AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

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Batch #14

1. SUBJECT CLASSIFICATION	A. PRIMARY Agriculture	AE10-0000-0000
	B. SECONDARY Agricultural economics	

2. TITLE AND SUBTITLE
Production campaigns with input constraints and various tax policies,a simulation analysis

3. AUTHOR(S)
Abkin,M.H.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1972	55p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Mich.State

8. SUPPLEMENTARY NOTES (*Sponsoring Organization, Publishers, Availability*)

9. ABSTRACT

10. CONTROL NUMBER PN-RAA-724	11. PRICE OF DOCUMENT
12. DESCRIPTORS Production capacity Simulation Taxation	13. PROJECT NUMBER 14. CONTRACT NUMBER CSD-1557 Res, 15. TYPE OF DOCUMENT

AID 590-1 (4-74)

PRODUCTION CAMPAIGNS WITH INPUT CONSTRAINTS AND VARIOUS TAX POLICIES: A SIMULATION ANALYSIS

CONTENTS

PRODUCTION CAMPAIGNS WITH INPUT CONSTRAINTS AND

VARIOUS TAX POLICIES: A SIMULATION ANALYSIS

Introduction

This paper presents and discusses the results of policy experiments conducted with a system simulation model of Nigeria's agricultural economy.[1] The experiments were designed to investigate the likely results of production campaigns in Nigeria's principal cash and staple food crops and how those results might be affected by postulated constraints on the availability of chemical and biological inputs and by policies regulating marketing board surplusses, export tax rates and the food marketing system. Before the simulation experiments are described and the results analyzed in the following sections, we shall discuss briefly the nature of the input constraints and other policies tested.

Input Constraints

Two types of input constraints were considered individually and in combination: constraints on biological and chemical inputs, respectively, for the establishment of the "modern" perennials and annuals being extended. (Only biological constraints were tested for annuals.) The current simulation model [1] does not consider capital and labor constraints to agricultural production decisions; these are among the areas for further modeling efforts. (The northern agricultural submodel does account for the availability of labor in determining the cultivable land area, and the southern submodel allows for land constraints [1, Chapters 4 and 5].)

For the perennials (cocoa, oil palm and rubber), different forms were postulated for the two types of constraints. The availability of chemicals was assumed to increase linearly (Eqn.1) at a rate proportional to the initial availability (*i.e.*, at the start of the production campaigns), while the availability of biological inputs was assumed to increase to a maximum as a negative exponential function (Eqn. 2 and Fig. A[2]). For the modernization of annuals (groundnuts, cotton and staple foods), the availability of

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[1]The model was developed at Michigan State University under USAID contracts AID/csd-1557 and AID/csd-2975.

[2]All figures are found at the end of this report.

biological materials was computed as a proportional increase over the contemporary demand for materials to maintain land that has already been converted to modern production (Eqn. 3).

(1) $CHMAV_i(t) = CHMAVI_i*(1 + CICP_i*t), \quad i = 5,\ldots,12$

(2) $BIOAV_i(t) = BIOAVI_i + (BICP_i - BIOAVI_i)*(1 - \exp[-t/BICD_i])$
$i = 5,\ldots,12$

(3) $BIOAV_i(t) = (1 + BICP_i)*DBMAT_i(t) \quad , \quad i = 1,\ldots,4,13,14$

(4) $TRMX_i(t) = \min[CHMAV_i(t)/CHMD_i) \quad , \quad (BIOAV_i(t)/BIMD_i)]$

(5) $TRLDP_i(t) = \min[TRLDPU_i(t), \quad TRMX_i(t)]$

(6) $TRLDD_i(t) = \min[TRLDDU_i(t), \quad (TRMX_i(t) - TRLDP_i(t))]$

where:

CHMAV = chemical inputs available--lbs./year

CHMAVI = chemical inputs available at the start of the production campaign--lbs./year

CICP = chemical input constraint policy (rate of change of chemicals available)--proportion of CHMAVI per year

BIOAV = biological inputs available--units/year

BIOAVI = biological inputs available at the start of the production campaign--units/year

BICD = exponent regulating rate of increase of inputs--years

exp = the exponential function

BICP = biological input constraint policy (maximum availability of biological inputs, $i = 5,\ldots,12$; proportion of contemporary input demands, $i = 1,\ldots,4,13,14$)

DBMAT = demand for biological materials to maintain land already modernized

TRMX = maximum rate at which land can enter modern production due to input constraints--acres/year

min = takes the minimum of the terms in brackets

CHMD = chemical input rate for establishment of modern production--lbs./acre

BIMD = biological input rate for establishment of modern production--units/acre

TRLDP(TRLDD) = constrained rate land enters modern production by direct promotion (by diffusion)--acres/year

TRLDPU(TRLDDU) = unconstrained rates (see Eqns. M3 and M13 in [1, Chapter 4, Appendix] and Eqn. L13 in [1, Chapter 5, Appendix])--acres/year

t = time measured from the start of the production campaigns--years

i = indexes the production campaigns--i = 1,...,14.

The chemical and biological input constraints to perennial modernization were calibrated to allow roughly the targets projected for replantings and new plantings of cocoa, palm and rubber [2, 3, 4]. The initial availability of inputs (CHMAVI and BIOAVI in Eqns. 1 and 2) was computed from initial values of these target planting rates and from the input rates recommended in [8]. Rates of increase and maximum values of input availabilities (CICP, BICP and BICD in Eqns. 1 and 2) were set to approximate the projected targets. In the case of annuals (groundnuts, cotton, food grains and food roots), biological input growth rates (BICP) were estimated either to conform to projected targets [5, 6] or, in the absence of such projections (the case of staple foods [7]), arbitrarily. These data are presented in Tables 1 and 2.

Although the postulated forms of the input constraints (Eqns. 1-6) may be unrealistic (*i.e.*, they are not projections of actually expected input availabilities--neither imports of chemicals nor production of biological materials), the purpose of these simulation experiments was not to project what would or could happen but rather to study the relative costs, in terms of the consequences of commodity production campaigns, of constraints on the inputs necessary for establishment. Realistic projections would require not only perhaps more likely assumptions regarding input availability (Eqns. 1-3) but also certainly a more sophisticated constraint mechanism (Eqns. 4-6). A possible example of such a mechanism--which would entail extensive revision of the current model--would be a recursive LP model which would allocate land among alternatives (including modern alternatives) so as to maximize (say) discounted expected net income subject to input constraints--labor and capital as well as chem[illegible]

TABLE 1
Constraint Data for Perennials Production Campaigns

Program	Initial Planting Rate[a]	Maximum Planting Rate[a]	Years to Maximum Planting Rate[a] (BICD)[h]	CHEMICAL CONSTRAINTS: Establishment Input Rate[b] (CHMD)[h]	CHEMICAL CONSTRAINTS: Initial Avail-ability[c] (CHMAVI)[h]	CHEMICAL CONSTRAINTS: Availability Growth Rate[d] (CICP)[h]	BIOLOGICAL CONSTRAINTS: Establishment Input Rate[e] (BIMD)[h]	BIOLOGICAL CONSTRAINTS: Initial Avail-ability[f] (BIOAVI)[h]	BIOLOGICAL CONSTRAINTS: Final Avail-ability[g] (BICP)[h]
1	2	3	4	5	6	7	8	9	10
Cocoa Replanting	6,000	60,000	5	110	660	1.8	600	3600	36,000
Palm Replanting (Palm Sector)	10,000	40,000	6	74.3	743	.5	72.5	725	2,900
Palm Replanting (Rubber Sector)	5,000	10,000	4	74.3	372	.25	72.5	362	725
Rubber Replanting	1,000	5,000	6	90	90	.67	205	205	1,025
Cocoa New Planting	6,000	12,000	2	110	660	.5	600	3600	7,200
Palm New Planting (Palm Sector)	5,000	10,000	5	74.3	372	.2	72.5	362	725
Palm New Planting (Rubber Sector)	4,000	14,000	6	74.3	297	.4	72.5	290	1,015
Rubber New Planting	6,000	38,000	4	90	540	1.33	205	1230	7,790

[a]Units: acrea/year for Cols. 2 and 3
years for Col. 4
Sources: [2, 3, 4]

[b]Units: lbs./acre
Source: [8]

[c]Units: thousand lbs./year
Source: Col. 5/Col. 2

[d]Units: proportion of Col. 6/year
Source: $\frac{\text{Col. 3 - Col. 2}}{\text{(Col. 2) x (Col. 4)}}$

[e]Units: units/acre
Source: [8] for palm and rubber
[2] for cocoa

[f]Units: thousand units/year
Source: Col. 8/Col. 2

[g]Units: thousand units/year
Source: Col. 8/Col. 3

[h]See Eqns. 1, 2 and 4.

TABLE 2
Constraint Data for Annuals
Production Campaigns

Program	Biological Availability Increase[a]	Establishment Input Rate[b]
Groundnuts	.03	130
Cotton	.3	25
Food (grains)	.5	16.5
Food (roots, North)	.5	850
Food (roots, South)	.5	827

[a]BICP in Eqn. 3
Units: proportion
Sources: estimated from projections in [5, 6] and arbitrary

[b]BIMD in Eqn. 4
Units: lbs./acre
Sources: adapted from [8, 9].

Other Policies

In addition to, and in combination with, the above input constraints, experiments (runs) were conducted in two areas of policy concern: the marketing of food, and taxes affecting producer prices, *e.g.*, marketing board surpluses and export taxes.

The NADC has recommended guaranteeing favorable producer prices for food crops and improving the food marketing system through the encouragement of marketing cooperatives and bulk purchasing and storage. (The recommended subsidization of inputs to food production campaigns is discussed in the next section.) To investigate the consequences of these policies being phased in profit and cost margins for the food marketing sector were cut in half over a period of about five years. In addition, wastage and spoilage in the marketing of food were also reduced.

The tax policies tested included marketing board surpluses and export taxes. Policy simulations investigated the relative consequences (including the elasticity of tax revenues) of alternatively leaving these two forms of taxes at current levels, changing them at once to a lower level (possibly zero), or linearly phasing them to a lower level (possibly zero). In addition, an agricultural income tax was considered as one possible alternate source of revenue when marketing board surplus rates were reduced.

It must be pointed out here that any comparison of the relative consequences of more or less public revenues vs. more or less private revenues must bear in mind that *no* assumption was made in these experiments regarding possible alternative investments of marketing board surpluses and other tax revenues.

Description of Runs and Output

Seventeen simulation runs were made to test various combinations of production campaigns, input constraints and tax and food marketing policies (Table 3). Each run simulated the time period 1953-1995. The model--constrained to approximate actual conditions from 1953-1965 [1, pp. 61-63 and 167-169]--began policy tests in 1970 and traced the results through 1995.

Two base runs were used as standards for comparison. The first run projected a continuation of present trends and policies. No production campaigns were specified, and marketing board and export tax rates were continued at assumed 1970 levels (Table 4). In the second run, 14 production campaigns (in groundnuts, cotton and food in the North, and in cocoa, oil palm and rubber in the South)[3] were conducted, and cesses of .0125 (one-eighth) d/lb. and .00625 (one-sixteenth) d/lb. were imposed on rubber exported and marketed domestically, respectively.

The remaining 15 runs (Table 3) considered the same production campaigns and tax policies of Run 2 in combination with various kinds and levels of input constraints and tax policies. Runs 3 - 7 tested the consequences of low, medium and high levels of biological and chemical input availabilities.

These levels were specified by the values of BICP and CICP in Tables 1 and 2. Medium levels assumed the values given in those tables. High and low levels of the chemical input constraints to the perennials assumed values 50% greater and less than the tabulated values, respectively, while biological inputs to the perennials were increased and decreased, respectively, by 25%. For the annuals, BICP was increased and decreased by 67% for cotton and groundnuts and 50% for food.

Runs 8 - 12 investigated the effects of raising producer prices by lowering marketing board and export taxes as indicated in Table 3, including the possibility of an income tax as an alternative source of revenue. Marketing board surpluses were phased linearly to lower levels over a ten-year

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[3]See a later subsection for a description of these production campaigns.

period beginning in 1970, while export tax rates were cut in 1970 (except in Run 8 where export taxes were phased out). In addition, the food marketing policies discussed in the last section were implemented in Runs 8 - 12. Finally, Runs 13 - 17 combined these tax policies with the input constraints of Runs 3 - 7.

TABLE 3
Policy Simulation Run Definitions

Run No.	Output Sets	Run Definition
1	1, 2, 3, 4, 5, 6	Base Run 1--continuation of present trends and policies
2	1, 2, 3, 4, 5, 6	Base Run 2--rubber cesses and 14 production campaigns (see Table 6)
3	1	Run 2 with medium biological availabilities
4	1	Run 2 with medium chemical availabilities
5	1, 2	Run 2 with medium biological and chemical availabilities
6	2	Run 2 with low biological and chemical availabilities
7	2	Run 2 with high biological and chemical availabilities
8	3	Run 2 with food marketing policies and phasing out marketing board and export taxes
9	3, 4, 5	Run 2 with food marketing policies, phasing marketing board tax rates in the North to .02 and in the South to .05, and cutting export taxes to .1
10	3	Run 2 with food marketing policies, phasing marketing board tax rates in the North to .04 and in the South to .1, and cutting export taxes to .05
11	4	Run 9 with a 3% tax on agricultural disposable income
12	4	Run 9 with a 6% tax on agricultural disposable income
13	5, 6	Run 9 with medium biological and chemical availabilities
14	5	Run 9 with low biological and chemical availabilities
15	5	Run 9 with high biological and chemical availabilities
16	6	Run 8 with medium biological and chemical availabilities
17	6	Run 10 with medium biological and chemical availabilities

TABLE 4
Model Assumptions For 1970 Values of
Marketing Board and Export Tax Rates

Commodity	Marketing Board Surplus Rate	Export Tax Rate
Groundnuts	.05	.15
Cotton	.05	.15
Cocoa	.20	.20
Palm Oil	.20	.15
Palm Kernels	.20	.15
Rubber	-	.15

Presentation of Output Results

The seventeen runs described above were grouped into six sets for purposes of graphical presentation and analysis of results in the next section of this report. Table 5 presents the rationales for these groupings.

