THE POTENTIAL EFFECTS OF ELIMINATING FERTILIZER SUBSIDY ON TURKISH AGRICULTURE: A SECTOR MODEL ESTIMATION

By

Asst. Prof. Dr. Erol H. Cakmak
Department of Economics
Bilkent University

and

Prof. Dr. Haluk Kasnakoglu
Department of Economics
METU

Paper prepared for the workshop on fertilizer price subsidy in Turkey, The Ministry of Agriculture and Village Affairs, February 1993, Ankara.

THE POTENTIAL EFFECTS OF ELIMINATING FERTILIZER SUBSIDY ON TURKISH AGRICULTURE: A SECTOR MODEL ESTIMATION

Subsidy to fertilizer utilization is a policy instrument frequently used by the governments in almost all developing countries, Turkey being no exception. It directly influences the relative profitability of alternative uses of land for the producers. The structure and volume of production, the amount of consumption, and net trade of agricultural products are certainly affected by the extent of fertilizer subsidy.

This study is intended to contribute to the deliberation of the fertilizer subsidy issue by performing quantitative estimates in a more systematic way using a sector model for Turkish agriculture.

To this end, section 1 discusses the basic structure of the model which is used to simulate the agricultural sector. Section 2 is devoted to the results of the simulations without fertilizer subsidy. The last section is reserved for concluding remarks.

It should be made explicit that the modelling approach, used in this study, is intended to supplement, not to substitute, the discussion of agricultural sector specific issues. The model is capable of showing the possible responses of the variables to specific scenarios in a more expeditious and systematic way than previously possible. Given the analytical boundaries of the model, it allows the policy analyst to evaluate the direct as well as the indirect effects of policy measures and to trace out the impact throughout the agricultural sector.

1. STRUCTURE OF THE MODEL

Guiding agricultural policy in Turkey is no easy task. Agricultural production is highly diversified due to variety of soils and agro-climatic conditions. The structure of production presents a challenging diversity with the regions having both crops in common and regional specialties. The techniques of production for the common crops are quite different among regions because of the differences in climate and resource endowments. The diversity in production points out an unusually interdependent production structure in the supply side. In addition, 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 policies will certainly be driven by the interactions among crops, regions, and techniques of production. Evaluating policy interventions in a partial context, rather than tracing their effects through the sector, can give misleading results. The direct effect of a new policy may be desirable, but it may be lessened or nullified by its indirect effects, which are more difficult to evaluate and predict. To take into account the interactions involved in the sector for the evaluation of policy effects and growth possibilities, a regional, partial equilibrium, static optimization model was designed.

Regional agricultural sector model for Turkey (RAST) is a sector-wide model in the sense that it describes total national supply (production and imports) and use (domestic demand for food, feed, and exports) of agricultural commodities. It is a single period model: the base year is 1988. The production side of the model is decomposable into submodels for each of three geographical areas. On the demand side, consumer behavior is regarded as price dependent, and thus market clearing commodity prices are endogenous to the model.

Figure 1. and 2. summarize the flow of inputs and outputs at the regional and national level respectively.[1]

*** Insert Figure 1 and 2 ***

The most important features of the model are the following:

i. The production side of the model is disaggregated to three regions for the exploration of interregional comparative advantage for the policy impact analysis.

ii. Crop and livestock subsectors are integrated endogenously. The

[1] The documentation of the model is available from the authors upon request.

livestock subsector gets inputs form crop production.

iii. Foreign trade is allowed up to base year level.

The regions in the model are aggregated from provincial data to minimize the aggregation error. In total, the model is based on 22 single annual crops, nine perennial crops, and six livestock activities. With three producing regions and several techniques of production for most crops, the total number of activities specified in the model is 123. The activities are distributed among regions depending on the dominant cropping pattern in the base year.[2]

The objective function of the model is quadratic in revenue and cost because it maximizes the area between linear demand and supply curves 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.

The supply side of the model incorporates a new technique known as Positive Quadratic Programming[3] (PQP), to overcome the overspecialization problem in production by using the information provided by the actual actions taken by 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 the 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 of the agents (maximization of economic surpluses) into the models' structure.

