Yapı Kredi Economic Review, Vol. I, No: 1, October 1986

TASM : TURKISH AGRICULTURAL SECTOR MODEL

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I. INTRODUCTION

As in most developing economies, agriculture plays a crucial role in the economic development of Turkey. The agricultural sector for a long time has been subjected to direct and indirect government intervention. Various instruments of agricultural policy such as output support prices, input subsidies, quotas, tariffs, credits, taxes, land distribution, extension services, etc. have been employed to achieve various objectives such as reduction of income and price instability, stimulation of output and income, satisfaction of domestic demand, improving balance of payments, etc. An obvious implication of the multiplicity of goals, and instruments available to achieve them, is the problem of choice, and, more important, the problem of conducting consistent agricultural policies. Because of the complexities of substitution and complementary effects inherent in the goal and instrument packages, the consequences of a given policy measure on various goals is not obvious a priori. The impact of several policy measures cannot be approximated by simply adding up the impact of isolated measures, and piecemeal analysis of agricultural policies can be quite misleading.

The Agricultural Sector Model for Turkey (TASM) has been developed to provide an internally consistent, quantitative framework of analysis in which to evaluate the effects of policy intervention.

The object of this paper is to introduce the theoretical and empirical foundations of TASM and to present a summary of validation tests performed to assess its reliability for policy

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simulations. An examination of the results of policy experiments with TASM on Turkish Agriculture has been postponed to a later paper.

II. HISTORY OF TASM

Work on TASM began in 1981, in connection with a World Bank Industrialization and Trade mission to Turkey. The first version, developed by P. Scandizzo, V. Le - Si, and the author, used the Portugal sector model as a basis and employed a mixture of Portuguese and Turkish data for the first experiments. The preliminary conclusions were reported in the ITS (Industrialization and Trade Strategy) mission report of the World Bank in 1982. Work on the next version of TASM started with a research grant from the World Bank, shortly after the ITS report. The data base was completely revised, and the model structure was substantially changed in order to adapt the model to Turkish Agriculture. In addition to expanding the model in terms of input and output coverage, livestock and processing sectors were also included, as were new features such as risk, rotations, quarterly specification of input demands and endogeneous production technology. Two new versions of TASM emerged. Le - Si, Scandizzo and Kasnakoğlu (1983) and Le - Si (1983), were used extensively in the World Bank Agricultural Sector Report (1983), to assess the implications of various policy alternatives in agriculture.

The version of TASM reported in this study, which draws heavily on the version reported in Le - Si, Scandizzo and Kasnakoğlu (1983), differs from earlier versions in three important aspects. First, utilizing the availability of new nonlinear programming algorithms like MINOS, the linearization of demand and risk functions (which were certainly important conveniences in the absence of algorithms to handle large scale non - linear programming problems) were eliminated in favor of a quadratic objective function. Second the linear cost functions were augmented with quadratic cost terms using a positive quadratic programming approach, developed by Howitt and Mean (1985). Third, the restrictive rotation activities were replaced by single crop activities, and a more realistic land input quality specification as required by the PQP approach was incorporated. The basic differences between the earlier and later versions of TASM are illustrated in Table 1.

TABLE 1

Differences between the Earlier and Recent Versions of TASM

	EARLIER	RECENT
Objective Function	Linearized Area under Demand Absolute Mean Deviation Risk Linear Cost Functions	Quadratic area under demand Quadratic risk Quadratic cost functions
Technology	Rotations only	Single crop activities and rotations
Resources	Dry - Irrigated - Rain Combinations for cropland	Dry - Irrigated - Rain - Temperature combinations for cropland
ANIMAL VS. TRACTOR technology	Not restricted	PQP costs introduced
Fallow Activity	Not restricted	PQP costs introduced
Calibration	Via data, elasticities	Via PQP terms
Data	Minor adjustments for calibration	Minor adjustments for consistency

III. MICROECONOMIC BACKGROUND FOR SECTOR MODELS

A mathematical programming sector model typically contains activities which represent production and consumption of outputs, resource constraints and costs, and output demand functions. A generic agricultural sector model formulation, which serves as a guide to the model presented in this paper as well as in a number of other sector modeling efforts, is presented below.

We shall assume that producers and consumers operate in competitive markets for both factors and outputs [1]. It is assumed further that each producer has a finite set of production processes each representing a particular way of combining factors to produce one unit of output. Each production process is assumed to be technically efficient, and the producer is assumed to maximize profit in choosing these production processes.

At the farm level, let $\hat{p}$ be a vector of anticipated product prices, c be a vector of unit activity costs, x be a vector of activity levels, M be a diagonal matrix of yields and let y equal Mx, a vector of total product outputs. The model of the firm is therefore

$$\text{Maximize } \pi = \hat{p}'y - c'x = \hat{p}'Mx - c'x \qquad (1)$$

$$\text{Subject to } Fx \leqslant r$$

where π is profit, F is a matrix of factor input coefficients and r is a vector of factor or resource availabities.

For the extension of the farm model to the sector level, let X, Y, C, W, G and R be the appropriate aggregates of x, y, c, w, g and r of the farm level variables respectively [2]. Assume also a linear inverse demand system :

$$P = A - BY$$

where P is a vector of expected market prices, A is a vector of demand function intercepts and B is a negative semidefinite matrix of slopes. The sector model may then be specified as :

$$\text{Maximize } Z = X'W(A - 0.5\, BWX) - C'X \qquad (2)$$

$$\text{Subject to } GX \leqslant R$$

where Z is net social benefit and $Y = WX$. Note that $X'W(A - 0.5\, BWX)$ is the sum of the area under all demand functions, and $C'X$ is the sum of the areas under all supply functions. The difference is the sum of producer $(Y'(A - BY) - C'X)$ plus consumer $(0.5Y'BY)$ surplus.

(1) See Duloy and Norton (1975) for modifications in the model structure for non - competitive behavior.

(2) For further discussion on the problems associated with aggregation see McCarl and Spreen (1980) and House (1983).

