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COMMITTEE ON COMMODITY PROBLEMS

INTERGOVERNMENTAL GROUP ON TEA

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AN APPROACH TO SIMULATING THE WORLD TEA ECONOMY: THE GLOBAL FAO TEA MODEL

I. INTRODUCTION

1. At its last session, the Intergovernmental Group on Tea recommended that information on expansion plans by producing countries be used in generating a medium-term outlook for tea so as to improve the quality of the projections. Since the structure of the existing FAO tea model did not allow for an explicit incorporation of new planting and replanting decisions, the Secretariat undertook a review of the model in order to see how such information could be accommodated. Previous research in this area has been limited in terms of country coverage and model specification, mostly as a result of constraints in data availability.

2. This document proposes a framework for modelling the dynamic nature of tea supply as a new component to the FAO tea model. The approach is based on the vintage capital structure model which allows for the distinction between the productivity of established capital trees and that of new plantings[1]. In addition, the specification provides for the inclusion of specific institutional differences between countries (e.g. planting subsidies, input subsidies, etc) and the heterogeneity of constraints in different producing countries. The model also makes a distinction between actual and feasible production levels and incorporates the effects of energy related costs. Investment decisions pertaining to area expansion or replanting are considered in the determination of the total feasible crop, which itself evolves on the basis of expected and actual price relatives. Price determination is based on global market clearing - the price that ensures total import demand is matched to total tea export supplies. A price transmission equation guarantees the linkage between producing/consuming countries and the world market, and further consists of policy variables related to border measures.

[1] The methodology adopted for the new FAO tea model draws from the work of Akiyama and Trivedi, "Vintage production approach to perennial crop supply. An Application to tea in major producing countries" Journal of Econometrics, 36: 133-161, 1987.

II. THEORY AND ISSUES

3. A major drawback with previous analyses of perennial crop supply response is that they do not explicitly distinguish between short-run and long-run supply response. Changes in relative prices can prompt two types of decisions at the producer level. First, a decision whether to intensify the use of variable input such as fertiliser and labour, as measured by the short-run elasticity, and second, a decision on whether to invest in new plantings or replanting, which is measured by the long-run elasticity. Typically, as a result of biological lags required in perennial cropping the, long-run supply elasticity is larger than the short-term counterpart. Therefore, an explicit distinction between short-run and long-run decisions can facilitate the analysis of the impact of policies (e.g. investment subsidies, fertiliser subsidy, etc) on the supply of tea and can help explain divergent patterns of supply in tea producing countries.

4. From the perspective of the medium-term outlook, planning decisions related to new planting and replanting serves two purposes. First, information on past plantings enters in the determination of the parameter related to the feasible production component of the supply equation, as described in the methodological section. Second, these estimates are used to assess expected additional capacity in the outlook period. Ultimately, the availability of data on investment will improve the accuracy of the projections, as highlighted by the Group.

III. MODEL FRAMEWORK

5. We begin by assuming total production of tea at time *t* is a function of planned production and a ratio of current to expected prices as follows:

$$Q_t = AQ_t^p \left(\frac{P_t}{P_t^e} \right)^{\theta} U_t \qquad (1)$$

where Q_t refers to actual/realized production, A is a scale factor, Q_t^p stands for planned quantity at time t, U_t refers to supply disturbance (e.g. a weather shock), θ is the elasticity of output with respect to the price, and P_t, P_t^e refer to price at time *t* and expected price at time t, respectively. Planned production Q_t^p is the profit-maximization level chosen at some point in time, *t-v*. Actual production Q_t is assumed to differ from planned production Q_t^p because of stochastic supply shocks and because expectations on prices may not be realised at time *t*. The perennial nature of tea farming implies that a gestation period is necessary before new plantings become productive. During that period expected product and input prices assumed at the time of planting may significantly diverge from those that prevail at time *t*. Only when $P_t = P_t^e$, planned production equals actual production, given a set values for *A* and U_t. Further transformations are needed in order to reduce equation (1) to a flexible form for estimation. Specifically, since neither Q_t^p nor P_t^e (and hence $\left(\frac{p_t}{p_t^e} \right)$) are directly observable, a decision on how to estimate their values must be made. We assume in most cases that P_t^e is a linear function of current and lagged P_t, where the number of lags is selected empirically. Planned production Q_t^p is dependent on planted and mature vintages available at some base period, supplemented by new productive plantings up to time *t*. Let us call this aggregate quantity, feasible production Q_t^f. Note that the profit maximizing output level would be at most equal to Q_t^f at time *t*. Feasible production is related to planned production through the following relationship:

$$Q_t^p = Q_t^f \left(\frac{Q_t^p}{Q_t^f} \right) \tag{2}$$

with

$$Q_t^f = k_1 \left(Q_t^{ef} \right)^{\varepsilon} \qquad k_1, \varepsilon > 0 \tag{3}$$

6. Equation (3) assumes that estimated feasible production Q_t^{ef} differs from true, and non-observable, Q_t^f by a factor k_1 as a result of the measurement error in calculating average age-yield profiles.

and

$$\frac{Q_t^p}{Q_t^f} = k_2 \prod_{i=0}^{m} (P_{t-i})^{\beta_i} \qquad \beta_i \geq 0 \tag{4}$$

where the profit maximizing level of output leading to Q_t^p is assumed to be a function of current and lagged prices, with Q_t^f being determined on the basis of past investments.