Output results were plotted rather than tabulated in order to facilitate visual comparisons of time paths, where the actual numerical levels projected were of less importance. In certain cases, however--*i.e.*, revenues from the rubber cess and growth rates of food production and overall agricultural production--time paths were tabulated.

Each of ten performance criteria were plotted for each of the six sets of runs; therefore, there are sixty graphs appearing at the end of this report. The ten output variables graphed are:

1. gross domestic product (assuming tax revenues are put to productive use)
2. value added in agriculture
3. value added in nonagriculture
4. balance of trade
5. agricultural sector tax revenues (including production, processing and marketing taxes, export taxes, income taxes, marketing board surpluses and rubber cess revenues)
6. agricultural income per capita (North)
7. agricultural income per capita (South)
8. market price of food (South)
9. nonagricultural food consumption per capita (South)
10. interregional food shipments (North to South)

TABLE 5
Policy Simulation Set Definitions

Output Set	Run Nos.	Set Definition
1	1, 2, 3, 4, 5	Biological and chemical constraints, individually and in combination
2	1, 2, 5, 6, 7	Three levels of combined input constraints
3	1, 2, 8, 9, 10	Three levels of marketing board and export tax reductions
4	1, 2, 9, 11, 12	Two levels of income tax to compensate other tax reductions
5	1, 2, 9, 13, 14, 15	Three levels of combined input constraints with tax reductions
6	1, 2, 13, 16, 17	Three levels of tax reductions with combined input constraints

Production Campaigns

The modernization executive component of the Nigerian simulation model [10] allocates a given budget to specified commodity production campaigns. Yearly campaign budgets, which follow the time profile of Figure B, are used to pay for both promotional and technical assistance extension work, for campaign overhead expenses, and for cash grants and input price subsidies; and to maintain a balance intended to keep the program solvent and to support participating farmers in the pipeline after funding has ceased (time TF in Figure B).

The fourteen production campaigns conducted in each simulation run (Runs 2 - 17) all had the same budget time profile: T0 = 1971, T1 = 1973, T2 = 1979, TF = 1981. Table 6 tabulates the policy specifications for each campaign. These include the maximum annual budget, recommended yield, input price subsidy, annual cash grant and the number of years the grant was to be given.

Now that the simulation experiments have been defined and described, we proceed in the next section to an analysis of the results.

Analysis of Results

This section will present a behavioral analysis of the simulation results in terms of the six sets of runs defined above in Table 5. By "behavioral analysis" is meant explanations, from the point of view of the model, of the relative time paths observed in the performance criteria. The results are graphed in the figures appearing at the end of this report. Care must

TABLE 6
Production Campaign Policies

Campaign	Maximum Annual Budget (£/year)	Recommended Yield[a] (lbs./acre-yr.)	Input Price Subsidy (proportion)	Cash Grant (£/acre-yr)	Years of Grant (years)
1. Groundnuts	2,000,000	1,000	.5	0	-
2. Cotton	1,000,000	600	.5	0	-
3. Food grains (North)	2,000,000	3,000	.5	0	-
4. Food roots (Middle Belt)	1,000,000	9,000	.5	0	-
5. Cocoa replanting	2,000,000	850	0	0	-
6. Palm replanting (Palm Zone)[b]	2,000,000	6,700	1.	5	3
7. Palm replanting (Rubber-Palm Zone)[b]	1,000,000	6,700	1.	5	3
8. Rubber replanting	2,000,000	1,000	.85	10	3
9. Cocoa new planting	750,000	950	0	0	-
10. Palm new planting (Palm Zone)[b]	750,000	6,700	1.	5	3
11. Palm new planting (Rubber-Palm Zone)[b]	500,000	6,700	1.	5	3
12. Rubber new planting	750,000	1,000	.85	0	-
13. Food roots (South, Annuals Zone)[b]	1,500,000	11,900	.5	0	-
14. Food roots (South, perennials zones)[b]	750,000	11,900	.5	0	-

[a]For perennials, yields at maturity. The food grains yield assumes the extension of hybrid varieties expected in the next few years [7].

[b]See [1, Chapter 5] for descriptions of the ecological zones.

be exercised in interpreting the graphs. The plots were made to spread the time paths over the page as much as possible in order to obtain fair resolution among the plots on the same graph (set of axes). Therefore, attention to the scale on the vertical axis will avoid misinterpretation of the comparative results.

Biological and Chemical Constraints

In terms of production (GDP--Fig. 1) and the tax revenues generated therefrom (Fig. 5), the results of the production campaigns (Run 2) were diminished when input constraints were in effect. It would appear that the chemical constraints (Run 4), as specified above, were less of a constraint than were the biological constraints (Run 3). This must be true since chemical constraints were only applied to the perennials; the modernization of annuals (including food) remained unconstrained in Run 4 as in Run 2. Of course, when the constraints were combined in Run 5, the tighter (biological) constraint was in effect, and the results of Runs 3 and 5 were similar.

It is interesting to note that, while Run 2 (and Run 4) stimulated *agricultural* production, *nonagricultural* value added (Fig. 3) showed a much more substantial gain over Run 1 than did agricultural value added (Fig. 2). Evidently, the improvement in GDP was due almost entirely to the nonagricultural sector.

The explanation has three aspects. First, most of agricultural production is food; therefore, the much lower food prices experienced in Runs 2 and 4 (Fig. 8) as a result of increased food production dampened the effect on value added. This was particularly evident in the last five years of the simulated time period where the increased production was virtually cancelled out by the drop in food prices (Fig. 2). Relative to the food prices of the base run (Run 1), we would see the expected improvement in agricultural value added in later runs.

The remaining two aspects to the explanation concern the nonagricultural sector and its interactions with agriculture. First, because of the lower food prices, the nonagricultural sector could, while eating more staples (Fig. 9), still have a greater proportion of its income to spend on non-food consumption, thus stimulating nonagricultural production. Finally, higher agricultural incomes (Figs. 6 and 7) and production also--through the secondary effects of increased demands for nonagricultural goods and services--stimulated growth in the nonagricultural sector.

It may be observed that, for about the first ten years of the simulation, agricultural income in the South (Fig. 7) and GDP (Fig. 1) were greater in the base run than in the later runs. This can be attributed to the initial reduction in the production of perennial commodities in the South resulting from the clearing of productive trees in the replanting programs. Later, as the new trees reached maturity, the results of Run 1 fell below the others.

Results for the balance of trade (Fig. 4) may appear rather puzzling. The highest trade balances were achieved under the *tightest* constraints (Runs 3 and 5). The puzzle can be solved if we break the trade balance down into exports and imports (Table 7).[4] We see that exports did behave similarly to other performance criteria, *e.g.*, GDP, taxes and nonagricultural value added. That is, the runs can be ranked according to highest-to-lowest results, *i.e.*, Runs 2, 4, 3, 5, 1. Imports, however, are another story, because, although they can be similarly ranked, they contribute negatively to the balance of trade.

The unconstrained production campaigns of Run 2 did increase exports more than imports (compared to Run 1), where all chemicals used in modern agricultural production (fertilizers, herbicides and insecticides) were, in addition to imports necessary for the increased nonagricultural growth, charged to imports. Runs 3 and 5 (with biological constraints) did even better in terms of foreign exchange because, although exports were substantially lower than in Run 2, imports were reduced even more. In this case, the modernization of annuals was constrained as well as was that of perennials, reducing the demand for chemical imports. But annuals, particularly food, contribute little if anything (except groundnuts) to exports; therefore exports were reduced relatively less than imports, resulting in a net increase in foreign exchange.

TABLE 7
Balance of Trade in 1995 and Input Constraints

Run	Exports (million £/yr.)	Imports (million £/yr.)	Balance (million £/yr.)
1. Present policies	1,468	792	676
2. Production campaigns	1,735	1,040	695
3. Production campaigns and biological constraints	1,563	819	744
4. Production campaigns and chemical constraints	1,695	1,024	671
5. Production campaigns and both constraints	1,558	825	733

[4]These are *total* imports and exports, although changes in them can almost all be attributed to the agricultural sector as a result of the policies tested. Secondary effects do cause minor changes from the nonagricultural sector.

Run 4, where only chemical constraints were applied to only perennial modernization, resulted in a worse foreign exchange position than even the base run. Whereas the modernization of perennials--the major contributor to agricultural exports--was curtailed by this constraint, the annuals production campaigns proceeded unconstrained as in Run 2, and so did the import demands for chemicals to fuel them. Needless to say, these results follow directly from the assumption made in defining the simulation experiments that chemical constraints would not apply to annuals.

These results might imply the desirability of an import substitution policy to manufacture fertilizers and chemical sprays in Nigeria. However, this discussion has focussed only (and only partially) on balance of trade questions and has said nothing about direct and other opportunity costs involved in import substitution policies.

The final observation to be made on the first set of runs concerns the interregional shipments of food (Fig. 10). In Runs 2 and 4, where food modernization was carried out in both North and South, shipments started later than in the other runs and remained relatively low. In the last five years, however, cash food demands increased rapidly in response to the corresponding decline in food prices (Fig. 8). Since most of the increased demand was in the South, North-South food shipments rose dramatically from 1990-1995. The South had most of the demand increase both because most of the nonagricultural population (relative to the agricultural population) resided there and because the lower food prices relative to the returns from the production of perennial commodities encouraged greater reliance on the food market by the agricultural population [1, Chapter 5].

Levels of Input Constraints

Runs 5, 6 and 7 tested medium, low and high levels of chemical and biological input availabilities as constraints to the modernization of agricultural production. The results are plotted in Figures 11-20.

In general, the results were as might have been expected. As the constraints were eased (*i.e.*, as availabilities went from low to high in Runs 6, 5 and 7), performance approached that of the unconstrained condition (Run 2). This progression was less apparent in some of the aggregate variables, *i.e.*, GDP (Fig. 11) and agricultural and nonagricultural value added (Figs. 12 and 13). Again, as discussed above, the increased agricultural production occurring in Runs 5, 6 and 7 as a result of the production campaigns (although constrained) is not apparent in Fig. 12 because of the lower food prices (Fig. 18). The production increases do become evident after 1990 in Fig. 12 as the food prices approached those of Run 1. Following the earlier discussion, the balance of trade *decreased* as the constraints were lessened.

Agricultural income in the North (Figs. 6 and 16) behaved interestingly in the presence of biological constraints on food modernization (Runs 3, 5, 6 and 7). Food production increased enough to lower the market price of food (Figs. 8 and 18) but not enough to offset the effect of the lower price on income. Southern agricultural income was not as sensitive to the price of food (Fig. 17) because food made up a smaller share of total agricultural production in the South than it did in the North. Southern incomes were lower in Runs 5, 6 and 7 (and 2) than in the base run until after 1980 primarily because of the removal of trees from production for replanting.

The sharp drop in food prices after 1990, however, did cause a corresponding drop in southern income. In this case, northern income was not similarly affected and continued to rise because the more rapid pace of modernization (and hence food production) there more than offset the price decline.

The time paths for nonagricultural food consumption (Fig. 19) mirrored those for the food price, *i.e.*, higher prices meant lower consumption and vice versa.

Tables 8-10 present the time paths of revenues of the rubber cesses, the food production growth rate and the total agricultural production growth rate.

Except for 1975, the rubber cess revenues behaved as expected: the greater the input availabilities, the greater the pace of modernization and, hence, the greater the revenues collected. In 1975, because of the constraints, less trees had been removed for replanting than in Run 2; therefore production was higher. By 1980, however, new trees had begun to bear, and the result discussed above was obtained.

TABLE 8
Rubber Cess Revenues Under
Three Levels of Input Constraints
(thousand £/year)

Run	YEAR				
	1975	1980	1985	1990	1995
1. Present policies	0	0	0	0	0
2. Production campaigns	91.2	101	162	290	428
5. Production campaigns with medium input availabilities	95.8	118	157	202	240
6. Production campaigns with low input availabilities	95.9	116	148	188	221
7. Production campaigns with high input availabilities	95.8	119	160	204	244

TABLE 9
Growth in Food Production Under
Three Levels of Input Constraints
(%/year)

Run	YEAR				
	1975	1980	1985	1990	1995
1. Present policies	2.95	2.77	3.13	3.31	2.88
2. Production campaigns	3.03	3.27	3.55	4.29	4.71
5. Production campaigns with medium input availabilities	2.94	2.89	3.24	3.36	3.14
6. Production campaigns with low input availabilities	2.94	2.88	3.19	3.35	3.04
7. Production campaigns with high input availabilities	2.94	2.89	3.18	3.36	3.23

TABLE 10
Growth in Agricultural Production
Under Three Levels of Input Constraints
(%/year)

Run	YEAR				
	1975	1980	1985	1990	1995
1. Present policies	2.63	2.44	2.88	3.00	2.48
2. Production campaigns	2.64	3.43	4.04	4.46	4.58
5. Production campaigns with medium input availabilities	2.61	2.64	3.13	3.21	3.00
6. Production campaigns with low input availabilities	2.62	2.62	3.04	3.16	2.86
7. Production campaigns with high input availabilities	2.61	2.67	3.11	3.22	3.07

The presence of input constraints substantially slowed the growth of both food production and total agricultural production relative to the unconstrained Run 2. Indeed, the biological constraint on food modernization was such that food production grew at a rate not much greater than in the base run (Run 1). Until the end of the simulated time period, there was not much difference among the results of the three levels of input constraints.

Food Marketing Policies and Levels of Tax Reductions

It is clear (Figs. 21-30) that improving the food marketing system (as described earlier) and reducing marketing board and export taxes--*i.e.*, insuring higher producer prices (relative to market prices) for both food and export commodities--as was done in Runs 8-10 dramatically stimulated not only the agricultural sector (Figs. 22, 26 and 27) but the entire economy as well (Figs. 21 and 23).

