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THE BASIC U.S. MODEL FOR THE IIASA/FAP GLOBAL SYSTEM OF FOOD AND AGRICULTURE MODELS: DOMESTIC UTILIZATION AND PRICES

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March 1981
WP-81-38
(revised version of
WP-80-8, January 1980)

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PREFACE

The Food and Agriculture Program of the International Institute for Applied Systems Analysis has been developing, as its major task, a global system of national food and agriculture models linked in a general equilibrium framework. The main objective is to analyze, over a 15- to 20-year horizon, the impact of national domestic and trade policies and of international agreements on the distribution of food and hunger in the world and on the pace of development in the LDC's. The United States, as a major exporter of food and feed grains, is a key link in the system. It can, through its aid, trade and domestic food policies, have a major influence, both intentional and unintentional, on the world food situation. Michigan State University (MSU) is collaborating with IIASA/FAP and the USDA in the development of basic and detailed models of U.S. food and agriculture for linkage in the FAP global system.

This working paper describes the demand side of the basic U.S. model. The supply side described elsewhere) is based on the domestic supply component of the MSU Agriculture Model, which has been under development at MSU for several years on a grant from the John Deere Corporation and other contract research support. This paper limits its scope to the demand and price components developed for linkage to IIASA's system.

The major contributors to the basic U.S. model are Michael Abkin, Donald Mitchell, Eric Wailes, Tom Christensen and Chris Wolf of MSU, and David Watt of USDA. Dan Kauffman, Tracy Miller and Dave Zeitler have contributed at various stages of data collection and parameter estimation, and others contributing to the MSU Agriculture Model over the years are too numerous to mention here.

CONTENTS

THE SIMPLIFIED U.S. MODEL (PRELIMINARY VERSION) FOR THE IIASA/FAP GLOBAL SYSTEM OF FOOD AND AGRICULTURE MODELS: DOMESTIC UTILIZATION AND PRICES

M. H. Abkin

Total utilization of each commodity includes exports, if any, and several components of domestic disappearance. Exports (actually net imports) are determined as a residual of domestic supply over demand in the simultaneous national- international exchange model of IIASA's linkage system consistent with world prices; domestic price, quota and stock policies; and assumed international agreements. Domestic utilization includes seed, losses, feed, nonfood industrial uses, government consumption, stocks and human consumption. Feed demand is discussed elsewhere with the supply side of the model, which is based on the MSU Agriculture model; prices and the other components of demand will be described here.

Commodities and Units

The thirty commodities of supply are aggregated to twenty commodities for utilization purposes, and these are further aggregated to IIASA's ten commodities for the international linkage. Table 1 shows the commodity correspondences and units used in the model. There remain a few relatively minor inconsistencies between the commodity definitions of this preliminary version of the U.S. basic model and those of the international system. These will be resolved in the "final"* version as the international commodity list for the basic system is expanded to the 19 commodities of the detailed model system in order to conduct analyses using both basic and detailed models. The current inconsistencies are:

1. alcoholic beverage consumption should be included in the "other foods" category, whereas the model currently includes it in aggregate consumption of the primary ingredients (e.g. wheat, coarse grains, fruits, etc.);

*The word "final" is in quotation marks because no model, if it is to remain useful, can ever have a final version.

Table 1. Commodities and units of U.S. simplified model.

International		Domestic Utilization		Domestic Supply	
Commodity[1]	Unit[3]	Commodity[1]	Unit[3]	Commodity[2]	Unit[3]
1. Wheat	th.MT (grain)	1. Wheat	th.MT (grain)	1. Wheat	th.bu
2. Rice	th.MT (polished)	2. Rice	th.MT (polished)	2. Rice	th.cwt. (rough)
3. Coarse grain	th.MT (grain)	3. Coarse grain	th.MT (grain)	3. Corn	th.bu
				4. Sorghum	th.bu
				5. Barley	th.bu
				6. Oats	th.bu
4. Beef, sheep	th.MT (carcass)	12. Beef	th.MT (carcass)	7. Fed beef	mi.lbs. (live)
				8. Nonfed beef	mi.lbs. (live)
		13. Lamb, mutton	th.MT (carcass)	9. Sheep & lambs	th.lbs. (live)
5. Dairy	th.MT (milk)	17. Dairy	th.MT (milk)	10. Milk	mi.lbs.
6. Other animal	th.MT (protein)	14. Pork	th.MT (carcass)	11. Pork	mi.lbs. (live)
		15. Poultry	th.MT (RTC)	12. Turkey	mi.lbs. (RTC)
				13. Chicken	mi.lbs. (RTC)
		16. Eggs	th.MT (fresh)	14. Eggs	mi.dozen
		18. Fish	th.MT (fresh)	15. Fish	mi.lbs. (fresh)
7. Protein feeds	th.MT (protein)	19. Protein feeds	th.MT (meal)	16. Soybeans	th.bu
				17. Cottonseed	th.tons
				18. Peanuts	th.lbs. (farm wt.)
				19. Flaxseed	th.bu
8. Other foods[4]	mi.$ (1970)	4. Potatoes	th.MT	20. Potatoes	th.cwt.
		5. Vegetables	th.MT	21. Vegetables	th.tons
		6. Dry beans	th.MT	22. Dry beans	th.cwt.
		7. Fruits, nuts	th.MT	23. Fruits, nuts	th.tons
				18. Peanuts	th.lbs. (farm wt.)
		9. Fats & oils	th.MT (oil)	11. Pork	mi.lbs. (live)
				16. Soybeans	th.bu
				18. Peanuts	th.lbs. (farm wt.)
				19. Flaxseed	th.bu
				24. Cottonseed oil	mi.lbs. (oil)
		10. Sugar[4]	th.MT (refined)	25. Cane sugar	th.tons (raw)
				26. Sugarbeets	th.tons (beets)
		11. Coffee,tea,cocoa[4]	th.MT (beans)	none	
9. Nonfood agri-culture	mi.$ (1970)	8. Tobacco	th.MT (farm wt.)	27. Tobacco	th.lbs.(farm wt.)
		20. Nonagriculture	mi.$ (1967)	28. Cotton	th.bales
				29. Wool	th.lbs.
10. Nonagriculture	mi.$ (1970)	20. Nonagriculture	mi.$ (1967)	30. Nonagriculture	mi.$ (1967)

Notes:

[1]Includes processed products in fresh equivalents.

[2]Additional commodities modeled on the supply side, but not on the demand side, are beef cows (th.head), dairy heifers (th.head), sows (th.head), corn silage (th.tons), and sorghum silage (th.tons).

[3]Unit symbols: th=thousand; mi=million; MT=metric tons; $ =U.S. dollars; RTC =ready to cook; bu = bushels; cwt=hundred weight (100 pounds); lbs=pounds; tons=short tons (2000 pounds)

[4]See the text for discussion of inconsistencies in the preliminary version of the U.S.simplified model.

2. use of sweeteners derived from corn should be included with sugar in "other foods" instead of its current accounting in "coarse grains";
3. "coffee, tea, cocoa" currently include only coffee; and
4. a few miscellaneous items, such as flowers and hides and skins, are not yet accounted for in "nonfood agriculture"; likewise for miscellaneous crops, such as rye.

Seed and Losses, and Industrial and Government Consumption

Seed rates per acre are assumed for wheat, rice, the four coarse grains, potatoes, dry beans, soybeans (accounted to fats and oils, and protein feeds) and cotton (accounted to protein feeds). Losses due to waste, spoilage, insects, etc., in farm and market storage, processing and distribution activities are modeled as proportions of annual production. In addition, milk fed to calves, as a proportion of milk production, is considered a feed use of milk, and eggs used for hatching is considered a seed use of eggs. The seed and loss rates used are shown in Table 2.

A general Cobb-Douglas functional form is postulated for the nonfood industrial consumption of each food commodity

$$DEMIND_i(t) = \alpha_i\left(\frac{CPRICE_i(t)}{CPRICE_{20}(t)}\right)^{\beta_i}\left(\frac{DOMSUP_{20}(t)}{1000}\right)^{\sigma_i} \quad (1)$$

where

$DEMIND_i$	= industrial demand for commodity i (th MT)
$CPRICE_i$	= consumer price of commodity i
$CPRICE_{20}$	= nonagricultural consumer price index (1967 = 1.00)
$DUMSUP_{20}$	= nonagricultural production (mi. 1967 dollars)
$\alpha_i, \beta_i, \sigma_i$	= parameters of the function

A preliminary data search for this version of the model yielded data on nonfood use of only two food commodities: fats and oils, and fish. The use of corn for methanol production (described elsewhere with the supply side of the model) is determined based on endogenously determined investments in distillation capacity and relative fuel-corn prices. Government incentive policies are included, and the contribution of the high-protein by-product to protein feed supply is accounted for. Zero industrial consumption is assumed for the other food commodities; further research will be necessary to determine whether this is a reasonable assumption (e.g., potatoes and sugar for starch, nondrinking alcohol, etc.).

Industrial demand for the nonagricultural commodity, in million 1967 dollars, is interpreted as demand for intermediate inputs and is computed using the same two-sector input-output model used to determine gross nonagricultural production.

$$DEMIND_{20}(t) = AIO_{21} \cdot VA67(t) + AIO_{22} \cdot VN67(t) \quad (2)$$

where

AIO_{21}	= dollars of nonagricultural input per dollar of agricultural output
VA67	= value of agricultural production at 1967 prices
VN67	= value of nonagricultural production at 1967 prices

Total government consumption expenditures (e.g. for the military, institutions, etc.) are assumed to be a fixed proportion (namely, 21 percent) of GNP. This total is modified in order to achieve the exogenously-specified national

Table 2. Seed and loss rates.

Commodity	Seed Rate (lbs/acre)	Loss Rate (percent)
1. Wheat	72.0	4
2. Rice (rough)	142.0	9
3. Coarse grains		6
- Corn	13.4	
- Sorghum	6.9	
- Barley	80.6	
- Oats	82.6	
4. Potatoes	1800.0	7
5. Vegetables	----	15
6. Dry beans	52.0	5
7. Fruit	----	15
8. Tobacco	----	6
9. Fats and oils }		0
19. Protein feeds }		0
- Soybeans	63.0	
- Peanuts	5.3*	
- Flax	7.5*	
- Cotton	26.0	
10. Sugar	----	1
11. Coffee	----	0
12. Beef	----	5
13. Lamb	----	5
14. Pork	----	5
15. Poultry	----	5
16. Eggs (hatched)	6.8*	0
17. Milk (for calves)	1.4*	3
18. Fish	----	5
20. Nonagriculture	----	0

*Percent of production.

trade balance (necessary for consistency within the global system) if that balance cannot be otherwise achieved at equilibrium prices given quota and tax rate constraints.

This total public expenditure is then allocated to the individual commodities by first assuming a proportion goes to the nonagricultural commodity, and then distributing the rest to the food commodities in the same proportion as lagged private consumption expenditures. The data for food consumption used to calibrate the human food consumption functions described below appear to have been derived as a residual in food balance sheet calculations, with no distinction between public and private consumers. Therefore, until this question can be resolved or other data can be found which explicitly identify government consumption of food commodities, all government consumption is assumed to be of the nonagricultural commodity.

Carry-Out Stock Demand

Stocks are considered in the model for wheat, coarse grains, milk, soybeans and peanuts. The oil and cake equivalents of soybean and peanut stocks are allocated to fats and oils and protein feeds, respectively. Milk stocks include the fresh milk equivalents of milk products stocks. Coarse grain stocks are modeled as an aggregate of corn, sorghum, barley and oat stocks.

The modeling of wheat and coarse grains stocks is more complicated than that of the other commodities, because stocks of these commodities are closely related to price control policies. Specifically, the government will act as a buyer (or stockpiler) of last resort, if necessary, in order to maintain a minimum farm price (or "loan rate"). At the other end, if farm price is rising above an upper target (the "call price"), the government will call in loans, essentially requiring farmers to sell the stocks they hold as part of government programs. It should be mentioned here that this version of the model does not distinguish different types of stocks, such as on-farm stocks, government buffer stocks, market stocks, etc. Rather, total national carry-out stocks are modeled in the aggregate.

