumstances prevailing at the time the forecast is made. Some general remarks can nevertheless be made.

The identification of the external time specific features of the forecasting situation requires active monitoring of economic developments. Sometimes relevant external information is explicit and visible. Examples are upcoming strikes, centralized wage agreements, unusual harvests, import restrictions and changes in tax laws. An important type of available and valid information is data concerning the first days, months or even first quarters of the forecasting period. That information is certainly relevant but for example an annual model cannot make direct use of it.

Some behavioural equations of a macroeconomic model are often compared to a set of corresponding micro-level equations or they may have been even constructed by aggregating micro-level equations. We might have in a forecasting situation micro-level data that reveals changes in micro-relationships and this suggests revisions also for the aggregate equations.

Some external information is difficult to find and exploit. One must usually work hard in order to make sure that nothing important has been forgotten. There are several potential information sources which must be checked such as business expectations surveys, sectoral forecasts and expert opinions. Before long a forecaster learns which external sources are worth consulting. Experience is a good advisor also when one has to rank contradictory hints obtained from different sources or when one has to decide how relevant a possibly reliable but minor piece of information actually is for the overall forecast.

2.3. Methods for manipulating econometric models

In our terminology, information presented by the predetermined variables of the model is not external to the model. Hence, unlike Hujer, Cremer & Knepel (1979), we don't include readjusting the values of the predetermined variables into the fine-tuning techniques. Thus fine-tuning necessarily requires either adjusting residuals or some sort of modifying the structural equations of the model. As the identities of the model guarantee the internal consistency of the overall forecast, only behavioural equations and possibly technical relations can be manipulated.

We classify the fine-tuning methods into three categories:

1) adjusting structural coefficients of the behavioural equations,
2) adjusting residual terms of the model and
3) exogenizing behavioural equations.

The first category comprises changing the values of certain parameter estimates e.g. price or income elasticities. Transforming information on e.g. unusual sales, business barometer readings and expert opinions into parameter adjustments is a complicated task that may require detailed studies before the change can be carried out.

A change in a single structural parameter may affect all the reduced form equations. Therefore changing a structural parameter is quite different to changing independently some reduced form coefficients. Note also that the economic theory behind the structural equations plays a crucial role in making the connection between external information and structural parameters. We do not have any such theory in order to adjust reduced form coefficients directly.

A special case arises when a whole equation is replaced by one which presumably better describes the situation. A new explanatory variable can, at least in the case of a linear model, be interpreted to mean that its coefficient before the introduction was zero. Of course, the changing of the parameters or equations of an existing model should be based on thorough comparison of competing explanations and their applicability in the given situation. Unfortunately, economic theory alone often cannot decide between candidate equations. The choice has then to be made according to statistical tests, common sense and the overall philosophy of the model. Re-estimating and changing the equations of the model is, on the other hand, part and parcel of the regular R & D work carried out at an institute that maintains a macro-model.

The second fine-tuning category is the one most frequently mentioned in the literature: adjusting the residuals. The term "add-factors" is commonly used for non-zero residuals. Some authors, e.g. Intriligator (1978,1984), associate the term with the reduced form residuals of the model. This is somewhat confusing because actual manipulating is applied on the structural form residuals, i.e. the stochastic disturbances of the behavioural equations.

A non-zero future residual bears a formal resemblance to changing the value of the intercept which in fact is a structural coefficient. However, the economic interpretation is often different. The value of the intercept is assumed either to remain constant or to change very slowly over time. On the other hand, future residuals are external, though generally unknown shocks.

Residual manipulation should be done in accordance with the variance-covariance characteristics of the error process. Thus if the error process is autocorrelated, the error manipulation in one period should also affect the value of errors in the following periods. Sometimes, however, special error schemes are called for. A case in point is a strike that causes a negative error in the strike period and a positive error in both the preceeding (hoarding) and in the next (catching up) period.

One obvious rationale for the use of non-zero residuals is associated with aggregation. A useful identity, called the basic theorem of aggregation (see Edgren, Turkkila & Y. Vartia, 1985) states that if $(x_1,y_1),\ldots,(x_n,y_n)$ are n observed values of the pair of variables (x,y) and $w_1,\ldots,w_n$, $\sum_{i=1}^{n} w_i = 1$, are arbitrary weights associated to them then

$$(5) \qquad \sum_{i=1}^{n} w_i x_i y_i = \bar{x}\bar{y} + \text{cov}(x,y) ,$$

where $\bar{x} = \sum_{i=1}^{n} w_i x_i$, $\bar{y} = \sum_{i=1}^{n} w_i y_i$ and $\text{cov}(x,y) = \sum_{i=1}^{n} w_i(x_i-\bar{x})(y_i-\bar{y})$.

