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## ANALYSING AGRICULTURAL SUPPLY RESPONSE IN ECONOMIES IN TRANSITION

David Hallam

### ABSTRACT

This paper reviews the scope for analysis of agricultural supply in transition economies. It assesses the applicability of standard dynamic econometric models in the transition context where structural breaks are present and time series data are limited. Models whose parameters vary for pre- and post-transition periods are considered and the use of Kalman filter and switching regression models is discussed. Where only post-transition data are available the possibility of using regional panel data is outlined. Finally, the paper concludes with some brief comments on the use of programming methods.

### Keywords:

AGRICULTURE SUPPLY ANALYSIS, TRANSITION ECONOMIES

## 1. Introduction

In a recent paper, Petit and Brooks (1994) pointed out the need for policy analysis in the CEECs based upon a 'sustained empirical underpinning', and note that currently 'this underpinning is weak, and the weakness is costly.' The policies pursued in the CEECs in their transition to market have been seen as detrimental rather than favourable to agricultural growth. Knowledge of how agricultural supply is likely to respond to policy-induced price changes is self-evidently important in the definition and selection of appropriate price policies. The response of CEEC agricultural output to policy reform is also the subject of external interest within the EU, where the budgetary costs of accession of the CEECs and their adoption of the CAP in some shape or form have been the subject of some controversy. More widely, the possible adoption of CAP-like policies in the CEECs may have important consequences for world trade.

Obtaining quantitative information concerning the likely response of agricultural supply to changes in output and input prices is therefore a desirable research objective in itself. Supply elasticity estimates could also be employed together with the corresponding results of demand analyses to assemble synthetic models of the agricultural sectors of the countries of interest (Mergos and Stoforos, 1997).

The concern of supply response analysis is the response of domestic agricultural production to changes in output and input prices, which may be policy-induced. The focus may be aggregate agricultural output and its responsiveness to changes in agriculture's terms of trade (output-input price ratios or agriculture's barter terms of trade) where analysis of overall agricultural growth is the primary objective. Alternatively, the focus may be on individual products to allow exploration of the effects of price movements on the commodity composition of agricultural output, or to consider certain products of particular quantitative importance in their own right - dairy production in Slovenia for example. Yields per unit land area or per animal are of interest as well as the scale of production reflected in areas planted and harvested. This paper discusses quantitative approaches to the analysis of agricultural supply and assesses their possible applicability to modelling supply response

in economies in transition, specifically those of Bulgaria, Romania and Slovenia.

It is ironic that while the economic transitions make a knowledge of agricultural supply response to price important, the structural breaks in fundamental economic behaviour which are entailed make modelling problematic. Economic and econometric modelling typically presumes a stable structure which is clearly not present in most CEECs. Furthermore, it appears that there may be little detailed and reliable data, especially concerning prices, available for either pre- or post-reform periods to allow econometric analysis.

Given the dramatic structural changes in the agricultural sectors of Bulgaria, Romania and Slovenia and the limitations of the data available it is apparent that detailed economic modelling may not be appropriate or possible. As Hall and O'Sullivan (1994) point out, 'Best practice is simply not an option'. If there is scope for econometric analysis it is likely to be confined to capturing basic and aggregated relationships, employing simple models in terms of selection of variables, and functional and dynamic specification.

A particular concern of this paper is the scope for application of standard dynamic econometric models in the analysis of agricultural supply response for Bulgaria, Romania and Slovenia. While such models have been widely applied, their applicability in the context of agricultural sectors in transition, where structural breaks are present and time series data are in any case limited, is uncertain. Econometric methods which have been applied in the context of economies in transition for the modelling of the relationships undergoing structural change are discussed. The possibility of estimating simple supply response relationships from pooled regional cross-section and time series data is also considered as an alternative where pure time series data are limited. Alternative approaches, relying on programming methods and less demanding in terms of data, are also mentioned.