McCarl and Spreen (1980) demonstrate that, the solution to the above problem yields an equilibrium where the individual producers' marginal conditions for profit maximization are maintained, and that the sector model's supply function is therefore an «aggregate» marginal cost schedule, and the sectoral factor demand functions are «aggregate» marginal value products schedules. Thus the model does not require explicit specification of supply of output or demand for factors schedules. Rather, these schedules are derived or projected internally based upon production possibilities, output demand and factor supply.

It is also possible to incorporate uncertainty into the above formulations. Several approaches have been used in the literature to incorporate risk into mathematical programming models of agriculture. The generic model stated above, is extended below for the «mean - variance» approach employed in this study.

Let h_i denote the net revenues of production activities, which are normally distributed with mean $\bar{h}_i$ and variance v_i : $h_i \sim N(\bar{h}_i, v_i)$ and h denote the sum of each firm's net revenues multiplied by its activity level, x_i, which are also normally distributed; $h \sim N(\bar{h}'x, x'Vx)$ where $\bar{h}$ is a vector of mean net revenues, x is the vector of activity levels and V is a matrix of production activity revenue variance, covariance coefficients. Assuming that the utility function is of the following form :

$$U(h) = 1 - e^{-ah} \qquad (3)$$

where, U (h) is utility and $\tilde{a}$ is the risk aversion parameter,

$$E(U) = E(h) - (\tilde{a}/2)\, V \qquad (4)$$

which can be maximized by.

$$\text{Max } E(U) = \bar{h}'x - (\tilde{a}/2)\, x'Vx \qquad (5)$$

Therefore, (1) can be extended to include risk as

$$\text{Maximize } U = \hat{p}'y - c'x - (\tilde{a}/2)\, x'Vx \qquad (6)$$

Subject to $Fx \leqslant r$

The farm model is extended to sector level, by specifying the aggregate variables $\hat{P}$, W, X, C, $\tilde{a}$ and $\bar{V}$ which correspond to the farm level variables $\hat{p}$, M, x, c, $\tilde{a}$ and V :

$$\text{Maximize } Z = X'W\,(A - 0.5\,WX) - C'X - (\tilde{a}/2)\,X'\bar{V}X \quad (7)$$

$$\text{Subject to } GX \leqslant R$$

where $(\tilde{a}/2)\,X'\bar{V}X$ is the risk premium and is included in the sum of areas under the supply functions.

IV. THE BASIC STRUCTURE OF TASM

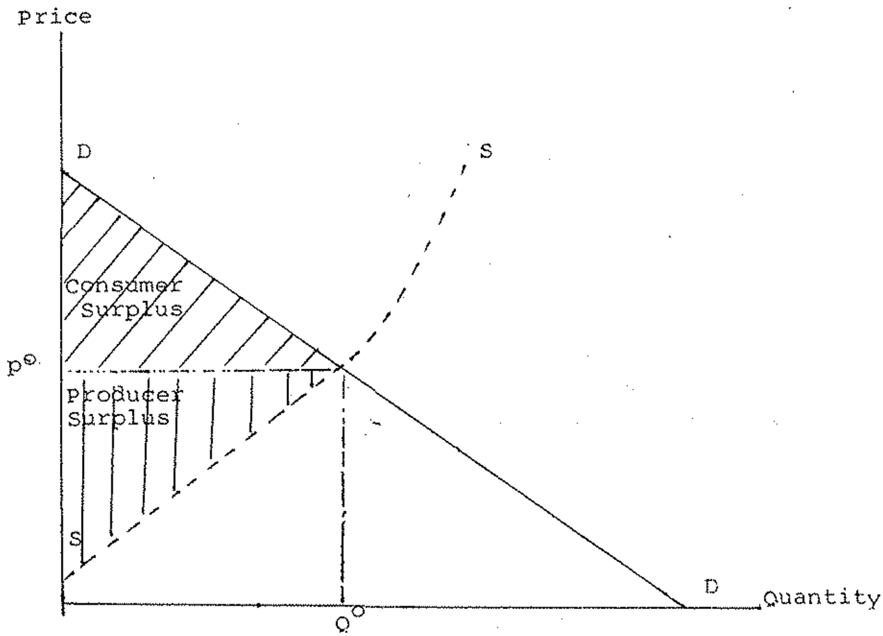
The model used to simulate the agricultural sector and the resource allocation effects of agricultural policies on production, consumption and trade patterns is a partial equilibrium, static optimization model.

The objective function maximized in the model is the sum of the consumers' and producers' surplus, plus net export revenue, and minus the reservation wage of labor. The treatement of price - endogenous demand is based on Duloy and Norton (1975) approach, augmented by risk costs which are included as part of the production costs within an E - V framework suggested by Hazell and Scandizzo (1974). The main elements of the objective function are illustrated in Figure 1, for a single crop.

For each of the products, an exogenous linear demand curve DD is specified. The supply curve SS is endogenous and is determined by the costs of production, including opportunity costs. Given the structure of consumer demands, production activities and trade possibilities, optimality entails equating supply to domestic plus foreign demand and prices to marginal costs for all commodities, making provisions for risk and allowing for the reservation wages for labor.

The core of the model consists of production activities and resource constraints. The input and output coefficients for single crop production and rotations are specified for each unit of land.

FIGURE 1
THE TASM OBJECTIVE FUNCTION



In addition to land, other input requirements for production are labor, tractors, fertilizers, animal power, seed and capital. Animal power is supplied by livestock production activities, and seed is supplied by the crop production activities (3). Labor, tractors and animal power are divided into four calendar quarters. The model is given a choice of two production techniques, animal or mechanized. It can assign any combination of weights to these two techniques to produce a single crop, depending on the optimal allocation of resources.

The livestock subsector works similar to the crop subsector. The explicit production cost for animal husbandry is labor. Other inputs required are cereals, hay and forage, which are by-products of crops, and concentrates which are derived from crops processed for human consumption. Pasture land is also required for animal

(3) In this version of the model, seed is treated as an exogenous input.

grazing, with the exception of poultry, to supplement livestock feeding. In addition to meat, milk, hides, wool and eggs, the livestock production activities also provide animal power used in crop production activities.