Among the three levels of tax reductions (Table 3), phasing out the marketing board and export taxes entirely (Run 8) provided the biggest stimulus (and the lowest tax revenues[5]). Run 10 gave slightly "better" results than did Run 9 because export taxes were given larger percentage cuts in Run 10 than were marketing board taxes in Run 9 (Tables 3 and 4). Having discussed the differences among Runs 8, 9 and 10, the remaining analysis of the third set of runs will concentrate on the results of Run 8 relative to those of Runs 1 and 2.

Raising agricultural producer prices had substantial impact on the total economy, nonagricultural and agricultural. The improvement in the level and growth of GDP (Fig. 21) reflected increases in both sectors of the economy (Figs. 22 and 23). The nonagricultural sector was given a boost--despite the lower marketing margins--by the increased demands for its goods and services resulting from lower food prices (Fig. 28) and higher agricultural incomes (Figs. 26 and 27). The lower food prices and higher nonagricultural incomes also led to a dramatic increase in nonagriculture's consumption of staple calories (Fig. 29). The model said nothing, however,

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[5]The remaining revenues (Fig. 25) were derived from the rubber cesses, the jangali tax and taxes on the northern food marketing sector.

about whether this increased consumption was a net increase of total caloric intake or whether it represented substitution for non-staples. Nor did the model deal with other indicators of good nutrition, particularly proteins.

Agricultural value added and incomes (Figs. 22, 26 and 27) were greatly improved over Run 2 as well as over Run 1 because of the stimulus to production from higher producer prices for food as well as export commodities. This was an effect not only of the supply elasticities but also of a more rapid shifting to the right of the supply curves as the pace of modernization was increased in response to increased profitabilities. Even the substantially reduced food market prices (Fig. 28) were not enough to dampen the improvement in value added and income, being somewhat offset by the higher proportion of market price received by the farmers--about 70% instead of about 50%.

Once again, the balance of trade (Fig. 24) appeared to give opposite results; *i.e.*, higher agricultural producer prices *decreased* the trade balance. Since we have seen that agricultural production increased (and we shall see it again below, Table 13)--especially the production of export commodities--the lower trade balance was due to higher levels of imports. This is understandable, because more imports were necessary to fuel both the agricultural expansion and the resulting nonagricultural growth.

It must be noted here, in evaluating these results, that the model said nothing about what it would cost--economically, politically, socially--to accomplish the "improved" food marketing system. On the other hand, nor did the model consider the possible returns to alternative investments of tax revenues.

Finally, let's take a look at the consequences of higher producer prices in terms of revenues from the rubber cesses and production growth rates (Tables 11-13).

Rubber cess revenues follow the results of export tax changes (there is no rubber marketing board): they are higher when export tax rates are lower due to the supply response to higher producer prices.

Initially, the higher food producer prices relative to market prices stimulated higher food production growth rates than in Run 2. Later,

TABLE 11
Rubber Cess Revenues Under
Higher Producer Prices
(thousand £/year)

Run	YEAR 1975	1980	1985	1990	1995
1. Present policies	0	0	0	0	0
2. Production campaigns	91.2	101	162	290	428
8. Run 2 with food marketing policies; and taxes phased out	95.0	111	184	336	490
9. Run 2 with food marketing policies; marketing board taxes low; export taxes medium	93.4	105	169	303	444
10. Run 2 with food marketing policies; marketing board taxes medium; export taxes low	95.6	108	178	321	472

TABLE 12
Growth in Food Production
Under Higher Producer Prices
(%/year)

Run	YEAR 1975	1980	1985	1990	1995
1. Present policies	2.95	2.77	3.13	3.31	2.88
2. Production campaigns	3.03	3.27	3.55	4.29	4.71
8. Run 2 with food marketing policies; and taxes phased out	3.50	3.39	3.57	4.19	4.20
9. Run 2 with food marketing policies; marketing board taxes low; export taxes medium	3.31	3.27	3.55	4.15	4.20
10. Run 2 with food marketing policies; marketing board taxes medium; export taxes low	3.23	3.25	3.58	4.16	4.17

TABLE 13
Growth in Agricultural Production
Under Higher Producer Prices
(%/year)

Run	YEAR 1975	1980	1985	1990	1995
1. Present policies	2.63	2.44	2.88	3.00	2.48
2. Production campaigns	2.64	3.43	4.04	4.46	4.58
8. Run 2 with food marketing policies; and taxes phased out	3.29	3.92	4.16	4.49	4.18
9. Run 2 with food marketing policies; marketing board taxes low; export taxes medium	2.95	3.61	4.07	4.46	4.21
10. Run 2 with food marketing policies; marketing board taxes medium; export taxes low	2.84	3.58	4.11	4.47	4.18

however, the substantially lower market prices (Fig. 28) slowed the growth rate below that of Run 2. By that time, the *level* of food production was nevertheless higher than in Run 2 due to the initial spurt, thus maintaining the increased value added and incomes (Figs. 22, 26 and 27).

Higher producer prices had a greater effect for a longer period of time on cash crops than on food (Table 13) because market prices--determined exogenously for every run--did not experience the decline food prices did. Growth rates slowed by the end of Runs 8-10 because the level of modernization achieved was closer to total modernization than in Run 2.

Levels of Income Tax with Other Tax Reductions

Runs 11 and 12 investigated a tax on disposable income of 3% and 6%, respectively, to compensate simultaneous reductions in marketing board and export taxes. Run 9 was arbitrarily chosen for comparison. The results are plotted in Figs. 31-40.

Tax revenues were indeed compensated (Fig. 35). While the 3% tax (Run 11) increased revenues almost to base run levels (no production campaigns and high taxes), the 6% tax (Run 12) brought in nearly the revenues of the unconstrained production campaigns with high taxes (Run 2).

However, assuming (as mentioned above) that tax revenues were not used productively, the economy was slightly depressed from Run 9 levels (Figs. 31-33). Less agricultural income after taxes (Figs. 26 and 27) meant lower demands for nonagricultural goods and services, reducing expansion in the nonagricultural sector from Run 9 results (Fig. 33). Lower nonagricultural incomes reduced staple food consumption (Fig. 39) in spite of slightly lower food prices (Fig. 38). The lower food prices were, indeed, a consequence of reduced demand, which also explains the slight reduction in agricultural value added (Fig. 32). The slowed expansion in both sectors of the economy reduced import demands enough to improve the balance of trade position (Fig. 34).

Again, it must be noted that no consideration was given in the model to what it would cost, in terms of administration and tax evasions, to collect income taxes.

Levels of Input Constraints with Tax Reductions

Runs 13-15 compared with Run 9 (chosen as representative of the runs assuring higher producer prices) the relative effects of medium, low and high levels of biological and chemical input availabilities, respectively.

The results (Figs. 41-50) were as expected: the looser the constraints (*i.e.*, the higher the availabilities) the closer the performance to that of unconstrained Run 9.

Looking at the three constraint runs as a group, the performance of GDP (Fig. 41) with constraints and higher producer prices was similar after about 1985 to its performance without constraints and lower producer prices (Run 2), although a higher growth rate was experienced in the latter case, reflecting the higher nonagricultural growth rate in Run 2 over Runs 13-15 (Fig. 43).

Although agricultural value added remained higher in Runs 13-15 (with input constraints) than in Run 2 with lower producer prices (Fig. 42), nonagricultural value added fell below its Run 2 value after about 1985, accounting for the behavior of GDP noted above. This can be attributed to the substantial decline in agricultural income in the North (Fig. 46) below Run 9 and Run 2 (and even Run 1!) levels. With the constraints, the pace of modernization, coupled with improvements in the food marketing system, was enough to lower food prices (Fig. 48) well below Run 1 and Run 2 levels (although not as low as in Run 9), but it wasn't enough to raise food production sufficiently to maintain high income levels. The South, where food production plays a relatively smaller role in agriculture, was not affected as much (Fig. 47). Lower (than Run 9) nonagricultural incomes, coupled with higher food prices, reduced nonagricultural staple food consumption (Fig. 49).

Interestingly, the rate of growth of the trade balance (Fig. 44) was *greater* in the presence of input constraints and higher producer prices than under any other conditions. This behavior was similar to the results discussed above for the first set of runs: chemical imports for all commodities, including food, were reduced as a result of lower modernization rates in the presence of constraints, whereas only the reduced production of export commodities is reflected in Fig. 44. In short, imports were reduced more than exports as a result of the constraints.

Levels of Tax Reductions with Input Constraints

The final set of runs examined the consequences of medium levels of input availabilities for production campaigns with the three levels of tax reductions specified in Runs 8-10 (Table 3).

The results (Figs. 51-60) were very similar to those described above (Figs. 41-50) for the fifth set of runs, where one level of tax reductions was tested with three levels of input constraints. Differences among the behaviors generated by Runs 13, 16 and 17 parallel those of the third set of runs (Figs. 21-30), where Runs 13, 16 and 17 correspond to Runs 9, 8 and 10, respectively (Table 3).

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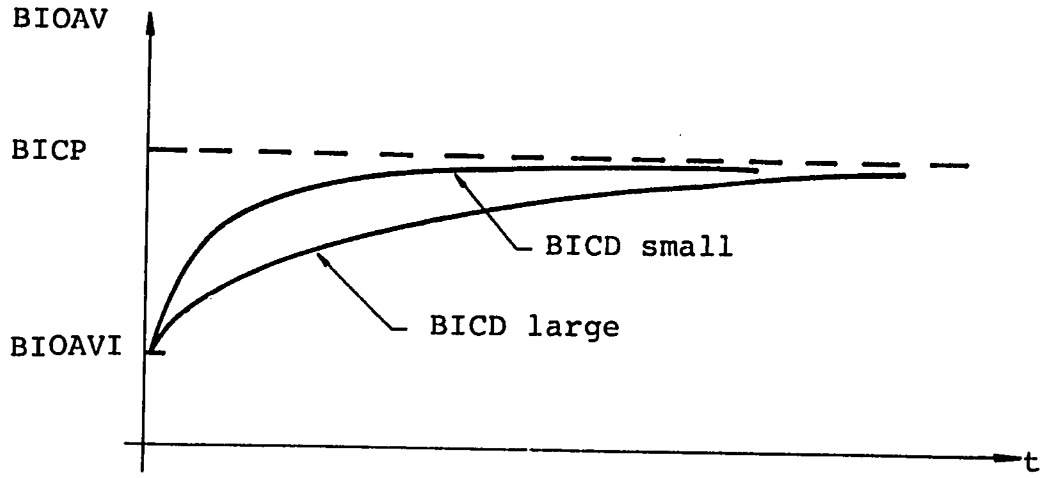

Figure A. The Availability of Biological Inputs for Perennials.

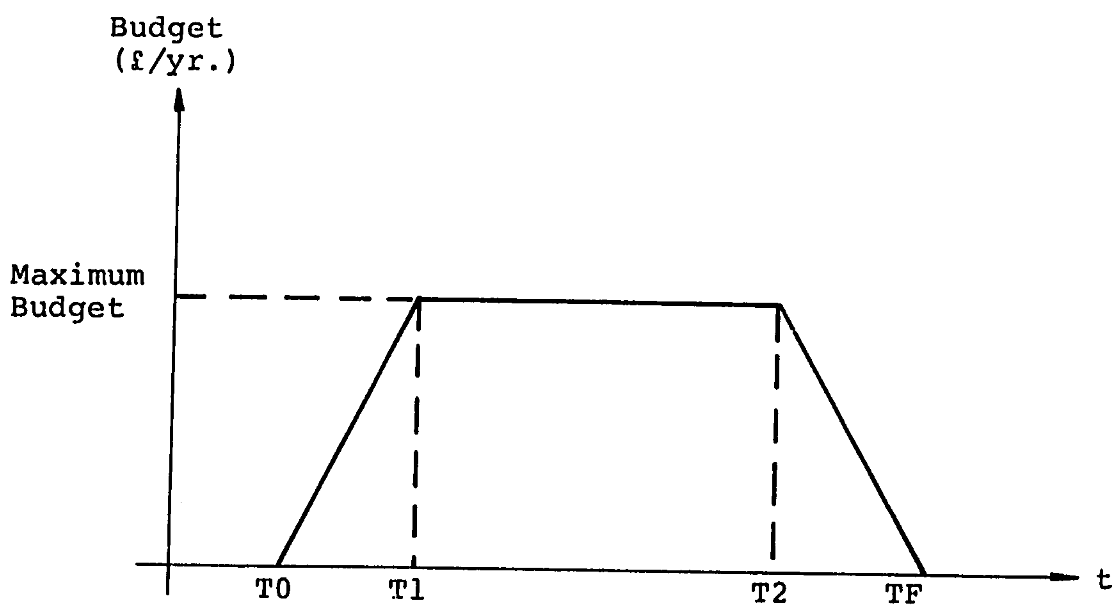

Figure B. Time Profile of Production Campaign Budget.

