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MEDIUM-TERM GROWTH PROSPECTS FOR TURKISH AGRICULTURE: A SECTOR MODEL APPROACH

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I. INTRODUCTION

At the end of the 1970s, following a period of rapid growth and structural transformation based on import-substituting industrialization policies, Turkey experienced a serious economic crisis. Accelerating inflation, high balance of payments deficits, and declining growth rates necessitated a major stabilization program in January 1980. In addition to its short-term goals, the program and its subsequent extensions embodied an explicit long-term objective of restructuring the general import substitution development strategy into one of outward-oriented or export-led industrialization. The new strategy consisted of reducing the scope and increasing the efficiency of state intervention, while emphasizing reliance on market forces.

For the agricultural sector this new strategy meant dismantling a wide ranging incentive system composed of output support policies and input subsidies. There was, for example, a sharp reduction in input subsidies, particularly fertilizer. The degree of intervention in output markets also declined, with a shift toward a floor price system that lessened the gap between domestic and border prices for agricultural products. In addition, the introduction of a competitive exchange rate policy and other steps toward trade liberalization, which included new export incentives, encouraged the export of agriculture-related products.

In the short run, the objectives of agricultural policy were to increase exports and decrease the fiscal burden demanded by agricultural input and output price support policy. However, the implications of this shift in development strategy raise fundamental questions over the medium and long terms:

(1) Is an annual growth rate of agricultural GDP around 3.0 per cent (as mentioned in the Fifth Five Year Development Plan) possible in the medium term?

(2) What are the trade-offs between the expansion of exports and self-sufficiency in foodstuffs? Specifically, what are the likely effects of the new strategy on the per capita consumption in major foodstuffs?

(3) What are the possible patterns of resource utilization and production resource requirements under an export-, market price–oriented strategy?

(4) What are the potential regional effects of the new strategy?

This article will hopefully contribute to the deliberation of the agricultural issues raised above by calculating quantitative estimates in a more systematic way.

I would like to thank Carl Gotsch, Haluk Kasnakoglu, and Erinc Yeldan for their helpful comments.

To this end, Section II discusses the basic structure of the model which is used to simulate the agricultural sector. Section III is devoted to the results of the projection application. In the last section, the policy implications of the simulation exercise will be discussed.

II. STRUCTURE OF THE MODEL

Guiding agricultural policy in Turkey is no easy task. Agricultural production is highly diversified due to a variety of soil and agro-climatic conditions. The structure of production presents a challenging diversity with regions having both crops in common and regional specialties. The techniques of production for common crops are quite different among regions because of the differences in climate and resource endowments. This diversity in production points out an unusually interdependent production structure on the supply side. On the demand side, the regions compete with each other for access to the same national and foreign markets.

The interdependencies in supply and demand show that the effects of changes in the government's policies will certainly be driven by interactions among crops, regions, and production technology. Evaluating policy intervention and growth possibilities in a partial context, rather than tracing their effects through the whole sector, can give misleading results. The direct effect of a new policy may be desirable, but may be lessened or nullified by indirect effects that are more difficult to evaluate and predict. To take into account interactions involved in the sector for the evaluation of policy effects and growth possibilities, a regional, partial equilibrium, and static optimization model was designed.

The basic structure of the Turkish Agricultural Regional Programming Model (TARP) is similar to the CHAC model for Mexico [3], the pioneering study in the use of mathematical programming for economic analysis in agriculture. TARP is a one-period sector-wide model in the sense that it describes total national supply (production and imports) and use (domestic demand for food, feed, and exports). The base year is 1981. Figures 1 and 2 summarize the flow of inputs and outputs at the regional and national levels.[1]

The most important features of the model are: (1) the production side of the model is disaggregated to seven regions to explore interregional comparative advantage for policy impact analysis; (2) the crop and livestock subsectors are integrated endogenously—the livestock subsector gets inputs from crop production and provides animal power for crop production; and (3) foreign trade is allowed in raw and as well as in processed form for a limited number of commodities.

The regions in the model are aggregated from provincial data to minimize the aggregation error. In total, the model is based on twenty-four single annual crops, twelve perennial crops, and seven livestock activities. Taking into account seven production regions and two production techniques, namely, mechanized and non-mechanized crop production, the total number of activities specified in the model is 831. The activities are distributed among regions depending on the dominant cropping pattern in the base year.

[1] The algebraic description of the TARP Model is presented in Appendix A.

Fig. 1. Regional Structure of TARP

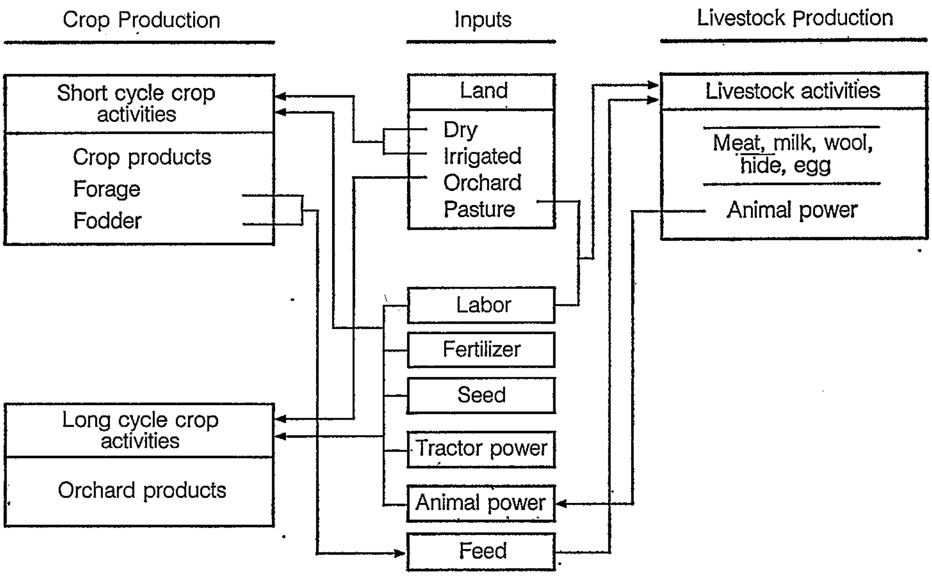
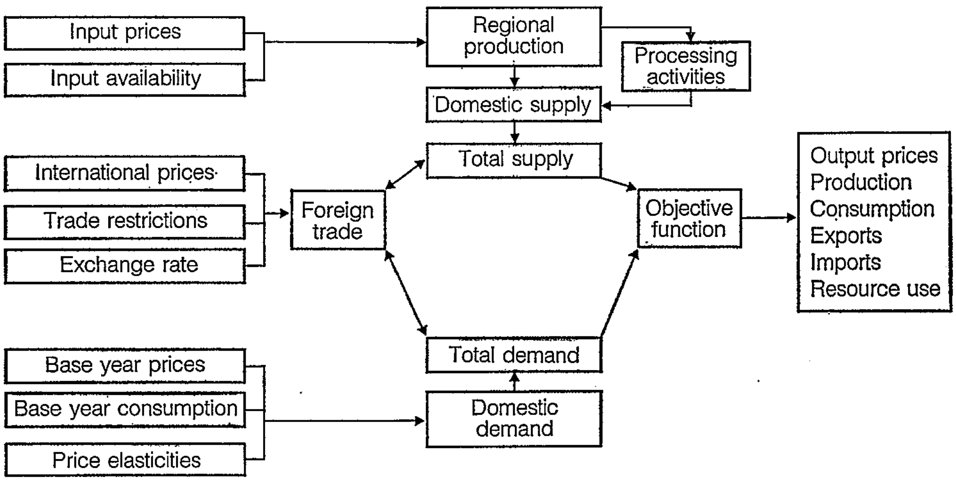