Since wheat and coarse grains stocks are modeled identically, the following discussion applies to both commodities. The basic hypothesis is that stocks build up as prices fall and are depleted as prices rise. A negative exponential function is assumed to represent this behavior over most of the relevant price range (curve II in Figure 1). For the function to be homogeneous of degree zero, the independent variable is the price P of the commodity relative to nonagricultural prices P_n. At the call price PC, stocks are assumed to have fallen to a minimum, pipeline level XL below which they will not go even if the relative price is higher than PC (curve III in Figure 1).

Since the government is assumed to be the stockpiler of last resort, the price will not fall below the loan rate PL. (Given the U.S. role in the world market for wheat and coarse grains, this implies supporting the world price as well.) This would imply a vertical, perfectly elastic segment of the stock demand curve at PL. In order for stocks to be a *function* of price, however, as required by the overall model, a negatively-sloped linear segment (curve I in Figure 1) is modeled between PL and zero.

At PL, stocks are assumed to be at their "normal" maximum XU and at zero their "logical" maximum $\overline{XU}$. The logical maximum $\overline{XU}$ is defined somewhat arbitrarily as 110 % of XU. At PL, the normal maximum XU is defined to be

$$XU(t) = \lambda Q(t) \qquad (3)$$

where

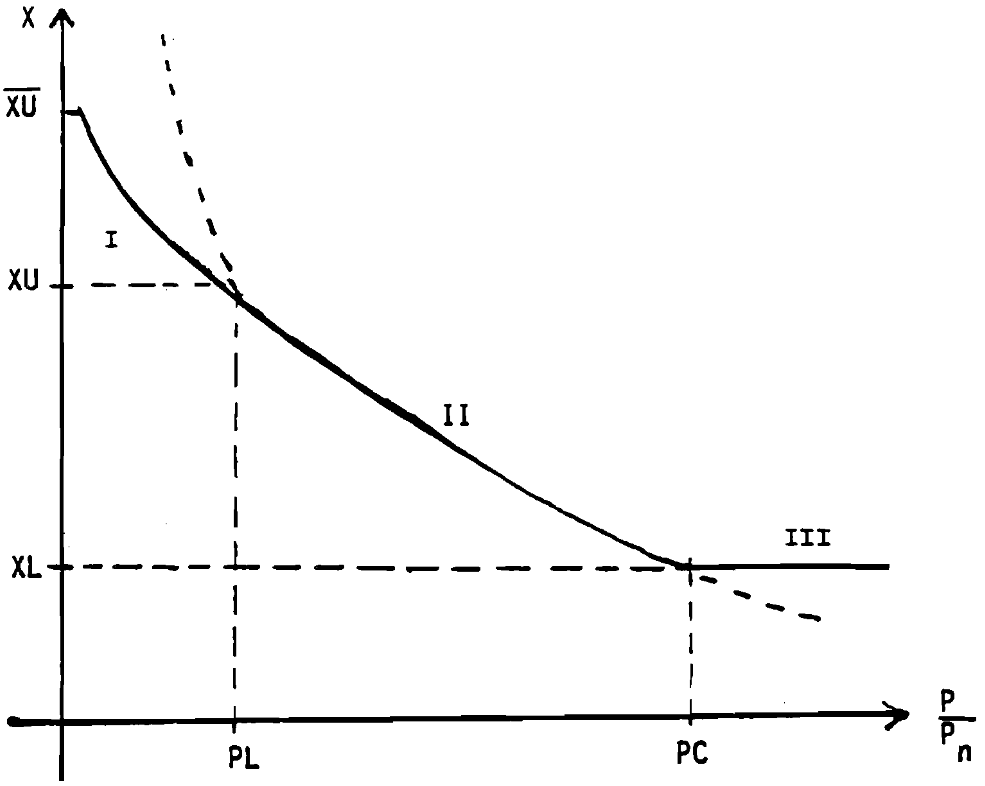


Figure 1. Carry-out stocks function: wheat and coarse grains

Q = total production (th MT)

λ = maximum stock as a proportion of production.

The parameter λ is currently assumed to be 65 percent for wheat and 23 percent for coarse grains. Similarly, at and above the call price PC, pipeline stocks XL are defined to be

$$XL(t) = \mu Q(t) \tag{4}$$

where μ is again a proportion of production (currently assumed to be 25 percent for wheat and 10 percent for coarse grains).

The negative exponential curve II has the form, for stock level X,

$$X(t) = \alpha e^{-\beta(P(t)/P_n(t))} \tag{5}$$

Two points on this curve are assumed to be known, namely, (PL, XU) and (PC, XL). Therefore, the parameters α and β can be determined as

$$\alpha = XU(t)e^{\beta PL(t)} \tag{6}$$

and

$$\beta = \frac{\ln(XU(t)/XL(t))}{PC(t) - PL(t)} \tag{7}$$

Thus, the curve is completely specified by the parameters λ and μ, and by the price policies PC and PL. It is interesting to note that, with α and β defined as in (6) and (7), the stock demand functions reduce to the Cobb-Douglas form, i.e.

$$X = (XU)^{\gamma}(XL)^{\delta} \tag{8}$$

whose exponents, which add to unity, are

$$\gamma = \frac{PC - (P/P_n)}{PC - PL} \text{ and } \frac{(P/P_n) - PL}{PC - PL} \tag{9}$$

For this version of the model, peanut stocks are projected exogenously, while milk and soybean stocks are modeled with the following econometrically estimated equations.

$$MLKSTK(t) = A_0 + A_1 \cdot MKSUPP(t) + A_2 \cdot DOMSUP_{17}(t) + A_3 \cdot GNPPC(t) \tag{9}$$

$$SBSTK(t) = B_0(QSUPSB(t))^{B_1} \tag{10}$$

where

MLKSTK	= milk stocks (th MT)
SBSTK	= soybean stocks (th MT)
MKSUPP	= milk support price (\$/kg)
$DOMSUP_{17}$	= milk supply (production plus carry-in stocks)(th MT)
GNPPC	= per capita GNP (th \$/person)
QSUPSB	= soybean supply (production plus carry-in stocks)(mi MT)

Human Consumption

A rather complicated nonlinear function is used to model the per capita consumption of each food commodity (in pounds per person per year) in order to exhibit a hypothesized mode of consumption behavior with respect to income, prices and time. Specifically, per capita consumption PCC is the product of three functions representing an income factor, a price factor and a time factor, respectively. For each food commodity i,

$$PCC_i(t) = f_i(M(t),P(t)) \cdot g_i(P(t)) \cdot h_i(t) \tag{11}$$

where M is current nominal per capita disposable income ($/person-year), P is a vector of nominal consumer prices ($/pound), and t is time, and where

$$f_i(M,P) = a_i + (b_i - a_i)e^{-c_i(M/CPI)^2} \tag{12}$$

$$g_i(P) = \prod_j [1 - x_{ij}d_j(1 - e^{-\sigma_j(P_j/CPI)})] \tag{13}$$

$$h_i(t) = \alpha_i + (\beta_i - \alpha_i)e^{-\delta_i(t-t_{0i})^2} \tag{14}$$

and where the consumer price index CPI is

$$CPI(t) = \sum_i \omega_i \frac{P_i(t)}{P_i(1967)} \tag{15}$$

As shown in Figures 2 and 3,* the income factor f and its parameters a and b have units of per capita consumption and are the major determinants of PCC, while g and h serve as multipliers. The price factor g is nominally unity when all prices are zero, and the time factor h is unity (with $\alpha=\beta=1$) for commodities with no time trend assumed.

Indeed, there are only four commodities (wheat, coarse grains, tobacco and milk) for which time trends are assumed to reflect changes in per capita consumption not reasonably attributable to price, income or other endogenous model variables. For example, a sharp decline in tobacco consumption per capita has been observed, beginning in about 1964 when the first Surgeon-General's report was issued on the health hazards of cigarette smoking. Zero food consumption of "protein feeds" is assumed ($a_{19}=b_{19}=0$), although this restriction may have to be relaxed if food use of soybeans can be expected to become significant in the U.S.

The asymptotic behavior of f_i has advantages over a constant income elasticity model, particularly in long-run analysis as real income increases, in that consumption will remain within reasonable physical and nutritional ranges. Indeed, the set of values for the a_is may be specified according to what could be considered to be a realistic or plausible dietary and nutritional mix in the limit "as real income goes to infinity." Note in Figure 2 that setting $b_i > a_i$ implies an inferior good, while $b_i < a_i$ indicates a normal good.

Cross-price effects in the price factor g_i, i.e. the impacts of the price of commodity j on consumption of commodity i, are reflected in the matrix $[x_{ij}]$. For the own-price effect, $i = j$, $x_{ij} = 1.0$, for complementary goods $x_{ij} > 0$, and for substitute commodities $x_{ij} < 0$. $x_{ij} = 0$ implies no cross-price effect. From this point of view, a commodity is a perfect complement to itself, i.e., one always eats rice with rice.

Note in equation (13) and Figure 3 that x_{ij} is a proportion of d_j. That is, the effect of commodity j's price on consumption of commodity i is proportional to its effect on own consumption, i.e., the consumption of commodity j. The d_j represents the maximum proportional deviation of commodity j consumption as the real price of j increases without limit. Thus, $d_j = 1$ implies consumption goes to zero "as real price goes to infinity", while $d_j = 0$ indicates no price response.

In order to maintain a consumption expenditure budget constraint, per capita consumption of the nonagricultural commodity PCC_{20} (in 1967 $/person) is computed as a residual, where the total budget is taken to be disposable

*A figure is not given for the time factor h; it would look exactly the same as Figure 2, with α and β in place of a and b, and $(t-t_0)$ in place of (M/CPI).

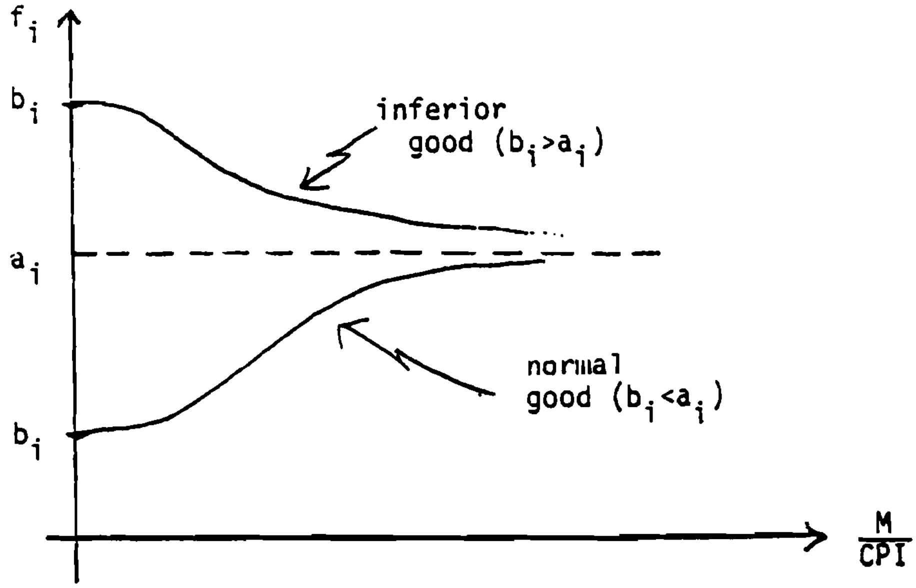


Figure 2. The income factor of per capita consumption.