The most appropriate methodology for analysing supply response need not be uniform across all three countries, or even across different products within each country. Neither are the alternative approaches mutually exclusive. What is appropriate depends upon the specific circumstances of the country (in terms of agricultural structure, product mix, and the stage reached in transition - which are very different in each of the three countries involved), on the product concerned, and the data available.

## 2. Data Requirements and Problems

Data availability is a major constraint on the choice of methodology for analysing agricultural supply. The first step in any supply analysis must be a thorough review of the available data. Specifically, information is required concerning the availability and quality of data on the quantities and prices of agricultural outputs and inputs. Data problems for the economies in transition have been widely discussed (see, for example, Blangiewicz *et al*, 1993).

In the case of the Central and Eastern European countries, it is not uncommon to find that data are simply unavailable for the variables of interest when there has been no perceived administrative reason for collection. If data are unavailable, then this clearly leads to misspecification and biased estimates of the parameters for those variables for which data are available. Where data are available they may not correspond on a one to one basis to the economic variables they are intended to represent, leading to problems of 'errors in variables'.

The accuracy of agricultural data in Central and Eastern European countries has been reviewed extensively by Jackson and Swinnen (1995). The latter review a range of statistical sources on agriculture in the CEECs, and note significant differences in production data from one source to another, including directions of change, and specifically between FAO data and the rest which all rely on official reports. They note that there are good reasons to believe that the data from all

sources include large measurement errors both before and after transition. In particular, they note that pre-transition data probably overstate production (by as much as 30-50%) while post-transition data understate it (by as much as 30%), giving an exaggerated impression of the extent of agricultural decline. These errors are of such an extent that even qualitative conclusions concerning the direction of agricultural change are problematic. Particular problems are noted with Bulgarian and Romanian data, in that there are large differences between official data (i.e. repeated in OECD) and FAO data for production of individual cereals. Jackson and Swinnen argue that one source of measurement error in production is the fact that pre-transition no allowance was made for losses, intermediate consumption, stocks etc. Losses in transport and storage are estimated for a number of countries at around 30% for cereals. Production statistics also did not follow FAO product standards (in Romania and Bulgaria, for example) which meant that variable amounts of foreign matter were included. It is also believed that use of inputs was overstated for the pre-transition period, partly as a result of wastage due to a lack of any system of incentives, but also because of a systematic exaggeration of quantities of inputs provided. Post-transition there has been a tendency towards under-reporting of output as small private enterprises have been dropped from the reporting system, and the informal sector has gone unreported. Also once property was transferred to private ownership there was no longer any incentive to overstate production levels - quite the opposite. While the econometric consequences of measurement errors which are random have been established, and appropriate techniques developed to deal with such errors, the situation with regard to measurement errors which are systematic is much less satisfactory.

A particularly difficult data requirement in Central and Eastern Europe is *homogeneity*. Econometric time series analysis requires 'long' series of consistent observations on the variables of interest. Blangiewicz *et al* (1993) suggest 'long' might be at least 15 annual observations or 24 quarterly, but these are really too few to obtain reliable results. During periods of transition there are often changes in the way data are computed - for example as a result of organisational changes or political considerations - thus the assembling of series of homogeneous data of adequate length is problematic. In fact in Central and Eastern Europe, the situation is more complex and serious because it is not just the data which have changed their basis, but rather the system they supposedly describe. This leads to *structural breaks*, which may make historic observations obsolete. This is further discussed below. The far-reaching implications of transition and the relatively short and often unstable post-transition period mean that homogeneous post-transition series will not generally provide sufficient degrees of freedom for conventional econometric supply analysis.

All data series need to be evaluated in these respects and their suitability for econometric modelling assessed. Obviously, it is necessary to bear in mind the continuing debate on the quality of economic data in Central and Eastern Europe. However, quantitative information is required for decision-making and as Blangiewicz *et al* (1993) conclude, bad data are probably better than no data.