Each production activity in the model defines a yield per hectare for crop production and yield per head for livestock production. The activities use fixed proportion of labor, tractor power, fertilizers, seeds and seedlings. The

---

[2] The list of activities are presented in the Appendix

[3] For a comprehensive description of the PQP methodology, see Howitt and Mean (1985).

relation between inputs and outputs are those which were observed in each region, and not necessarily biological or economic optima.

The core of the model consists of production activities and resource constraints. The input and output coefficients for crop production are specified for each unit of land. All of the activities are listed in the Appendix.

Output from crop production activities is divided into three categories: crop yield for human consumption, crop yield for animal consumption and crop by-product yield (such as forage, straw, concentrate and oilcake) for feed.

The commodity production activities in the model also constitute factor demand activities. Some factor supply functions are perfectly elastic (such as fertilizers), some are perfectly inelastic (e.g., categories of land). In the former category, factor prices are exogenous; in the later they are endogenous in the model.

Five groups of inputs (land, labor, tractor power, fertilizer and seed) are incorporated in RAST.

Land is classified in four classes: dry, irrigated, tree, and pasture.

Labor, and tractor power constraints are specified on a quarterly basis. The labor input is measured in man-hour equivalents and shows actual time required on the field. The tractor hours correspond to the usage of tractors in actual production and transportation related activities.

The two kinds of fertilizer, namely nitrogen and phosphate, are measured in terms of nutrient contents. They are considered to be traded goods and are not restricted by any physical limits.

In addition to the costs of labor tractor 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.

Livestock Production is an integrated part of the model at the national level.

The commodities are distributed between different production selling activities at the national level. First, there are domestic demand activities which are generated by linear demand curves. Domestic demand includes the domestic consumption of processed commodities in raw equivalent form. Second there is a demand for cereals used for feeding in the livestock sector. Third, the model allows export of commodities at exogenous prices both in raw and raw equivalent form for processed commodities. It is possible to augment the supply of commodities through import activities at exogenously determined prices.

There are 3 agricultural production regions (Aegean-Mediterranean coastal region, GAP Region, and the rest of Turkey) in the model. The regional division for the model is presented in Figure 3.

*** Insert Figure 3 ***

The data used in the model were put together from various sources such as the State Institute of Statistics, State Planning Organization, and Land and Water Development Agency (currenly known as Directorate of Village Affairs). FAO and World Bank sources were also used to complement and cross check the data from national sources.

The model has been subjected to a comprehensive validation procedure.[4] The validation results supported the model's use for policy planning and impact analysis.

The model has been solved using the linear and non-linear programming software GAMS-MINOS (Brooke, et.al, 1988) on a PC.

2. MODEL EXPERIMENTS AND RESULTS

Given the framework of the study, two different comparative static experiments have been conducted with the model. The description of the experiments are as follows:

No Subsidy Experiment: Given the subsidy rates in terms of nutrients contents in the base year of the model, the prices of nitrogen and phosphate fertilizers were increased by 45.9% and 82.1%, respectively. This situation corresponds to

[4] For a comprehensive discussion of the validation procedure see Cakmak (1992) and Bauer and Kasnakoglu (1990).

the full elimination of subsidy on fertilizer.

No Subsidy + Income Transfer Experiment: For this experiment, it is assumed that the amount extracted from the agricultural sector after the elimination of fertilizer subsidy will be transferred to the consumers as negative tax. The share of fertilizer subsidy in GDP was around 0.5% in the base year. Hence, the income of the consumers was increased by the same proportion.

The overall results of the simulations are presented in Table 1. As expected, the producers bear the negative impact of

*** Insert Table 1 ***

removing fertilizer subsidy. The welfare of the producers declines by 8.1%, with only 1.65% decline in the welfare of the consumers. The volume of production is not affected much, but the effect on basic food production is relatively high. Shadow price of land shows the rent accruing to the producer at the margin. The farmers are seriously hit by the decline in the land value index. The weighted land value index shows that dry-land rent will decrease by more than 80%. The slight change in the prices of agricultural commodities is principally due to a rather serious deviation of exports towards domestic consumption. The increase in the income of the consumers is not enough to compensate for the loss of the farmers, since most of the agricultural products have low income elasticity.

