AGRICULTURAL INPUT-OUTPUT MODEL

ENVIRONMENTAL MODULE

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1. Disaggregation of input-output table

To rearrange the I-O table of 1998[1] to obtain an agriculture focused one, two sources of data were used; I-O table[2] for the year 1998 prepared by Turkish Statistics Institute and commodity balance tables[3] in Turkey. The sector number 01, namely growing of cereals and other crops (GCC), was disaggregated further into wheat, maize, sunflower, and cotton by using commodity balance tables which provides information about total domestic demand, total production (excluding waste and loss), final consumption (private and public), gross fixed capital formation (private and public), stock change, exports, and imports of the products, as well as their distribution to feed and seed use.

Disaggregation has been done systematically, firstly, in domestic transactions component of the I-O table and then in imports component, lastly they were added together horizontally. In order to find out the use/sales of wheat, maize, cotton and sunflower by/to different sectors (intermediate demand for these products), equation 1 was employed and to find out the inputs used by wheat, maize, cotton and sunflower equation 2 was utilized.

$$us_{ij} = (tind_i - usse_i - usfe_i - fd_i)\gamma_{GCCj} \quad (1)$$

$$us_{ik} = \left(\frac{qp_k}{qp_{GCC} - m_{GCC}} \right) \chi_{iGCC} \quad (2)$$

where;
fd_i: final demand for the $_i^{th}$ sector

[1] Recent available I-O table in Turkey. However, since Turkey has suffered from two major earthquakes in 1999 and from two severe economic crises since 1998, radical changes are not expected in the interindustry transactions of the new I-O table (2002) that will be available in early 2008.
[2] Covers the I-O table for domestic output and for imports, TURKSTAT (2004).
[3] See Akyil (1999), Aydogus et al. (1998), Dellal and Ege (2000) and Dolekoglu (2001) for further information.

$_k$: wheat, maize, cotton, sunflower
m_{GCC}: imports of GCC
qp_k: output of $_k^{th}$ sector
qp_{GCC}: total output of GCC ($qp_{GCC} - m_{GCC}$: domestic output of GCC)
$tind_i$: total intermediate demand for $_i^{th}$ sector
us_{ij}: use/sales of $_i^{th}$ sector by/to $_j^{th}$ sector
us_{ik}: use/sales of $_i^{th}$ sector by/to $_k^{th}$ sector
$usfe_i$: demand/use for/of $_i^{th}$ sector for feed
$usse_i$: demand/use for/of $_i^{th}$ sector for seed
χ_{iGCC}: use/sales of $_i^{th}$ sector by/to GCC
γ_{GCCj}: inter-industry demand coefficients

where; $\gamma_{GCCj} = \dfrac{\chi_{GCCj}}{tind_{GCC} - usse_{GCC} - usfe_{GCC}}$

and χ_{GCCJ} is the use/sales of GCC by/to sector $_j$ and $tind_{GCC}$ is the intermediate demand, $usse_{GCC}$ is the sales for seed and $usfe_{GCC}$ is the sales for feed use of GCC. It is assumed here that γ_{GCCj} is same for wheat, maize, cotton and sunflower to the sales of $_i^{th}$ sector[4]. Above methodology was used to disaggregate the imports component also. Finally, domestic and imports components were added horizontally to get total agriculture focused I-O table at basic prices for the year 1998 for Turkey.

2. Solution procedure

The I-O analysis simply measures the magnitudes of direct and indirect variation in total production caused by changes in the final demand. The solution procedure of the model is summarized through the equations 3 to 7. Given X as the vector of total production (equation 3), it is equal to sum of Ax and Y (final demand vector), where Ax represents the matrix of intermediate demand and A is the matrix of technical coefficients $[a_{ij}]$ found as in equation 4. In equation 4, x_{ij} is the sale of $_i^{th}$ sector to sector $_j$ and X_j is the total outlay of sector $_j$.

$$X = Ax + Y \tag{3}$$

$$a_{ij} = \frac{x_{ij}}{X_j} \tag{4}$$

Rearranging equation (3) and simplifying it results in equation 6, in which $(I - A)$ is required to be a non-singular matrix in order to find a solution for X. Then by using the Leontief inverse, $(I - A)^{-1}$, total industrial output can be obtained by solving equation 7 with respect to exogenous changes in Y by calculating both direct and indirect effects in the chain of inter-industries linkages.