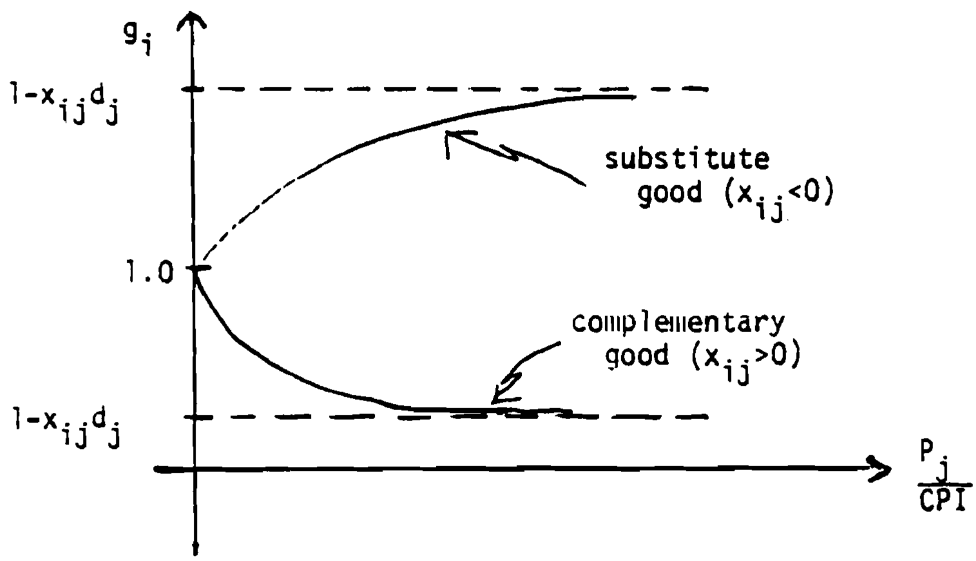


Figure 3. The price factor of per capita consumption.

income M, implying savings as a component of PCC_{20}.

Econometric estimation of the parameters - a_i, b_i, c_i, d_i, x_{ij}, α_i, β_i, σ_i, δ_i for i and j = 1, 2,...,18 - has not yet been attempted. Preliminary judgemental estimates were made and then further refined in "manually tuning" the model to track PCC for the 1970-1976 period using actual historical values for M and P over that period. Although elasticities as such are not used in the model, as a check on model performance with these parameter values, Table 3 shows elasticities computed from the partial derivatives of PCC in equation (11) with respect to prices and income. In addition, the Appendix includes plots comparing historical observations PCCACT with simulation results PCC using the parameter values estimated in this way. The following measure of overall goodness of fit for these result

$$\sum_{t=1955}^{1976} \sum_{\substack{i=1 \\ i \neq 19}}^{20} \left| \frac{PCC_i(t) - PCCACT_i(t)}{PCCACT_i(t)} \right| \tag{16}$$

has a value of 22.3. For 22 years (1955-1976) of data on each of 19 commodities, i.e. 418 observations, this implies an average error of about 5.3 percent per observation. With emphasis given on tuning to track the 1970-1976 period, earlier tracking for some commodities is not too good. This is particularly evident for those with a time trend factor (wheat, tobacco and milk).

Prices

Prices are the major feedback from the simultaneous national-international exchange system to the national model. Domestic consumer prices are determined based on world prices and national price policies. A "target" (or "desired" or "normal") price for each commodity PD_i is defined to be proportional to the retail-level world price PWD_i.

$$PD_i = DPD_i \cdot PWD_i \tag{17}$$

where DPD can be interpreted to embody not only tariff policies, for instance, but also quality and other differences between the domestic commodity and the world commodity, transportation costs, etc. The retail-level world price PWD_i is defined as the world price PW_i plus a domestic marketing/processing margin PRM_i representing a quantity of the nonagricultural good (commodity n) times the price of that good. PRM_i is also used as the margin between domestic farm and consumer prices.

$$PWD_i = PW_i + PRM_i \cdot PW_n \tag{18}$$

The price PD_i will be the equilibrium price P_i unless a specified minimum QEX_i or maximum QIM_i demand constraint is effective, where these can be interpreted as export and import quotas, respectively. These quotas are defined each year in the model based on minimum and maximum self-sufficiency rates and minimum and maximum year-to-year changes in consumption for each commodity. If one of these constraints is effective, the equilibrium price P_i will be below or above PD_i, respectively, unless buffer stock behavior is modeled. In that case (as for wheat, coarse grains, milk and protein feeds discussed above), equilibrium carry-out stocks will deviate above or below a target level, respectively, where the target stocks are those determined in equations (5), (9) and (10) above. Maximum and minimum stocks are also specified, and if the stock adjustment is such as to make a stock constraint effective, *then* P_i will deviate from PD_i.

Table 3. Price and income elasticities of demand in 1970.

Quant. \ Price	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}
	Price Elasticities										
1	-0.047	0.013	0.002	0.013	0.009	0.007	0.005	-0.002	-0.001	-0.002	-0.001
2	0.005	-0.077	0.003	0.024	0.044	0.019	-0.012	-0.013	-0.004	-0.014	-0.004
3	-0.007	0.004	-0.019	-0.003	-0.017	-0.001	-0.015	-0.017	-0.005	-0.019	-0.005
4	0.011	0.025	-0.000	-0.179	0.051	0.020	-0.005	-0.006	-0.002	-0.007	-0.002
5	-0.001	-0.000	-0.000	0.014	-0.301	0.017	0.045	-0.001	-0.000	-0.001	-0.000
6	0.017	0.018	0.000	0.035	0.046	-0.076	0.006	0.007	0.002	0.008	0.002
7	-0.002	-0.000	-0.000	-0.000	0.019	-0.000	-0.232	-0.002	-0.001	-0.002	0.009
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.037	0.000	0.000	0.000
9	-0.019	-0.004	-0.001	-0.004	-0.031	-0.001	-0.018	-0.020	-0.041	-0.022	-0.006
10	-0.002	-0.000	-0.000	-0.000	-0.002	-0.000	0.012	-0.002	-0.001	-0.111	0.004
11	0.012	0.002	0.001	0.003	0.013	0.001	0.012	0.013	0.004	0.014	-0.091
12	-0.011	-0.002	-0.001	-0.002	-0.012	-0.001	-0.011	-0.012	-0.004	-0.013	-0.004
13	0.025	0.005	0.002	0.005	0.027	0.001	0.024	0.027	0.009	0.030	0.008
14	-0.001	-0.000	-0.000	-0.000	-0.001	-0.000	-0.001	-0.001	-0.000	-0.001	-0.000
15	-0.018	-0.004	-0.001	-0.204	-0.020	-0.001	-0.018	-0.020	-0.006	-0.022	-0.006
16	0.015	0.003	0.001	0.003	0.016	0.001	0.014	0.016	0.005	0.017	0.005
17	0.003	0.001	0.000	0.001	0.003	0.000	0.003	0.003	0.001	0.004	0.001
18	-0.014	-0.003	-0.001	-0.003	-0.015	-0.001	-0.013	-0.015	-0.005	-0.016	-0.004
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	-0.004	-0.001	-0.010	-0.003	-0.006	-0.001	-0.004	-0.018	-0.004	-0.003	-0.004

Quant. \ Price	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	Income Elas.	Σ^*
1	-0.003	-0.002	-0.002	-0.001	0.024	-0.003	-0.001	0.000	-0.067	0.057	-0.00
2	-0.020	-0.015	-0.011	-0.006	-0.006	-0.025	-0.004	0.000	-0.493	0.688	-0.00
3	-0.026	-0.019	-0.015	-0.008	-0.008	-0.032	-0.005	0.000	-0.635	0.850	-0.00
4	-0.009	-0.007	-0.005	-0.003	-0.003	-0.012	-0.002	0.000	-0.229	0.362	-0.00
5	-0.001	-0.001	-0.001	-0.000	-0.000	-0.002	-0.000	0.000	-0.030	0.265	-0.00
6	0.011	0.008	0.006	0.003	0.003	0.013	0.002	0.000	0.264	-0.375	0.00
7	-0.003	-0.002	-0.002	-0.001	-0.001	0.002	-0.001	0.000	-0.067	0.283	-0.00
8	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.011	0.023	0.00
9	-0.031	-0.023	-0.018	-0.010	-0.009	-0.039	-0.006	0.000	-0.766	1.067	-0.00
10	-0.003	-0.002	-0.002	-0.001	-0.001	-0.002	-0.001	0.000	-0.071	0.184	-0.00
11	0.020	0.015	0.011	0.006	0.006	0.032	0.004	0.000	0.495	-0.573	0.00
12	-0.601	0.045	0.126	0.057	0.011	-0.023	0.070	0.000	-0.457	0.843	-0.00
13	0.070	-0.106	0.038	0.030	0.013	0.052	0.018	0.000	1.025	-1.299	0.00
14	0.076	0.020	-0.549	0.048	0.005	-0.001	0.056	0.000	-0.023	0.371	-0.00
15	0.057	-0.007	0.048	-0.241	-0.009	-0.038	0.024	0.000	-0.744	1.026	-0.00
16	0.024	0.018	0.014	0.008	-0.122	0.030	0.005	0.000	0.594	-0.664	0.00
17	0.005	0.004	0.003	0.002	0.010	-0.194	0.001	0.000	0.123	0.028	0.00
18	0.031	-0.011	0.015	0.010	-0.007	-0.028	-0.294	0.000	-0.552	0.922	-0.00
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
20	-0.017	-0.003	-0.013	-0.008	-0.006	-0.017	-0.007	0.000	-0.972	1.100	0.00

*Σ = the sum of income and all cross-price elasticities; it must equal zero for homogeneity.

These prices are at the 10-commodity international aggregation and must be disaggregated to the U.S. model's 20-commodity utilization level for consumer prices and the 30-commodity supply level for farm prices (see Table 1). The 10-commodity aggregate prices P_i are related to the 20-commodity aggregate prices CP_k by

$$P_i = \left[\sum_k \omega_k \frac{CP_k}{\sigma_k}\right] / \sum_k \omega_k \tag{19}$$

for i = 1, 2, ..., 10 and where the summation is over commodities k belonging to aggregate i. In (19), ω_k is the consumer price index weight of equation (15), and σ_k is a unit conversion factor, e.g., th.MT of carcass weight to th.MT of protein equivalent (see Table 1).

For commodities with a one-to-one correspondence, i.e. wheat, rice, coarse grains, milk and nonagriculture, the consumer prices are simply

$$CP_k = \sigma_k P_i \tag{20}$$

For the other commodities, the CP_k are determined from econometrically estimated equations, generally as functions of per capita income, per capita supply, and other prices. Each CP_k in a group i is then ratioed, given P_i, so (19) holds.

Producer prices PP_k at the 20-commodity level are determined from consumer prices and an assumed farmer share α_k

$$PP_k = \delta_k \alpha_k CP_k \tag{21}$$

where δ_k is a unit conversion, e.g. from $/pound for consumer prices to $/bushel for farm prices. The marketing/processing margins PRM_i used in (18) are computed from the farmer shares α_k by

$$PRM_i = \left\{\left[\sum_k \omega_k (1 - \alpha_k) \frac{CP_k}{\sigma_k}\right] / \sum_k \omega_k\right\} / P_n \tag{22}$$

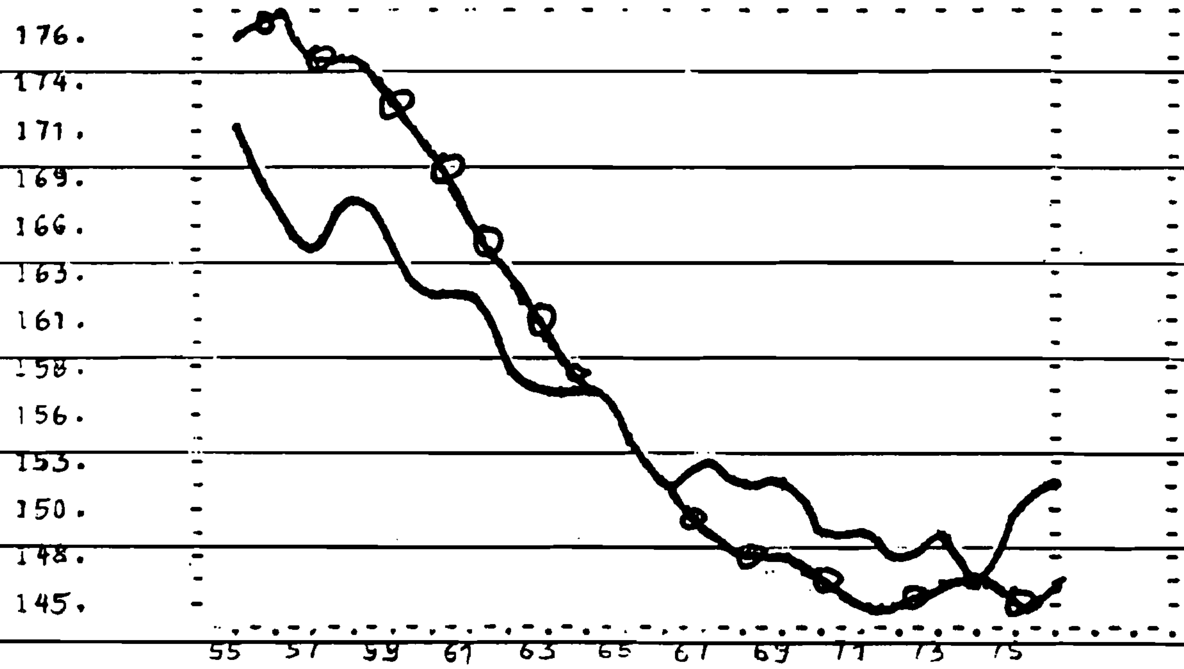
where, again, the summation is over commodities k in group i.