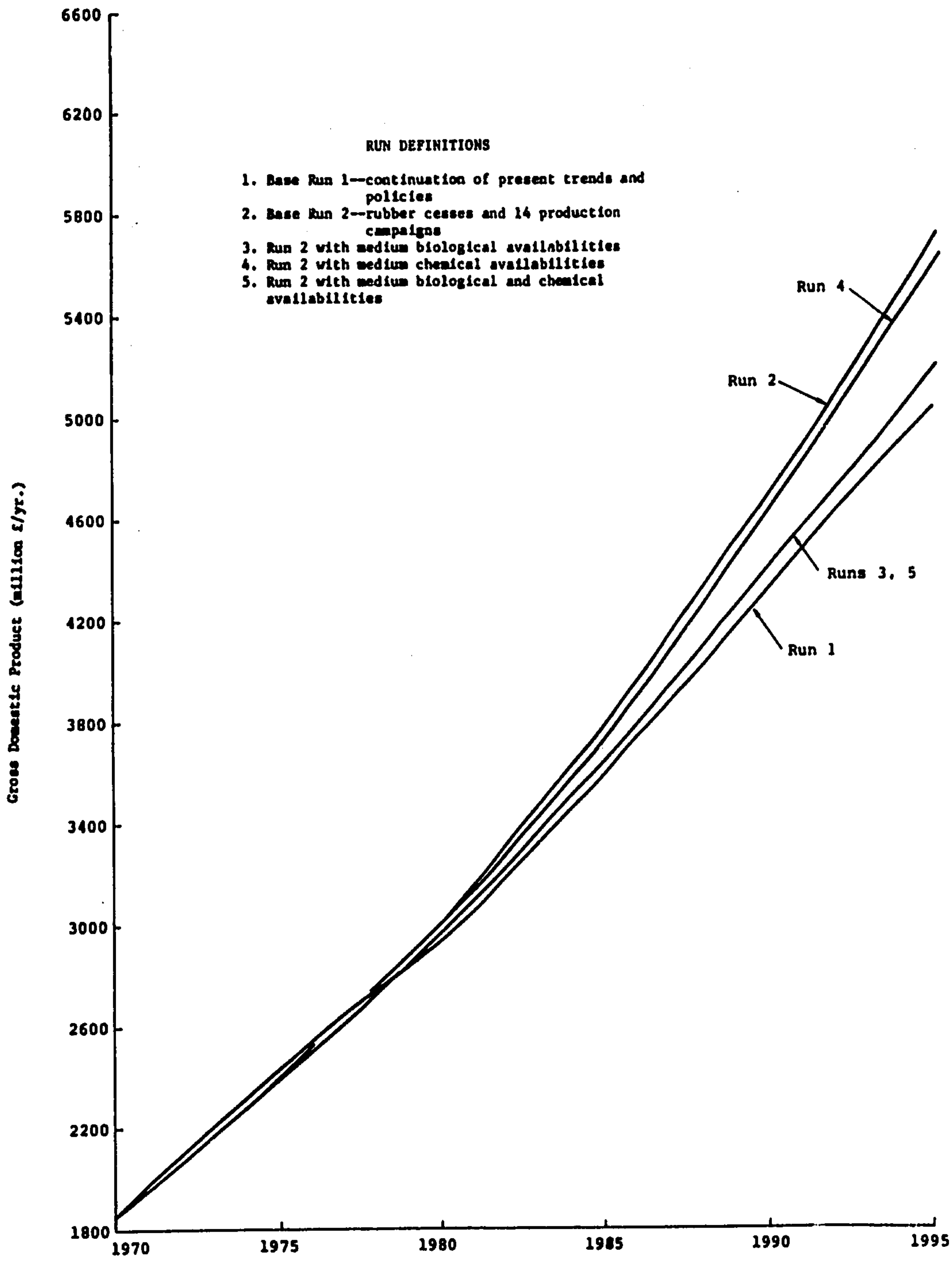

Fig. 1 Gross domestic product (assuming tax revenues are not put to productive use), 1970-1995, with biological and chemical input constraints.

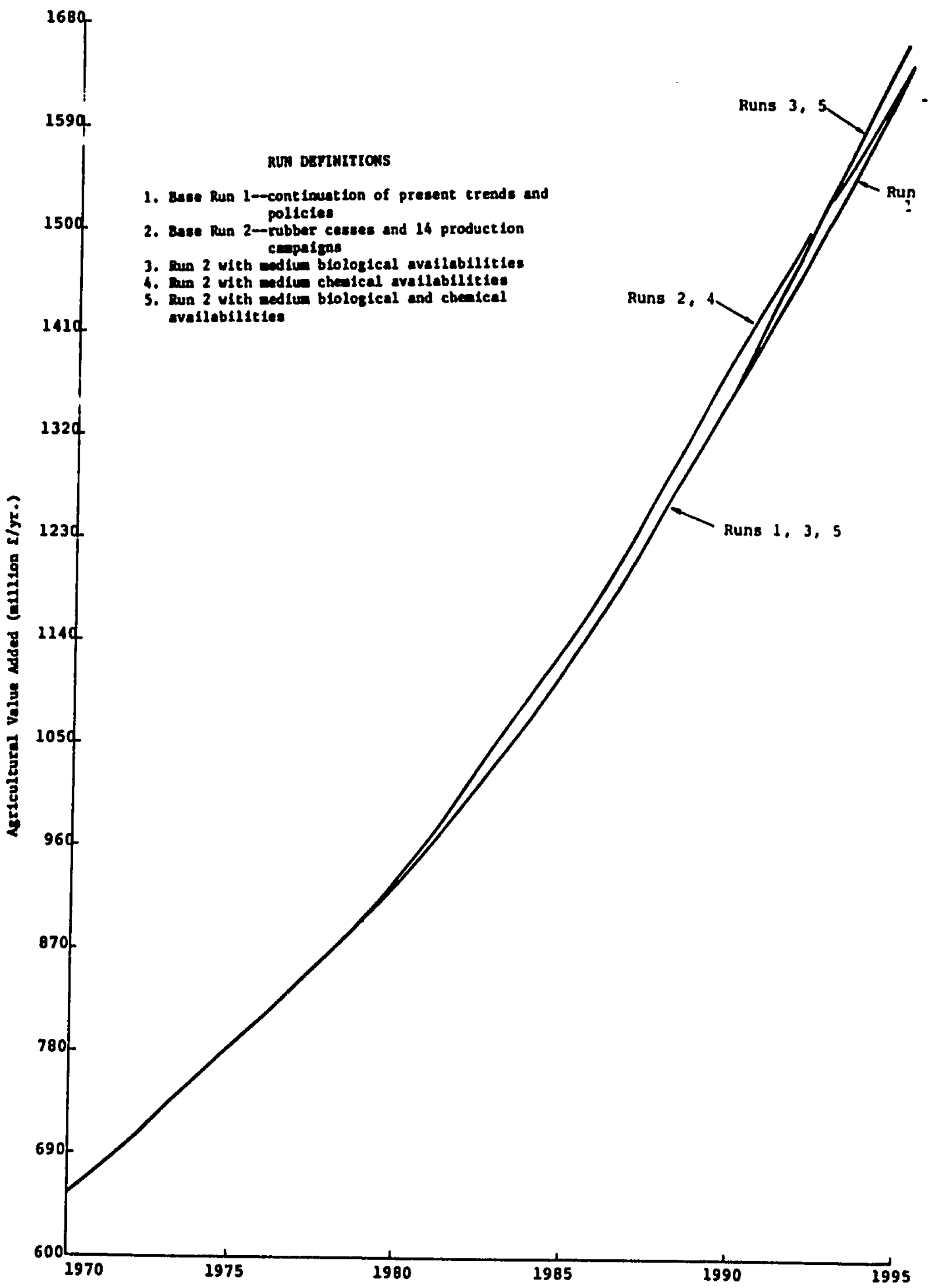

Fig. 2 Value added in agriculture, 1970-1995, with biological and chemical input constraints.

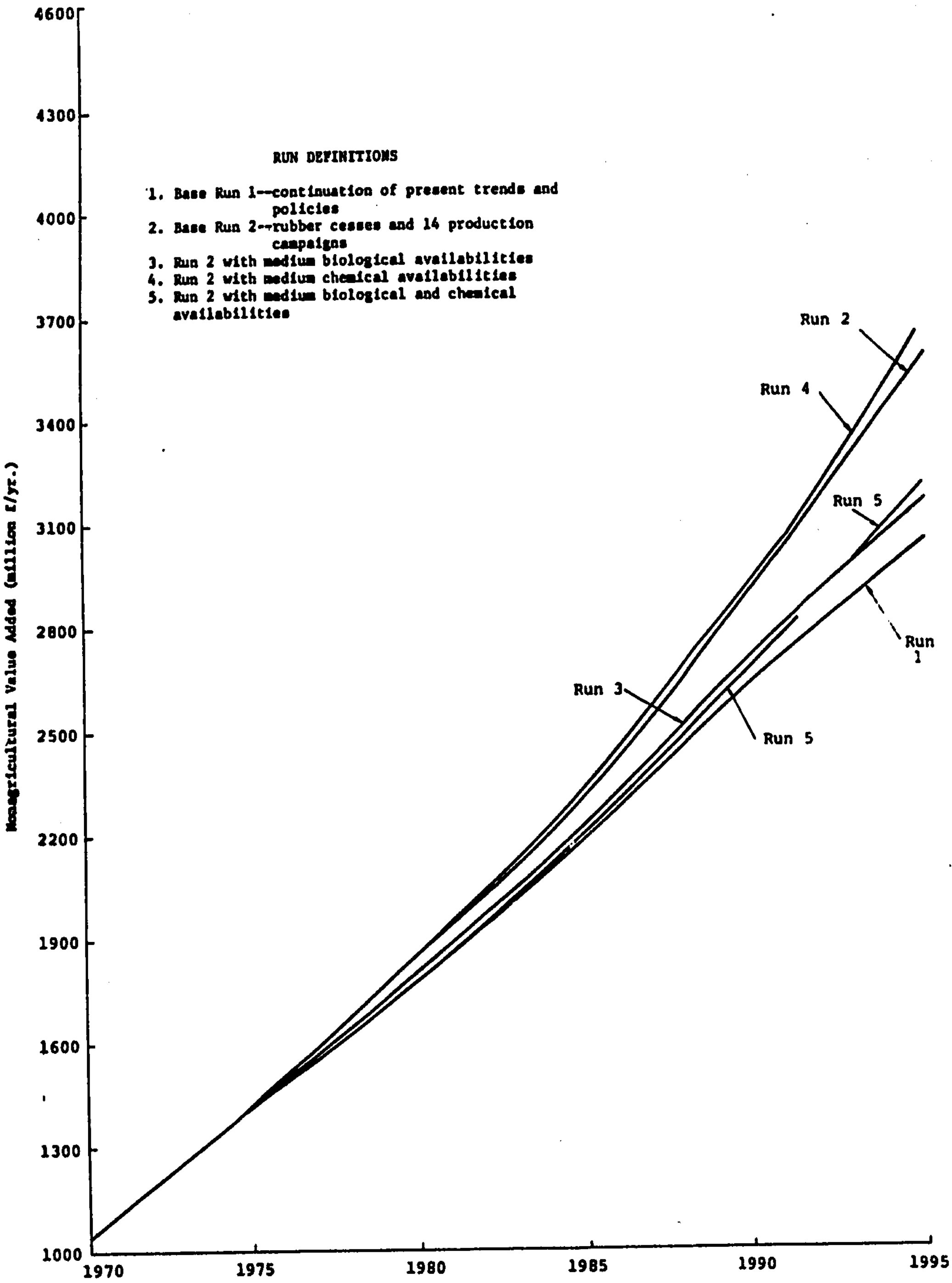

Fig. 3 Value added in nonagriculture, 1970-1995, with biological and chemical input constraints.

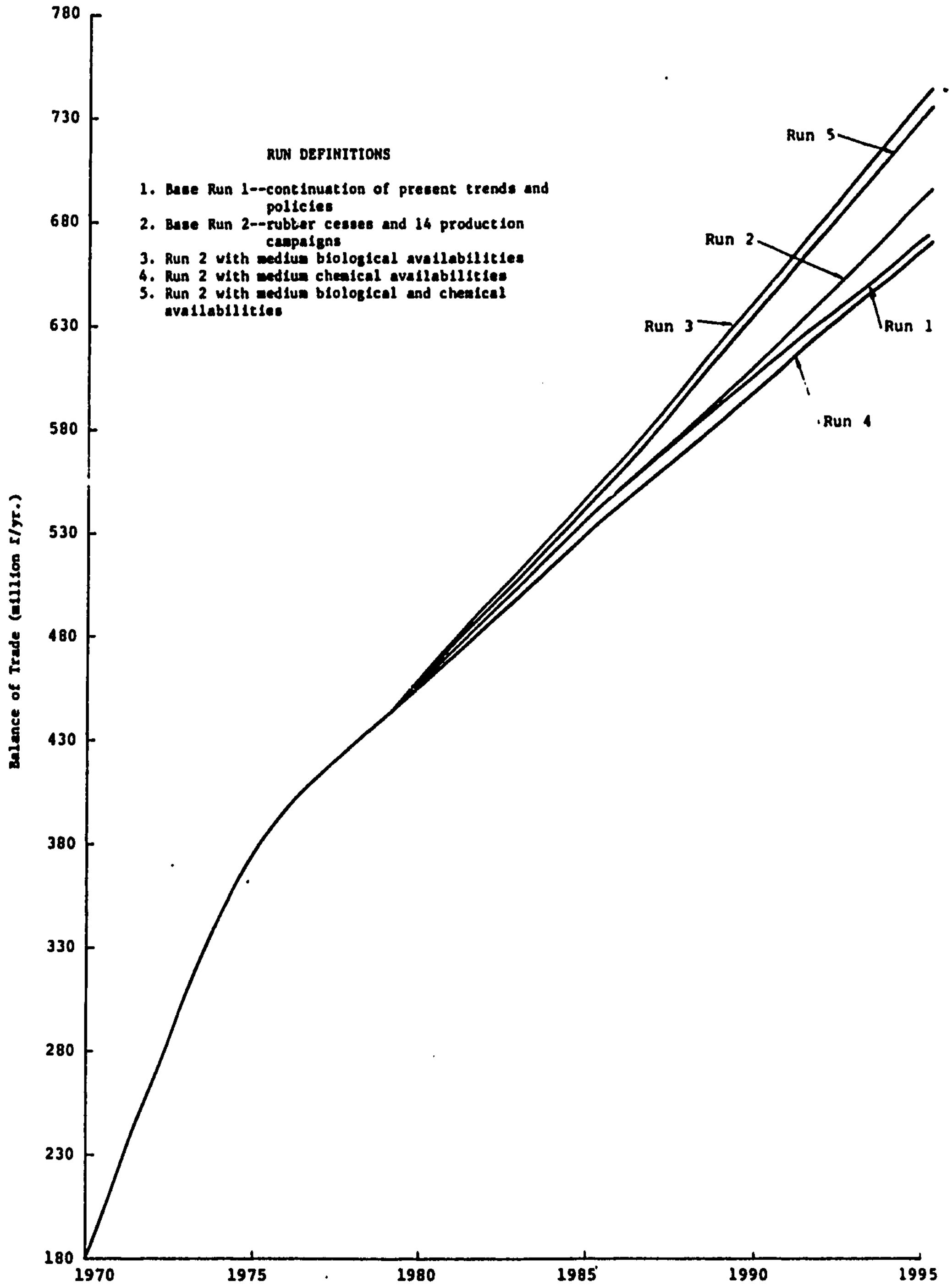

Fig. 4 Balance of trade, 1970-1995, with biological and chemical input constraints.