[4] Although this may seem to be a rough estmate, no other data is available which show the relative shares of wheat, maize, cotton and sunflower in the sales of GCC sector to the $_j$ sector. In addition not enough time series data do exist to estimate the shares econometrically.

$$X - Ax = Y \quad (5)$$
$$X(I - A) = Y \quad (6)$$
$$X = (I - A)^{-1} Y \quad (7)$$

3. Industry specification in the aggregated agricultural I-O table

Aggregated version of agricultural focused input-output table

1 Growing of cereals and other crops n.e.c.
2 Wheat
3 Maize
4 Sunflower
5 Cotton
6 Growing of vegetables, horticultural specialties and nursery products
7 Growing of fruit, nuts, beverage and spice crops
8 Farming of animals
9 Agricultural and animal husbandry service activities, except veterinary activities
10 Forestry, logging and related service activities
11 Fishing
12 Mining and quarrying [08-12]
13 Production, processing and preserving of meat and meat products
14 Processing and preserving of fish and fish products
15 Processing and preserving of fruit and vegetables
16 Manufacture of vegetable and animal oils and fats
17 Manufacture of dairy products
18 Manufacture of grain mill products, starches and starch products
19 Manufacture of prepared animal feeds
20 Manufacture of bakery products
21 Manufacture of sugar
22 Manufacture of cocoa, chocolate, sugar confert. & other food products n.e.c.
23 Manufacture of alcoholic, soft drinks and mineral waters [23-24]
24 Manufacture of tobacco products
25 Manufacture of textiles [26-32]
26 Wood, furniture, paper, publishing [33-37, 67]
27 Manufacture of fertilizers, pesticides, other agro-chemicals, paints, and varnishes [40-41]
28 Manufacture of coke, refined petroleum prod., basic chemicals, rubber, plastics, glass, ceramic prod., non-metallic minerals, etc. [38-39, 42-49]
29 Manufacture of ferrous, non-ferrous metals, various machinery, vehicles, etc. [50-66, 68]
30 Energy production and distribution [69-70]
31 Water and Construction [71-72]
32 Transport [73, 78-81]
33 Services [74-77, 82-97]

4. Industry specification in the disaggregated agricultural I-O table

Disaggregated version of agriculture focused input-output tables

01 Growing of cereals and other crops n.e.c.
011 Wheat
012 Maize

013 Sunflower
014 Cotton
02 Growing of vegetables, horticultural specialties and nursery products
03 Growing of fruit, nuts, beverage and spice crops
04 Farming of animals
05 Agricultural and animal husbandry service activities, except veterinary activities
06 Forestry, logging and related service activities
07 Fishing
08 Mining of coal and lignite
09 Extraction of crude petroleum and natural gas
10 Mining of metal ores
11 Quarrying of stone, sand and clay
12 Mining and quarrying n.e.c.
13 Production, processing and preserving of meat and meat products
14 Processing and preserving of fish and fish products
15 Processing and preserving of fruit and vegetables
16 Manufacture of vegetable and animal oils and fats
17 Manufacture of dairy products
18 Manufacture of grain mill products, starches and starch products
19 Manufacture of prepared animal feeds
20 Manufacture of bakery products
21 Manufacture of sugar
22 Manufacture of cocoa, chocolate, sugar confert. & other food products n.e.c.
23 Manufacture of alcoholic beverages
24 Manufacture of soft drinks; production of mineral waters
25 Manufacture of tobacco products
26 Manufacture of textiles
27 Manufacture of other textiles
28 Manufacture of knitted and crocheted fabrics and articles
29 Manufacture of wearing apparel, except fur apparel
30 Dressing and dyeing of fur; manufacture of articles of fur
31 Tanning and dressing of leather; man.of luggage, handbags, saddlery and harness
32 Manufacture of footwear
33 Sawmilling and planning of wood
34 Manufacture of wood and of products of wood and cork
35 Manufacture of paper and paper products
36 Publishing
37 Printing and service activities related to printing
38 Manufacture of coke, refined petroleum products
39 Manufacture of basic chemicals, plastics & synthetics rubber
40 Manufacture of fertilizers and nitrogen compounds
41 Manufacture of pesticides, other agro-chemicals and paints, varnishes
42 Manufacture of pharmaceuticals, medicinal chemicals &botanical products
43 Manufacture of cleaning materials, cosmetics & man-made fibers
44 Manufacture of rubber products
45 Manufacture of plastic products
46 Manufacture of glass and glass products
47 Manufacture of ceramic products
48 Manufacture of cement, lime and plaster related articles these items
49 Cutting and finishing of stone and man. of non-metallic mineral products n.e.c.
50 Manufacture of basic iron and steel
51 Manufacture of basic precious and non-ferrous metals
52 Casting of metals
53 Manufacture of fabricated metal products, tanks, reservoirs &steam generators