### 3. Econometric Models of Agricultural Supply Response

Since the appearance of Nerlove's work forty-five years ago, most studies of agricultural supply response have relied on dynamic econometric supply functions estimated directly from time series data. The specification has typically been some variant of the Nerlovian partial adjustment model to accommodate delays in response to price movements. Empirical results with such models have been regarded as satisfactory, although the theoretical basis - in particular the notion of fixed targets - is not strong. Recent work has recast the supply response model in error correction form, with the partial adjustment model nesting within it, and with a stronger theoretical basis (Hallam and Zanoli, 1993). In either case, the focus on the dynamics of supply and on the time series properties of the variables concerned imposes a need for lengthy time series of homogeneous observations. In general, as discussed above, the process of transition implies that such data sets will simply not be available.

Recent years have seen an increasing number of supply analyses based in duality and derived from profit functions. Such models have the advantages that they can easily accommodate multiple outputs and inputs, and are, at least in principle, firmly based in production theory. The variables concerned are the same as for the dynamic time series models - quantities supplied, output prices and input prices, although in the case of a restricted profit function, quantities of quasi-fixed factors are also included. However, the data sets used for estimation are typically microeconomic farm survey results in panel data form. Such data sets have become increasingly available to analysts. While they may contain very large numbers of data points because of the large numbers of farms in the cross-section, meaningful price variation is in general provided only in the time series dimension. The latter is often inadequate. In any case, farm-level panel data sets are not available for any of the three countries of interest here.

#### **4. Transition to Market and Structural Breaks**

It was noted above that one of the major obstacles facing analysis of supply response is the continuing structural change in the CEEC agriculture which limits the relevance of any historic supply and price data which might be available and militates against the establishment of stable supply relationships. Structural breaks present serious modelling problems in themselves, but also add a major complicating factor to other specification problems, notably the identification of the time series properties of variables. It might be thought that physical production relationships would be less affected by structural breaks than behavioural supply relationships, but it must be remembered that production functions are the outcome of an optimisation process with input levels endogenously determined. Even simple yield analyses will be affected. In fact, attempts at modelling any aspect of the CEEC economies face these difficulties to a greater or lesser extent, and there is now a growing body of literature concerning the most appropriate econometric response.

The structural breaks have a further dimension as far as modelling for the agricultural sector is concerned. The issue is not only one of changing behaviour patterns, but also a change in the economic agents responsible for them, as the pre-reform state farm planning system and production targets were replaced by adoption of the price mechanism to varying extents, with production and resource use decision-making devolved to individuals. The normal expectation would be that private land-holders would be responsive to price incentives, and there is evidence of this in the sharp decline in output as agriculture's terms of trade deteriorated. However, supply response, especially upwards, may be dampened by technical and institutional constraints not only within agriculture but also in the input industries and the food marketing system.

The timing and nature of reform varies from country to country. In Romania, for example, reform began in 1989, while in Bulgaria it began in 1991. The number of post-reform time series data points is therefore extremely limited and inadequate for econometric time series analysis. Furthermore the post-reform period has been characterised by structural instability as the reform process continues with the transition to private ownership of land, declining food demand, and the worsening terms of trade for agriculture as a result of partial liberalisation. The period has also been characterised by policy reversals. In Bulgaria, for example, minimum guaranteed price systems were introduced but subsequently discontinued more than once. In such circumstances, meaningful stable parameter estimates may be difficult to obtain whatever the number of time series observations available. The Slovenian experience has been entirely different, with little disruption to agricultural structures and economic behaviour.

It seems therefore that time series data sets confined to the post-reform period are inadequate for econometric analysis. Econometric modelling would have to embrace the pre- and post-reform periods and the transition process itself. This leads to the specification of some kind of time-varying parameter model.