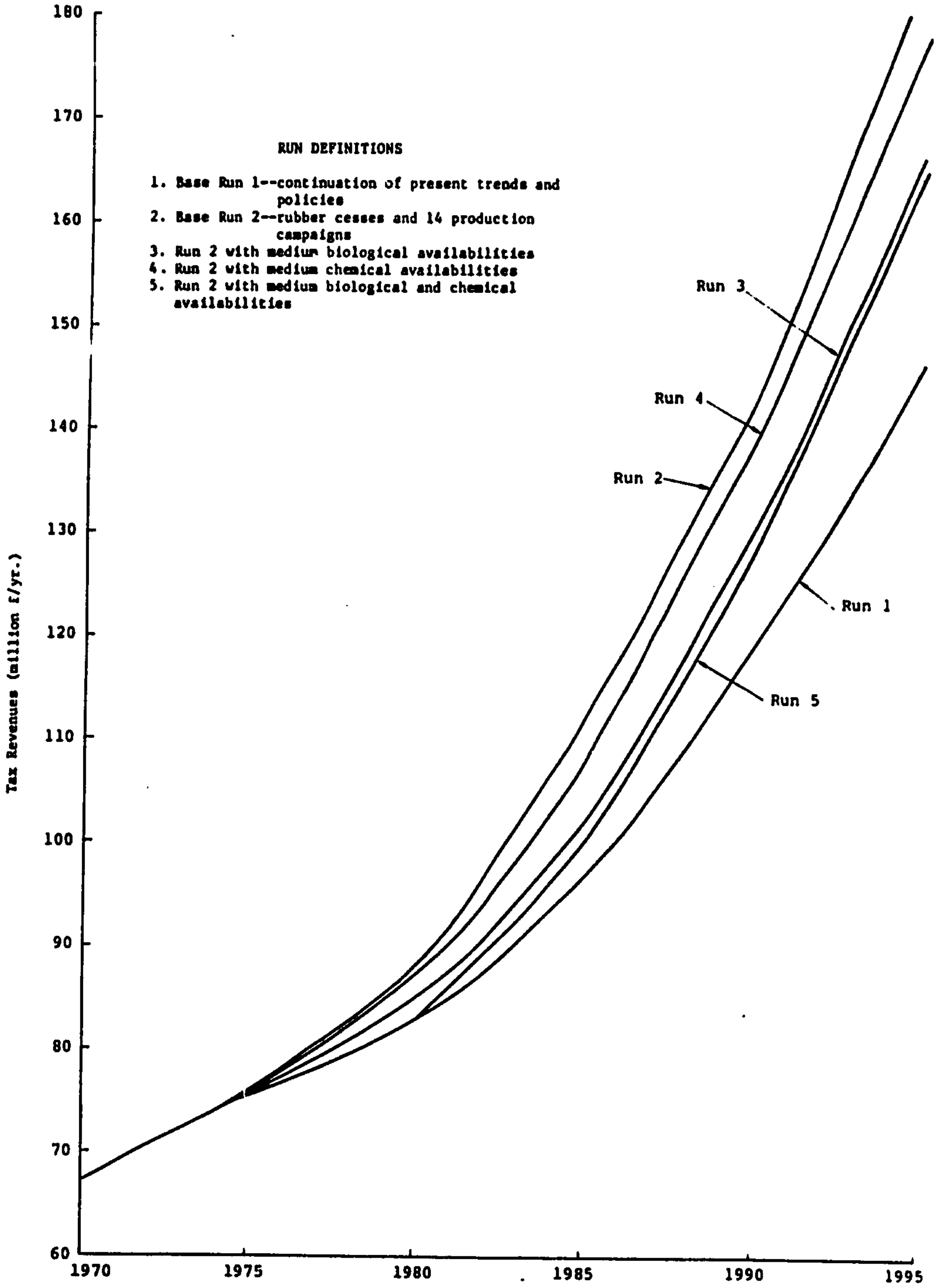

Fig. 5 Agricultural sector tax revenues, 1970-1995, with biological and chemical input constraints.

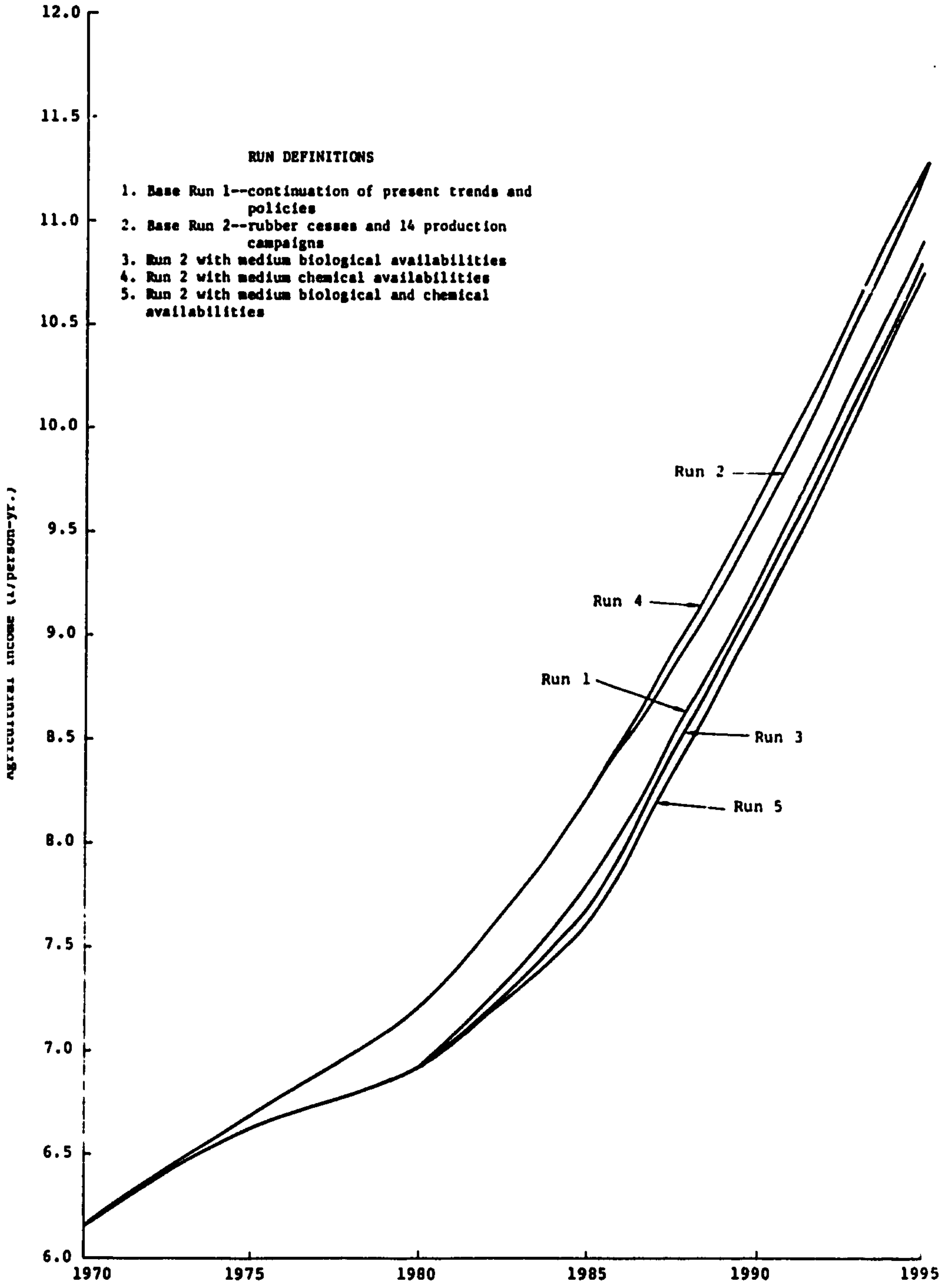

Fig. 6 Agricultural income per capita (North), 1970-1995, with biological and chemical input constraints.

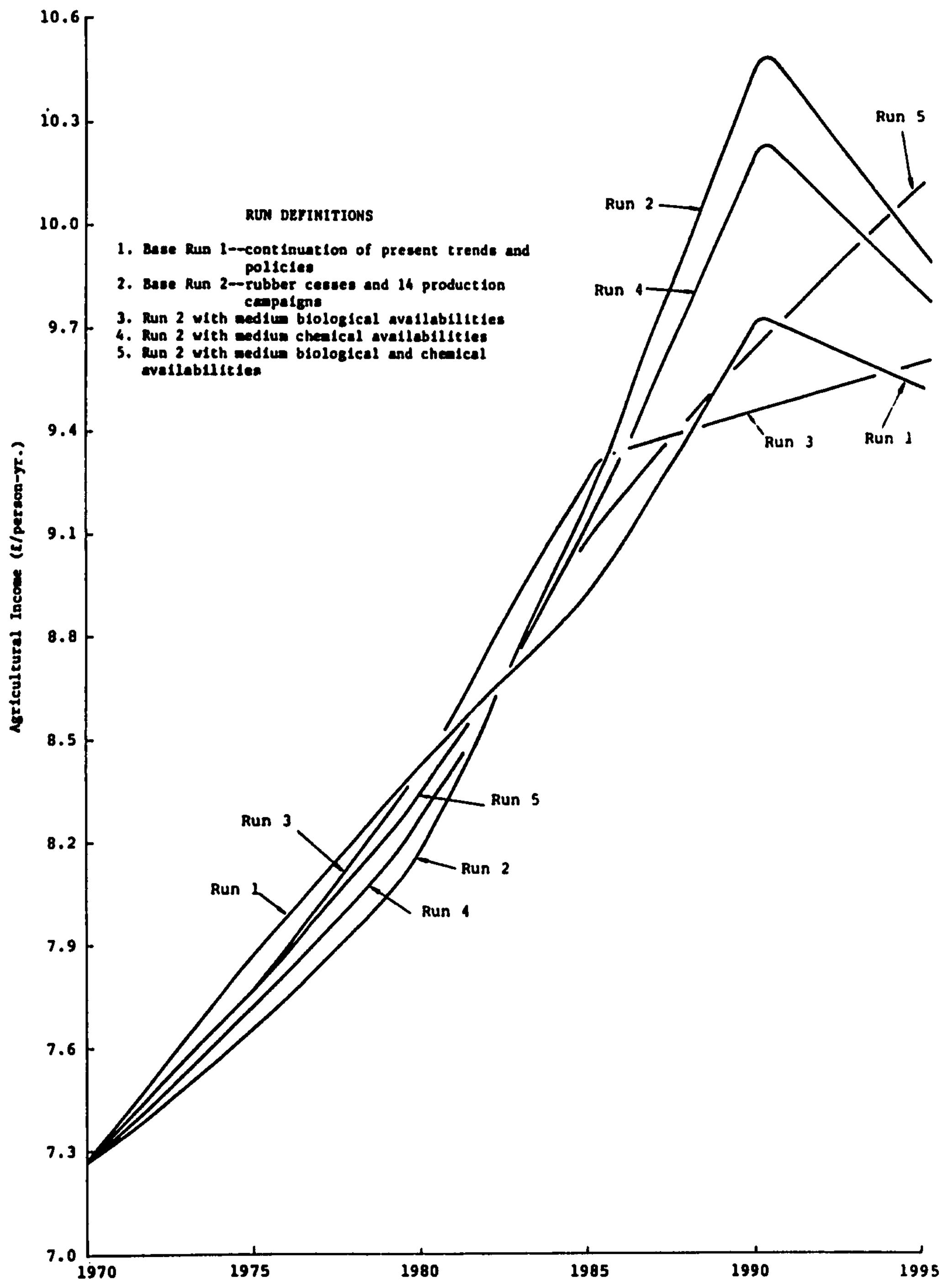

Fig. 7 Agricultural income per capita (South), 1970-1995, with biological and chemical input constraints.