54 Manufacture of other fabricated metal products; metal working service activities
55 Manufacture of general purpose machinery
56 Manufacture of special purpose machinery
57 Manufacture of domestic appliances n.e.c.
58 Manufacture of office, accounting and computing machinery
59 Manufacture of electrical machinery and apparatus n.e.c.
60 Manufacture of radio, television and communication equipment and apparatus
61 Manufacture of medical, precision and optical instruments, watches and clocks
62 Manufacture of motor vehicles, trailers and semi-trailers
63 Building and repairing of ships, pleasure and sporting boats
64 Manufacture of railway and tramway locomotives and rolling stock
65 Manufacture of aircraft and spacecraft
66 Manufacture of transport equipment n.e.c.
67 Manufacture of furniture
68 Manufacturing n.e.c.
69 Production, collection and distribution of electricity
70 Manufacture of gas; distribution of gaseous fuels through mains
71 Collection, purification and distribution of water
72 Construction
73 Sale, maintenance and repair of motor vehicles, motorcycles; retail sale of fuel
74 Wholesale trade and commission trade, except of motor vehicles and motorcycles
75 Retail trade, except of motor vehicles and motorcycles; repair of personnel &household goods
76 Hotels; camping sites and other provision of short-stay accommodation
77 Restaurants, bars and canteens
78 Transport via railways
79 Land transport; transport via pipelines
80 Water transport
81 Air transport
82 Supporting and auxiliary transport activities; activities of travel agencies
83 Post and telecommnications
84 Financial intermediation, except insurance and pension funding
85 Insurance and pension funding, except compulsory social security
86 Real estate activities
87 Renting of machinery and equip. without operator and of personal & household goods
88 Computer and related activities
89 Research and development
90 Other business activities
91 Education
92 Health and social work
93 Activities of membership organizations n.e.c
94 Recreational, cultural and sporting activities
95 Other service activities
96 Public services
97 Ownership of dwelling

5. Multipliers

6. Backward Linkages

7. Forward Linkages

8. Incorporating environment component to I-O model

The I-O model can be used to trace the environmental discharges in an economy, as firstly introduced and used in Leontief (1970). To incorporate environment into input-output analysis equation 8 is introduced.

$$EB_i = eb_i X \qquad (8)$$

where EB_i is the vector of environmental burden of sector $_i$ and eb_i is the vector of environmental discharges of type $_i$ per monetary unit of sector's output. In order to solve for EB_i, simply X in equation 7 is substituted into equation 8. As a result, economic data can be linked with resource use (such as energy and ore consumption) and/or environmental impact categories (such as greenhouse gas emissions, toxic discharges, ozone depletion potential, hazardous or non-hazardous waste), as in equation 9.

$$EB_i = eb_i (I - A)^{-1} Y \qquad (9)$$

8.1. Identifying the environmental pollution caused by enteric fermentation and savannas

Agricultural activities contribute directly to emissions of greenhouse gases through a variety of different processes. CH4 is produced in herbivores as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream. Both ruminant animals (e.g., cattle, sheep) and some non-ruminant animals (e.g., pigs, horses) produce CH4. Although ruminants are the largest source, they are able to digest cellulose, a type of carbohydrate, due to the presence of specific microorganisms in their digestive tracts. The amount of CH4 that is released depends on the type, age, and weight of the animal, the quality and quantity of the feed, and the energy expenditure of the animal.

The burning of savannas – areas in tropical and subtropical formations with continuous grass coverage – results in the instantaneous emissions of carbon dioxide, but because the vegetation re-grows between burning cycles, the carbon dioxide released into the atmosphere is reabsorbed during the next vegetation growth period. Net CO2 emissions are therefore assumed to be zero. However, savanna burning also releases gases other than CO2, including CH4, CO, N2O and NOx.