Fig. 2. National Structure of TARP



The model is used as a tool to provide an internally consistent quantitative framework for the analysis of programs and policies in Turkey's agricultural sector. In general terms, the modeling exercise carried out in this study parallels other studies previously carried out at the national or regional level,[2] but the present

[2] For a comprehensive review of programming models used in agricultural policy analysis, see [5]. Previous research on Turkish agricultural sector models are discussed in [7].

model enhances earlier studies in several important ways. Most notable are the regionalization of production and the validation procedure carried out for the model. In addition, the data and structure of the model reflect the production and consumption environment which has been in effect since the shift toward market-oriented policies that began in 1980.

Experiments conducted with the model show how a sectoral model can help to shed light on a variety of issues confronting agricultural policymakers. It has been used, for example, to address questions related to growth, regional and national supply responsiveness, factor use, and production and consumption mixes.

Although TARP is a constrained optimization model in the mathematical sense, it is a descriptive model with respect to economic behavior. Policy goals are not maximized directly, but rather the model is used to simulate sectoral behavior under alternative assumptions about policy instruments. This feature of the model helps to make it a useful aid in decision making.

The model has been subjected to a comprehensive validation procedure.[3] The validation results supported the model's use for policy planning and impact analysis; its construction complements other on-going discussions on the assumptions, issues, and outcomes related to agriculture. The model provides a framework for tracing the direct and indirect effects of policies through a detailed and flexible representation of the complex technical and structural relationships which characterize Turkish agriculture. The simulation results reflect the data used as well as the assumptions which shaped the structure of the model at the time of application. The results, in a sense, present a snapshot of the sector viewed through the structure of the model. With a different set of assumptions than the one used for the base year, the application results could diverge from the present state. The model, being an abstraction of the actual environment, is able to address the issues, and the results match a high number of "if" statements.

A. *The Methodology*

Often programming models used for agricultural policy analysis show a far greater specialization of production than is observed. This problem is exacerbated when the model is built on a regional basis with very few empirical constraints and with wide diversity in crop production. Several remedies, such as adding upper and lower bounds and rotation constraints are used in the literature to calibrate the models to the observed data. On the other hand, tightly constrained models can only produce the subset of results that the calibration constraints dictate. Assuming that farmers are rational, which implies the observed cropping pattern is optimal, the overspecialization problem is due to the discrepancy between the linear cost (production) function implied by the LP model and the cost function faced by farmers (or by the first order conditions implied by the model). For this reason, the supply side of this model incorporates a new technique known as Positive Quadratic Programming (PQP).[4] PQP overcomes the overspecialization problem in production by using the information based on the actual behavior of

[3] The validation steps in the TARP model is presented in Appendix B. For a comprehensive discussion of the validation procedure see [2].

[4] For a comprehensive description of the PQP methodology, see [6] and [9].

the farmers. The underlying assumption of the methodology is that farmers operate in competitive markets and maximize profits. An important implication of this assumption is that the regional cropping pattern in the base year represents a global optimum of the maximization problem. It is consistent with the main goal of the sector models: to simulate the response of producers to changes in market environments, resource endowments, and production techniques. Hence, although the models are optimization models mathematically, they become simulation models by incorporating the behavior (maximization of economic surpluses) of the agents into the models' structure.

The acceptability of the models in the literature depends on whether or not they can approximate the observed values in the base year. At the sector level, normative statements are difficult to support and provide little help for policy analysis in decentralized economies, but the identification of interdependencies and causal relationship can help to answer production-related policy questions. Approximating actual cropping patterns in regional models is difficult to achieve with an unconstrained model, because it is not possible to estimate all the costs and benefits of growing a specific crop. In addition, given quantifiable resource constraints, the production function used in linear programming implies constant returns to scale. However, agricultural production by nature exhibits diminishing returns to scale mainly due to risk and land quality. The increase in the production of a specific crop could be realized by expanding its production to less suitable soil; then the benefit of diversification would be diminished. The revenue is linear in output, and so the concavity of the profit function is contained in the cost function. The unknown Hessian of the cost function is estimated by using the dual values of the area constraints on crop production activities. In other words, PQP specification is based on the discrepancy between the linear cost function and the cost function implied by the farmers' behavior. It is assumed that farmers stop producing the most profitable crops, not because of constraining resources, but because marginal net benefits are equal to increasing marginal costs. Rising marginal costs are assumed to be a function of risk aversion as well as declining marginal product. The algorithm is called "positive" because the original normative quadratic programming model is modified to reflect the information contained in the data based on the observed behavior of the farmers.

The implementation of the methodology for the sector model can be described in two stages. The first stage is similar to the validation step of the programming models. The model is calibrated and reproduces exactly the observed output levels of the base year by running the model with the calibration constraints. In the second stage, the dual values obtained from the crop area constraints are incorporated as quadraitc penalty terms in the cropwise objective function of the problem in Stage 2, and the upper bound constraints on acreage are removed.[5] Without any upper and lower bounds and rotational activities, the model's reaction to policy changes is a smooth trade-off based on changing comparative advantage.