Hall (1993) provides a clear description of the process of model reduction from the general statement of the data generating process through the stages of marginalisation, conditioning assumptions, specification of functional form, and estimation where the structure is subject to change. The end result is an encompassing model with changing parameters which is relevant to both pre- and post-reform regimes. An awareness of structural change must inform each of the stages of model reduction. The marginalisation and conditioning must be sufficiently general to include relevant variables from both regimes. Estimation is the stage most affected by the existence of structural change.

Hall (1993) provides a simple illustration of the need for more general marginalisation and conditioning, and the specification of the encompassing model which can be adapted here to describe supply determination in the transition from a planned to a market system. Under the planning system, the major influence on supply of each farm,  $S_i^p$ , is the planning target specified,  $S_i^*$ , so that

$$S_i^p = \alpha S_i^*$$

$\alpha$  can differ from unity to allow for systematic over- or under-production. Under the market system, supply,  $S_j^m$ , is affected by output prices,  $P$ , and input prices,  $I$ .

$$S_j^m = \beta_1 P + \beta_2 I$$

Total supply under either regime would be the sum of supply across all farms:

$$S = \sum_i S_i^p$$

under planning, and

$$S = \sum_j S_j^m$$

under the market system. If the regime changed in a completely discrete way, then the nesting model would be

$$S = \delta \sum_i S_i^p + (1 - \delta) \sum_j S_j^m$$

where  $\delta$  would shift from zero to one in a completely discrete fashion, and if the timing of the regime change is known the model is the traditional switching regression model equivalent to separate regressions for each sub-sample. Hall argues that a more realistic form of change would be one in which farms would shift individually from one system to the other but not all at the same time. In the case of aggregate agricultural supply the same effect would be achieved as the supply of an increasing range of products became market determined in systems which had previously allowed some exceptions to planned production. The switch between the regimes is therefore smooth rather than discrete. Total supply would still be the sum of supply from each farm, but now it would sum together the individual types of farm:

$$S = \sum_{i \in p} S_i^p + \sum_{j \in m} S_j^m$$

and so

$$S = \alpha \left( \sum_{i \in p} S_i^p / S \right) S^* + \sum_{j \in m} (\beta_1 P + \beta_2 I)$$

When supply is fully plan determined the coefficient on  $S^*$  would have the full value of  $\alpha$ , and there would be no effect from the market variables. When supply is fully market determined, the coefficient on  $P$  would be  $N\beta_1$  and the coefficient on  $I$  would be  $N\beta_2$ . As the determination of supply moves from the planned system to the market system, the coefficient on  $S^*$  would fall to zero and the coefficients on  $P$  and  $I$  would rise from zero to their full values.

Hall favours the use of the Kalman filter (Harvey, 1987) in the estimation of the time-varying parameter model. There are other possibilities which rely more on the standard approaches to estimation of switching regression models. Klos' (1993) study of Polish exports provides a number of

examples.

The appropriate modelling response to structural breaks depends upon the dynamics of transition. Charemza (1993) argues that the estimation of a -varying parameter model via an updating procedure such as the Kalman filter is appropriate only under the assumption that the parameters are changing continuously throughout the sample period while maintaining long-run equilibrium (cointegrating) relationships between the variables. Charemza argues that the transition process in the CEECs is of a different nature and is best described by a kind of continuous structural change with (different) constant long-run relationships operating for the pre- and post-transition periods. In the period of transition there may be no constant long-run (cointegrating) relationships and the error term will be non-stationary for this period. In this model the long-run mechanism is of limited memory and with the absorption of new information, the old may be forgotten as belonging to the old regime. Charemza proposes the use of recursive regression methods which reflect the dynamics of economic transition.

All three of the countries of interest here have undergone structural change to a greater or lesser extent. However, it is only in the case of Slovenia that these can be explored econometrically. In the case of Bulgaria and Romania the existence and significance of structural change are self-evident and in any case require little analysis. Their experience does, however, illustrate the difficulties of accommodating structural change in econometric models. Prior to transition agricultural production and resource use reflected plan targets rather than optimising decisions at farm level, while official prices for agricultural products showed no variation year after year. The concept of a pre-transition supply relationship, therefore, has little relevance and in any case could not be estimated empirically.