The commodities produced by the production activities are then distributed between : (i) domestic demand generated through demand curves; (ii) demand for cereals used for feeding in the livestock sector; (iii) demand for seeds used in crop production activities; (iv) exports in raw form; (v) exports in processed form. On the supply side, besides domestic production, some commodities are allowed to be imported at exogenous prices.

Since generally the data available are most reliable at the farmgate level, prices and some quantities used in the model are incorporated at this level. The import price is then the CIF price plus transportation and marketing margins; export price is FOB minus the margins, for all commodities in raw or processed form. The domestic demand functions are also calculated at the farmgate level.

In addition to commodity and area balance equations, trade, production, area, etc., limit equations may be used for model validation, as market absorption constraints or for different policy experiments. The basic structure of the model is illustrated in Figure 2.

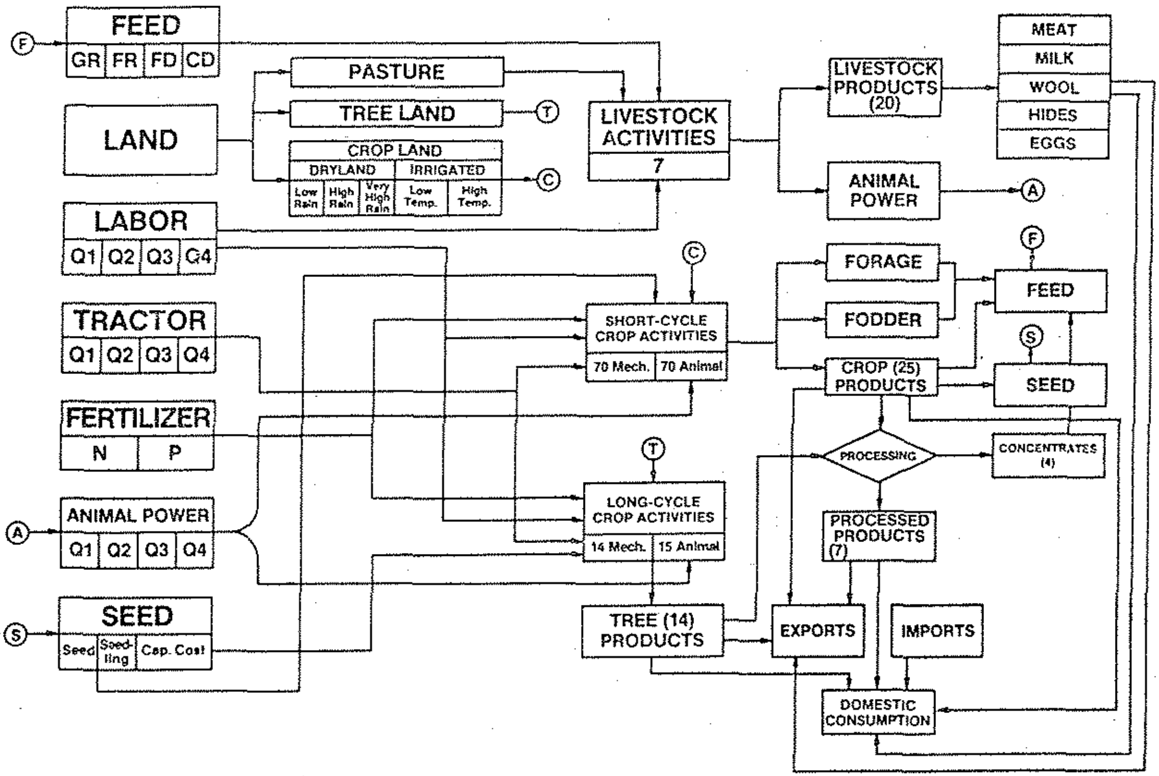
V. THE DATA

TASM is based on 15 types of orchards, 70 crop rotations and 7 livestock activities. Taking into account the two production techniques, namely mechanized and non-mechanized for crop production, the total number of production activities specified in the model is 176.

The data used in the model are gathered mainly from SIS, SPO, FAO, TOPRAKSU and WORLD BANK sources. The lack of Turkish statistics suitable for this kind of modelling exercise forced the researchers to piece together the required data from different sources, and in many cases to employ unpublished raw data. In

FIGURE 2

BASIC STRUCTURE OF TASM



what follows, we briefly state the nature of the data employed in this paper (4).

Crop Production and Rotation Activities

In TASM there are 33 single annual crop and 15 perennial crop activities. In addition, 12 rotations for sugarbeet and 25 multiple cropping activities are incorporated as linear combinations of single crop activities with different land input requirements (5). The input - output coefficients corresponding to these activities, with the exception of rice, hazelnuts, tea, soybean and sesame, for mechanized technology are based on the ongoing «Production Inputs and Costs of Agricultural Crops in Turkey» research conducted by TOPRAKSU. The data collected by TOPRAKSU using daily bookkeeping method is the most reliable data of its kind currently available in Turkey despite its limitations of coverage and bias towards mechanized technology. The non - mechanized activity coefficients are calculated using a conversion factor of 1/10 for tractor power and animal power, from the mechanized activity coefficients reported in TOPRAKSU data.

Livestock Activities

The seven livestock activities specified in TASM include sheep, ordinary goat, Angora goat, cattle (cow, oxen, bull, young cattle), buffalo, mule (horse, mule, donkey), and poultry (hens, cocks, turkeys). On the input side, besides outputs and by - products from crop activities (feed grains, forage, fodder and concentrates), pasture land and labor are required. The output of the livestock activities include meat, milk, wool, hides and eggs in addition to animal power provided to crop production activities (6).

Inputs

Six groups of inputs (land, labor, animal power, tractors, fertilizer and seeds), are incorporated in TASM. Labor, animal

(4) Further details on the data can be found in Le - Si, Scandizzo, Kasnakoğlu (1983) and Kasnakoğlu (1983).

(5) See the algebraic statement of TASM for the crops and activities incorporated in TASM. Also note that 5 fallow activities for cereals are included in the 33 single annual crop activities.