As noted earlier, it can be shown that the quadratic nonlinearity in the objective

[5] Equations (1)–(20) in Appendix A are used in the first stage run of the model for the estimation of the PQP terms. In the second stage run of the model the calibration constraints (equations [17]–[19]) are removed and equation (20) is replaced by equation (21).

function results from a quadratic production function and/or mean-variance risk specification. The quadratic term can be called as the implicit cost, since it is implied (in a positive sense) by farmers' crop allocations.

B. *The Objective Function*

The objective function of the model is quadratic in revenue and cost because it maximizes the area between linear demand and supply curves (see equation [21] in Appendix A). The maximand consists of the sum of consumers' and producers' surplus plus net export revenue. The optimal solution entails equating supply to domestic plus foreign demand and prices to marginal costs for all commodities.

By incorporating linear demand curves, it is possible to solve the model for prices and quantities endogenously and simultaneously. The model considers the sector as the price maker, but implicitly assumes that producers and consumers are price takers, and hence they operate in perfectly competitive output and factor markets.[6]

The incorporation of demand curves in the model means that the programming solution will correspond to market equilibria.[7] The sector-wide effects of various policies and exogenous changes—e.g., subsidizing or taxing inputs or output prices, or varying the exchange rate—can be investigated. Furthermore, the inclusion of demand curves makes it possible to identify the distribution of benefits from changes in agricultural output. For example, if the domestic demand is price inelastic, then the economic return to producers from an increase in output is negative, whereas the effect on consumers' welfare is positive.

C. *Production Technology Matrix*

TARP contains more than eight hundred activities to describe the production of fifty-six commodities.[8] Each production activity defines a yield per hectare for crop production and yield per head for livestock production. The activities use fixed proportions of labor, tractor and animal draught power, fertilizers, seeds and seedlings. The relationship between inputs and outputs are those which were actually observed in each region and are not necessarily biological or economic optima. The ratio of each input and output varies regionally for each crop.

Six groups of input (land, labor, tractor power, animal power, fertilizer, and seed) have been incorporated in TARP. Land is classified in four categories: dry, irrigated, orchard, and pasture.

Seasonality in agriculture has been captured by specifying labor, animal power, and tractor power on a monthly basis. Labor and tractor power are directly constrained by current availability. The supply of animal power is controlled endogenously by livestock production activities. Labor input is measured in man-hour equivalents and shows actual time required in the field. Tractor hours correspond to the usage of machinery in actual production and transportation-related activities.

The two kinds of fertilizer, namely, nitrogen and phosphate, are measured in

6 For models with alternative market forms see [3] and [11].
7 For a proof see [8].
8 See Appendix A for the list of commodities incorporated in the model.

terms of nutrient content. They are considered to be traded goods and are not restricted by any physical limits.

In addition to the costs of labor, tractor power, and fertilizer, seed and seedlings (for vegetables and tobacco) are included as production costs for annual crops. Fixed investment costs are assigned for perennial crops.

The livestock subsector is an integrated part of the model. The explicit production cost for animal husbandry is labor. Other inputs required are cereals, straws and forage, which are byproducts of crop production. Pasture land is also required for grazing, except in the case of poultry. The inputs are all given in fixed proportions.

D. *The Data Sources*

The data can be grouped in two main clusters: (1) micro level production coefficients which form the core of the model, and (2) regional and national data such as the regional cultivated land, production, national consumption, factor prices, and international trade statistics.

The data was put together based on various sources from such institutions as the State Institute of Statistics (SIS) [12]–[21], the State Planning Organization [22], and the Land and Water Development Agency [23] [24]. FAO [4] and the World Bank [25] sources were also used to complement and cross-check the data from Turkey.

The model has been solved using the linear and nonlinear programming software MINOS [10]. The credibility of the model is evaluated by testing its performance for a period other than the base year and for which the value of exogenous variables for the projected year are used to update the model and the benchmark data for the projected year are compared with the simulated magnitudes (see Appendix B).

III. MEDIUM-TERM GROWTH PROSPECTS FOR TURKISH AGRICULTURE

The medium-term growth prosptcts for Turkish agriculture are analyzed projecting the model to 1990. The base projection is carried out by expanding resource endowments and permitting some yield growth, with appropriate adjustments made on demand to reflect income and population growth. Historical international trade limits are released to reflect export market penetration. Variants of the base projection are run to test the effects of more rapid irrigation development and other policy variables on sectoral performance.

To set up the projection, a number of changes must be made to the parameters or exogenous variables of the model that simulate the effects of investment, autonomous technological change, input price policy, and growth in the whole economy.

A. *Adjustments for the Projection*

In projecting the model from 1981 to 1990, four types of adjustments must be taken into account: changes in total demand, resource endowments, input prices, and technology.

(1) Changes in total demand: Increases in disposable income per capita, population growth, and changes in trade possibilities are the main factors that drive changes in total demand. The effects of growth in population and income per capita on product markets are simulated in the model by rotating the demand curves in the price quantity space to positions corresponding to higher levels of consumption in the projection year. Income growth raises the demand for commodities by different factors depending on the Engel elasticity. Export and import upper bounds are changed from their base year magnitudes to take into account the possibility of export market penetration.

(2) Changes in resource endowments: More irrigated land is assumed to be available as a result of actual or potential investment during the projection period. The regional distribution of the increase is determined by the potential irrigation possibilities of the regions. The regional growth in animal herd size is assumed to follow the growth pattern of the five-year period prior to the base year. The labor and tractor power endowments are revised according to the historical growth rates.

(3) Changes in input prices and supply functions: Projections are carried out in constant prices. It is assumed that the only real price change in production inputs occurs in fertilizer price due to the elimination of subsidies. As a result, the intercept terms of the implicit cost curves will change, but their slope terms are assumed to remain constant during the projection period.

(4) Changes in technology: In programming models which incorporate several techniques of production for a single crop, part of the changes in technology over time can be captured by endogenous movements along the production function. However, the production function might shift outward over time due to autonomous technological change. The input-output relationship for crop and livestock activities in TARP are adjusted for the projection simulations to reflect anticipated changes due to the adoption of improved technologies and/or changes in the choice among techniques already in use. For each crop and livestock activity, a certain increase in productivity per hectare or per animal is projected with a corresponding increase in factor input. Except for a few commodities, the yield growth per year is assumed to be similar to the growth rates realized prior to the base year. Data on increases in productivity per animal and factor use were acquired from the World Bank [25].