The 20-commodity producer prices are then disaggregated to the 30-commodity level. For example, it is assumed that PP_3 for coarse grains represents the corn price. The farm prices of barley, oats and sorghum are then related to that of corn and to the share of those commodities in total feed grain production FGQT by equations of the type

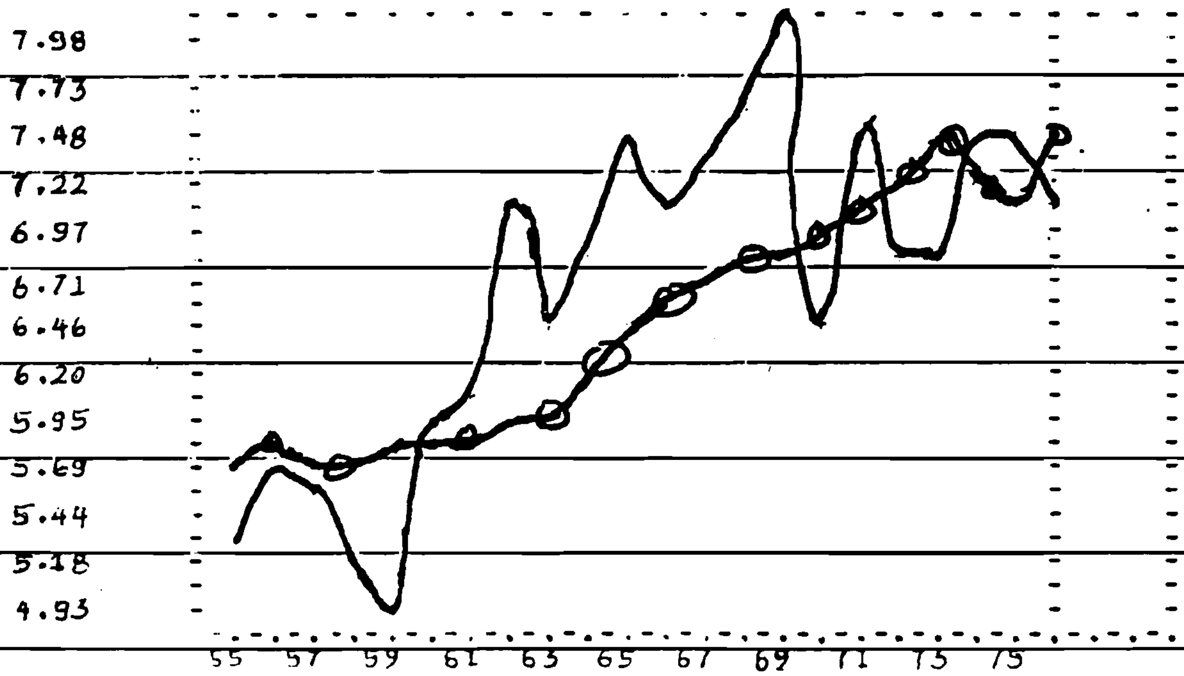
$$PPCG_j = \alpha_j + \beta_j PP_3 + \gamma_j \frac{Q_j}{FGQT} \tag{23}$$

APPENDIX

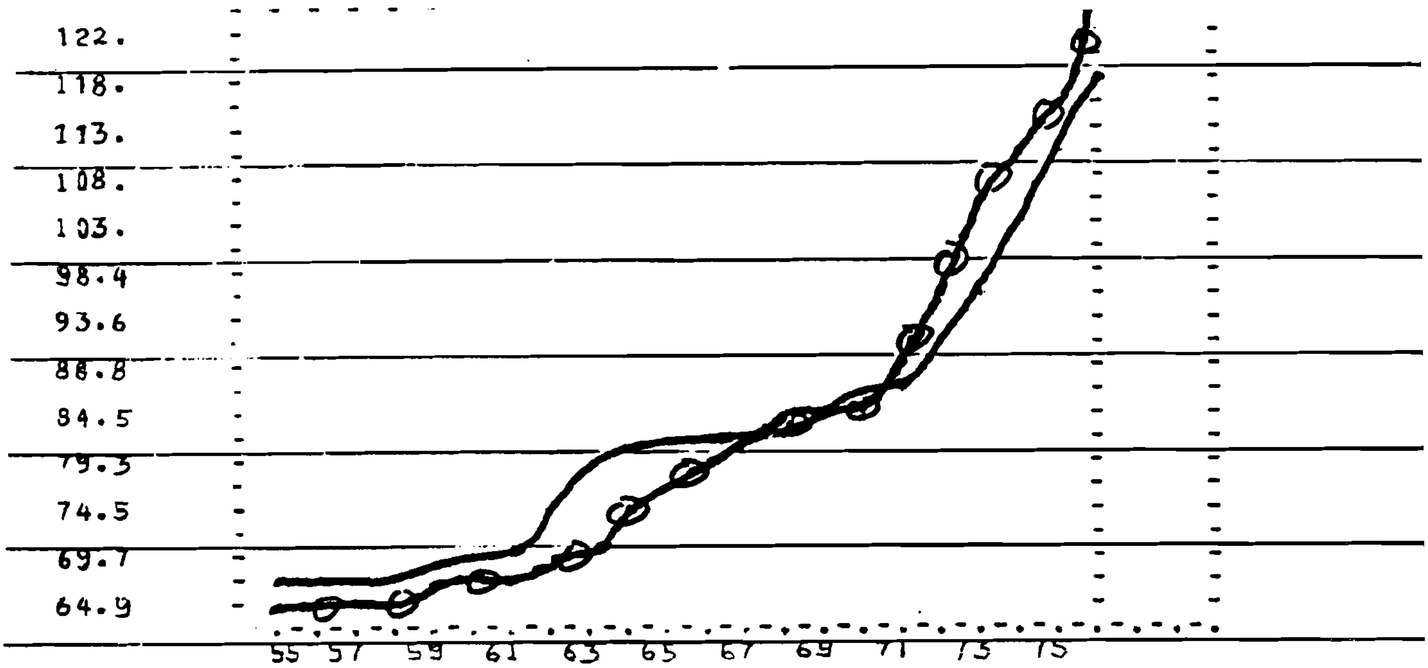
The following charts include plots and tables comparing actual and estimated per capita consumption over the years 1955-1976 using the preliminary data derived as desribed in the text. The sum of absolute values of proportional errors over all 418 observations (19 commodities and 22 years) is 22.3, or an average of about 5.3 percent per observation. The last two columns in the table of each chart compare the year-to-year percentage change in the two series, where the same sign in the two columns means the estimated (indicated by *) and the actual (indicated by +) change in the same direction. In the plots, the actual series is indicated by —— and the estimated by —o—.



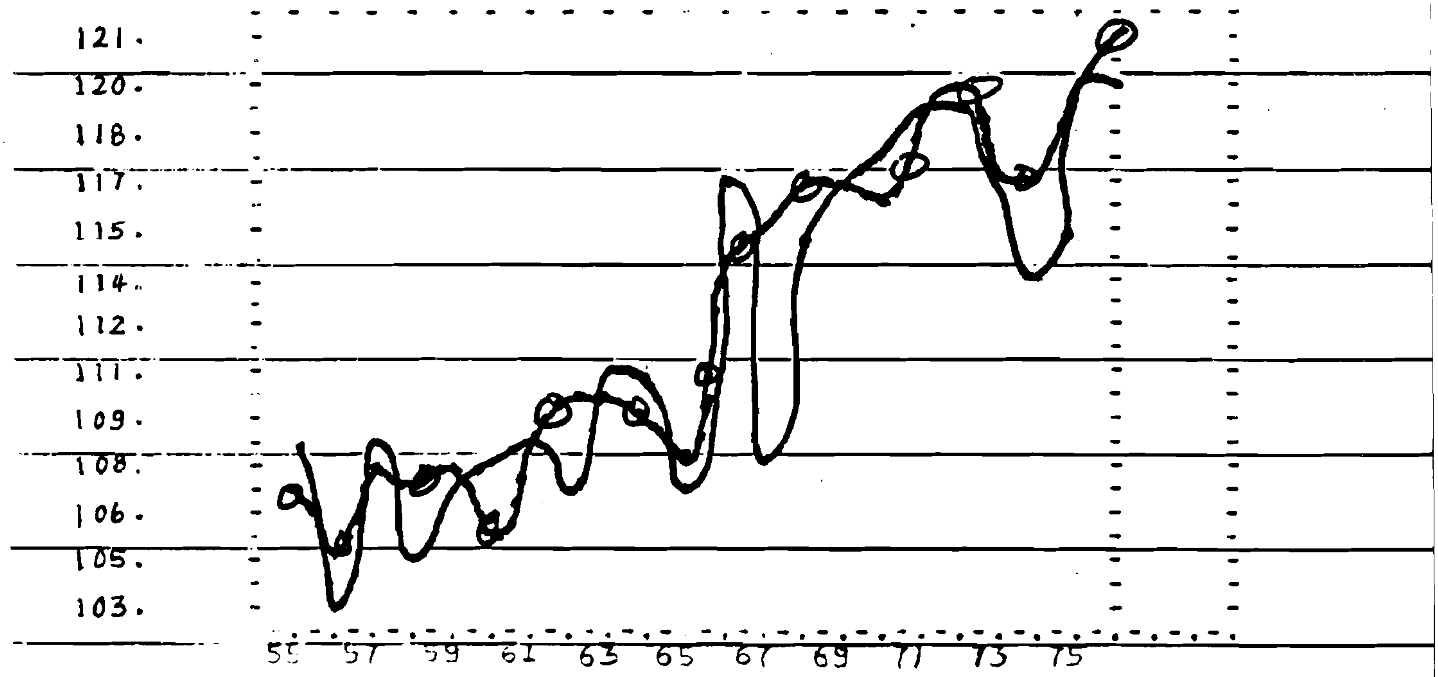
Actual (-) and estimated (-θ-) values for 1 - WHEAT