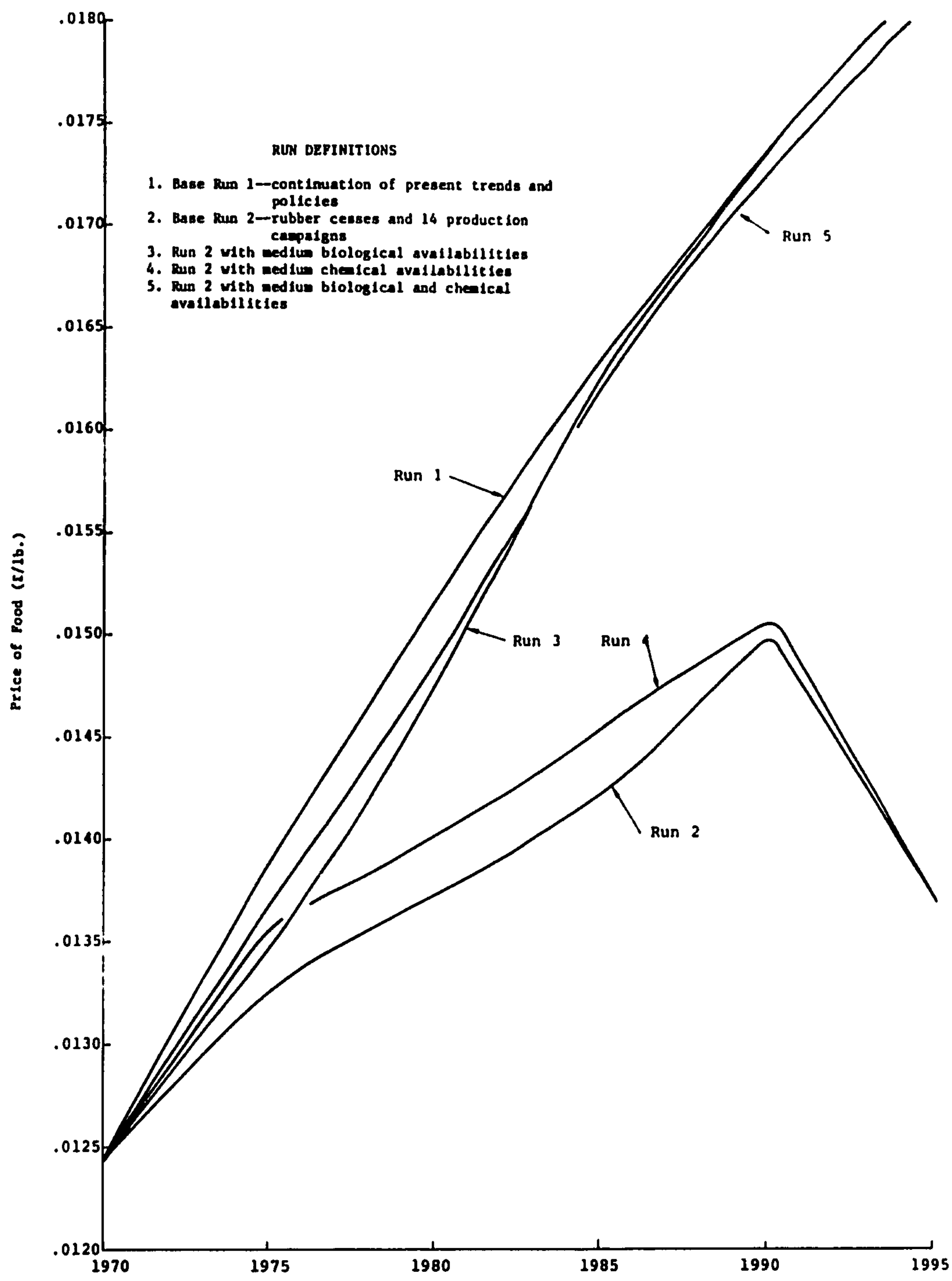

Fig. 8 Market price of food (South), 1970-1995, with biological and chemical input constraints.

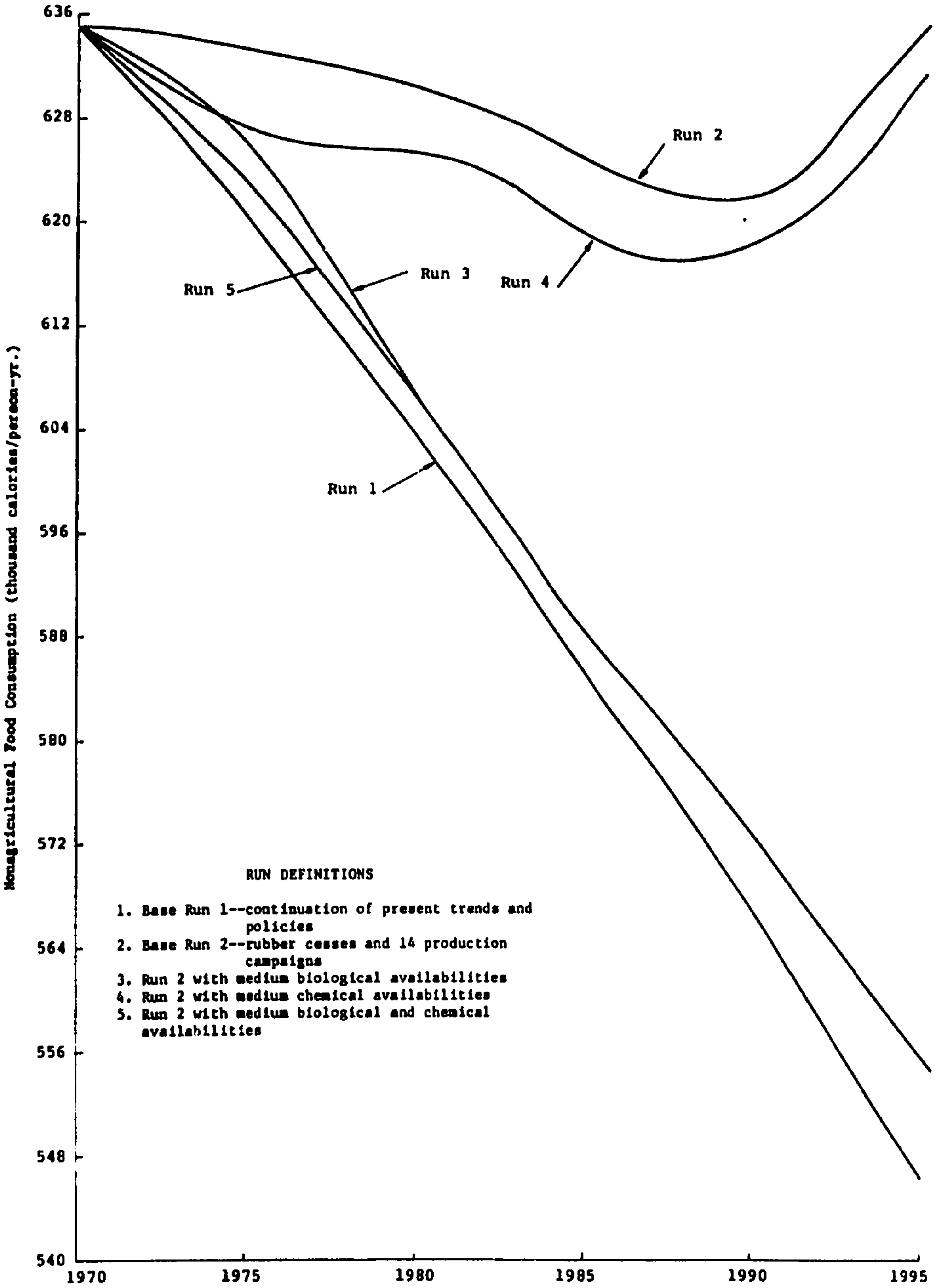

Fig. 9 Nonagricultural food consumption per capita (South), 1970-1995, with biological and chemical input constraints.

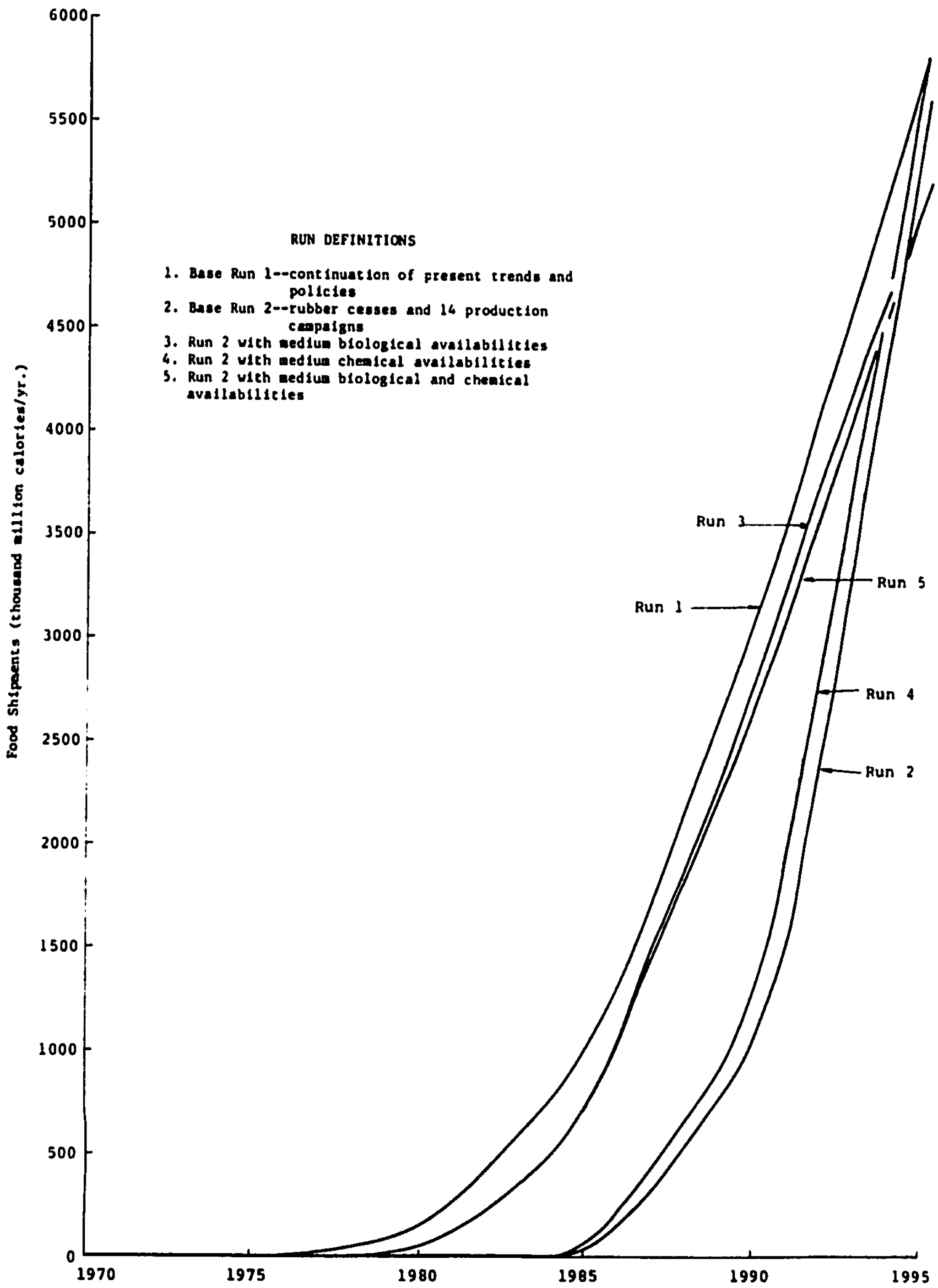

Fig. 10 Interregional food shipments (North to South), 1970-1995, with biological and chemical input constraints.

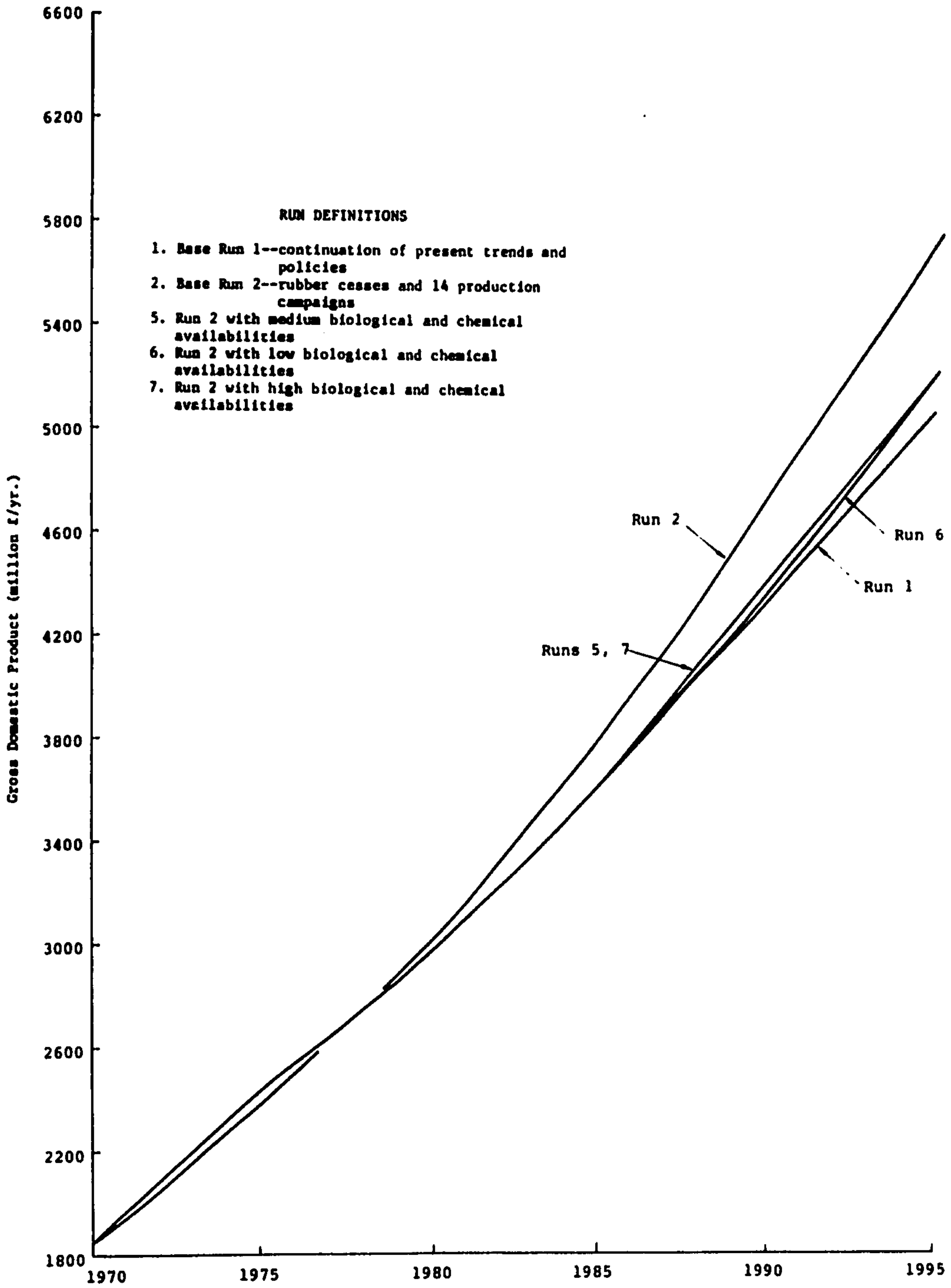

Fig. 11 Gross domestic product (assuming tax revenues are not put to productive use), 1970-1995, with three levels of combined input constraints.