B. *The Results of Projection to 1990*

Table I compares key indicators at the sectoral level from the 1990 projection solution and 1981 base. The TARP projection solution implies a growth rate of 3.0 per cent per year in gross production value during 1981–90. The corresponding growth rate in value-added stays around 2.5 per cent per year, a figure compatible with the performance of the agricultural sector in recent years.[9]

Increases in agricultural employment are close to population growth rates. This is mainly due to the shift of agricultural production to more labor-intensive crops. However, only a small portion of the increase in value-added can be attributed to gains in labor productivity. Value-added in agriculture is distributed among landowners, tenant farmers, and landless workers. Unfortunately, TARP can only

[9] Agricultural GDP growth rate during 1980–84 was 2.3 per cent per year.

TABLE I

OUTPUT, INCOME, AND EMPLOYMENT: 1981 AND 1990 BASE CASES

(All values at constant 1981 farm-gate prices)

	Base Solution 1981	Projection 1990	Growth Rate 1981–90 (% p.a.)
Value of production (U.S. $ million)	15,049	19,135	3.0
Value-added[a] (U.S. $ million)	12,030	14,626	2.5
Agricultural employment[b] (1,000)	6,585	7,961	2.4
Value-added per worker (U.S. $)	1,827	1,839	0.6
Labor content of the value-added	36	38	

[a] Value-added = gross value of production less cost of fertilizer, tractor and animal power, and working capital items. The costs of fixed asset investment are not included.

[b] Male adult equivalent, assuming five hours per day actually spent in the field and 295 days worked per year. Number on the basis of hours of employment during the peak month of the year.

differentiate between labor and non-labor income. The labor content of value-added shows that the relative earnings of labor will not change during the period.

1. *Area and production effects*

The projection results point out the importance of irrigated land. All of the irrigated land newly put into production is used without any decline in the regional shadow prices for irrigated land. Slight increases in the use of dry land are observed in relatively irrigation scarce regions, such as the Black Sea and Eastern regions, mainly for the cultivation of feed crops. In all other regions, dry cultivated areas decline, due largely to the elimination of fertilizer subsidies. Dry areas devoted to cereal production in the base year shift to pulse production. High value crops, such as tubers and vegetables, gain most from the increase in irrigated land.

The structure of production is fairly responsive to structural and policy changes (Table II). In crop production, the greatest growth occurs in vegetable production (3.7 per cent) and the lowest in cereal production (1.5 per cent). Without any intervention in output markets, the growth rates reflect the effects of income elasticities and the export possibilities of the commodity groups. In case of cereals, part of the increase in production is absorbed by livestock production as feed.

The projected regional production pattern indicates that regional specialization would increase, especially for export crops (pulses, vegetables, fruits and nuts). The production of export crops will grow faster than cereals in all regions. However, the more fertile coastal regions are expected to achieve relatively higher growth rates than inland parts of the country in the production of export crops. The Mediterranean and Aegean regions will benefit most from the changes in the consumption and export structures due to their advantages in yields and resource endowments of irrigated land.

TABLE II

AGGREGATE RESULTS OF 1990 PROJECTION

(All values at constant 1981 farm-gate prices)

	Production (U.S. $ Million)			Consumption (U.S. $ Million)			Net Trade (U.S. $ Million)			Price Index 1990 (1981=100)
	Base Solution 1981	Projection 1990	Growth Rate 1981–90 (% p.a.)	Base Solution 1981	Projection 1990	Growth Rate 1981–90 (% p.a.)	Base Solution 1981	Projection 1990	Growth Rate 1981–90 (% p.a.)	
Cereals	3,925	4,432	1.5	3,304	3,696	1.4	45	43	−0.6	115
Wheat	2,713	2,998	1.3	2,573	2,838	1.2	6	0	−45.5	117
Others	1,212	1,434	2.1	731	858	2.0	39	43	1.3	106
Pulses	324	385	2.2	126	165	3.4	194	215	1.3	100
Tuber crops	949	1,207	3.1	921	1,172	3.1	23	29	2.9	97
Vegetables	1,186	1,586	3.7	1,170	1,542	3.5	15	18	2.2	97
Oil crops	303	375	2.7	298	378	3.0	7	9	2.8	107
Industrial crops	1,236	1,469	2.2	839	1,069	3.1	577	610	0.7	104
Fruits and nuts	3,654	4,712	3.2	3,174	4,084	3.2	185	225	2.5	91
Livestock products	3,474	4,970	4.6	3,403	4,882	4.6	116	141	2.5	106
Processed products							370	495	3.7	n.a.
Total	15,051	19,136	3.0	13,235	16,988	3.2	1,532	1,785	1.9	103

Individual crop prospects vary considerably. At one extreme, cotton's annual projected growth rate is 1.5 per cent. At the other extreme, tomato production is projected to grow by almost 4 per cent per year. Wheat and barley production are expected to expand by 1.3 per cent and 2.1 per cent per year respectively. Wheat exports decline to zero in 1990; however, barley exports increase by 20 per cent. Rice is the only major agricultural import item, but its production is expected increase by almost 3 per cent per year despite competition from imports.

The interpretation of changes in livestock production requires great caution, because the model does not incorporate fixed investment costs or any other overhead costs for expanding the livestock inventory. But if livestock inventory is assumed to follow its historical rate of expansion, it is possible to say that with any increase in demand, livestock production has a greater potential to expand than crop production. Part of the growth in cereal production can be attributed to the need for feed crops to nourish the growing livestock inventory. Although the model structure is rigid in its feed requirements, the high growth potential of the livestock subsector points to fierce food-feed competition. This competition is immediate because most of the pasture and meadow lands are already overgrazed. The Central and Eastern regions are projected to remain the major suppliers of livestock products with 30 per cent and 25 per cent of the total production respectively. In the Eastern region livestock production accounts for 62 per cent of the total regional production.

2. *Consumption and price effects*

The projected growth rates for consumption according to major commodity groups point out that considerable changes will occur in the consumption bundle. The largest change is a fall in cereal consumption, especially wheat. Only moderate gains are expected in other commodities, but substantial increases are indicated for livestock (including poultry) over the base period (4.6 per cent per year).