(6) See Le - Si, Scandizzo, Kasnakoğlu (1983) and Evans, Le - Si (1983) for an Alternative Livestock Version of TASM.

power and tractors are introduced on a quarterly basis. Land is classified into treeland, pastureland and cropland. The cropland is further divided into eight classes, which distinguish between various combinations of irrigation, temperature and rainfall. The labor input is measured in man - hour equivalents and shows the actual time required for a given activity on the field. The tractor hours correspond to the usage of tractors in actual production and transportation related to these production activities. Two kinds of fertilizers, namely Nitrogen and Phosphate are measured in terms of nutrient contents. In the case of annual crops, amounts of seed or seedlings requirements are introduced as production costs. For non - annual or perennial crops fixed investment costs are assigned instead.

Crop Yields

Output from crop production activities is divided into three: crop yield for human consumption, feed yield for animal consumption and forage yield, or crop by - product, for animal consumption. In addition, concentrates are derived, from the processing of raw materials for human consumption. The forage yield is imputed using (feed yield/total yield) and (forage yield/total yield) ratios. The historical yields for tree crops and vegetable crops are also imputed, since they are given per tree in the case of the former and for aggregate of vegetables in the case of the latter.

Livestock Yields

The outputs of the livestock activities include animal power, meat, milk, wool, hides and eggs. The animal power is estimated using the ratios of cattle, buffalo and mules employed as draft animals and assuming 500 working hours per year per pair. The meat yields for all animals and milk yields for cattle and buffalo are from the World Bank's Agricultural Sector Study Mission estimates. The remaining milk, wool and egg yields are based on SIS statistics. The hide yields are obtained by converting numbers of hides to Kgs. using conversion factors 2.6 for sheep and goat and 20.5 for cattle and buffalo.

Output and Input Prices

Output prices used in TASM are farmgate prices, and are based on SIS figures. The costs of labor, tractors, fertilizer, seed for annual crops and fixed capital for perennial crops are based on TOPRAKSU estimates.

Resource Availability

The labor resource availability for the base year is computed by converting the agricultural labor force in 1979 to man-hour equivalents with the assumption that there are 5 working hours in a day, and 294 working days in a year. Available tractor hours for 1979 are calculated by assuming 5 working hours a day and 300 working days for each tractor, and multiplying these with the number of tractors in 1979. The livestock inventory is based on the number of livestock in 1979. The land resource availabilities by types of land are pieced together from TOPRAKSU data which distinguishes between irrigated and rainfed land, but not by rainfall and SIS data which distinguishes land by rainfall but not by irrigation. The tree stock in 1979 covers the area under both bearing and non-bearing trees.

Processing Factors, Costs and Concentrate Coefficients

Wheat, corn, rye, rice, sunflower, olive, soybean, sesame, sugarbeet and tea are processed for consumption, and concentrates are obtained as a by-product of this processing for animal consumption. The processing costs are computed using the following formula, with the assumption that the profit margin in processing is 20 percent for all crops:

Processing Cost = [(Export Price in Processed Form) —
(Export Price in Raw Form)] * (0.80)
(Processing Factor).

Crop and Livestock Production

The crop and livestock production data used in TASM validation are taken mainly from official statistics reported by SIS.

However, production data for wheat, barley, rye - oat - millet, dry beans and tobacco were deflated and those for lentils and chich - peas, sunflower and corn were inflated slightly due to biases discovered in the statistics, when compared to the results of various other studies and censuses and in light of calibration runs to be discussed below (7). For meat and milk output of livestock activities, estimated figures are based on SPO figures rather than underestimated SIS figures, which cover only meat produced from animals processed in municipal slaughterhouses (8).

Foreign Trade

The data related to foreign trade involves trade and prices in unprocessed as well as processed products. The quantity of exports and imports of unprocessed products, with the exception of livestock meat are based on official statistics. The trade prices are FOB and CIF at farmgate, adjusted for marketing and transportation costs. Foreign trade is allowed for the following processed products; wheat flour, tomato paste, sunflower oil, olive oil, dry tea, raisins and shelled hazelnuts (9).

Consumption and Demand

Domestic consumption is defined as: Production + Imports — Exports — Feed ± Processed Trade. Wheat, corn, rye, wet rice, sunflower, olive, soybean, sesame, sugarbeet and tea are processed for human consumption. The domestic demand functions relate observed consumption quantities to observed prices at farmgate, and were estimated by forcing a linear line through the observed base year consumptions and farmgate prices with the given price elasticities. The price elasticities are, on the other hand estimated from FAO (1971) income ealsticities, using the Frisch (1959) method.

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(7) See, for example, World Bank (1983) and Gençağa (1983).

(8) A more detailed discussion on the nature of biases in SIS data and methods of adjusting employed can be found in Le - Si, Scandizzo, Kasnakoğlu (1983) and Kasnakoğlu (1983).

(9) Livestock meat exports are based on World Bank estimates, which incorporate exports of live animals which are underestimated in official statistics, due to non - coverage of illegal exports.

Risk

The E — V risk formulation employed in the model uses the per hectare revenue variances for different crop, rotation and livestock activities. The revenue variances for activities are calculated from time series data on deflated farmgate prices (with 1979 = 100) and adjusted yields (for discrepancies between model yields and official yields). The risk aversion coefficient Φ is taken to be 1 in this version of the model ([10]).

The Exchange Rate

During 1979 two official exchange rates are observed in Turkish economy, due to the devaluation of the currency. In the base solution simulations, the simple arithmetic average of the exchange rates, (35 TL/$ and 47 TL/$) 41 TL/$ was used to convert domestic prices into dollars and vice versa.

(10) See Hazell and Scandizzo (1974) for the theoretical discussions on the risk formulation.