As a sketchy example of how micro-level information can lead to non-zero residuals, suppose that the commodity imports equation is constructed on the basis of a set of simple micro-level equations

$$(6) \qquad \dot{m}_i = \beta_i \dot{p}_{mi} + \varepsilon_i \qquad i = 1,\ldots,n$$

where $\dot{m}_i$ and $\dot{p}_{mi}$ refer to relative changes in the volume and price of the i:th import category, β_i and ε_i being the estimated price elasticity of import and the residual, respectively. Let the corresponding macro equation be some weighted average of the micro equations,

(7) $$\dot{M} = \sum_{i=1}^{n} w_i \dot{m}_i \ .$$

It follows that

(8) $$\dot{M} = \sum_{i=1}^{n} w_i \beta_i \dot{p}_{mi} + \sum_{i=1}^{n} w_i \varepsilon_i = \bar{\beta}\bar{\dot{p}}_m + \text{cov}(\beta, \dot{p}_m) + \bar{\varepsilon} \ .$$

Consider now the case of a rapid rise of oil prices compared to smaller price changes in other import categories. The short-term price elasticity of fuels and lubricants is estimated to be a negative number much closer to zero than the average price elasticity of imports. In this case β and $\dot{p}_m$ cannot be taken as uncorrelated. Hence the use of the aggregate equation $\dot{M} = \bar{\beta}\bar{\dot{p}}_m$ would clearly give misleading results and the residual $\text{cov}(\beta,\dot{p}_m)+\bar{\varepsilon}$ cannot be replaced by zero in this particular situation. A positive estimate for the residual would be more appropriate to take care of the effect of the covariance term.

Studying past residuals shows the forecaster what the model explains and what it doesn't. This gives a hint of where and when non-zero residuals may be needed and it also tells something about their impacts. Whenever possible, economic reasoning should be applied in assessing the value of future residuals. When no relevant economic theory can be found also mechanical extrapolation rules may be resorted to. Thus e.g. a recently observed residual can be extrapolated if it is regarded as the impact of some unknown intervening factor believed to remain in effect during the forecasting period. The references given in the introduction offer a fairly representative assortment of various mechanical residual generating procedures.

The third fine-tuning category concerns exogenization of an endogenous variable by temporarily fixing it to a value determined by external information. This can be done when reliable information is available about a future value of the variable. Cases in point are a centrally negotiated wage agreement that offers a more reliable estimate of (negotiated) wage change than a wage equation estimated from historical data and long term trade contracts for foreign trade variables. Similarly, forecasts prepared near the end of the forecasting period may effectively use already existing statistical figures.

Technically, a model structure with some endogenous variables exogenized can be written as a weighted average of the original equations and the exogenized equations. The i:th structural equation is written

$$(9) \qquad y_i = \hat{y}_i + e_i(F_i(y,z,u) - \hat{y}_i)$$

$$= e_i F_i(y,z,u) + (1-e_i)\hat{y}_i$$

where the indicator

$e_i = 1$ if the original i:th equation is applied

$e_i = 0$ if the i:th equation is exogenized

and $\hat{y}_i$ refers to the exogenized value of y_i.

By collecting the indicators e_i into a diagonal matrix $E = \lceil e_i \rfloor$ the structural form of the model can be expressed as

$$(10) \qquad y = EF(y,z,u) + (I-E)\hat{y} .$$

In fact, the weights e_i must not necessarily be dichotomous but also "genuine" weighted averages ($0 < e_i < 1$) of the original and exogenized equations can in some cases be used, depending on the reliability of external information.

3. CONNECTIONS BETWEEN ALTERNATIVE MANIPULATION METHODS

There is a simple but important correspondence between the three fine-tuning techniques: any feasible model solution, achieved by means of either coefficient changes, exogenizations or a combination of both, can alternatively be obtained through the third manipulating technique, non-zero residuals.