The results of the experiment for commodity groups are presented in Table 2. The basic staple, wheat, is the most

*** Insert Table 2 *****

affected commodity from the elimination of fertilizer subsidy, whereas the impact on the total volume of production and consumption are negligible. The decrease in the net exports is mainly due to the decline in the exports of wheat and pulses.

The decline in the use of fertilizer is relatively small compared to the increase in its price (Table 3). Yet, the

*** Insert Table 3 ***

increase in the cost of fertilizer and in its share in total factor cost indicate that farmers might face difficulties in the procurement of operating capital. The relatively large increase in the price of phosphate fertilizer have diverse effects according to the availability of the regional irrigated land. The coastal region seems to gain comparative advantage in the phosphate intensive crops.

The immediate effect of increasing fertilizer prices causes an upward shift in the supply curves of the crops. The costs of production increase, and given a constant demand for the crops, the production decrease, along with the fertilizer use. However, the decline in the production is much less than expected area due to the change in relative profitability of production techniques and crops. Overall reduction in production reduces the competition for the scarce resource, land, and therefore the opportunity cost for all types of land decreases. The result is a downward shift in the implicit supply curves of the crops.

Two types of supply shifts occur. The first is a shift in techniques of production. Either the production of crops which can be cultivated on both dry and irrigated land, moves from dry to irrigated land, or if it is possible to cultivate the crop using fallow and without fallow activities, the crop (especially in the rest of Turkey) moves from without fallow to a rather less fertilizer intensive fallow activities in most cases. The second effect, is the crop shift. The production of some crops actually increase because of the decline in total production costs.

The substitution possibilities in the production structure indicate that the negative production effects of eliminating fertilizer subsidy result in a chain of effects starting from the fertilizer price and leading to production costs and hence to production levels. At the sectoral level, this chain of effects appears to be significant, so that the result is a rather small decline in both production and fertilizer use.

The overall and regional effects of eliminating fertilizer subsidy on the production of selected crops are presented in Table 4 and 5, respectively. Apart from wheat, lentil production

*** Insert Table 4 and 5 ***

is affected the most. It seems that the expansion of lentil production on fallow land will not be possible if the fertilizer subsidy is removed. The production levels of high value cash crops are not significantly affected.

The regional responses to the increase in the fertilizer price are different. The least affected region is the Aegean-Mediterranean Coastal Region. The crop substitution effect is the deciding factor in the relatively small loss in the regional volume of production.

The price effects of eliminating fertilizer subsidy for selected crops are shown in Table 6. In most commodities, the

*** Insert Table 6 ***

substitution of exports for domestic consumption prevents the increase in domestic prices. In addition, the prices of some crops (i.e. barley, corn, and chick-pea) declines. Turkey might have the opportunity to expand her exports if the fertilizer subsidy is removed.

3. CONCLUSION

Before presenting the general results of the model one point should be made explicit. The nature of the results is the reflection of data used as well as the assumptions which shape the structure of the model. The results, in a sense, present the snapshot of the sector seen through the structure of the model. The model, being the abstraction of the actual environment, is able to address the issues and the results follow a high number of "if" statements which were made explicit in the first section.

The substitution possibilities in the production structure indicate that the negative production effects of eliminating fertilizer subsidy result in a chain of effects starting from the fertilizer price and leading to production costs and hence to production levels. At the sectoral level this chain of effects appears to be significant, so that the result is a rather small decline in both production and fertilizer use.

Phasing out the fertilizer subsidy had different effects with respect to both crops and regions. The high value cash crops and the regions with relatively high endowment of irrigated land were the least affected from the elimination of fertilizer subsidy.

The effects on the consumption and price level of agricultural products are not significant due to the shift of commodities from the export markets.

The transfer of the total fertilizer subsidy to the consumers does not change the picture seriously. The producers are slightly better off, but the export of commodities with high income elasticity decreases by a rather significant proportion.