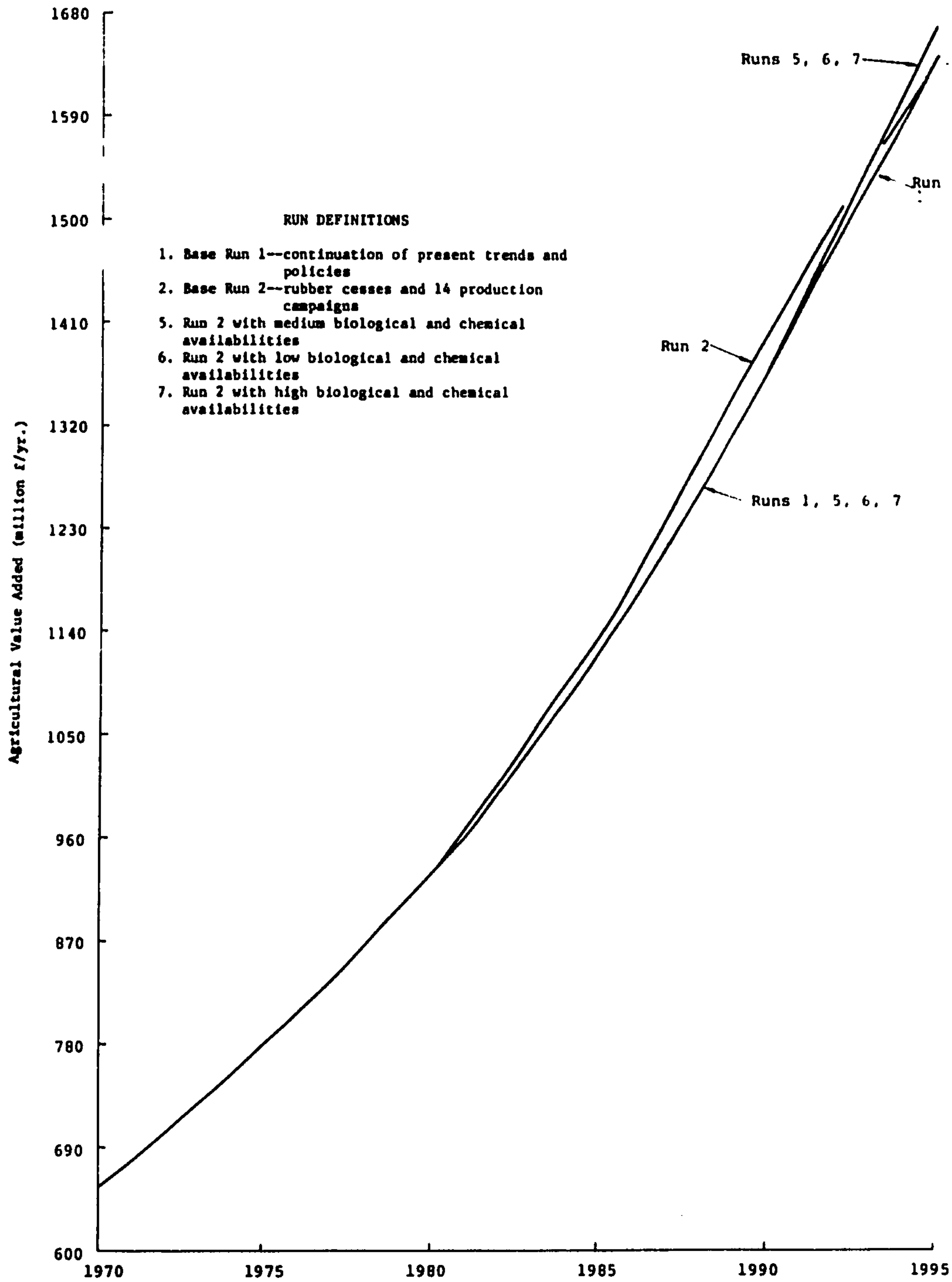

Fig. 12 Value added in agriculture, 1970-1995, with three levels of combined input constraints.

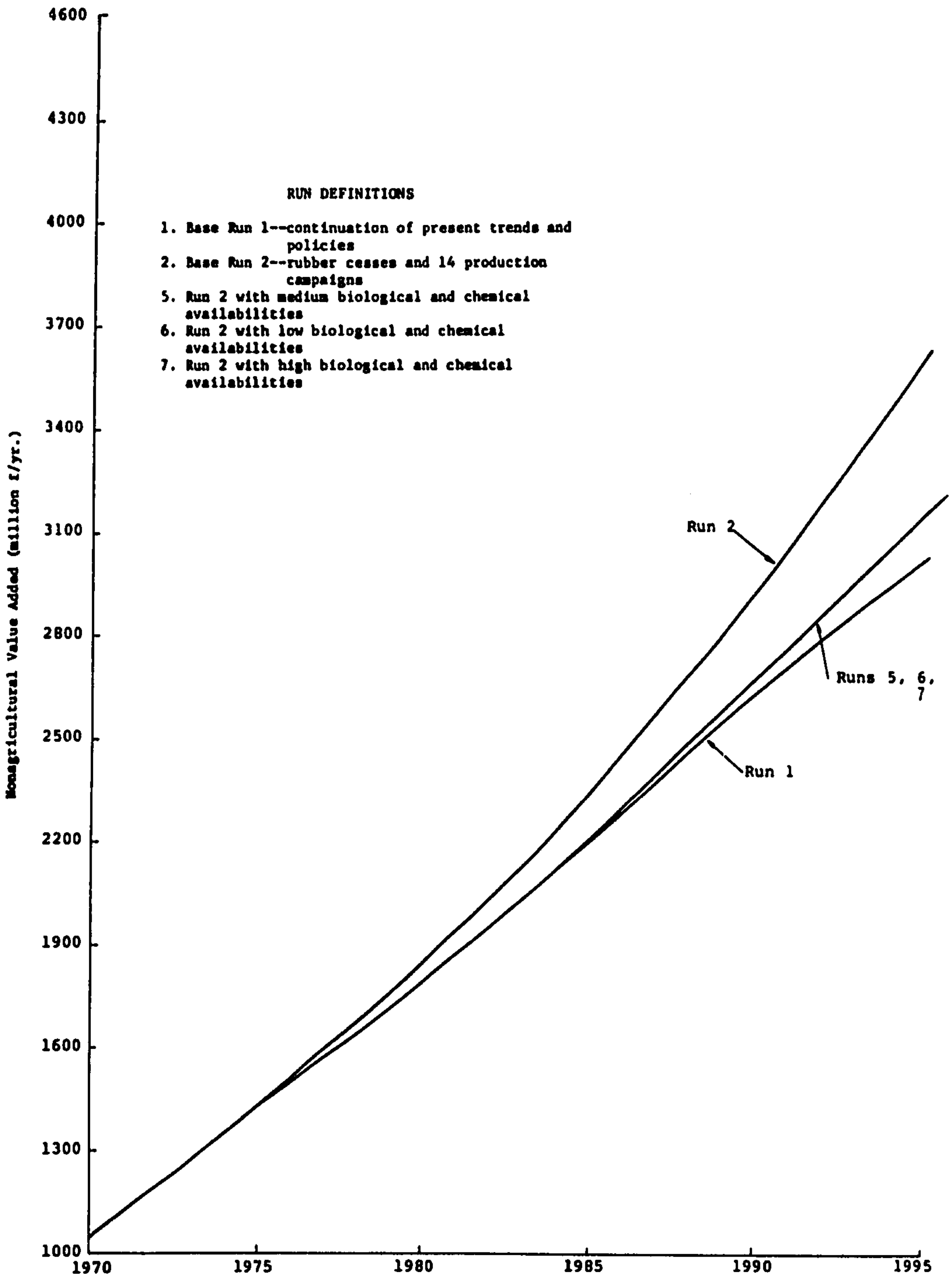

Fig. 13 Value added in nonagriculture, 1970-1995, with three levels of combined input constraints.

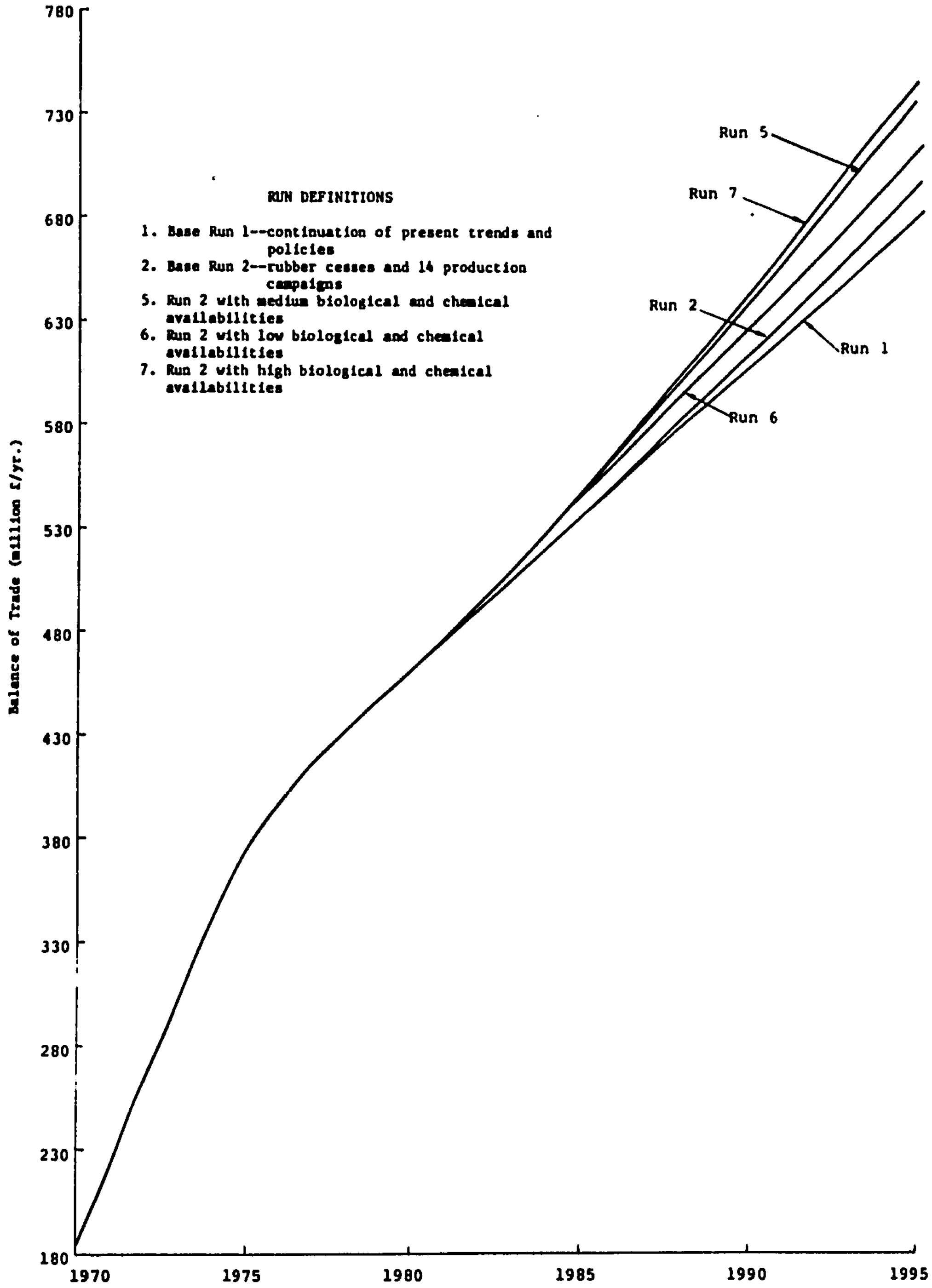

Fig. 14 Balance of trade, 1970-1995, with three levels of combined input constraints.