THE ALGEBRAIC STATEMENT OF TASM

A. INDICES

s_1 Basic Land Types

Dry Low Rainfall
Dry High Rainfall
Dry Very High Rainfall
Irrigated Low Temperature
Irrigated High Temperature
Tree Area
Pasture

s_2 Land Types Without Rainfall or Temperature Distinction

Dry High or Very High Rainfall
Dry Either Rainfall
Irrigated Either Temperature

l Labor (Divided into 4 quarters)

Labor 1Q
Labor 2Q
Labor 3Q
Labor 4Q

a Animal Power (Divided into 4 quarters)

Animal 1Q
Animal 2Q
Animal 3Q
Animal 4Q

m Tractor Power (Divided into 4 quarters)

Tractor 1Q
Tractor 2Q
Tractor 3Q
Tractor 4Q

f Fertilizer

Nitrogen
Phosphate

d Seeds

Wheat
Corn
Rye, Oats, Millet, etc.
Rice
Barley
Chick-pea
Dry Bean
Lentil
Potato
Onion
Green Pepper
Tomato
Cucumber
Sunflower
Groundnut
Cotton
Sugar Beet
Tobacco
Melon
Pistachio
Alfalfa
Fodder

o **Output**

Wheat	Corn
Rye, Oats, Millet, etc.	Rice
Barley	Chick-pea
Dry Bean	Lentil
Potato	Onion
Green Pepper	Tomato
Cucumber	Sunflower
Olive	Groundnut
Cotton	Sugar Beet
Tobacco	Tea
Citrus	Grape
Apple	Peach
Apricot	Cherry
Wild Cherry	Melon
Strawberry	Banana
Quince	Pistachio
Hazelnut	Soybean
Sesame	
Sheep Meat	Sheep Milk
Sheep Wool	Sheep Hide
Goat Meat	Goat Milk
Goat Wool	Goat Hide
Angora Meat	Angora Milk
Angora Wool	Angora Hide
Beef	Cow Milk
Cow Hide	Buffalo Meat
Buffalo Milk	Buffalo Hide
Poultry Meat	Eggs

g **Livestock Inputs from Crop By-Products***

F - Wheat	F - Corn
F - Rye	F - Rice
F - Barley	F - Pulses
F - Alfalfa	F - Fodder
C - Rye	C - Wheat
C - Sugar Beet	C - Barley

t **Production Technique**

Animal	Mechanized

*F stands for straws and C stands for concentrates or pulps.

i. Crop Production Activities

Single Crop Activities

Activity	Land Type**	Crop
SWHEATD	DRY.HRET	WHEAT
FWHEATD	DRY.ERET	WHEAT/FALLOW
SWHEATI	IRR.ERET	WHEAT
SCORN.D	DRY.VRET	CORN
FCORN.D	DRY.HRET	CORN/FALLOW
SCORN.I	IRR.ERET	CORN
SRYE..D	DRY.HRET	RYE-OATS-MILLET
FRYE..D	DRY.ERET	RYE-OATS-MILLET/FALLOW
SRICE.I	IRR.ERHT	RICE
FRICE.I	IRR.ERET	RICE/RICE/FALLOW
SBARLYD	DRY.HRET	BARLEY
FBARLYD	DRY.ERET	BARLEY/FALLOW
SCKPEAD	DRY.HRET	CHICKPEA
SCKPEAI	IRR.ERET	CHICKPEA
SDBEANI	IRR.ERET	DRYBEAN
SLENTLD	DRY.HRET	LENTIL
SPOTATI	IRR.ERET	POTATO
SONIOND	DRY.VRET	ONION
SONIONI	IRR.ERET	ONION
SGPEPPI	IRR.ERET	GREENPEPPER
STOMATI	IRR.ERET	TOMATO
SCUCUMI	IRR.ERET	CUCUMBER
SSUNFLD	DRY.VRET	SUNFLOWER
SSUNFLI	IRR.ERET	SUNFLOWER
SGRNUTI	IRR.ERHT	GROUNDNUT
SSBEANI	IRR.ERET	SOYBEANS
SSESAMI	IRR.ERET	SESAME
SCOTTNI	IRR.ERHT	COTTON
STOBACD	DRY.HRHT	TOBACCO
SMELOND	DRY.HRET	MELON
SMELONI	IRR.ERET	MELON
SALFALI	IRR.ERET	ALFALFA
SFODDRD	DRY.HRET	FODDER

Sugarbeet Rotation Activities

Activity	Land Type	Crop
RWHSR.I	IRR.ERET	WHEAT/SUGARBEET
RCRSR.I	IRR.ERET	CORN/SUGARBEET
RSFSR.I	IRR.ERET	SUNFLOWER/SUGARBEET
RAASR.I	IRR.ERET	ALFALFA/SUGARBEET
RWHSRAI	IRR.ERET	WHEAT/SUGARBEET/ALFALFA
RWHSRSD	DRY.VRET	WHEAT/SUGARBEET/SUNFLOWER
RWHSRDD	DRY.VRET	WHEAT/SUGARBEET/DRYBEAN
RWHSRFD	DRY.VRET	WHEAT/SUGARBEET/FALLOW
RWHSRLD	DRY.VRET	WHEAT/SUGARBEET/LENTIL
RWHSRWD	DRY.VRET	WHEAT/SUGARBEET/WHEAT
RWHSRCD	DRY.VRET	WHEAT/SUGARBEET/CORN
RWHSRMD	DRY.VRET	WHEAT/SUGARBEET/MELON

**R = Rainfall; T = Temperature; E = Either; V = Very High; H = High

Multiple Crop Activities (3 Crops in 2 Years)

Activity	Land Type	Crop
MWC.C.I	IRR.ERHT	WHEAT-CORN/COTTON
MWC.G.I	IRR.ERHT	WHEAT-CORN/GROUNDNUT
MWC.R.I	IRR.ERHT	WHEAT-CORN/RICE
MWC.V.I	IRR.ERET	WHEAT-CORN/VEGETABLE
MWC.O.I	IRR.ERET	WHEAT-CORN/ONION
MWC.S.I	IRR.ERET	WHEAT-CORN/SESAME
MWS.C.I	IRR.ERHT	WHEAT-SOYBEAN/COTTON
MWS.V.I	IRR.ERET	WHEAT-SOYBEAN/VEGETABLE
MWS.O.I	IRR.ERET	WHEAT-SOYBEAN/ONION
MBC.C.I	IRR.ERHT	BARLEY-CORN/COTTON
MBC.R.I	IRR.ERHT	BARLEY-CORN/RICE
MBC.V.I	IRR.ERET	BARLEY-CORN/VEGETABLE
MBC.O.I	IRR.ERET	BARLEY-CORN/ONION
MBC.S.I	IRR.ERET	BARLEY-CORN/SESAME
MBS.C.I	IRR.ERHT	BARLEY-SOYBEAN/COTTON
MBS.R.I	IRR.ERHT	BARLEY-SOYBEAN/RICE
MBS.V.I	IRR.ERET	BARLEY-SOYBEAN/VEGETABLE
MBS.O.I	IRR.ERET	BARLEY-SOYBEAN/ONION
MRC.C.I	IRR.ERHT	RYE-CORN/COTTON