To explain this, we start from the non-manipulated model structure (1) and its basic solution (2), corresponding to a given choice z^0, u^0. Next we assume that the model has been manipulated through coefficient adjustments, exogenizations or both. We write the manipulated structural form as

(11) $y = F^*(y,z,u)$.

and denote by y^* the solution, corresponding to z^0 and u^0,

(12) $y^* = F^*(y^*,z^0,u^0)$.

Now the same solution y^* could as well be obtained by introducing an additive correction vector δ into the initial model structure (1) so that

(13) $y = F(y,z,u) + \delta$.

Requiring now that the solution of (13), given z^0 and u^0, must equal y* gives a simple condition for choosing δ,

(14) $$\delta = F^*(y^*,z^0,u^0) - F(y^*,z^0,u^0).$$

Formula (14) shows how simple it is to calculate the corresponding correction vector δ by using the original and manipulated structure of the model, once the whole manipulated solution y* has been determined. It also shows the intuitively obvious fact that for the non-manipulated equations, e.g. the identities of the model, the corresponding corrections terms δ_i must be zero.

Figure 2: The correspondence between alternative manipulation strategies

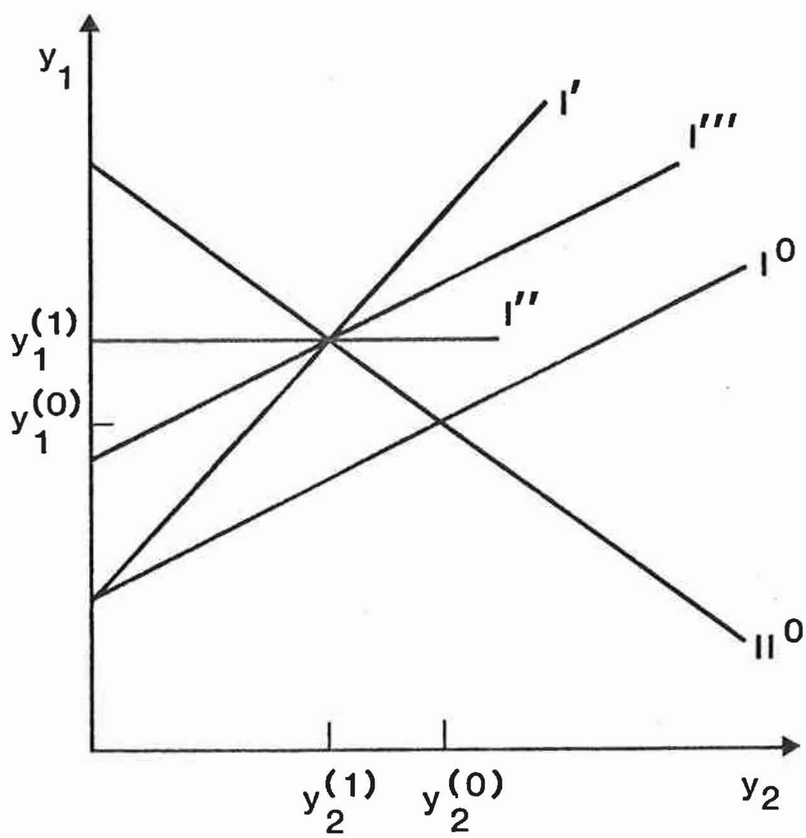


Figure 2 illustrates the correspondence between various fine-tuning methods in a two-dimensional linear economy. The straight lines I^0 and II^0 represent the first and second structural equation of the original model, given z^0 and u^0. The interception of the lines gives the basic solution $y^{(0)}$. Now, manipulate the first equation by changing the value of the structural coefficient of y_2. As a consequence the first line is rotated to the position I' and the new model solution $y^{(1)}$ is obtained in the interception of the lines I' and II^0. Now one can immediately see how the same manipulated solution could alternatively have been achieved by either direct exogenization of y_1 (line I'') or by manipulating the residual (line I''').

Exogenizing a behavioural equation is a straightforward way to guide a variable to a desired direction but it also changes the simultaneity of the model considerably. Changing the values of structural parameters also distorts the reactions of the model but the intervention is not as radical as when feed-back links are cut in exogenizations. An obvious appeal of residual adjustment as a manipulation strategy is that it does not alter the reduced form coefficients (of a linear model) and thus the post-manipulation reactions of the model.[1)]

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1) Investigation of the reduced form changes resulting from structural coefficient adjustments and exogenizations leads in the case of a linear model to some well-known exercises of linear algebra, associated to the sensitivity properties of a matrix inverse due to changes in the matrix to be inverted. Especially, regarding exogenizations, the situation bears much resemblance to studying so called semi-reduced forms of an econometric model, see Vajanne & Pylkkänen (1984).

