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Chapter Author: Benjamin M. Friedman

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A NOTE ON UNCERTAINTIES IN CONTROL APPLICATIONS

BY BENJAMIN M. FRIEDMAN

Walsh and Cruz [10] have tackled an interesting subject in applying the Kalman filter technique to a constrained optimization problem in macroeconomics, using as the constraint system the familiar linear macroeconometric model estimated by Pindyck [6]. The motivation for using a Kalman filter is that, unlike the deterministic control applications which Pindyck [6, 7] or I [2, 3] presented, the Walsh–Cruz application includes a wide variety of uncertainties. In addition to following the procedure of Kendrick and Majors [5] for taking account of stochastic parameters of the constraint system (i.e., the macroeconometric model), the problem addressed by Walsh and Cruz includes (1) additive disturbances (i.e., pure noise) in the system equations, (2) errors of measurement of both the state variables and the system parameters, and (3) uncertain initial conditions.

In using their Kalman filter procedure in the macroeconomic application, however, Walsh and Cruz treated these uncertainties in a way which is inconsistent with the underlying raison d'etre of stochastic optimization in economics. In particular, the solution procedure reported by Walsh and Cruz consisted of arbitrarily adjusting the variance levels of the noise processes until they obtained combinations of state variable and control variable paths which they concluded (according to an unspecified criterion) were reasonably realistic. The extent of each element of uncertainty in the problem therefore became a variable input. The only difference between the variances and the control variables was that Walsh and Cruz adjusted the variances by hand but set the control variable values by the Kalman filter equations which they showed.

In the context of economic applications, the uncertainties present in control problems are not variable inputs to be selected arbitrarily. The reason why Milton Friedman's [4] or Brainard's [1] arguments about the effects of uncertainty on discretionary policy are important is that these uncertainties—not only the qualitative fact of their presence, but also their quantitative extent—are a given aspect of the environment in which the policy maker must operate. Even in the case of the multi-period adaptive control procedures described by Prescott [8, 9], in which the policy maker can learn from the implicit experimentation aspect of his policy choices, the extent of each element of uncertainty in the problem as of the beginning of the relevant time interval is a datum. In an economic application, therefore, the essence of stochastic optimization is that particular uncertainties, which have a bearing on the effects of the policy maker's actions, are entirely beyond the scope of his influence (much less his arbitrary manipulation).

How might one restructure the Walsh–Cruz application in light of these principles? While there is clearly room for disagreement about the best way to measure relevant uncertainties, one potentially fruitful approach would be to

proceed as follows: First, following and extending Walsh and Cruz, the variance–covariance structure of the stochastic system coefficients should correspond to the variance–covariance matrix associated with the estimation of the econometric model itself. Secondly, the variances and covariances of the additive disturbances in the system equations should correspond to the variance–covariance matrix derived from the estimated residuals of the econometric model; if some technique (e.g., two-stage least squares, or instrumental variables) is used to derive consistent estimates of the system coefficients, then the variance–covariance matrix derived from the estimated residuals will be a consistent estimate of the variance–covariance matrix of the true disturbances. Thirdly, motivating reasonable values for the variances (and perhaps covariances) associated with measurement errors of the state variables and the initial conditions is less straightforward, but one suggestion is to relate them to the historical experience of revisions in preliminary data for the particular variables in question. Regardless of the specific device used to quantify these uncertainties, the important point is that their extent is a given fact of the environment which the policy maker must take into account.

Harvard University

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