It is not possible to detect the income distributive effects of changes in the consumption structure, because a lack of data makes it impossible to specify demand functions according to income groups. Part of the decline in cereal consumption and increase in high income elastic crops, such as livestock products and vegetables, can be explained by the shift in the consumption bundle of the upper income classes. On the other hand, these changes show that the per capita consumption of wheat, Turkey's main staple, is bound to decline in the projected year since the total consumption growth rate is 1.2 per cent per year, whereas the population is expected to grow by at least 2.1 per cent per year.

Various structural and policy changes lead to changes in the real prices of agricultural commodities via a series of regional and crop substitutions in production and consumption. Laspeyres indices of major commodity groups are presented in Table II. Due to a relatively higher improvement in yields and an increase in the availability of irrigated land, the real prices of vegetables and tuber crops decline slightly. However, the prices of commodities that have a significant share in the consumption bundle of lower income groups show relative increase. For example, the highest increase occurs in the price of wheat, a 17 per cent rise during the eight year period. In addition, sugar beet and sunflower prices are expected to increase by 11 per cent and 12 per cent respectively by 1990. One positive aspect of the results is that prices of pulses remain constant through the period. The consumption of pulses increases by 3.4 per cent per year, which is higher than the population growth rate. The rather moderate increase in the price of livestock products is mainly due to the promotion and intensification of poultry production which has been incorporated in the projection assumptions. As a result, the price of poultry meat is expected to decline sharply by more than 40 per cent, whereas red meat prices will increase by 9 per cent.

3. *Developments in exports and comparative advantage*

As mentioned earlier, export limits are released to some extent from the base period magnitudes to reflect recently adopted government trade liberalization policies, but the projected export quantities have still upper bounds to reflect realistic export market penetration. The average growth rate per year during the period 1980–85 of 2.5 per cent, which overlaps with the liberalization era, is taken as the basis for the potential increase in exports. The expected export quantities for all traded commodities are realized except for wheat and cotton. Total exports are expected to grow at an average annual rate of 1.9 per cent. Cotton exports, on the other hand, decline by 1.5 per cent per year. The best performance in exports is shown by processed items, which include such traditional export products as olive oil, tea, dried fruits, and shelled hazelnut.

TARP can also be used to identify social profitability in exports by tabulating exchange or domestic resource cost for export commodities from the simulation results. A Bruno-style [1] estimate of the TL cost of an additional dollar of exports may be calculated from the dual values of trade bounds. Shadow prices on export bounds show the potential increase in the objective function (equation since exports are evaluated at the farm-gate equivalent export prices, these shadow prices signify the amount of producers' excess profits per incremental unit exported. [21] in Appendix A) by releasing the export bounds by one unit. In other words, The difference between the exogenous export price and producers' excess profits gives the marginal cost of domestic production or marginal return on selling the commodity in the domestic market. Production costs derived from the model are a composite of input costs exogenously priced and input costs endogenously valued by the model. The latter are composed of a marginal valuation of fixed resources and the implicit costs embodied in PQP terms. The exchange cost is calculated as the ratio of marginal product costs in TL to the export price in dollars, thus measuring the level of production costs in TL required to earn a dollar in exports.

Several conclusions can be drawn about the competitiveness of Turkish agriculture in international markets from Table III. First, a comparison of the exchange costs with the prevailing exchange rate (US$1 = TL112.3) shows that overall Turkish agriculture is quite competitive in the world market at the margin. Significant potential gains in exports may be realized by increasing export marketing efforts, assuming that Turkey is a small country. Second, the ranking of the major export crops remains stable during the projection period. Third, the

TABLE III

COMPUTATION OF EXPORT COMPARATIVE ADVANTAGE: EXCHANGE COST

	1981	Rank	1990	Rank
Cereals	89.1	IV	92.3	IV
Wheat	104.9	13	123.1	14
Barley	86.9	10	92.3	9
Pulses	100.4	VI	109.9	VII
Chick peas	82.8	8	76.3	3
Dry beans	110.4	14	112.3	13
Lentil	112.3	15	112.3	13
Tuber crops	84.9	III	87.0	III
Potato	112.3	15	107.9	12
Onion	81.4	7	81.5	7
Vegetables	98.6	V	96.2	V
Tomato	99.1	12	97.1	11
Green pepper	55.6	1	53.8	1
Oil crops	76.6	I	78.0	I
Olive	75.4	4	76.1	3
Groundnut	76.9	5	78.5	5
Industrial crops	102.0	VII	97.2	VI
Cotton	112.3	15	112.3	13
Tobacco	88.3	11	82.7	8
Fruits and nuts	79.0	II	85.8	II
Citrus	79.9	6	97.0	10
Apple	74.9	3	67.2	3
Hazelnut	66.0	2	59.8	2
Melon	84.0	9	79.7	6

Note: Exchange cost is the level of production costs required (in TL) to earn a dollar in foreign exchange through export.

tabulations give some clues on how to improve the gains from trade by changing the composition of agricultural exports. For instance, the exchange costs for olive (or olive oil), groundnut, vegetables, and apple show a high potential for foreign exchange earnings. However, cotton and lentil exports, which have high shares of total export revenue, are not profitable at the margin. Further increases in the export of these crops is only possible through export subsidies. Therefore, the results indicate the importance of the Fruit and Vegetable Project (MEYSEB), which has been recently revitalized by the Ministry of Agriculture and Forestry and the World Bank.

C. *Variants of the Base Projection*

The Fifth Five Year Development Plan [22] emphasizes structural transformation and export-oriented policies, rather than price support policies for agricultural development. First, the importance of improving the performance of existing irrigation networks and increasing investment in infield development, drainage, and land reclamation are emphasized in the plan. Second, institutional reorgani-

TABLE IV

VARIANTS OF THE BASE PROJECTION: ESTIMATES OF GROWTH RATES, 1981–90

	Base	S1	S2	S3
Instruments[a]				
Irrigation investment		X	X	X
Export promotion			X	X
Technical progress				X
Production	3.04	3.12	3.22	3.47
Value-added	2.47	2.52	2.77	3.09
Consumption	3.17	3.17	3.15	3.32
Price index (1981=100)	103	102	103	99
Exports	1.93	2.63	4.14	5.1
Employment	2.4	2.69	2.9	2.88
Share of labor in value-added[b]	37.48	37.68	37.18	36.28

[a] See text for the explanation of the scenarios.
[b] Percentage share.

zation of the extension services is given priority for technological development in agriculture. For this purpose "The Agricultural Extension and Applied Research" project has been recently set up. Agricultural exports are targeted to rise by 9.1 per cent per year, and the achievement of this rise is tied to (1) continuous export promotion, especially that directed toward the Middle East countries, and (2) flexible exchange rate policies.