Table 1. CH4 and N2O Emissions (in 1000 Tones and % 1998) from Enteric Fermentation and Savannas Activities

Sectors	*Growing of cereals and other crops n.e.c.*	*Wheat*	*Maize*	*Farming of animals*	*Total Emissions*
N2O	0.13	0.33	0.03	-	0.49
CH4	6.58	16.45	0.85	641.34	665.22
			%		
N2O	27.13	66.80	6.07	-	100
CH4	0.99	2.47	0.13	96.41	100

SOURCE: UNFCCC.

Table 1. reveals the results of CH4 and N2O Emissions from enteric fermentation and savannas activities in Turkey for the year 1998. Total emissions of N2O in growing of cereals and other crops, wheat and maize sectors was 0.49 thousand tones in which wheat contributed 0.33 thousand tones which makes 66.8 percent of total emissions. Growing of cereals and other crops and maize added 0.13 and 0.03 thousand tones which make 27.13 and 6.07 percent of total emissions of N2O respectively. In terms of CH4, total emissions was 665.22 thousands tones and only one sector - farming of animals contributed overwhelmingly with 641.34 thousand tones that make 96.41 percent of total emissions and second was wheat with just 2.47 percent of total emissions.

8.2. Environmental costs of fertilizers

Although fertilizers increase productivity – necessary to meet food needs of growing population demands. However, its consumption has long-term harmful effects on soil fertility and quality; water quality (ground and surface water contamination); acid rains; biodiversity; and human health.

Excessive use of nitrogen fertilizer brings nitrogen losses from agro-ecosystems and leads to nitrogen pollution and exposes a number of problems for human and ecological health, reduced soil fertility, diminished crop production, and other consequences of inadequate nitrogen supply (Mosier et al., 2004). In other words, fertilizers when applied sustainably help maintain soil health, soil quality and increase productivity and economic returns. However, applied in excess contribute to the pollution of surface water and groundwater, negatively affect yields, and waste farm resources. Some excess nutrients, such as nitrates, can pose a human health risk when concentration levels in drinking water exceeds.

Nitrate increases the growth of algae and aquatic plants; so, when nitrate is separated out from soil and is discharged into streams will cause development of undesirable micro-organisms. In addition, the algal blooms that result from excess nitrogen and phosphorus cloud water, blocking sunlight to important underwater grasses that are home to numerous species of young fish, crabs, and other aquatic creatures. Phosphorus destroys the

environment when excess amounts are added to a lake. This increases algae growth, making swimming, fishing, and boating unpleasant or difficult. When excess aquatic organisms die; decomposition removes oxygen from water and leads to fish kills (Magdoff and Harold, 2000).

Table 2. displays the consumption of fertilizers in Turkey for the year 1998. Wheat sector consumes the highest share of nitrogen, phosphorus and potassium with 73.50, 79.74 and 62.74 percent respectively. Whereas cotton takes the immense share in nitrogen, phosphorus and potassium consumption with 9.89, 6.88 and 4.56 percent respectively. Sunflower consumes fewer shares of nitrogen and phosphorus, however it consumes significant share of potassium after wheat. Maize and growing of cereals and other crops n. e. c. use little share.

The impact of exogenous final demands is examined also on nitrogen efficiency. Nitrogen efficiency is simply ratio of total nitrogen uptake (output) to the total nitrogen available (input) in an agriculture system (OECD, 2001). This indicator provides a physical measure of nitrogen use efficiency in agriculture. Mathematically it can be represented in the following manner:

$$NE = \frac{Output}{Input} \qquad (10)$$

where
NE: Nitrogen Efficiency
Output: Sum of Harvested Crops and Pasture
Input: Sum of Inorganic Fertilizers, Net Live Stock Manure and Other Nitrogen Inputs[5]

Table 2. Fertilizers Consumption by Type by Product in 1998 (in tones)

Sectors	Growing of cereals and other crops n.e.c.	Wheat	Maize	Sunflower	Cotton
Nitrogen	117663.6	1309207	125110.2	53124.46	176110.6
Phosphorus	62227.76	727527.6	36037.52	23824.45	62728.03
Potassium	1266.2	33958.41	2573.16	13863.62	2467.47
	%				
Nitrogen	6.61	73.50	7.02	2.98	9.89
Phosphorus	6.82	79.74	3.95	2.61	6.88
Potassium	2.34	62.74	4.75	25.61	4.56

Source: Koc et al. (2000) and Author's Calculation.

[5] That includes biological nitrogen fixation, nitrogen recycled from organic matter, nitrogen contained in seeds and planting materials and atmosphere deposition of nitrogen. For more details see please OECD Environmental Indicators, Methods and Results 2001.

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