In the Slovenian case, greater continuity in farm structures and market behaviour means that structural changes in supply relationships can be meaningfully explored using a broadly homogeneous data set extending over some thirty years (Erjavec *et al*, 1996). In this study, simple dynamic supply models involving lagged responses to output and input prices were estimated using recursive regression along the lines suggested by Charemza (1993). These regressions led to plausible magnitudes for supply elasticities: around 1 for beef and maize; around 0.5 for pork, and close to zero for the more State-regulated products, wheat and milk. The analysis revealed continuing decline in supply elasticities, and evidence of structural breaks with the policy reforms of the mid 1970s, and under transition in the mid 1980s.

## 5. Supply Analysis Using Pooled Regional Cross-Section and Time Series Data

Where pre-transition data cannot be used to model through the transition process, and post-transition time series data do not provide sufficient degrees of freedom to estimate supply parameters for the post-transition period alone, the number of observations might be augmented by exploiting regional cross-section data. This yields a regional panel data set. Such data sets have been used to model agricultural supply in China.

In the panel data context, a simple supply relationship can be written

$$S_{it} = \alpha + \beta_1 P_{it} + \beta_2 I_{it} + \mu_i + u_{it}$$

where the variables are defined as before, but now the subscripts denote the *i*th region and the *t*th time period.  $\mu$  represents the 'individual effect' for each region and will reflect differences in, for example, land quality. Where there are no significant regional individual effects, and where the slope parameters are assumed not to vary from one region and/or one time period to another this specification leads to a pooled regression. However, pooled regression parameter estimates will be biased if individual effects do exist. The significance of any individual effects can be tested using a Breusch-Pagan test. A number of alternative assumptions are possible as to how the slope parameters vary from one region and time period to another, but here it is assumed for simplicity that

these are the same for all regions and time periods.

A number of estimators are possible for the panel model where individual regional effects are significant. Two widely-used estimators are the *within* estimator, and the Balestra-Nerlove generalised least squares or *variance components* estimator (Balestra and Nerlove, 1966). The *within* estimator simply consists of applying OLS to deviations from individual region means. It assumes that the  $\mu_i$  are fixed effects for each region and hence leads to a variable intercept model:

$$S_{it} = \alpha_i + \beta_1 P_{it} + \beta_2 I_{it} + u_{it}$$

where

$$\alpha_i = \alpha - \mu_i$$

It provides a consistent estimator of the slope parameters even where the explanatory variables and the disturbance are correlated. However, the transformation to mean differences eliminates any time invariant variables, and the estimator may not be fully efficient since it ignores cross-sectional variation. Given the *within* parameter estimates for the  $\beta$ s the intercepts for each region can be calculated.

The Balestra-Nerlove or *variance components* estimator (Balestra and Nerlove, 1966) is a GLS estimator which assumes the  $\mu$  are random rather than fixed (although no distributional assumptions are required for  $\mu$ ), and so the individual effects become part of a compound disturbance.

$$S_{it} = \alpha + \beta_1 P_{it} + \beta_2 I_{it} + (\mu_i + u_{it})$$

One disadvantage is that GLS is biased if the explanatory variables are not independent of the individual effects.

While the number of observations can be increased by exploiting regional panel data, the benefits of doing so depend upon the additional variation this introduces. Reliable estimates of price effects will only be obtainable if prices vary from region to region, and that variation is meaningful. Furthermore, the *within* estimator requires variation around regional means and the limited number of years since transition may mean that there are insufficient time series data points to obtain meaningful price variations.

The regional panel data approach has been used with some success in the case of Bulgaria, but no sensible results could be obtained using Romanian data.