The present structure of fertilizer subsidy favors the heavy users of fertilizer. These can be identified as the farmers with irrigated land and/or the ones cultivating high value cash crops which require intensive use of fertilizer. Therefore, the system actually supports more the section of agriculture with higher yield and higher return. The impact of this situation on income distribution is obvious: the relatively well-off farmers get more subsidy than the others. Ironically, irrigated agriculture and the production of high value cash crops are the least affected from the removal fertilizer subsidy. The land rental rate for dry land decreases by more than 80%, whereas the decline for irrigated land is around 20%. The production of vegetables, perennials, and industrial crops are relatively less affected from the policy shift.

Should the fertilizer subsidy be phased out? The answer depends upon the government's goals related to the agricultural incentives and incomes. Given the past performance of agriculture, it seems that the shift of support from input and output prices towards irrigation and technology development will be more beneficial to the farmers in the long run. This shift in support policies, combined with complementary education and information provision, will make the farmers more responsive to the incentives.

REFERENCES

Bauer, S. and Kasnakoglu, H., (1990) "Non-linear Programming Models for Sector and Policy Analysis," Economic Modelling, July.

Brooke, A., Kendrick, D., and Meeraus, A., (1988). GAMS A User's Guide, The Scientific Press, California.

Cakmak, E. H., (1992). "Medium-term Growth Prospects for Turkish Agriculture: A Sector Model Approach," The Developing Economies, Vol. 30, No.2, June.

Howitt, R. E. and Mean P., (1985). "Positive Quadratic Programming Models", Working Paper No:85-10, University of California, Davis, California.