Three different scenarios were simulated to find out about the relative importance of agricultural development policies and their effects on the agricultural sector. The scenarios are comparative static experiments starting from the base projection. Hypothetically successful performances in irrigation, export promotion, and technological improvement are incorporated consecutively into the model. By adding one instrument at a time, rather than strict comparative advantage analysis, it is possible to detect both the relative importance of the policy instrument for agricultural growth and the performance of the sector.

All adjustments are assumed to take place relative to base projection assumptions. The scenarios are defined as follows:

Scenario 1 (S1): Regional irrigated land endowments are expanded by 1 per cent per year in addition to the expansion assumed in base projection.

Scenario 2 (S2): Scenario 1 plus export quantities increase by 100 per cent over the assumed increase in the base projection. Ceilings on the potential size of export markets are maintained in an attempt to portray a more realistic trading environment.

Scenario 3 (S3): Scenario 2 plus additional improvement in yields by 1 per cent per year over the base projection.

The macro results of the experiments are presented in Table IV. The experiments indicate that a successful Scenario 3 should occur to achieve a 3.0 per cent annual growth rate in agricultural GDP during the period. On the consumption

TABLE V

GROWTH RATES IN PRODUCTION AND PER CAPITA CONSUMPTION OF AGRICULTURAL PRODUCTS: FIFTH DEVELOPMENT PLAN AND TARP ESTIMATES

Crops	Production		Crops	Per Capita Consumption	
	Fifth Plan[a]	TARP[b]		Fifth Plan[a]	TARP[b]
Wheat	2.4	1.3	Wheat	0.0	−0.9
Barley	4.1	2.1	Rice	3.8	0.7
Cotton	1.6	1.4	Other cereals	1.9	−0.2
Sugar beet	1.3	2.9	Pulses	0.2	1.3
Sunflower	3.9	2.2	Vegetables	0.5	1.3
Citrus	3.4	3.0	Citrus	−0.2	1.1
Meat[c]	5.8	4.4	Meat	2.0	2.3
Milk	5.0	3.5	Milk	2.6	1.3
Eggs	9.4	9.2	Eggs	4.5	5.7

[a] Calculated from SPO [22].
[b] Calculated from TARP base projection.
[c] Including poultry meat.

side, the results show a definite trade-off between domestic consumption and exports. The benefit of irrigation expansion to the consumer disappears with a higher growth rate in exports. But the negative effects of export promotion can be prevented by slightly higher growth in yields as indicated by the results of S3. One positive effect of export promotion can be seen in employment increase. Agricultural employment improves significantly from S1 to S2, whereas there is no change from S2 to S3. The improvement from S1 to S2 is mainly due to the high labor intensity of export crops. With improvements in yields, the model's choice of technology shifts slightly from nonmechanized to mechanized. Despite the increase in production and employment, the relative earnings of labor do not improve in any of the scenarios compared to base year value.

IV. CONCLUSIONS AND POLICY IMPLICATIONS

The results of medium-term growth prospects pinpoint an important development resulting from more market price– and export-oriented policies. Given a high population growth rate, there is a significant trade-off between food security and export earnings. Present export-oriented policies would mean an end to self-sufficiency in major foodstuffs and a shift in the production pattern toward crops with high income elasticity.

TARP and the Fifth Development Plan growth rates for selected agricultural commodities are presented in Table V. The results indicate that the planned targets will be impossible to achieve with only the moderate performance by the sector assumed in the base projection. Experiments with the variants of the projection show that the Fifth Development Plan targets can be realized only if the conditions for the "successful scenario (S3)" are met. This scenario assumes higher increases in irrigation development, export promotion, and technological development than the base projection. However, the experiments showed that a growth rate in agricultural GDP of around 3.0 per cent per year until 1990 is feasible, if certain key policies are pursued.

The arable land frontier in Turkey was already reaching its limits in the late 1960s. Continued agricultural growth requires a marked increase in agricultural productivity either from yield increases or, to a lesser extent, from more intensive use of existing cultivated areas. The projection results point out two general key policies: (1) increasing the rate of investment in quick yielding irrigation projects, especially completing on-farm projects in the areas where the irrigation infrastructure has been completed, and (2) more efficient generation and transfer of productivity-increasing improvements in the agricultural sector which requires institutional changes in research and extension services. The negative production effects of eliminating fertilizer subsidies on some crops (mainly cereals) and increasing subsidies for inputs such as seeds, fuel, and credits can be prevented by giving more emphasis to the above types of policy.

The regional impact of the simulations suggests the importance of the livestock subsector for the relatively less-developed eastern regions. Therefore, the transition from extensive to intensive technology in animal husbandry is crucial for interregional balanced growth under the new development strategy.

The projection results indicate further that export-oriented policies would be incompatible with the targets set in the Fifth Development Plan: "Except for the import of seed stock and stud animals, the home demand (of agricultural products) will to a large extent be met by indigenous production, the imports necessitated by price and export policies being considered in agricultural programmes. The objective aimed at is to raise the export of agricultural products by an average 9.1 per cent per annum" [22, p. 54]. The projection scenarios clearly indicate a strong trade-off between domestic consumption and exports. As a result of the shift in production pattern to crops for which Turkey has comparative advantage, the continued availability of a reasonably low cost source of calories and nutrients (wheat, sugar, and oils) will be possible only if import constraints on these commodities are relaxed. The government must be willing to allocate scarce foreign exchange resources to acquire these commodities.