7. Combining (3) and (4) into (2) then into (1) and taking logs, we obtain the basic supply equation:

$$\ln Q_t = \ln(A) + \varepsilon \ln Q_t^{ef} + \chi \ln(P_t) - \theta \ln(P_t^e) + \sum_{i=1}^{m} \beta_i \ln(P_{t-i}) + \ln(U_t) \tag{5}$$

which stipulates that current tea production depends on the estimated feasible production –which in turn is a function of past decisions on plantings and uprooting - adjusted by current and expected prices. The advantage of this specification is that total supply response can be summarised by a short-term and a long-run component. The long-run supply elasticity can be computed as follow:

$$\eta_{q,p}^l = \frac{d \ln Q^p}{d \ln P^e} \frac{d \ln P^e}{d \ln P} + \frac{d \ln \left(f \left(\frac{P}{P^e} \right) \right)}{d \ln P} \tag{6}$$

8. The first derivative term of equation (6) measures the sensitivity of the planned production with respect to variation in expected prices while the second measures the elasticity of expectations. If both are small, then the long-run elasticity will equal the short-run elasticity, which is defined as the response of current production as a result of an unanticipated price change. Higher output can be achieved in the short-run following intensification in the use of variable inputs such as fertilisers for example.

9. The estimated feasible production takes the following form:

$$Q_t^{ef} = e_t^{\lambda_1} Q_t^{os} + Q_t^{np} + Q_t^{ur} \tag{7}$$

where:

Q_t^{ef} refers to estimated feasible production, Q_t^{os} stands for old stocks – which is subject to disembodied technological change and to declining production due to aging $e_t^{\lambda_1}$ – Q_t^{np} refers to new plantings, and Q_t^{ur} stands for uprooting. We proceed by quantifying productive capacity existing at some base period, say b_0, which we call Q_t^{os}. Existing capital stock at b_0 is supplemented by new plantings Q_t^{np} while uprooting of unproductive trees reduces total capacity (Q_t^{np} is set exogenously at this stage). Using information on age and yield profiles, a production capacity index can be constructed and Q_t^{np} can be expressed as:

$$Q_t^{np} = e_t^{\lambda_2}\left(\sum NY_{t-v}CSN_{t-v}\right) \qquad (8)$$

where CSN_t stands for the cumulated sum of new plantings since period b_0, and NY_{t-v} refers to normalised yield. NY_{t-v} can be normalised with respect to base period b_0. We assume that NY_{t-v} is subject to disembodied technological change ($e_t^{\lambda_2}$) at a constant rate of λ_2. Finally in the case where no information is available on age and yield profile, Q_t^{ef} can be estimated as a function of a linear or quadratic trend.

10. Once Q_t^{ef} is evaluated, the basic supply equation (5) is then estimated for the major tea producing countries. We assume that tea production is homogenous across countries and between the different tea vintages. In other words, there is no differentiation between quality. The basic supply equation is required to be estimated for smallholders and tea estates to account for the variations in supply response inherent in both groups. Aggregating the production level of these two groups gives total tea output at time *t*. In the case where there is no possibility of disaggregating the data into smallholders and estates, a single supply equation will be used. Particular attention will be paid to policy incentives that encourage producers to increase long-term supply response, through investments in new plantings and also short-term response through input subsidies. Also on the supply side, the link with the energy market (oil prices) is created by deflating tea producer prices by a cost index. This index is driven by the relative importance of input groups composed of tradables, non-tradables and energy, in tea production costs.

IV. CONCLUSION AND ISSUES TO CONSIDER

11. Following the Group's recommendation to improve the quality of the production outlook by taking into account expected expansion plans by producing countries, the Secretariat undertook a full review of the FAO world tea model. This document outlined the main characteristics of the proposed new structure and how it is derived from theory. The proposed methodology was used to simulate supply behaviour for India, as data constraints prevented the new approach being applied to all producing countries. Therefore, the Group may wish to make a decision on the following matters:

a) Adoption of the proposed methodology and its application to major tea producing countries.

b) The provision to the Secretariat with a complete set of data on:
   i) past plantings;
   ii) expected new plantings; and
   iii) replanting by producing countries.

c) The establishment of a focal point at the Tea board/association level to liaise with the Secretariat on issues related to data and statistics.