Multiple Crop Activities (4 Crops in 2 Years)

Activity	Land Type	Crop
MFC.WGI	IRR.ERHT	FODDER-COTTON/WHEAT-GROUNDNUT
MFC.WSI	IRR.ERHT	FODDER-COTTON/WHEAT-SOYBEAN
MFC.BSI	IRR.ERHT	FODDER-COTTON/BARLEY-SOYBEAN
MFC.RSI	IRR.ERHT	FODDER-COTTON/RYE-SOYBEAN
MAC.WSI	IRR.ERHT	ALFALFA-COTTON/WHEAT-SOYBEAN
MAC.BSI	IRR.ERHT	ALFALFA-COTTON/BARLEY-SOYBEAN

Tree Crop Activities

Activity	Land Type	Crop
OLIVE.D	TREE	OLIVE
TEA...D	TREE	TEA
CITRS.I	TREE	CITRUS
GRAPE.D	TREE	GRAPE
GRAPE.I	TREE	GRAPE
APPLE.I	TREE	APPLE
PEACH.I	TREE	PEACH
APRIC.I	TREE	APRICOT
CHERR.I	TREE	CHERRY
WCHER.I	TREE	WILD CHERRY
STBER.I	TREE	STRAWBERRY
BANAN.I	TREE	BANANA
QUINC.I	TREE	QUINCE
PISTA.D	TREE	PISTACHIO
HAZEL.D	TREE	HAZELNUT

Livestock Activities

SHEEP
GOAT
ANGORA
CATTLE
BUFFALO
MULE
POULTRY

c **Land Choices**

Dry Low Rainfall
Dry High Rainfall
Dry Very High Rainfall
Irrigated Low Temperature
Irrigated High Temperature

j **Livestock Production Activities**

Sheep
Goat
Angora
Cattle
Buffalo
Mules, Camels, Horses, etc.
Poultry

y **Year**

1974 to 1979

b **Area**

Same as the 35 field and tree crops in o plus alfalfa and fodder

bc **Cereal Area**

Wheat
Corn
Rye
Rice
Barley

bf **Fallow Area**

FWHEATD
FCORND
FRYE..D
FRICE.D
FBARLYD
RWHSRFD

po **Processed Products**

Wheat Flour
Tomato Paste
Sunflower Oil
Olive Oil
Dry Tea
Raisin
Shelled Hazelnut

e **Production Cost Structure**

Labor
Tractor
Fertilizer
Seed
Capitals

B. PARAMETERS (DATA)

P	Crop production coefficients
Q	Livestock production coefficients
I_{oc}	Land Matrix for Undifferentiated Land
P_{cost}	Crop production costs
Q_{cost}	Livestock production costs
Q_q	Crop used for feed index (1 = yes, 0 = no)
Proctrade	Conversion factor for processed products
Concentrate	Concentrate coefficients derived from crop processing
Exprice	Export prices at farmgate
Imprice	Import prices at farmgate
Ppprice	Trade prices of processed products at farmgate
Resav	Resource availability
Revar	Revenue variances of crop and livestock activities
α	Demand function intercept
β	Demand function slope
Φ	Risk aversion coefficient
Tech	Ratio of animal to tractor technology
Fallo	Ratio of fallow land to cereal land
PQPA	PQP term for animal technology
PQPT	PQP term for tractor technology
PQPb	PQP term for crop areas
PQPbc	PQP term for cereal area
PQPbf	PQP term for fallow area

C. ACTIVITIES (VARIABLES)

CROPS	Crop production activities
PRODUCT	Livestock production activities
LANDC	Land choice for different rainfall and temperature
PFERT	Fertilizer use
PRCOST	Production costs
TOTALPROD	Total production
TOTALCONS	Total consumption
IMPORT	Import
EXPORT	Export
PPTRADE	Processed product trade (- for imports, + for exports)
ANIMAL	Land cultivated with animal
TRACTOR	Land cultivated with tractor
TECHNOLOGY	Deviation from base year ANIMAL/TRACTOR ratio
AREA	Crop and tree areas
CERAREA	Cereal area
FALAREA	Fallow area
FALLOW	Deviation from base year FALAREA/CERAREA ratio

D. ALGEBRAIC STATEMENT OF TASM

Land Constraints

(1) $\sum_i \sum_t P_{s_1,i,t} * CROPS_{i,t} + \sum_j Q_{s_1,j} * PRODUCT_j + \sum_c Ioc_{s_1,c} * LANDC_c \leq Resav_{s_1}$ for all s_1

[Land use by crop and livestock production] [Undifferentiated land use] [Land availability]

(2) $\sum_i \sum_t P_{s_2,i,t} * CROPS_{i,t} = \sum_c Ioc_{s_2,c} * LANDC$ for all s_2

[Undifferentiated* land use by crop production] [Total undifferentiated land use]

Labor and Tractor Constraints

(3) $\sum_i \sum_t P_{l,i,t} * CROPS_{i,t} + \sum Q_{l,j} * PRODUCT_j \leq Resav_l$ for all l

[Labor use by crop and livestock production] [Labor availability]

Equation (3) with index m instead of l refers to tractor constraints.