Figure 3. Regional Disaggregation of Turkey in RAST

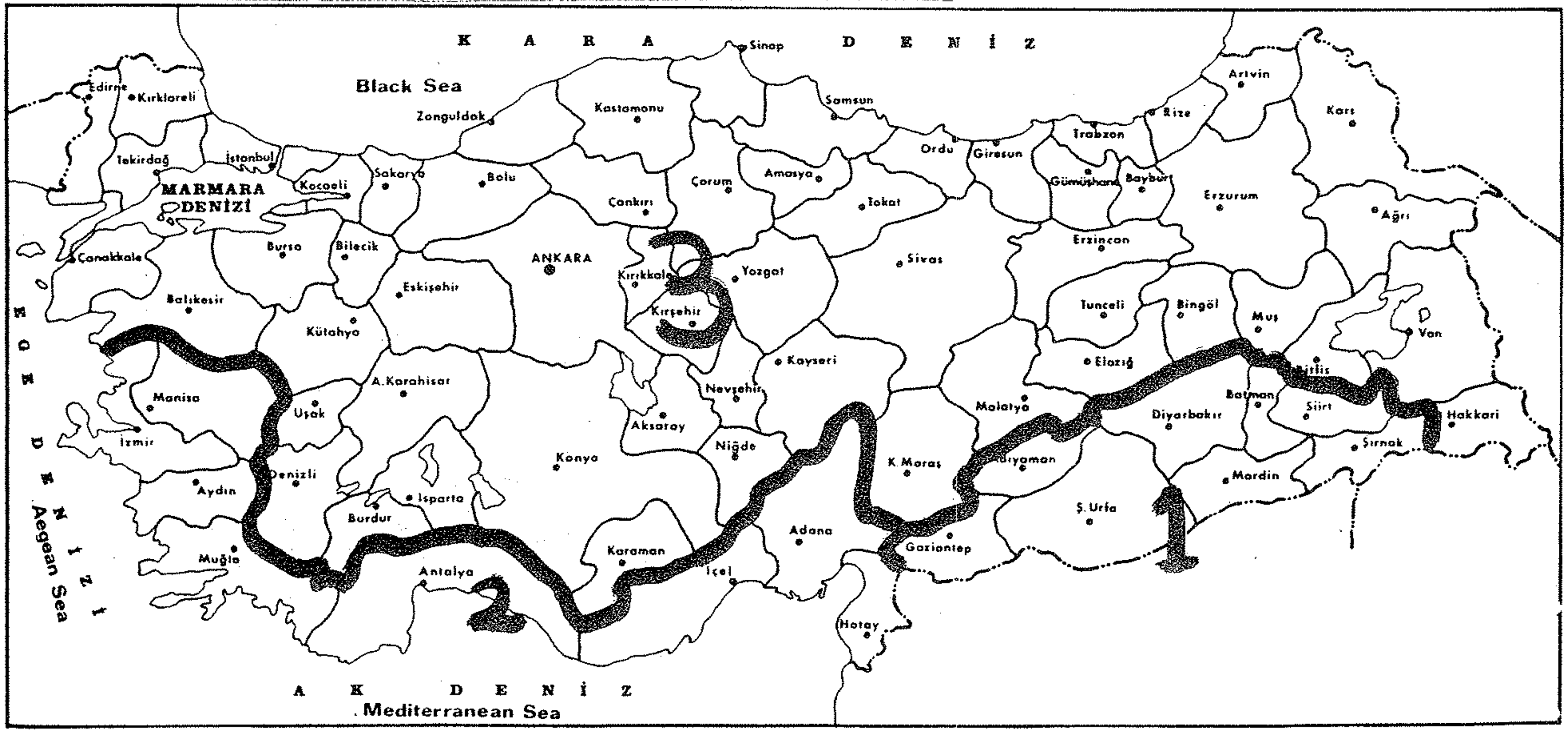

Figure 1. Regional Structure of RAST

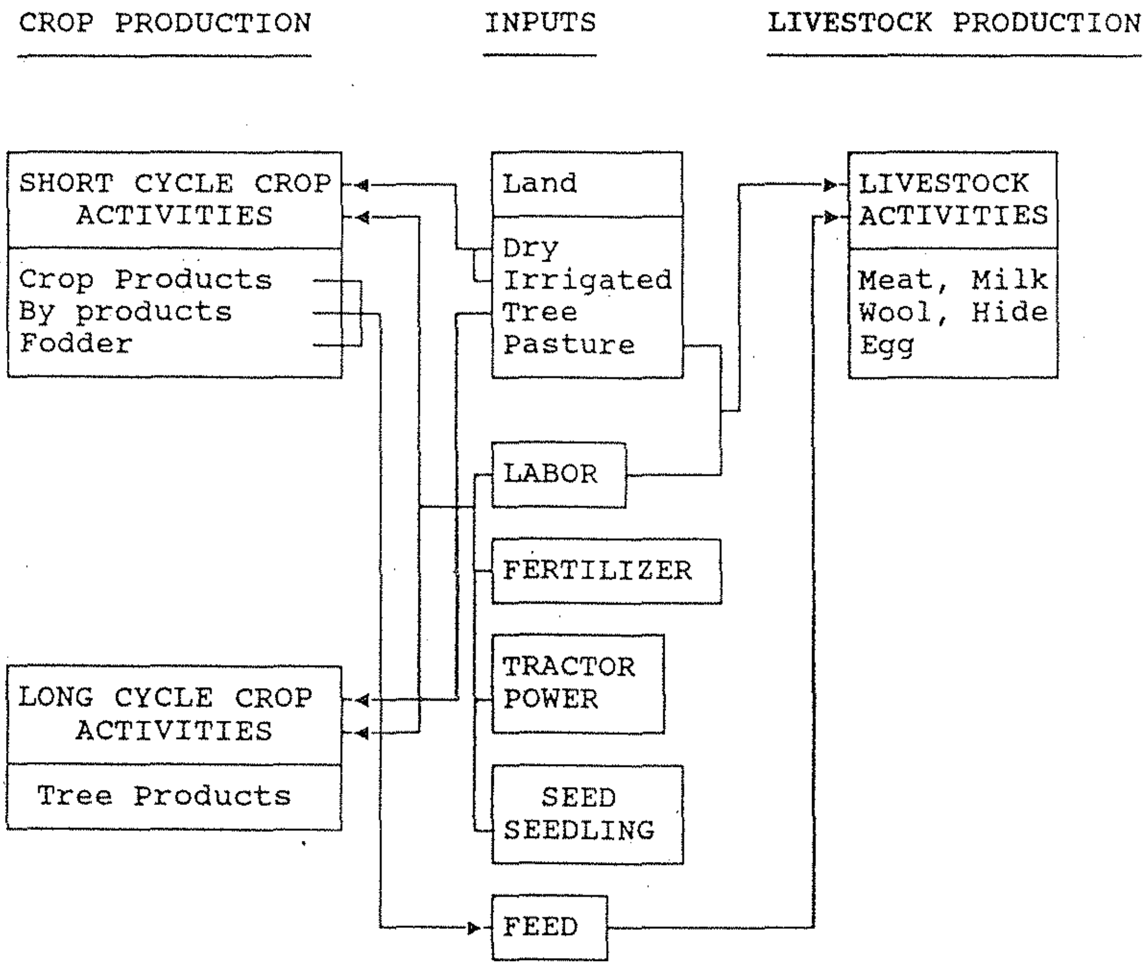

Figure 2. National Structure of RAST

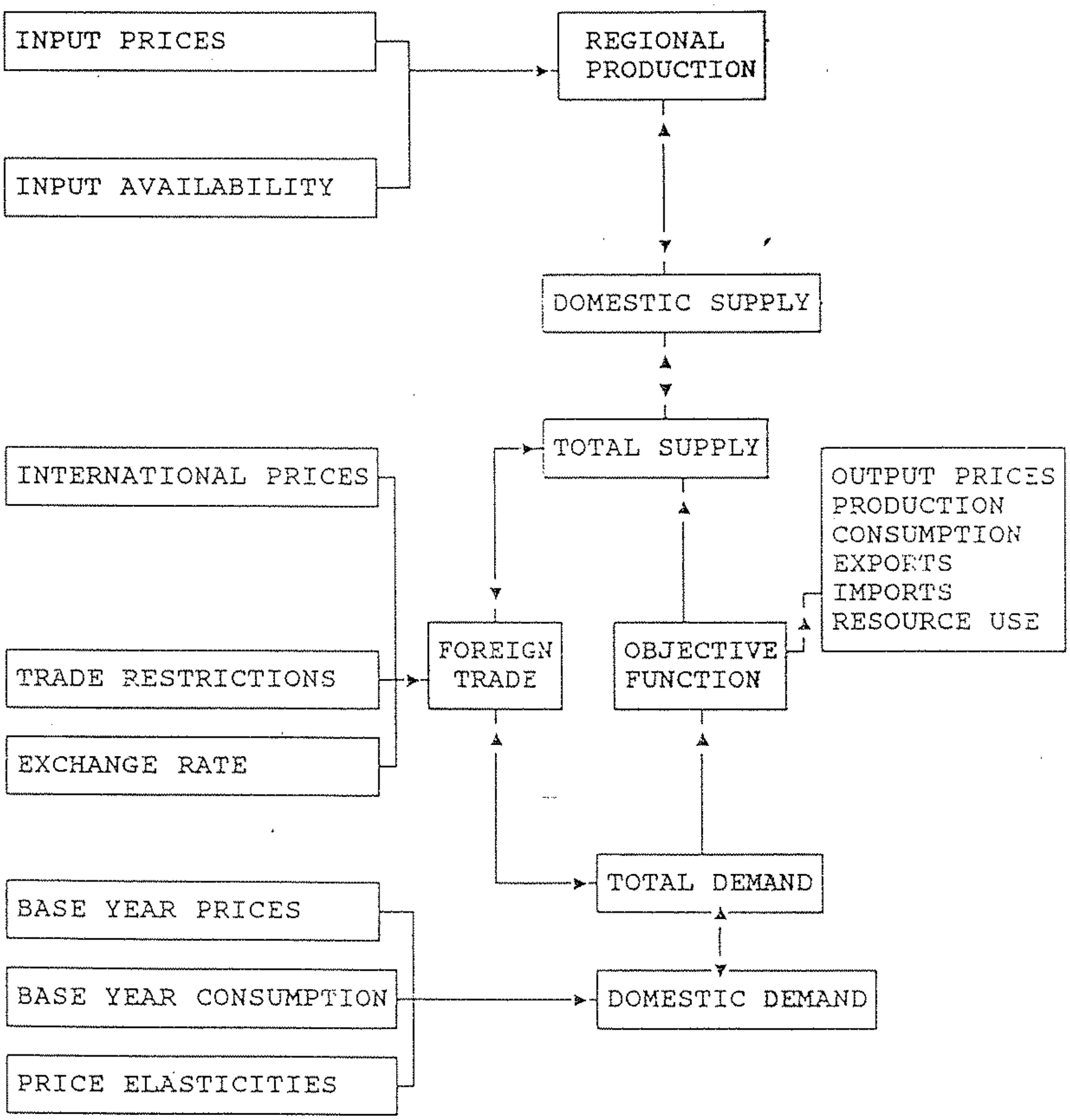

Table 1. Overall Effects of Eliminating Fertilizer Subsidy (Base run = 100)

	No Subsidy	No Subsidy + Income Transfer
Total Welfare	98.35	98.94
Consumers' Welfare	99.81	100.28
Producers' Welfare	91.91	93.08
Volume of Agricultural Production	99.07	99.21
Volume of Crop Production	98.85	99.00
Volume of Food Crops Production	96.86	96.90
Agricultural Net Exports	93.08	92.59
Net Exports of Crop Products	92.98	92.64
Agricultural Price Level	100.66	101.32
Price Level of Crop Products	100.83	101.03
Land Value Index		
Dry Land	16.45	16.53
Irrigated Land	81.00	81.01

Table 2. The Impact of Eliminating Fertilizer Subsidy on Product Groups

	Volume of Production			Volume of Consumption			Net Trade		