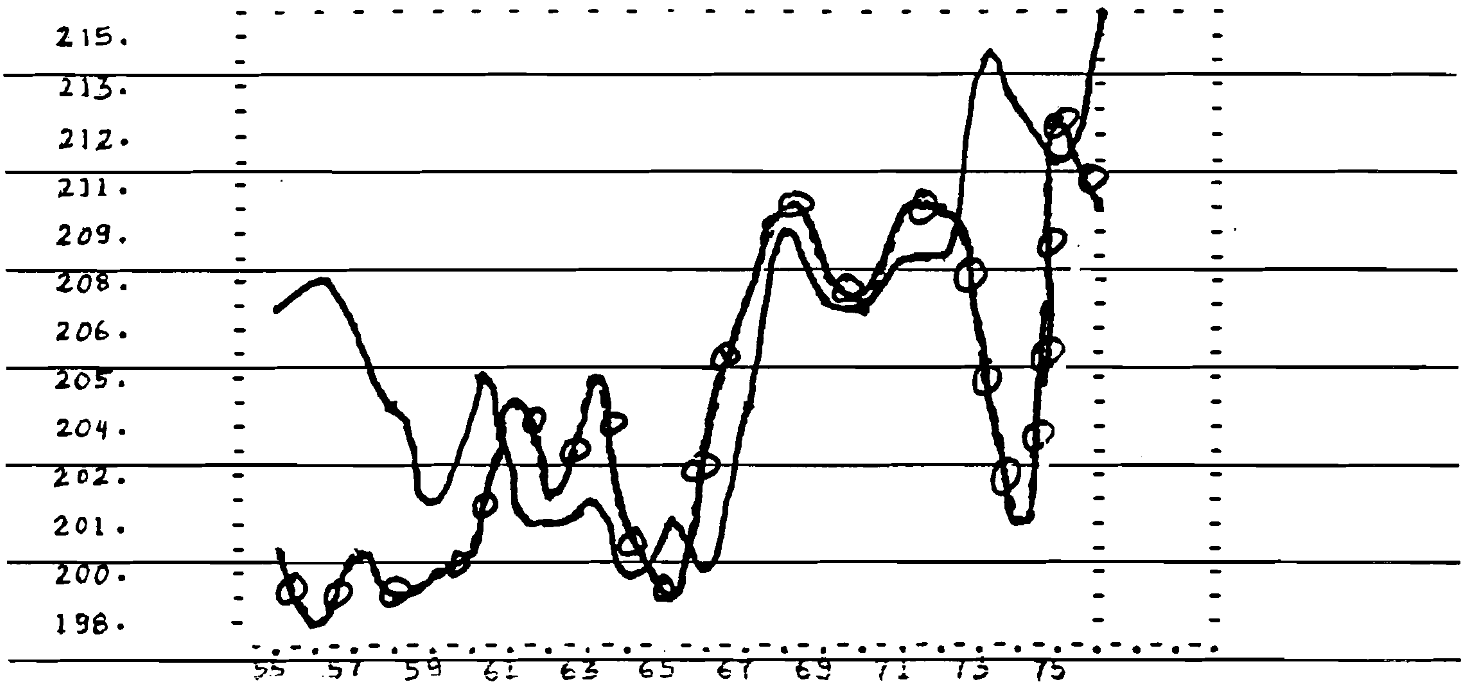
Actual (-) and estimated (-θ-) values for 2 - RICE



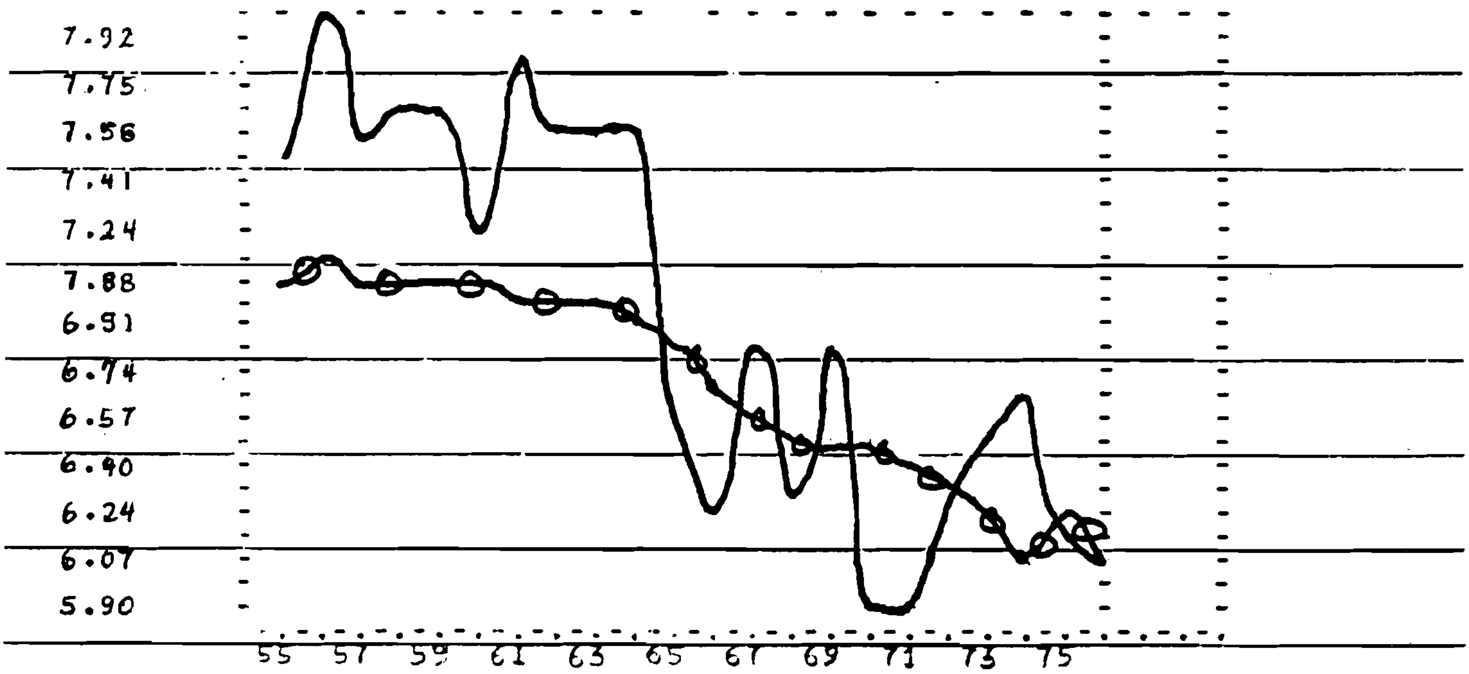
Actual (-) and estimated (-⊖-) values for 3 - COARSE GRAIN



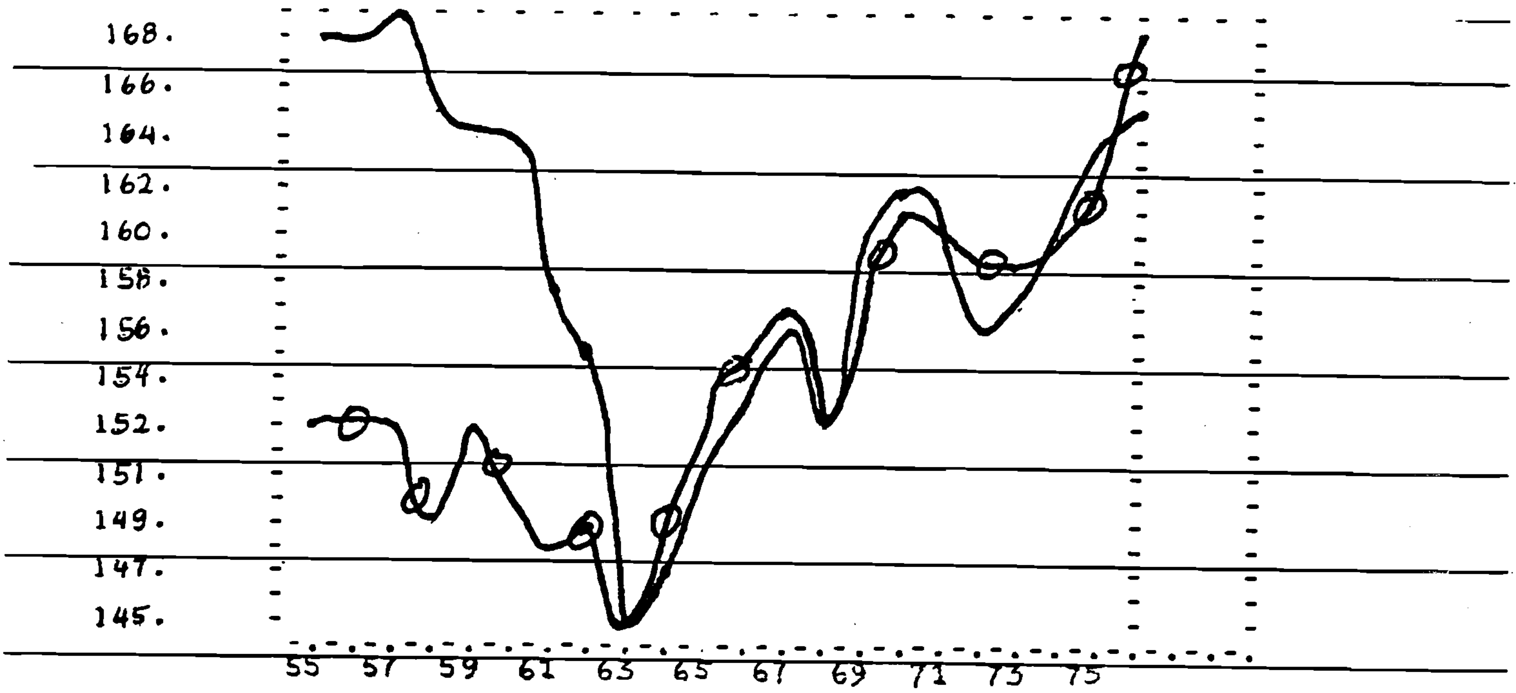
Actual (-) and estimated (-⊖-) values for 4 - POTATOES



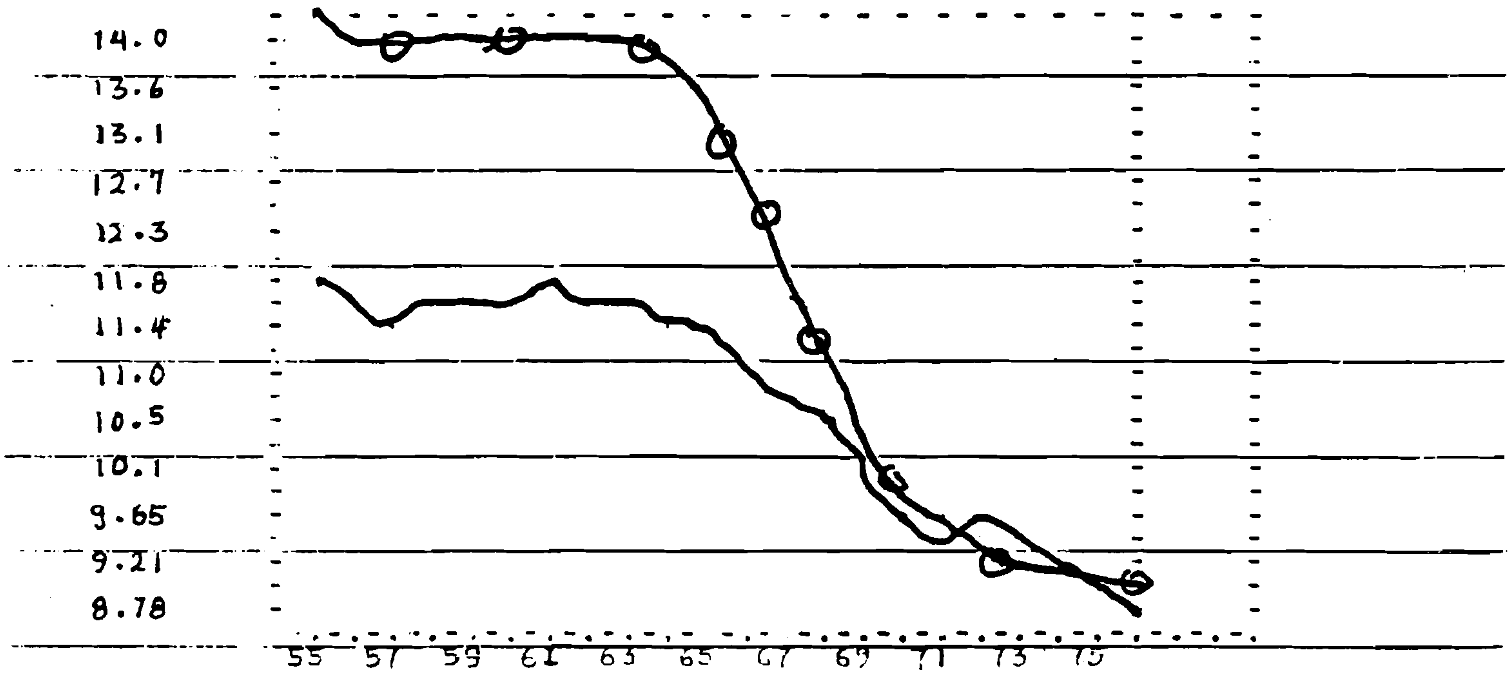
Actual (-) and estimated (-θ-) values for 5 - VEGETABLES