Animal Constraints

(4) $\sum_i \sum_t P_{a,i,t} * CROPS_{i,t} \leq \sum Q_{a,j} * PRODUCT_j$ for all a

[Animal power required by crop production] [Animal power provided by livestock production]

(5) $PRODUCT_j \leq Resav_j$ for all j

[Livestock production] [Animal inventory]

Fertilizer Accounting

(6) $\sum_i \sum_t P_{f,i,t} * CROPS_{i,t} = PFERT_f$ for all f

[Fertilizer used by crop production] [Total fertilizer use]

Production Costs

(7) $\sum_i \sum_t Pcost_{e,i,t} * CROPS_{i,t} + \sum_j Qcost_{e,j} * PRODUCT_j = PRCOST_e$ for all e

[Cost of production by crop and livestock] [Total production cost]

Production Balances

(8) $\sum_i \sum_t P_{o,i,t} * CROPS_{i,t} + \sum_j (1-Qq_o) * Q_{o,j} * PRODUCT_j = TOTALPROD_o$ for all o

[Products produced by crop and livestock production] [Total production]

Commodity Balances

(9) $TOTALPROD_o + IMPORT_o = TOTALCONS_o + \sum_j Qq_o * Q_{o,j} * PRODUCT_j + EXPORT_o + \sum_{po} (1/Proctrade_o) * PPTRADE_o$ for all_o

[Total production] [Import] [Total consumption] [Crops used as livestock feed] [Export] [Trade of processed products]

Feed Balances

(10) $\sum_i \sum_t P_{g,i,t} * CROPS_{i,t} + \sum_o Concentrate_{g,o} * TOTALCONS_o \geq \sum Q_{g,j} * PRODUCT_j$ for all g

[Feed produced by crop production] [Concentrates derived from human consumption] [Feed required by livestock]

Total Area Balances

(11) $\sum_i \sum_t P_{b,i,t} * CROPS_{i,t} = AREA_b$ for all b

[Areas used by crop production activities] [Total crop area]

Technology Balances

(12) $\sum_{b}\sum_{i} P_{b,i,t} * CROPS_{i,t} = ANIMAL$ for t = animal

{Areas cultivated by animal technology} {Total animal cultivated area}

(13) $\sum_{b}\sum_{i} P_{b,i,t} * CROPS_{i,t} = TRACTOR$ for t = tractor

{Areas cultivated by tractor technology} {Total tractor cultivated area}

(14) $ANIMAL - Tech * TRACTOR = TECHNOLOGY$

{Deviations of the {ANIMAL - TRACTOR} technology use from the base year}

Fallow Balances

(15) $\sum_{bc}\sum_{i}\sum_{t} P_{bc,i,t} * CROPS_{i,t} = CERAREA$

{Areas under cereals} {Total cereal area}

(16) $\sum_{bf}\sum_{i}\sum_{t} P_{bf,i,t} * CROPS_{i,t} = FALAREA$

{Areas under fallow activities} {Total fallow area}

(17) $FALAREA - Fallo * CERAREA = FALLOW$

{Deviation of {FALAREA - CERAREA} from the base year}

Trade Restrictions for Base Runs*

(18) $IMPORT_o \leq IMPORT_{o,1979}$

(19) $EXPORT_o \leq EXPORT_{o,1979}$

(20) $PPTRADE_{po} \leq PPTRADE_{po,1979}$

Restrictions for PQP First Stage Runs Only*

(21) $AREA_b \leq AREA_{b,1979} * 1.001$

(22) $TECHNOLOGY \leq 0$

(23) $FALLOW \leq 0$

Objective Function (for Stage 2)**

(24) $\sum_{o}[\alpha_o * TOTALCONS_o - 0.5\beta * TOTALCONS_o^2] + \sum_{o} Exprice_o * EXPORT_o - \sum_{o} Imprice_o * IMPORT_o + \sum Ppprice_{po} * PPTRADE_{po}$

{Area under demand curves} {Export revenue} {Import costs} {Net revenue from processed product trade}

$-\sum_{e} PRCOST_e - \Phi\{[\sum_{i}\sum_{t} Revar_i * CROPS_i^2] - [\sum Revar_j\, PRODUCT_j^2]\}^{1/2}$

{Production costs} {Risk costs}

$-0.5 \sum_{b} PQPb_b * AREA_b^2 - 0.5\{PQPA * ANIMAL^2 + PQPT * TRACTOR^2\} - 0.5\{PQP_{bc} * CERAREA^2 + PQPbf * FALAREA^2\}$

{Total area PQP terms} {Technology PQP terms} {Fallow PQP terms}

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*These restrictions are employed to obtain the PQP terms, and replaced by the PQP terms, in the second stage.
**The objective function for stage 1 is the same, except the PQP terms at the end are not included.

VII. VALIDATION AND CALIBRATION: A PQP APPROACH

Before a sector model can be used to simulate the effects of policy interventions, it must be tested for reliability, or subjected to validation tests. Generally, validation tests involve comparing the simulated results of these models for a base year with those observed in that year.

Policy makers, and even many economists, have been reluctant to rely heavily on programming models for planning, due to the poor performance of these models at the disaggregated levels, and due to the lack of widely accepted validation procedures. Considerable attention has been devoted in the last decade to methods which attempt to improve the performance of such models. Such efforts resulted in the modification of constraints via rotations and flexibility constraints and the modification of the objective function via downward sloping output demand functions and risk or penalty functions. Finally, as a last resort, the model parameters such as demand elasticities, risk aversion coefficients, and even model data are subjected to adjustments in an effort to bring the models' simulated results in line with the observed values in the base period ([11]).

In this paper, a method termed Positive Quadratic Programming (PQP), is employed to calibrate TASM with the base year 1979 and projections into 1981 are employed to validate the model as well as the performance of PQP terms introduced into the objective function .

The PQP method amends the objective function of the models presented earlier by a positive measure of the nonlinear part of the cost functions. This cost is calculated from the discrepancy between the linear cost function implied by Leontief technology, and the nonlinear function implied by the observed crop allocation decisions ([12]).

Empirical implementation of positive programming is achieved in two stages. The first stage starts with the data and specification

(11) A comprehensive review and evaluation of validation procedures used in agricultural sector models can be found in Kasnakoğlu and Howitt (1985a and 1985b).

(12) For the theoretical development of the PQP approach see Howitt and Mean (1985).

of a conventional LP (or QP) problem. The actual regional crop acreages $(\tilde{x})$ are increased by a small perturbation ϵ consistent with (Howitt and Mean [1985]) Theorem I, say (.001) $\tilde{x}$, and are formulated as upper bound inequality constraints. The constrained LP problem is now run to obtain the dual values on the calibration constraints for the n — m crops at interior optima. The ϵ perturbation of the calibration constraint right hand side ensures that relevant resource constraints will be binding on the resource constrained crops in the basis.