	With Subsidy (US$ m)	No Subsidy (% change)	No Subsidy +Income Transfer (% change)	With Subsidy (US$ m)	No Subsidy (% change)	No Subsidy +Income Transfer (% change)	With Subsidy (US$ m)	No Subsidy (% change)	No Subsidy +Income Transfer (% change)
Grains	3,108	-3.28	-3.33	2,281	-0.10	-0.09	226.6	-44.60	-45.72
Wheat	2,058	-5.01	-5.13	1,636	-0.18	-0.18	228.2	-44.29	-45.40
Others	1,051	0.12	0.19	644	0.12	0.15	-1.6	0.00	0.00
Pulses	590	-2.37	-2.26	315	0.33	0.70	280.8	-5.35	-5.55
Industrial Crops	1,460	-0.75	-0.62	1,082	-0.28	0.05	415.9	-1.89	-2.30
Oil Crops	458	0.12	0.48	457	0.12	0.48	4.1	0.00	0.00
Tubers	685	-1.95	-1.84	661	-0.18	0.02	24.2	-50.31	-52.53
Vegetables	2,217	-0.04	0.20	2,042	-0.04	0.28	181.6	0.00	-0.78
Perennials	4,196	-0.14	0.13	3,508	-0.16	0.15	807.1	0.00	0.00
Livestock Products	3,059	0.01	0.08	3,211	0.01	0.17	26.1	0.00	-11.15
Total	15,773	-0.93	-0.79	13,558	-0.08	0.14	1,966.4	-6.92	-7.41