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APPENDIX A

ALGEBRAIC PRESENTATION OF THE MODEL

Indices

s = land type: dry, irrigated, orchard, pasture
r = region: 1. Marmara, 2. Aegean, 3. Black Sea, 4. Central, 5. Mediterranean, 6. East, 7. Southeast
l = labor: divided into twelve months
a = animal power: divided into twelve months
m = tractor power: divided into twelve months
f = fertilizer type: nitrogen, phosphate
i = crop production activities
j = livestock production activities
po = processed products: wheat flour, tomato paste, sunflower oil, olive oil, dry tea, raisin, dried fig, shelled hazelnut

c = production costs: labor, tractor, fertilizer, seed or seedlings, capital (for perennial crops)
o = output: wheat, corn, rice, rye, barley, chickpea, dry bean, lentil, potato, onion, tomato, green pepper, cucumber, eggplant, sunflower, olive, groundnut, cotton, sugar beet, tobacco, sesame, soybean, garlic, apple, tea, citrus, grape, peach, apricot, cherry, melon, pistachio, quince, hazelnut, fig, alfalfa, sheep-meat, sheep-milk, sheep-wool, sheep-hide, goat-meat, goat-milk, goat-hair, goat-hide, angora-meat, angora-milk, angora-wool, angora-hide, cow-meat, cow-milk, cow-hide, buffalo-meat, buffalo-milk, buffalo-hide, poultry-meat, eggs
g = livestock inputs from crop by-products:
as forage and straw (wheat, corn, rye, barley, pulses, alfalfa, fodder);
as concentrates and pulps (wheat, barley, rye, sugar beet)
t = production technique: mechanized, animal
ca = cereal land differentiation: dry, irrigated, and fallow areas for wheat, corn, rye, and barley
ba = land differentiation for crops except cereals

Parameters

cp = crop production coefficients
lp = livestock production coefficients
$ccost$ = crop production costs
$lcost$ = livestock production costs
fci = feed crop dummy (is equal to 1 if the crop used for feed, 0 otherwise)
$conv$ = conversion factor for processed products
po = processed products
exp = export prices at farm-gate
imp = import prices at farm-gate
$procp$ = international prices of processed products
$resav$ = resource availability
α = demand function intercept
β = demand function slope
pqp = PQP term for crop and orchard area
$barea$ = crop and orchard areas for the base year
e = perturbation factor (is equal to 1.001)

Variables

$CROP$ = crop production
$LSTOCK$ = livestock production
FERT = fertilizer use
$COST$ = production costs
$REGPROD$ = regional production
$TOTPROD$ = total production
$TOTCONS$ = total consumption
$IMPORT$ = imports
$EXPORT$ = exports

$PROCTR$ = processed product trade
$AREA$ = crop production area

Equations

Land constraints:

$$\sum_i \sum_t cp_{r,s,i,t} * CROP_{r,i,t} + \sum_j lp_{r,s,j} * LSTOCK_{r,j} \leq resav_{r,s}, \quad \text{for all } s \text{ and } r. \qquad (1)$$

Labor constraints:

$$\sum_i \sum_t cp_{r,l,i,t} * CROP_{r,i,t} + \sum_j lp_{r,l,j} * LSTOCK_{r,j} \leq resav_{r,l}, \quad \text{for all } l \text{ and } r. \qquad (2)$$

Tractor power constraints:

$$\sum_i \sum_t cp_{r,m,i,t} * CROP_{r,i,t} \leq resav_{r,m}, \quad \text{for all } m \text{ and } r. \qquad (3)$$

Balances for draft animal services:

$$\sum_i \sum_t cp_{r,a,i,t} * CROP_{r,i,t} - \sum_j lp_{r,a,j} * LSTOCK_{r,j} = 0, \quad \text{for all } a \text{ and } r, \quad (4)$$

$$LSTOCK_{r,j} \leq resav_{r,j}, \quad \text{for all } j \text{ and } r. \qquad (5)$$

Fertilizer accounting:

$$\sum_i \sum_t cp_{f,r,i,t} * CROP_{r,i,t} = FERT_{f,r}, \quad \text{for all } f \text{ and } r, \qquad (6)$$

$$\sum_r FERT_{f,r} = FERT_f, \quad \text{for all } f. \qquad (7)$$

Feed balances:

$$\sum_i \sum_t cp_{r,g,i,t} * CROP_{r,i,t} \geq \sum_j lp_{r,g,j} * LSTOCK_{r,j}, \quad \text{for all } r \text{ and } g. \qquad (8)$$

Production costs:

$$\sum_i \sum_t ccost_{c,r,i,t} * CROP_{r,i,t} + \sum_j lcost_{c,r,j} * LSTOCK_{r,j} = COST_{c,r}, \quad \text{for all } c \text{ and } r. \qquad (9)$$

Production balances:

$$\sum_i \sum_t cp_{r,o,i,t} * CROP_{r,i,t} + \sum_j lp_{r,o,j} * LSTOCK_{r,j} = REGPROD_{r,o}, \quad \text{for all } o \text{ and } r, \qquad (10)$$

$$\sum_r REGPROD_{r,o} = TOTPROD_o, \quad \text{for all } o. \qquad (11)$$

National commodity balances:

$$TOTPROD_o + IMPORT_o = TOTCONS_o + \sum_r \sum_j fci_o * lp_{o,r,j} * LSTOCK_{r,j} + EXPORT_o + \sum_{po} (1/conv_o) * PROCTR_o, \quad \text{for all } o. \qquad (12)$$

Trade limits:

$$EXPORT_o \leq EXPORT_{o,1981}, \quad \text{for all } o, \qquad (13)$$

$$IMPORT_o \leq IMPORT_{o,1981}, \quad \text{for all } o, \qquad (14)$$

$$PROCTR_{po} \leq PROCTR_{po,1981}, \quad \text{for all } po. \tag{15}$$

Area accounting rows and PQP calibration constraints:[a]

For cereals only:

$$\sum_i \sum_t cp_{r,ca,i,t} * CROP_{r,i,t} = AREA_{r,ca}, \quad \text{for all } ca \text{ and } r, \tag{16}$$

$$AREA_{r,ca} \leq barea_{r,1981} * e, \quad \text{for all } r \text{ and } ca. \tag{17}$$

For all other crops:

$$\sum_i \sum_t cp_{r,ba,i,t} * CROP_{r,i,t} = AREA_{r,ba}, \quad \text{for all } ba \text{ and } r, \tag{18}$$

$$AREA_{r,ba} \leq barea_{r,1981} * e, \quad \text{for all } r \text{ and } ba. \tag{19}$$