Although it would be preferable to estimate the quadratic production function coefficients for the constrained crops, they are neither required nor possible for the single time period case.

The vector of (k — m) dual values from the first stage problem for the interior crops is multiplied by the negative reciprocal of the observed acreages $\tilde{x}_i$ $i = 1 \ldots k - m$ and used as the diagonal coefficients of the quadratic cost function in the second stage problem. The second stage problem is then solved for the optimal base period solution. The principal steps are :

a. Given a standard LP or QP and the vector of actual acreage grown $\tilde{x}$. Perturb $\tilde{x}$ by ϵ and add the calibration constraints.

b. Run the first stage problem. The observed crop vector, $\tilde{x}$ is kx1 (k>m), therefore the first stage will result in m binding resource constraints, and k — m dual values corresponding to the binding calibration constraints.

c. If the production function is quadratic in land and separable, the implicit cost function is quadratic in x, and has the form $1/2\tilde{x}^T E\tilde{x}$ where E is a (k — m) x (k — m) positive semidefinite matrix. By the PQP theorem II (Howitt and Mean)

$$-\lambda^* = E\tilde{x}$$

Given the minimal data set $\tilde{x}$, cross cost effects are restricted to zero, and thus for the single period calibration case considered here E is a diagonal matrix with nonzero elements e_{ii} where :

$$e_{ii} = -\lambda_i^* / \tilde{x}_i$$

corresponding to the interior cropping activities.

d. Using the values e_{ii}, the second stage problem is specified as

$$\text{Max } f(x) + 1/2x'Ex$$
$$\text{Subject to } Ax \leq b \quad x \geq 0$$

The second stage problem calibrates exactly with the base year vector $\tilde{x}$ without additional constraints, and is available for policy analysis in the knowledge that the model response will be determined by economic comparative advantage and resource constraints that have a clearly demonstrated empirical basis. In TASM, the objective function is amended with three sets of PQP terms, calculated as described above, to capture the implicit costs or benefits associated with the use of land, fallow rotations and mechanized technology, that could not be captured by the linear functions ([13]).

VIII. VALIDATION TESTS ON TASM

Since the base solution from TASM augmented with PQP terms calibrates exactly with the base year, the conventional validation procedure of comparing the observed and simulated base year values becomes irrelevant. Therefore the 1979 base year runs are used on the one hand to estimate the implicit costs associated with land use, fallow practice and use of mechanized technology and on the other hand to calibrate the model data for internal consistency ([14]). To test the reliability of the model for policy

(13) For details on the implementation of the PQP approach in TASM see Kasnakoğlu and Howitt (1985a).

(14) The data for TASM, as described in Part V, is gathered from a number of different sources. Therefore minor corrections were required in the data to achieve consistency. A detailed account of calibration experience with TASM can be found in Kasnakoğlu and Howitt (1985a).

simulations, the 1979 base solution was then employed to project 1981. For this projection 1979 base year data including yields, demand functions, risk costs, factor costs, exchange rate, trade bounds as well as the PQP terms were updated with ex-post 1981 data or exogeneous projections. The nature of these exogeneous projections and ex-post information employed for 1981 are summarized in Table 2. The comparison of the simulated changes in area, production and consumption, from 1979 to 1981 with the actual changes as presented in Tables 3-5 form the basis of the validation tests on TASM ([15]).

The comparison of the simulated changes in area, production and consumption with the observed changes between 1979 and 1981 show that, with the exception of few products, TASM has been able to predict changes in direction and magnitudes with no significant bias, and has been demonstrated to be a reliable tool for policy analysis.

TABLE 2

DATA AND PARAMETER MODIFICATIONS FOR 1981 SIMULATIONS

General Area	Specific Area	Nature of Change
Resource Constraints	Land, Tractor, Labor, Animal Stock Availability	Those observed in 1981
Foreign Trade	Exchange Rate	Average of the three exchange rates in 1981
	Imports & Exports	Those observed in 1981
Resource Costs	Reservation Wage, Tractor Rent, Fertilizer Costs, Seed Costs, Investment Costs	Those observed in 1981
		Estimated from Input-Output Prices in 1981
Leontief Matrix	Yields	1979 modified yields updated with change in SIS yields in 1979 and 1981
Demand Functions	Price Elasticities	Based on repositioned demand functions obtained by imposing income and population growth and 1981 consumption and price information on the 1979 demand functions
Risk Costs		Inflated by percent change in producer's prices from 1979-1981
PQP Terms	Area, Technology, Fallow	Inflated by percent change in average factor costs from 1979-1981

(15) Further results and discussions on validation tests can be found in Kasnakoğlu and Howitt (1985a).

TABLE 3

PERFORMANCE OF TASM IN PREDICTING DIRECTIONS OF CHANGES

Direction Predicted	Area	Percent	Production	Percent	Consumption	Percent
Correct	31	.89	50	.91	53	.96
Incorrect	4	.11	5	.09	2	.04

TABLE 4

PERFORMANCE OF TASM IN PREDICTING ABSOLUTE CHANGES

Percent	Area		Production		Consumption	
Error	Number	Percent	Number	Percent	Number	Percent
< 2	12	.343	25	.456	24	.436
2-4.9	15	.429	17	.309	18	.327
5-10	5	.143	7	.127	7	.127
> 10	3	.086	6	.109	6	.109
Total	35		55		55	

TABLE 5

REGRESSIONS OF ACTUAL CHANGE RATIOS ON PROJECTED RATIOS

	Intercept	Slope	R	N
AREA	.235 (4.69)	.767 (15.87)	.89	33
		.991 (118.3)	.81	33
PRODUCTION	.136 (.90)	.904 (6.79)	.48	51
		1.021 (35.21)	.47	51
CONSUMPTION	.056 (1.24)	.782 (40.49)	.97	53
		1.002 (54.24)	.97	53

Note: two extreme observations in the cases of area and consumption and four extreme observations in the case of production are excluded from the regressions. See Kasnakoglu and Howitt [1985a] for a discussion on those products.

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