Note: Volume = Base run prices multiplied by model scenario output

Table 3. The Impact of Eliminating Fertilizer Subsidy on the Use and Cost of Fertilizer (Base Run = 100)

	No Subsidy	No Subsidy + Income Transfer
Use of Fertilizer		
Nitrogen	95.78	95.81
Phosphate	97.83	97.84
Cost of Fertilizer	156.37	156.41
Share of Fertilizer Cost in Total Factor Cost	144.20	144.09
REGIONAL IMPACT		
Aegean and Mediterranean		
Nitrogen	89.43	89.45
Phosphate	100.31	100.32
GAP		
Nitrogen	97.92	97.94
Phosphate	98.49	98.50
Rest of Turkey		
Nitrogen	97.57	97.61
Phosphate	97.42	97.44

Table 4. The Impact on the Production of Selected Crops
(Base Run = 100)

	No Subsidy	No Subsidy + Income Transfer
Wheat	94.99	94.87
Barley	100.14	100.19
Corn	100.20	100.23
Chick-pea	100.56	100.68
Lentil	94.00	93.98
Sugar beet	98.75	99.12
Cotton	98.88	98.85
Sunflower	99.75	100.11
Potato	99.77	99.93
Melon	99.99	100.33
Tomato	99.98	100.14
Grape	99.79	100.01