## 6. Supply Response Analysis Using Programming Models

Programming models are potentially implementable using minimal data sets - a single cross-section observation on agricultural production - and hence offer a possible solution to the problems posed by the lack of time series data and the structural breaks caused by the reform. However, specification of farm level programming models requires information concerning farm outputs and resource use typically derived from farm surveys. Such data are available for a limited sample of farms in Slovenia. For sectoral analysis involving stratification of all farms into homogeneous groups, definition of representative farms for each group, and the aggregation of representative farm results, information concerning farm structure and classification is required. Validation of the model minimally requires information concerning production levels for some chosen base year.

Supply responses and input demand responses to own or cross-price changes can be explored through the familiar parametric programming approach for each representative farm. Repeated solution of the linear program to maximise or minimise the specified objective function subject to the resource constraints with varying prices allows the generation of a sequence of price-quantity combinations; these trace out a step supply response function, from which arc elasticities may be calculated. Smooth functions can be obtained by regression of the solved quantities on the various



prices (Shumway and Chang, 1977). The function will be upward-sloping provided that there are more column vectors for production than there are crops i.e. more than one technology for each crop. Hazell and Norton (1986) suggest that the number of production vectors should be at least six or eight times the number of products, although some of these may be potential rather than actual. Representative farm supply response functions can be aggregated to sector level provided the necessary population data are available.

Interpretation of the resulting elasticities is slightly vague since they share some long-run as well as some short-run characteristics. The long-run characteristics stem from the fact that the elasticity measures move between two static equilibrium positions, while the short-run characteristics stem from the fact that there are fixed inputs. The equilibrium nature of the solutions and hence measured elasticities may mean that the elasticities are rather larger than those econometrically estimated from time series data, although this is not always the case. Scope for exploration of the dynamics of supply using simple representative farm models is limited, although some possibilities for dynamic supply analysis are offered by dynamic and recursive programming.

Besides the advantage of a lesser need for data mentioned above, supply analysis using programming models may have certain advantages from a policy analysis point of view: the relative responsiveness of supply to alternative policy measures can be explored, e.g. guaranteed output prices or subsidised input prices. A wide range of cross-price effects can be considered, whereas econometric models may be restricted in this respect by multicollinearity problems; disaggregated responses by farm types or regions can be estimated. The programming model also allows technical and institutional factors to be taken into account to a greater extent than is possible with econometric approaches, and these, at least in Slovenia where 70% of land is 'less favoured', may be the most significant influences on agricultural supply response.

Results for representative farms can be aggregated for sector-level analysis. However, the classification of farms into homogeneous groups and the aggregation of results for representative farms may not be straightforward. Conditions for perfect aggregation relating to technological and economic homogeneity are stringent (Day, 1963), and detailed farm structure information is required. Some aggregation bias seems inevitable, but this might be minimised in a practically implementable way by the grouping of farms according to agroclimatic region and products produced (Buckwell and Hazell, 1972).

However the limitations of programming models, which stem from the assumptions upon which they are based, are well known. One difficulty in the current context is the specification of an appropriate objective function. The relevance of the traditional profit maximisation or cost minimisation single objectives needs to be established. All coefficients of the model are assumed to be known, and accurate farm level information on enterprise input-output coefficients and resource constraints is needed. All activities and resources are assumed to be homogeneous. Finally, the assumptions related to technology might be questioned. Activities are assumed to be *additive* (i.e. there are no interaction effects between activities), and resource requirements *proportional* (i.e. resource requirements per unit of activity are assumed to be constant regardless of the level of activity). Additivity and proportionality imply linearity in the activities with constant returns to scale Leontief production function. The programming step supply response functions may include steps whose range is wider than the levels of policy change, making programming models unsuitable for the analysis of certain policy measures.

Current research at the University of California on calibrated production equilibrium models is apparently capable of fitting crop specific non-linear Cobb-Douglas and CES production relationships from the same sort of minimal linear programming data set (Howitt, 1995). Clearly this approach may have relevance to the modelling of CEEC agriculture.

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