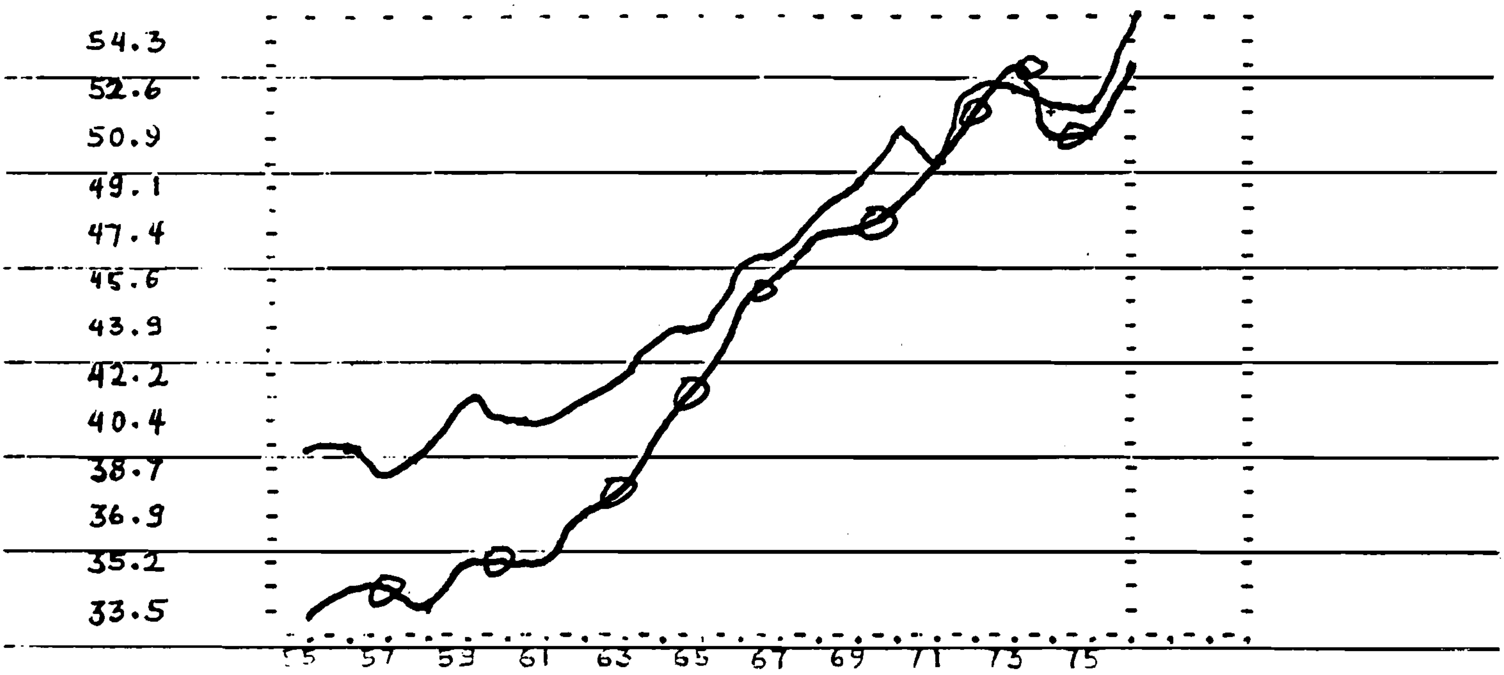
Actual (-) and estimated (-θ-) values for 6 - BEANS



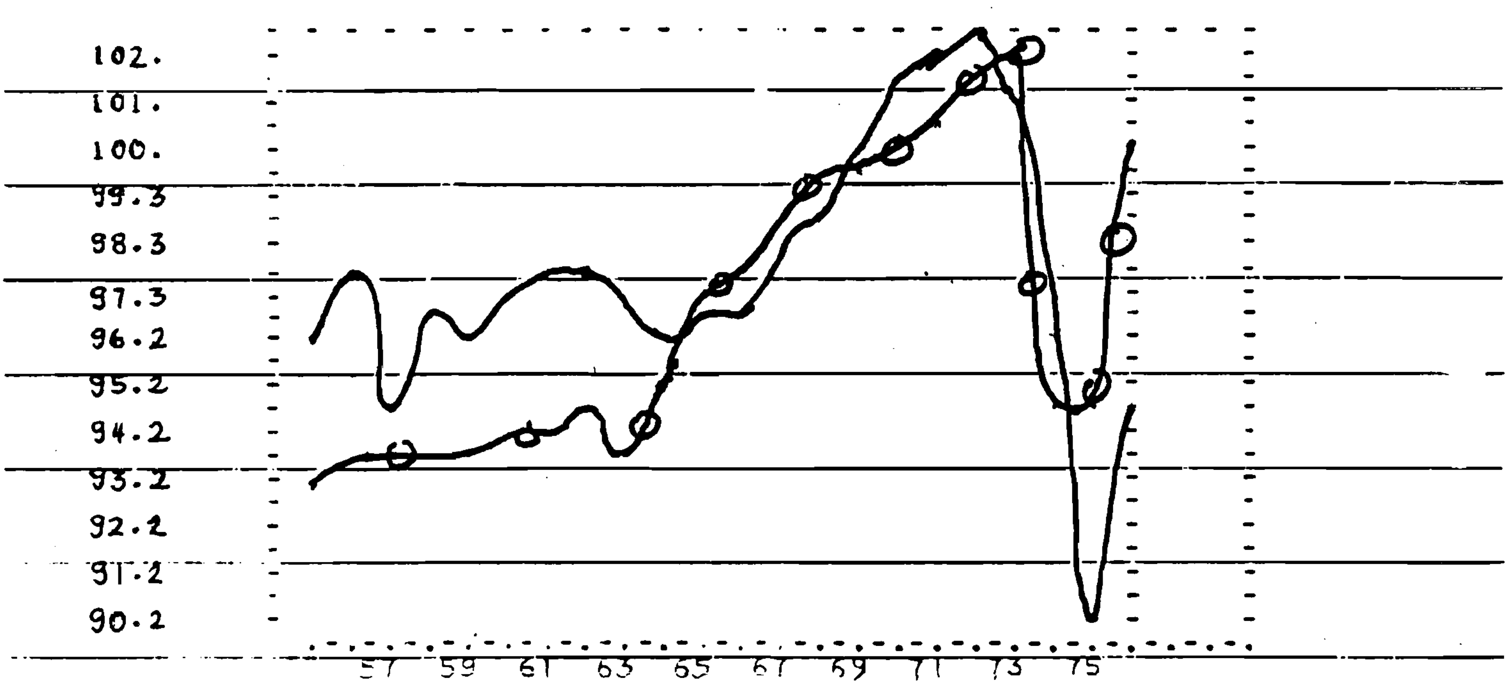
Actual (-) and estimated (-θ-) values for 7 - FRUIT



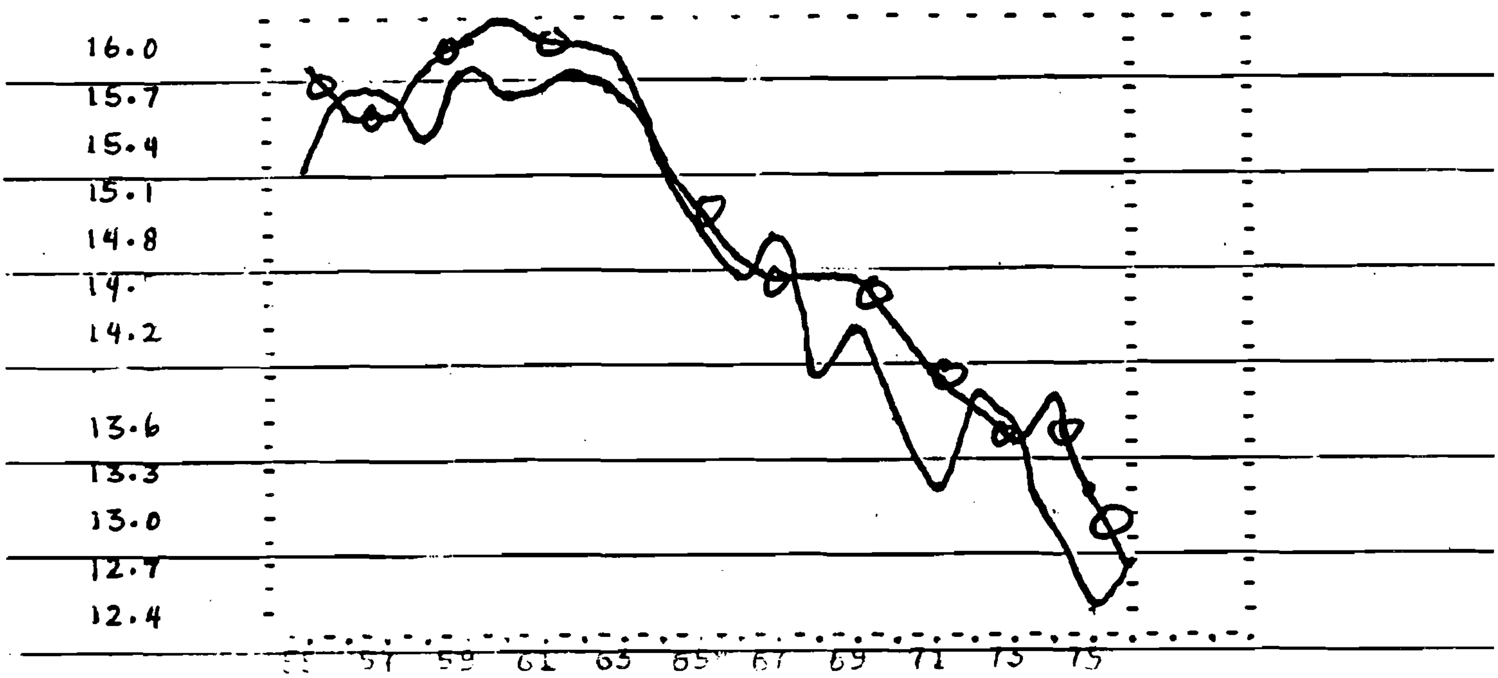
Actual (-) and estimated (-θ-) values for 8 - TOBACCO