Objective function for Stage 1:

$$\sum_o [\alpha_o * TOTCONS_o - 0.5\beta_o * TOTCONS_o^2] + \sum_o exp_o * EXPORT_o - \sum_o imp_o * IMPORT_o + \sum_{po} procp_{po} * PROCTR_{po} - \sum_c \sum_r COST_{c,r}. \tag{20}$$

$$\begin{bmatrix}\text{Area under}\\ \text{demand functions}\end{bmatrix} + \begin{bmatrix}\text{Revenue from}\\ \text{exports}\end{bmatrix} - \begin{bmatrix}\text{Costs of}\\ \text{imports}\end{bmatrix} + \begin{bmatrix}\text{Net revenue from}\\ \text{processed product trade}\end{bmatrix} - \begin{bmatrix}\text{Costs of}\\ \text{production}\end{bmatrix}.$$

Objective function for Stage 2:

$$\ldots\ldots \text{Equation (20)} - 0.5[\sum_r \sum_{ca} pqp_{r,ca} * (AREA_{r,ca})^2] - 0.5[\sum_r \sum_{ba} pqp_{r,ba} * (AREA_{r,ba})^2]. \tag{21}$$

$$\ldots\ldots - \begin{bmatrix}\text{Land differentiated}\\ \text{PQP terms for}\\ \text{cereals only}\end{bmatrix} - \begin{bmatrix}\text{Regional area}\\ \text{PQP terms for}\\ \text{all other crops}\end{bmatrix}.$$

APPENDIX B

VALIDATION OF THE TARP MODEL

The validation procedure for the TARP model consists of three steps. The first step is the verification of the technological data set and evaluating the relevance of assumptions on the market environment prior to any attempt to use the model. Calibration of the model solution to actual base year values comprises the second step. The last step is to test the predictive ability of the model.

In the verification step the only problem encountered was related to the inconsistencies in the relative production coefficients of some crops when two or more

[a] Equations (17), (18), and (19) are used in the first stage run of the model for the estimation of the PQP terms. They are removed from the second stage run.

observations for a region were available. Since the regional production coefficients were gathered from the small-scale surveys of TOPRAKSU [23], the problems were solved either by discussions with TOPRAKSU experts or by analyzing the plot by plot results of the survey, if available.

For the calibration of the model a base year solution for 1981 was obtained using the PQP methodology. The first stage run with the actual acreage constraints (equations [16]–[19] in Appendix A) serves both to obtain implicit cost terms for the second stage unrestricted model and to check for consistency among interrelated quantities. For example, in TARP, crop production is regional and the livestock sector endogenous to the model at the regional level. Thus, the regional acreages, production, and national consumption are interrelated via regional yields, input coefficients for livestock production, and international trade. If the right-hand side of the regional calibration constraints are consistent with the production coefficient of the crop production subsector, and we assume a well performing livestock sector, we can expect to achieve calibration of the model in Stage 1. This was not the case for the first runs of TARP. The areas of crops calibrated with the observed acreages, but the production of those crops cultivated on both dry and irrigated land showed significant divergence from the actual magnitudes. Further exploration of the data in terms of aggregate quantities and minor adjustments in the structure of the model were necessary. After these adjustments were made, the model solution replicated the 1981 base year for most crops. Area-production and production-consumption linkages were satisfactory, except for outputs that can be produced by both single crop activities and fallow rotations. Unfortunately, these crops are cereals, which occupy a large share of total agricultural production. For these crops, fallow and irrigated technologies dominated total production. Although the model calibrated with respect to total acreages, the production of these crops was higher than the observed quantities in the base year. Inconsistent area-production linkage also caused inconsistent consumption quantities, because trade is limited to the base year quantities. Instead of taking the arbitrary approach of changing the profitability of the dominant activities, the calibration constraints for wheat, barley, corn, and rye were disaggregated. Separate calibration constraints for dry, irrigated, and fallow activities have been added to the model (see equations [16] and [17] in Appendix A).

After data and minor structural adjustments were made, the shadow values of the calibration constraints obtained in the first stage run were transformed into PQP terms. They were included in the objective function, and the calibration constraints (equations [16]–[19] in Appendix A) were removed for the second stage run of the model. The results of the second stage run indicated that base year area, production, and consumption calibrated very closely with the actual magnitudes without adding any ad hoc constraints. To measure goodness of fit, the percentage absolute deviation (*PAD*)[b] between observed and simulated values

[b] $PAD = \frac{\sum_i |X_i^o - X_i^p|}{\sum_i X_i^o}$

where

o = observed value of variable X for the ith product,

p = predicted value of variable X for the ith product.

was used. The regional *PADs* for area cultivated and production are less than 10 per cent for all regions except the Black Sea region. The national *PADs* are less than 6 per cent for area, production, and consumption. The discrepancies between the observed and simulated values are considered to be tolerable given the size and the interdependencies inherent in the model.

Before any attempt is made to use the model for policy impact studies, some simple projection tests are required to judge the robustness of the initial base year calibration. The test for predictive ability of the model, which constitutes the third step in the validation procedure, involves how well the model solution, when specified with updated projection year data, corresponds to the real situation for the projected year. Several changes were made in the updating process: demand curves used in the base year were shifted according to population and income growth from 1981 to 1982; and resources availabilities, the exchange rate, trade prices and quantities, and factor prices were replaced by those observed in 1982.

Given changes in the parameters of the model, the fit of the projection results with the actual results provides evidence about how well the model performs as a policy analysis tool. The approach taken here is similar to base projection applications of the mathematical programming models plus one other advantage, which is the availability of actual benchmark data for the projected year. Since the model is targeted to serve as a multi-purpose planning tool for agriculture, tests will compare predictions of all macro variables (production, consumption) with the benchmark data for the predicted year. The detailed results of the projection, together with the actual data, is reported in [2].

Percentage average deviations (*PADs*) and regression equations are used to test the goodness of fit for the projected figures. The regression equations for the production and consumption volumes are of the form: $\log Q^o = a + b \log Q^p$; where Q^o is the observed figure of a given commodity, Q^p is the projected figure, and a and b are estimated by the regression. If, apart from random error, the model simulated the observed levels perfectly, intercept a and slope b should not differ from zero and unity respectively. The coefficient of determination from the regression indicates the goodness of fit. The log transformation is used to abstract the slope coefficient from the scale and unit differences among commodities.

For all regions and for Turkey as a whole, the intercept and slope coefficients are not significantly different from zero and unity respectively at the 95 per cent level. Deviations in simulated production and consumption are also at reasonable levels: average deviations for production and consumption are 7.4 per cent and 8.2 per cent from the actual 1982 estimates, respectively.