The discussion above has shown that the original model structure can always be restored during the course of forecasting, at the same time retaining the model solution as it stands at the moment. The key instrument is the residual adjustment vector δ which could be called the vector of computational shifts. This correspondence between various fine-tuning techniques has some important practical implications.

For example, when a new forecasting round is at the beginning it is natural to start with the model corresponding to the latest tuning, i.e. the tuning assumed relevant when the previous forecasting round was closed. All structural modifications are cancelled and replaced by the corresponding residual adjustments. After this the original model structure is in force and the values of lagged variables can be updated and the model solved. The model solution now shows how our view concerning the future of the economy should be adjusted when data changes that have taken place since the last round are taken into account.

In the second stage the future values of exogenous variables can be changed, keeping the residual adjustments unchanged. This model run gives an idea of how the overall forecast will change because of updating our views concerning the exogenous factors. These preliminary forecasting runs are quite instructive and they should be carried out as routine exercises before starting the actual forecasting process.

In the manipulation stage that follows the correspondence between structural change and residual adjustment can be used for checking that the manipulations result in residuals that are in reasonable accordance with the error process of the model.

4. FINE-TUNING AND FORECASTING ACCURACY

In this section we give some empirical evidence of the benefits of fine-tuning. Our material is based on short-term macroeconomic forecasts published biannually by the Research Institute of the Finnish Economy. The time span of the forecasts is the current and the next year. Only spring and fall forecasts of the current year will be considered here. The econometric model developed in the institute has been in extensive use in the forecasting process ever since the construction of a prototype version of the model (Vartia, 1974). From 1978 on there are complete documents on the final computer runs of each forecasting round, including the values of the computational shifts corresponding to the manipulations used.

In assessing the accuracy of forecasts we first reconstructed the published spring and fall forecasts for 1981-83, using the current version of the model. An analogous analysis for 1978-80 had earlier been performed by Mustonen (1982). The values of the predetermined variables were set equal to those used in the actual published forecasts. The behavioural equations were exogenized and set to their relevant forecast values and the corresponding computational shifts were calculated.

Next mechanical, non-adjusted forecasts were produced, using the same values of the predetermined variables as those used above in reconstructing the original, adjusted forecasts. The residuals were not set categorically to zero but the differences between the computational shifts of the reconstructed and the original forecast runs were used as the values of the model's residuals.[2)] This strategy was regarded as a reasonable way to neutralize the effects of the changes of the model.

Table 1: MAD-values for actual and mechanical forecasts, 1978-83

	spring		fall	
	actual forecast	mechanical forecast	actual forecast	mechanical forecast
1978	1.82	5.81	1.75	6.02
1979	3.05	2.52	1.12	2.23
1980	1.12	2.63	0.73	3.39
1981	1.73	3.14	1.07	2.64
1982	2.00	2.45	1.33	2.11
1983	1.66	2.41	0.97	1.88
1978-83 on average	1.90	3.17	1.17	3.05

In Table 1 the forecasting errors of actual (adjusted) forecasts and mechanical (non-adjusted) forecasts are compared in terms of mean absolute deviation (MAD) criterion, computed over the 13 dependent variables of the behavioural equations. Other indicators of accuracy essentially provide the same picture and are therefore not given here. The variables of the model are mainly percentage relative differences so that the figures of the table are expressed in percentage points.

The mechanical forecast has a lower MAD value than the actual forecast only for spring 1979. In all other cases the actual forecasts have had a better average fit and the difference is in most cases considerable.

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2) The calculated shifts of the reconstructed forecast runs were slightly different compared to the original ones, reported in the forecast documents. The differences are due to the changes in the model compared to the versions used in 1981-83. The changes are, however, relatively small and, for example, tracking down the original (or quasi-original) values for all predetermined variables caused no serious problems.