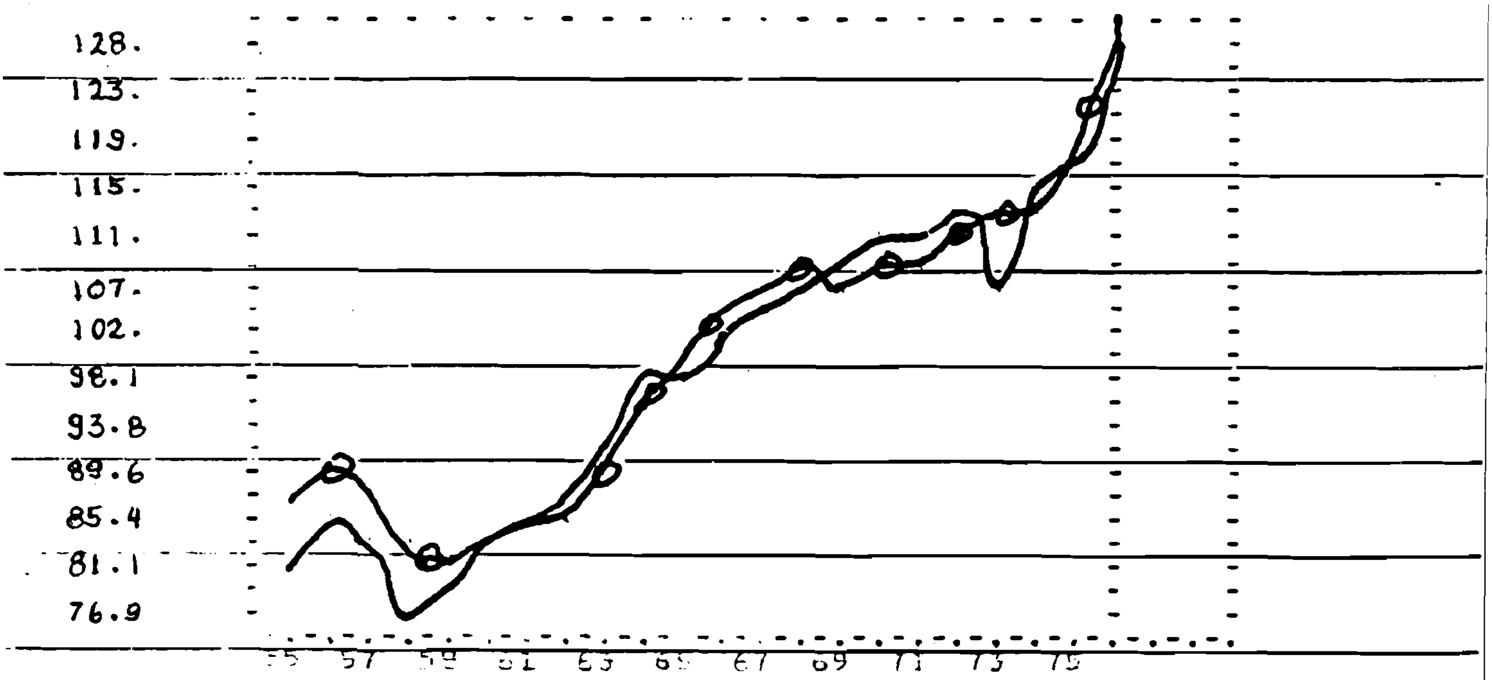
Actual (-) and estimated (-θ-) values for 9 - FATS/OILS



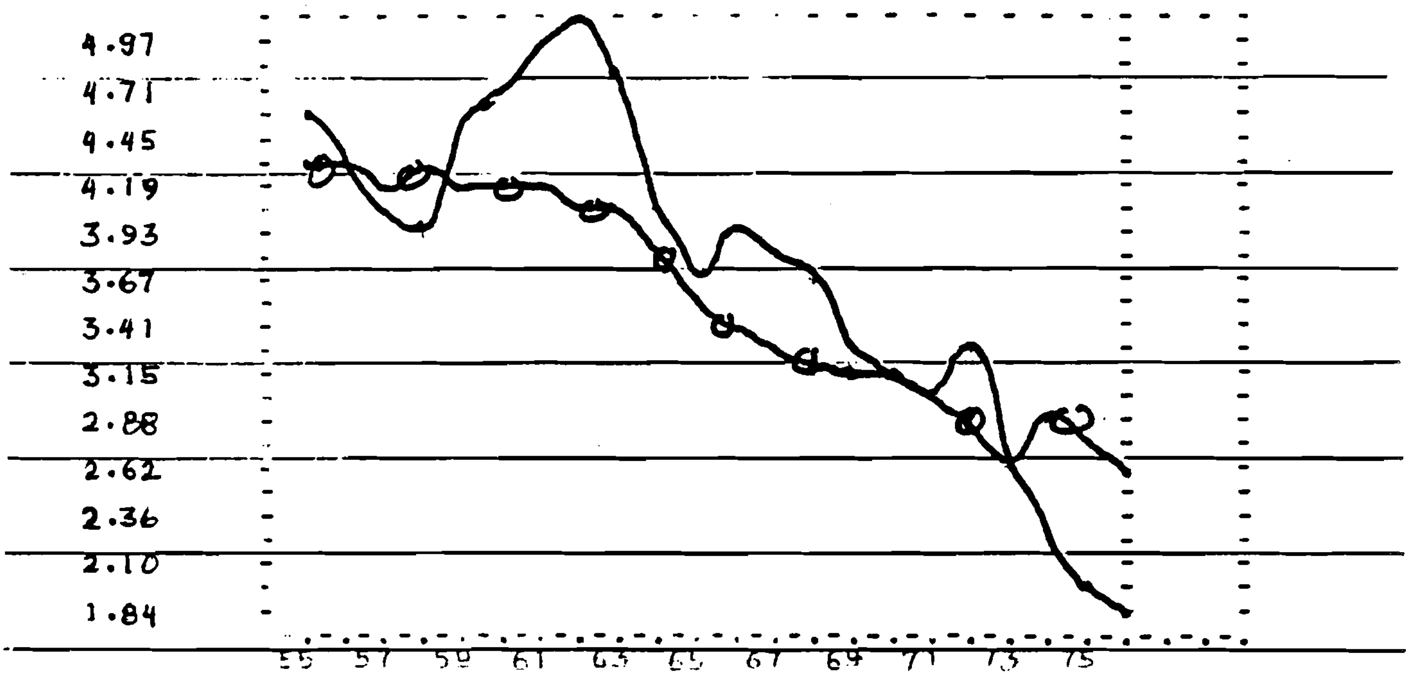
Actual (-) and estimated (-θ-) values for 10 - SUGAR



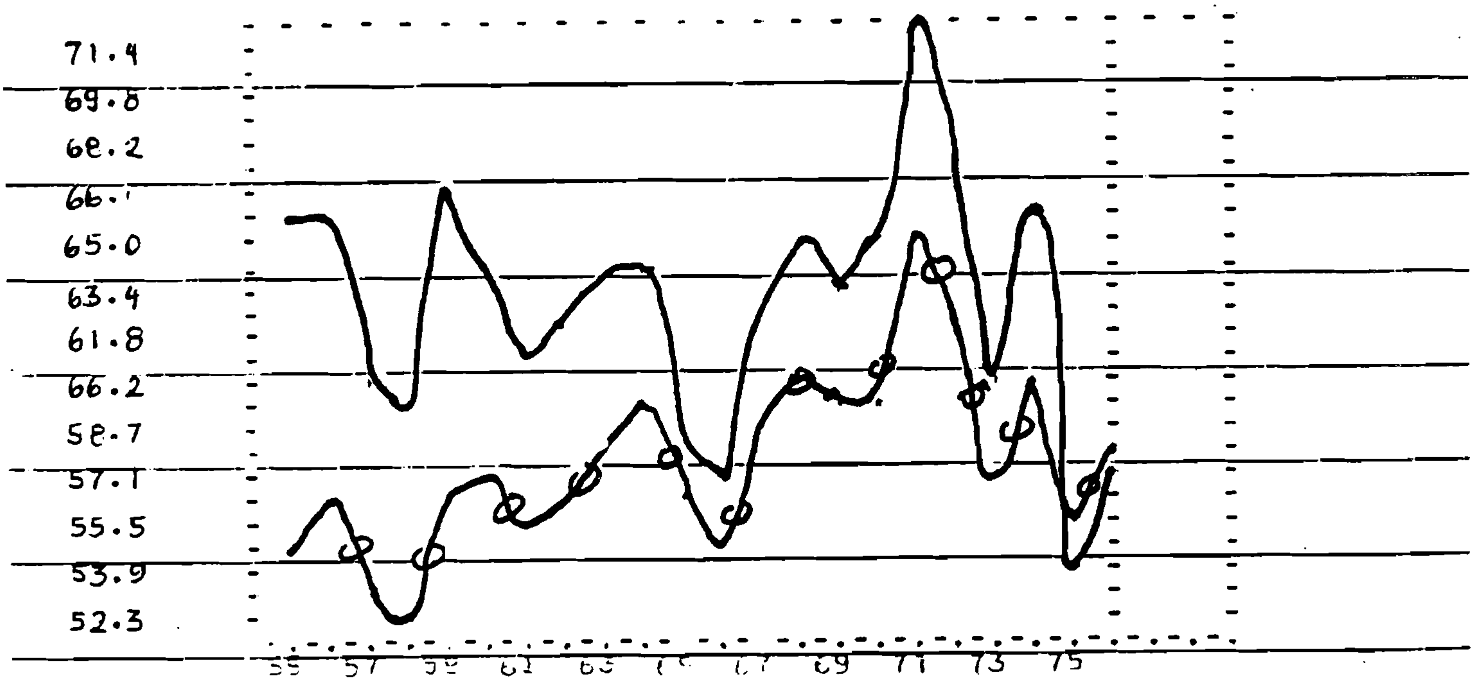
Actual (-) and estimated (-θ-) values for 11 - COFFEE



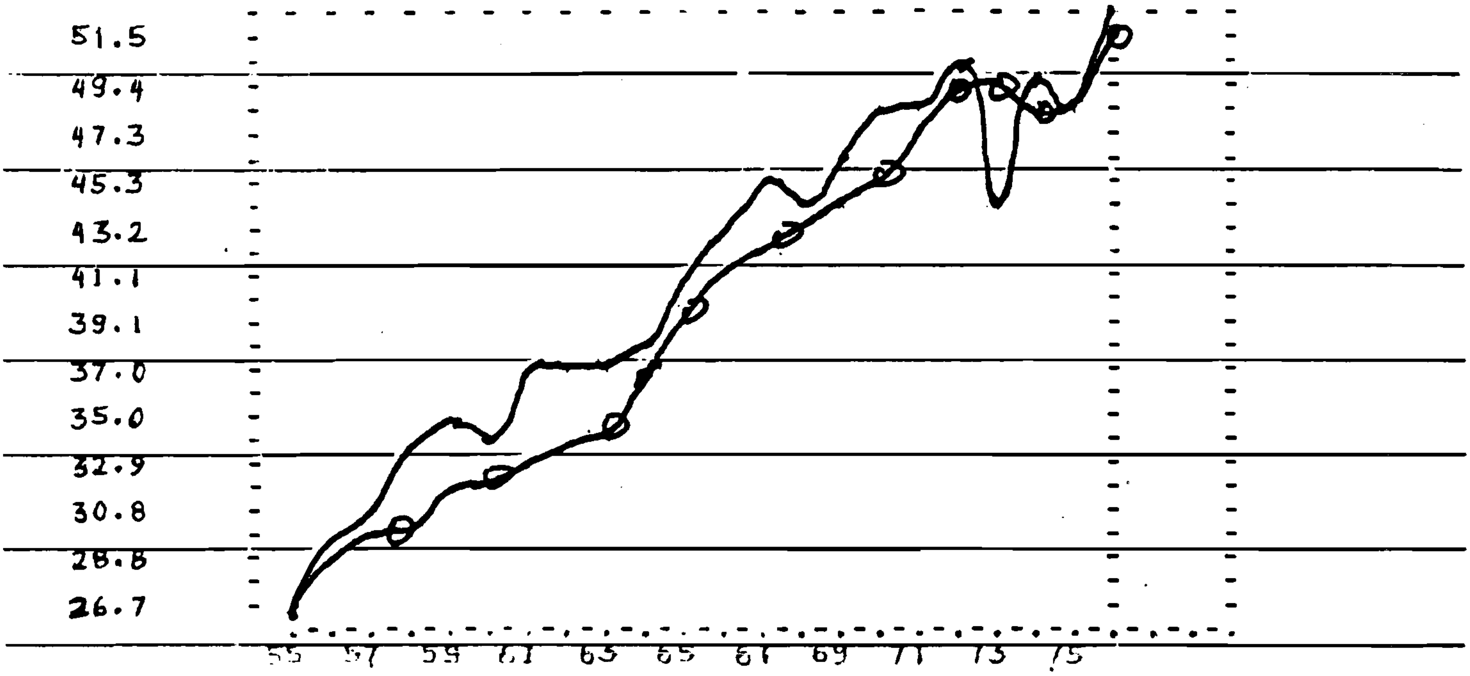
Actual (-) and estimated (-θ-) values for 12 - BEEF