Table 5. The Effects of Eliminating Fertilizer Subsidy on the Regional Crop Production (Base Run =100)

	Aegean and Mediterranean	GAP	Rest of Turkey
Volume of Production	99.10	98.85	98.74
	(28.8)	(9.7)	(61.5)
For Selected Crops			
Wheat	86.15	97.71	95.92
	(12.3)	(9.6)	(78.1)
Barley	88.86	99.84	100.46
	(4.2)	(16.4)	(79.3)
Corn	479.63	83.81	96.64
	(19.6)	(0.3)	(80.1)
Chick-pea	101.75	100.07	100.43
	(9.6)	(17.5)	(72.9)
Lentil	7.39	96.84	76.91
	(0.2)	(78.8)	(21.0)
Sugar beet	104.54	n.a.	98.71
	(0.7)	(0.0)	(99.2)
Cotton	99.07	98.28	98.07
	(78.7)	(12.4)	(8.9)
Sunflower	106.14	101.88	99.69
	(0.9)	(0.6)	(98.5)
Potato	97.85	98.01	99.96
	(9.5)	(0.4)	(90.1)
Melon	99.15	101.31	100.20
	(35.6)	(17.7)	(46.7)
Tomato	100.08	100.26	99.91
	(33.1)	(4.4)	(62.4)
Grape	100.14	99.26	99.78
	(33.1)	(20.8)	(46.2)

Notes: The numbers in paranthesis are the regional shares in the base year
n.a.= not applicable

Table 6. Price Effects of Eliminating Fertilizer Subsidy for Selected Crops (Base Run = 100)

	No Subsidy	No Subsidy + Income Transfer
Wheat	100.69	100.69
Barley	99.35	99.38
Corn	99.37	99.40
Chick-pea	94.36	94.42
Lentil	100.00	100.00
Sugar beet	103.67	103.77
Cotton	100.00	100.00
Sunflower	100.79	100.90
Potato	101.11	101.21
Melon	100.25	100.25
Tomato	100.13	100.28
Grape	101.25	101.42

APPENDIX

Table A.1. Regional Distribution of Production Activities

Activities		Regions(2)		
Name	Type(1)	1	2	3
a. Single Crop Activities				
Barley	D	X	X	X
Barley	F		X	X
Chick-peas	D	X	X	X
Chick-peas	I	X	X	X
Corn	D	X	X	X
Corn	I	X	X	X
Corn	F		X	X
Cotton	I	X	X	X
Cucumber	I	X	X	X
Dry beans	I	X	X	X
Eggplant	I	X	X	X
Fodder	D	X	X	X
G. pepper	I	X	X	X
Groundnut	I	X		
Lentils	D	X	X	X
Melon	D	X	X	X
Melon	I	X	X	X
Onion	D	X	X	X
Onion	I	X	X	X
Potato	I	X	X	X
Rice	I	X	X	X
Rye	D	X	X	X
Rye	F	X	X	X
Sesame	D	X	X	X
Soybean	I	X		
Sunflower	D	X	X	X
Sunflower	I	X	X	X
Tobacco	D	X	X	X
Tomato	I	X	X	X
Wheat	D	X	X	X
Wheat	I	X	X	X
Wheat	F	X	X	X
Alfalfa	I	X	X	X

Table A.1.-continued on the next page

Table A.1.-continued

Activities		Regions(2)		
Name	Type(1)	1	2	3
b. Perennial Crop Activities				
Apple	T	X	X	X
Citrus	T	X		
Fig	T	X	X	X
Grape	T	X	X	X
Hazelnut	T			X
Olive	T	X	X	X
Peach	T	X	X	X
Pistachio	T		X	
Tea	T			X
c. Livestock Production Activities				
Sheep		X	X	X
Goat		X	X	X
Angora				X
Cattle		X	X	X
Buffalo		X	X	X
Poultry		X	X	X

Notes: (1) D=Dry, I=Irrigated, F=Fallow, T=Tree.
(2) 1. Aegean and Mediterranean coast
2. GAP Region
3. Rest of Turkey.