The superiority of the adjusted forecasts is most evident in 1978 when the mechanical forecast would have been disasterous.[3)]

As could be expected forecasts produced in the fall are generally more accurate than those made in the spring. For actual forecasts this holds true for all years and improvements are considerable. For mechanical forecasts, however, in one case out of three accuracy deteriorates and where improvement occurs it is smaller than for actual forecasts.

Comparisons of this kind can always be criticized by arguing that the superiority of manipulated forecasts is due to major flaws in the model used. However, our experience has given us every reason to believe that similar results would emerge with most econometric models. Consequently, we think that our results have wider relevance.

5. CONCLUDING REMARKS

The discussion concerning the role of econometric models has sometimes exaggerated the difference between an analysis based on formal models and an analysis based on intuitive reasoning. There are individuals both among theoretical econometricians and practical economists who do not believe in combining econometric models with personal judgement. However, our experience in macroeconomic forecasting supports the use of systematized fine-tuning and model adjustments.

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3) In Finland that year was one of accelerating growth and lower inflation after a three years stagflation period. The investment and export equations of the model are strongly dependent on lagged explanatory variables and failed to foresee this change.

As far as we know, there are no generally accepted rules for proper model manipulating. We think that developing general rules for fine-tuning is a challenging research topic and worth much more effort than spent thus far. In this paper we have discussed some aspects to be taken into account when constructing such a set of rules.

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APPENDIX: The Case of a Linear Model

An important special case of (1) is the linear model the structural form of which we write as

(A1) $y = Ay + Bz + u\,.$

The matrices (I-A) and B, compatible with y and z, include the structural form coefficients of the endogenous and predetermined variables, respectively. The square matrix (I-A) is assumed to be non-singular. The reduced form can then be written as

(A2) $y = \Pi z + Cu$

where $C = (I-A)^{-1}$ and $\Pi = CB$. The reduced form yields the basic solution,

(A3) $y^0 = \Pi z^0 + Cu^0\,,$

and the partial derivatives which are constant in the linear model,

(A4.1) $\partial y_i/\partial z_j = \pi_{ij}\,, \qquad \Pi = \{\pi_{ij}\}$

(A4.2) $\partial y_i/\partial u_k = c_{ik}\,, \qquad C = \{c_{ik}\}\,.$

For a linear model the calculation principle (14) has an alternative. Let the linear model be initially as (A1) and after manipulations as

(A5) $y = A^*y + B^*z + u\,,$

the counterpart of (13) now being

(A6) $y = Ay + Bz + u + \delta$

and in this case

(A7) $\delta = (A^*-A)y^* + (B^*-B)z^0\,.$

In a linear framework we can alternatively make use of the reduced form coefficients of the model. Assume that vector y can be partitioned into y_1 and y_2 corresponding to the equations to be manipulated and those not to be manipulated, respectively. We write (A1) in the partitioned form as

$$\text{(A8)} \quad \begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{pmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{pmatrix} \begin{pmatrix} y_1 \\ y_2 \end{pmatrix} + \begin{pmatrix} B_1 \\ B_2 \end{pmatrix} z + \begin{pmatrix} u_2 \\ u_2 \end{pmatrix}$$

and the corresponding reduced form as

$$\text{(A9)} \quad \begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{pmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{pmatrix} \left[\begin{pmatrix} B_1 \\ B_2 \end{pmatrix} z + \begin{pmatrix} u_1 \\ u_2 \end{pmatrix} \right]$$

$$\text{where} \quad \begin{pmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{pmatrix} = C = (I-A)^{-1} .$$

Now partition (A6) equivalently and write $\delta = (\delta_1' \; \delta_2')'$.
Since δ_2 is zero it is a straightforward task to show that[1]

$$\text{(A10)} \quad \delta_1 = C_{11}^{-1}(y_1^* - y_1^0) ,$$

where y_1^0 and y_1^* refer to the pre-manipulation (A1) and post-manipulation (A5) values of y_1, given z^0 and u^0.

The benefit of (A10), compared to (A7), is that only y_1^* needs to be evaluated for determining δ. For example, when the basic solution is known and all planned manipulations are exogenizations formula (A10) allows evaluating the consequences of potential exogenizations in terms of the corresponding residual corrections δ_1.

1) Formula (A10) for the linear case is reported at least in Llewellyn & Samuelson (1981). However, their treatment of the general non-linear case does not involve the simple calculation principle given in section 3, formula (14).

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