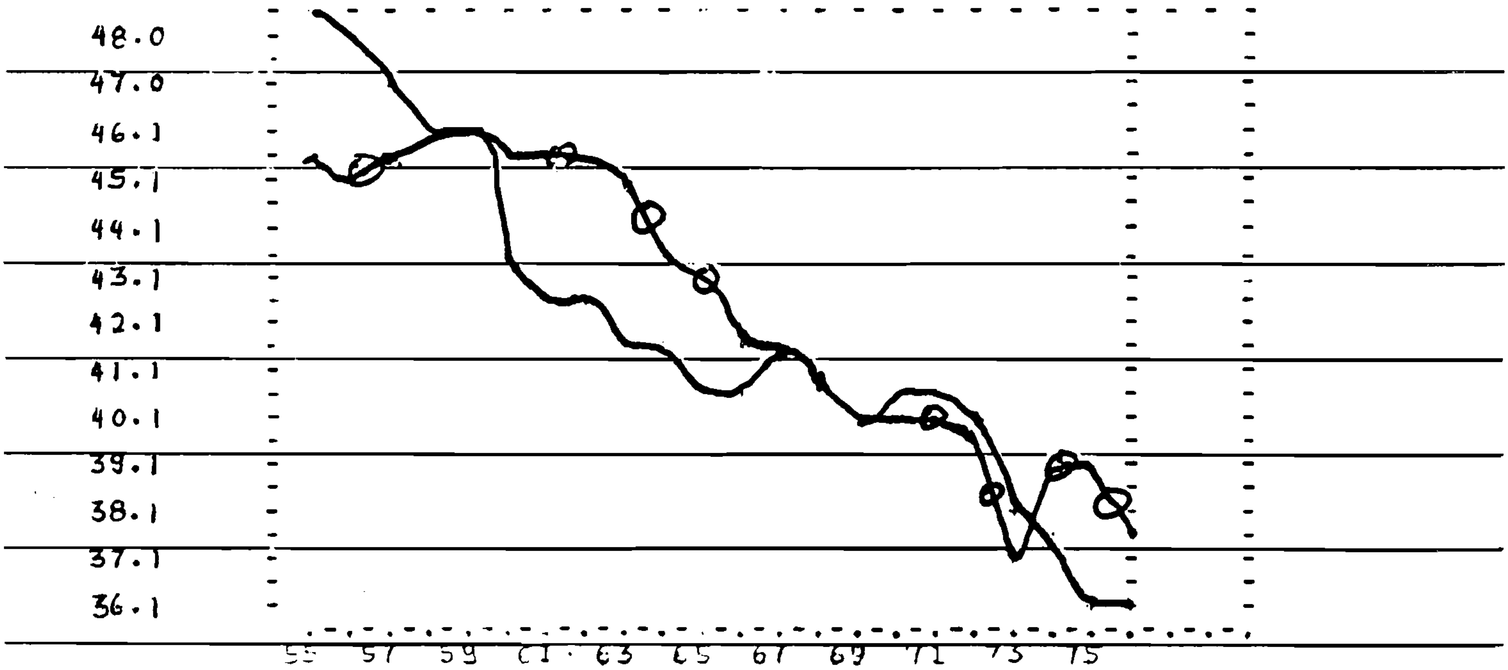
Actual (-) and estimated (-θ-) values for 13 - SHEEP



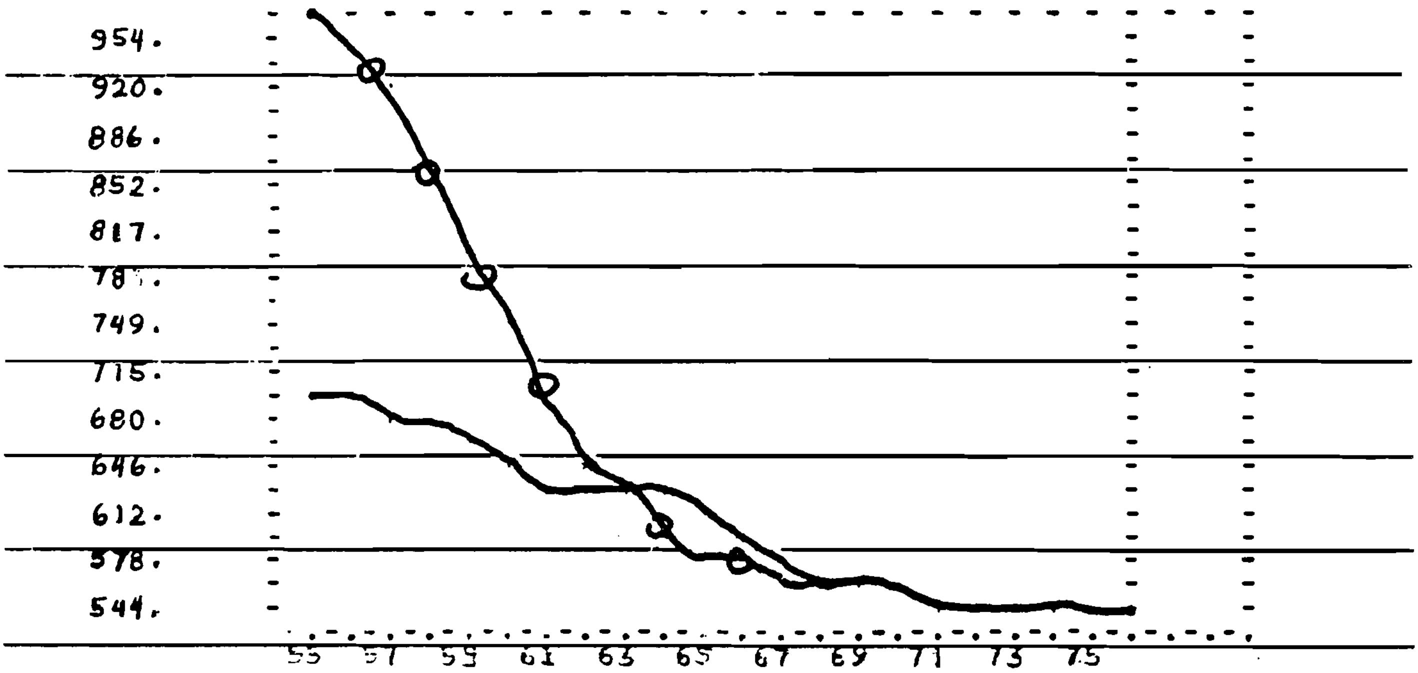
Actual (-) and estimated (-θ-) values for 14 - PORK



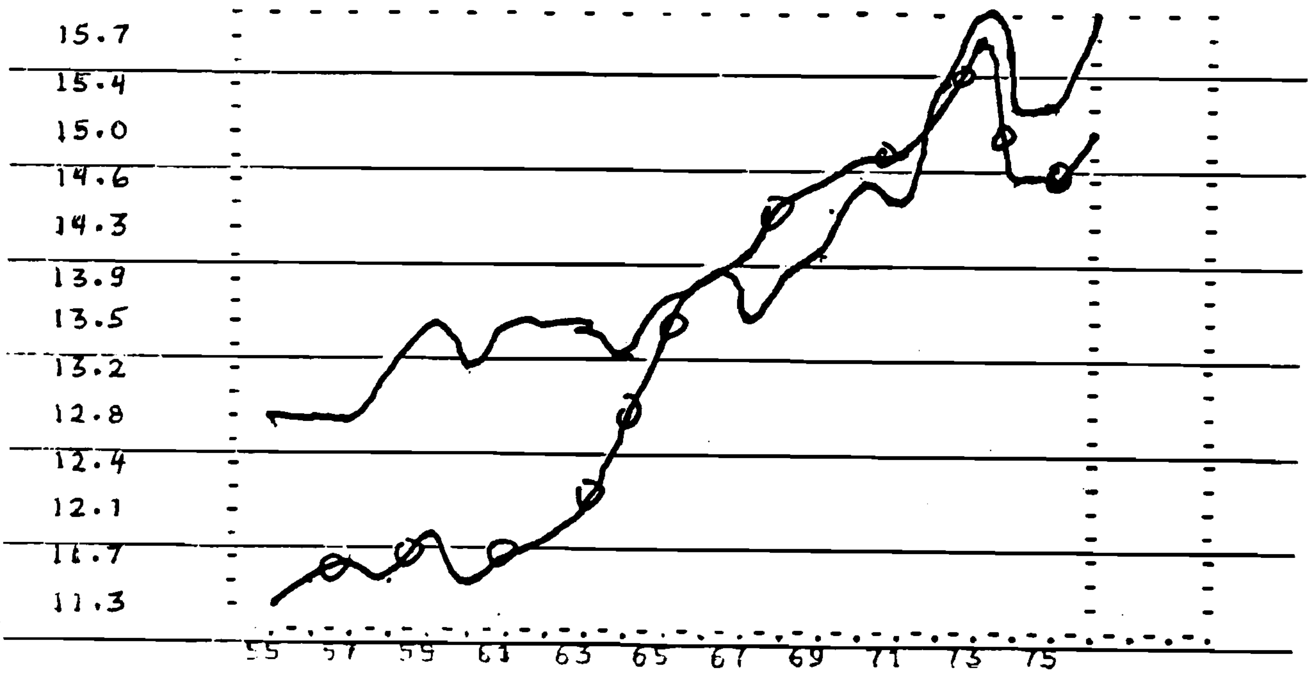
Actual (-) and estimated (-θ-) values for 15 - POULTRY



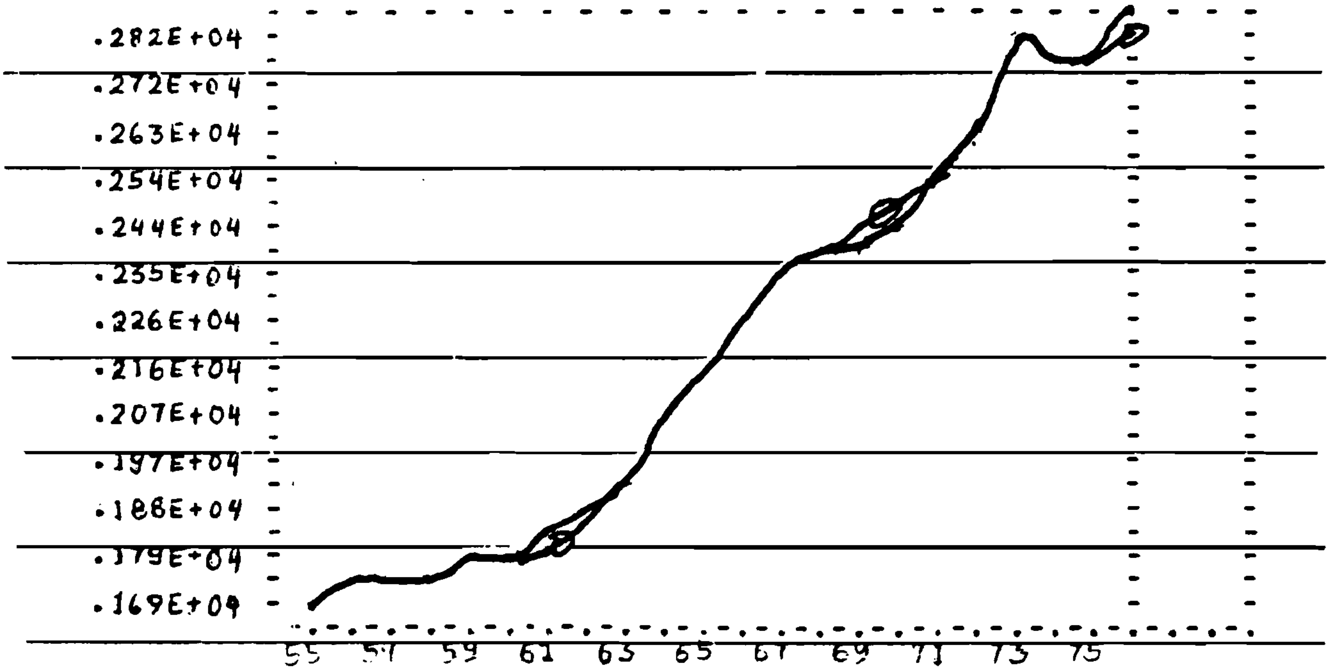
Actual (-) and estimated (-θ-) values for 16 - EGGS



Actual (-) and estimated (-θ-) values for 17 - MILK



Actual (-) and estimated (-θ-) values for 18 - FISH



Actual (-) and estimated (-θ-) values for 19 - OTHER