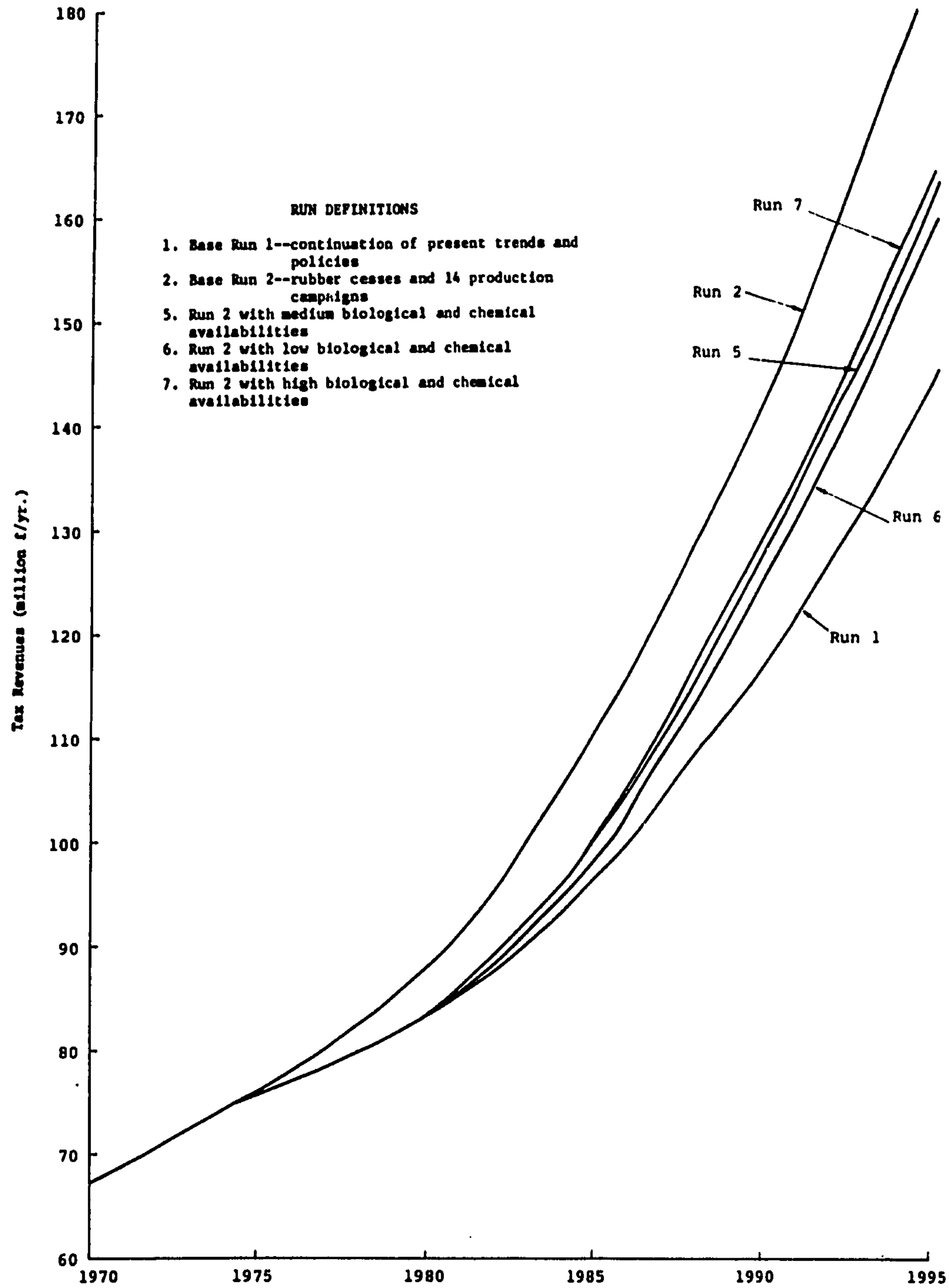

Fig. 15 Agricultural sector tax revenues, 1970-1995, with three levels of combined input constraints.

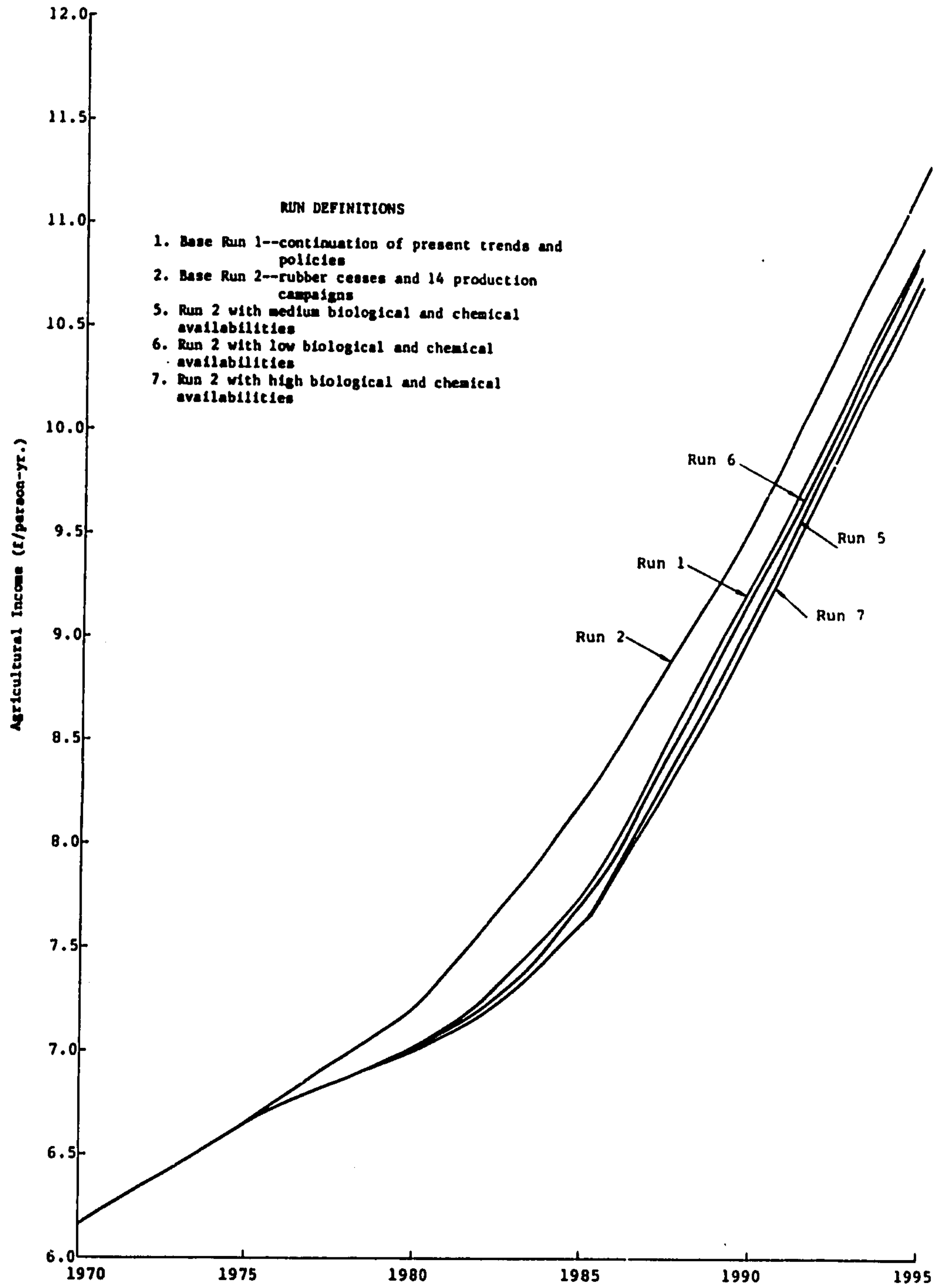

Fig. 16 Agricultural income per capita (North), 1970-1995, with three levels of combined input constraints.

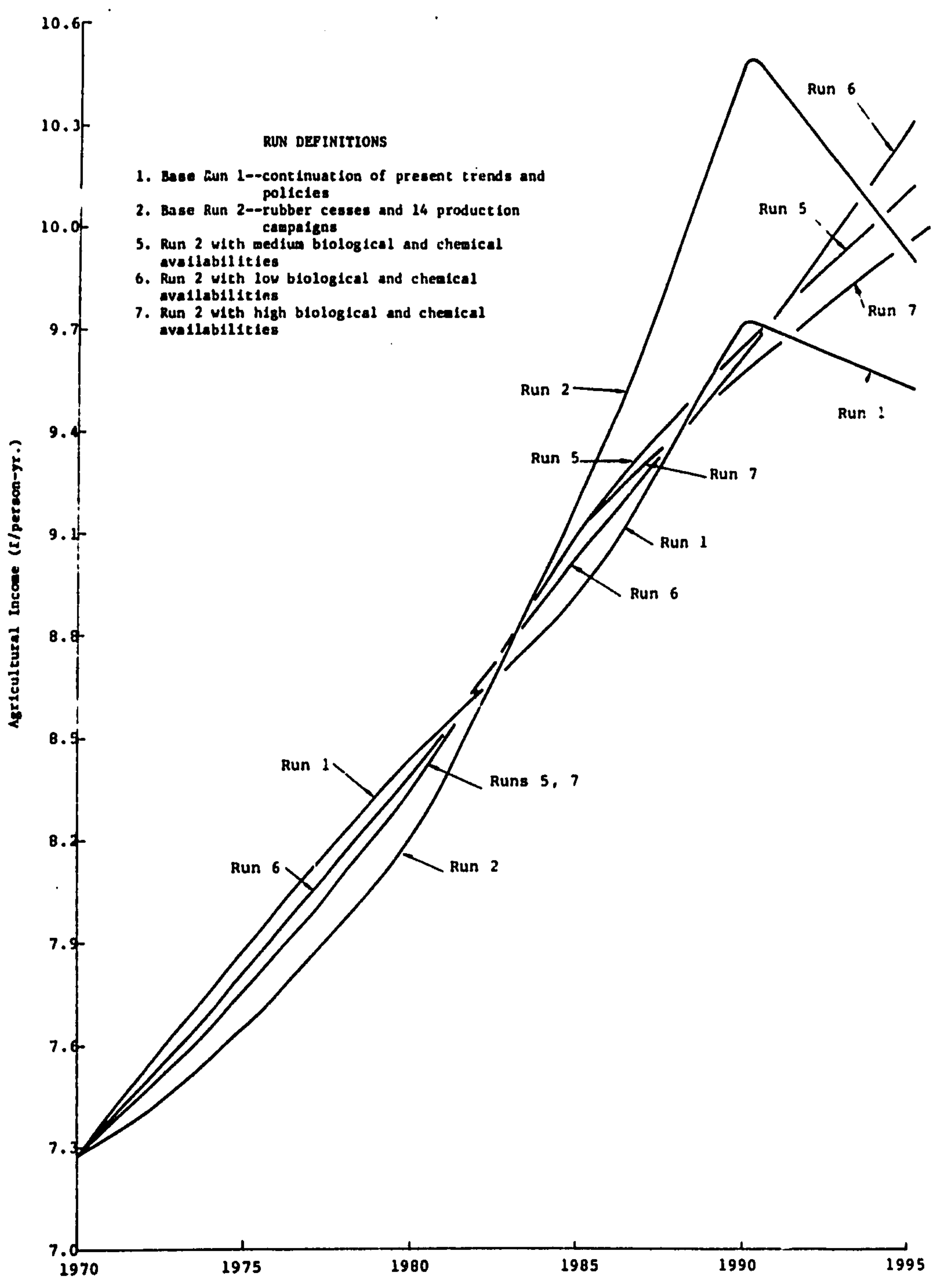

Fig. 17 Agricultural income per capita (South), 1970-1995, with three levels of combined input constraints

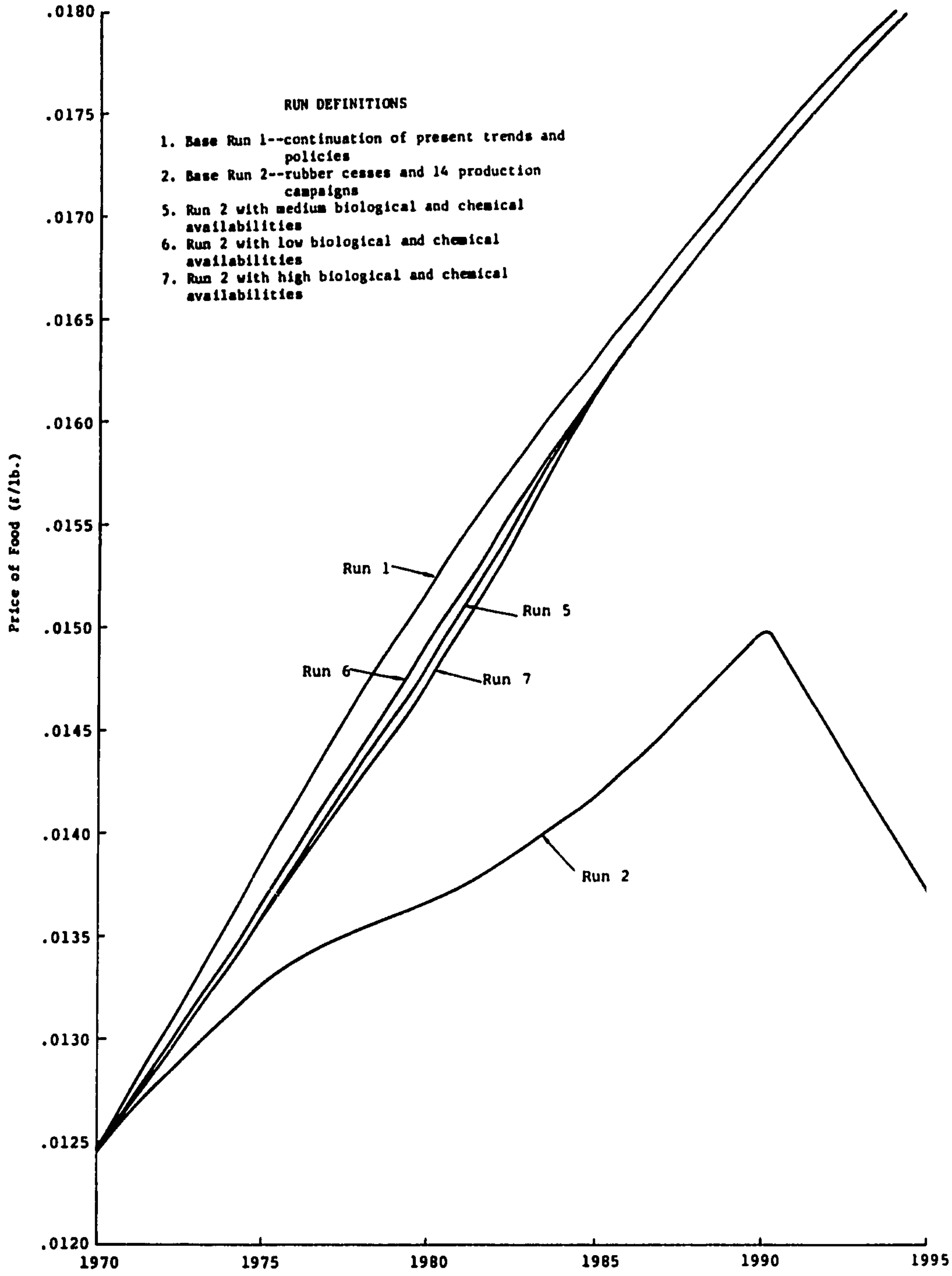

Fig. 18 Market price of food (South), 1970-1995, with three levels of combined input constraints.

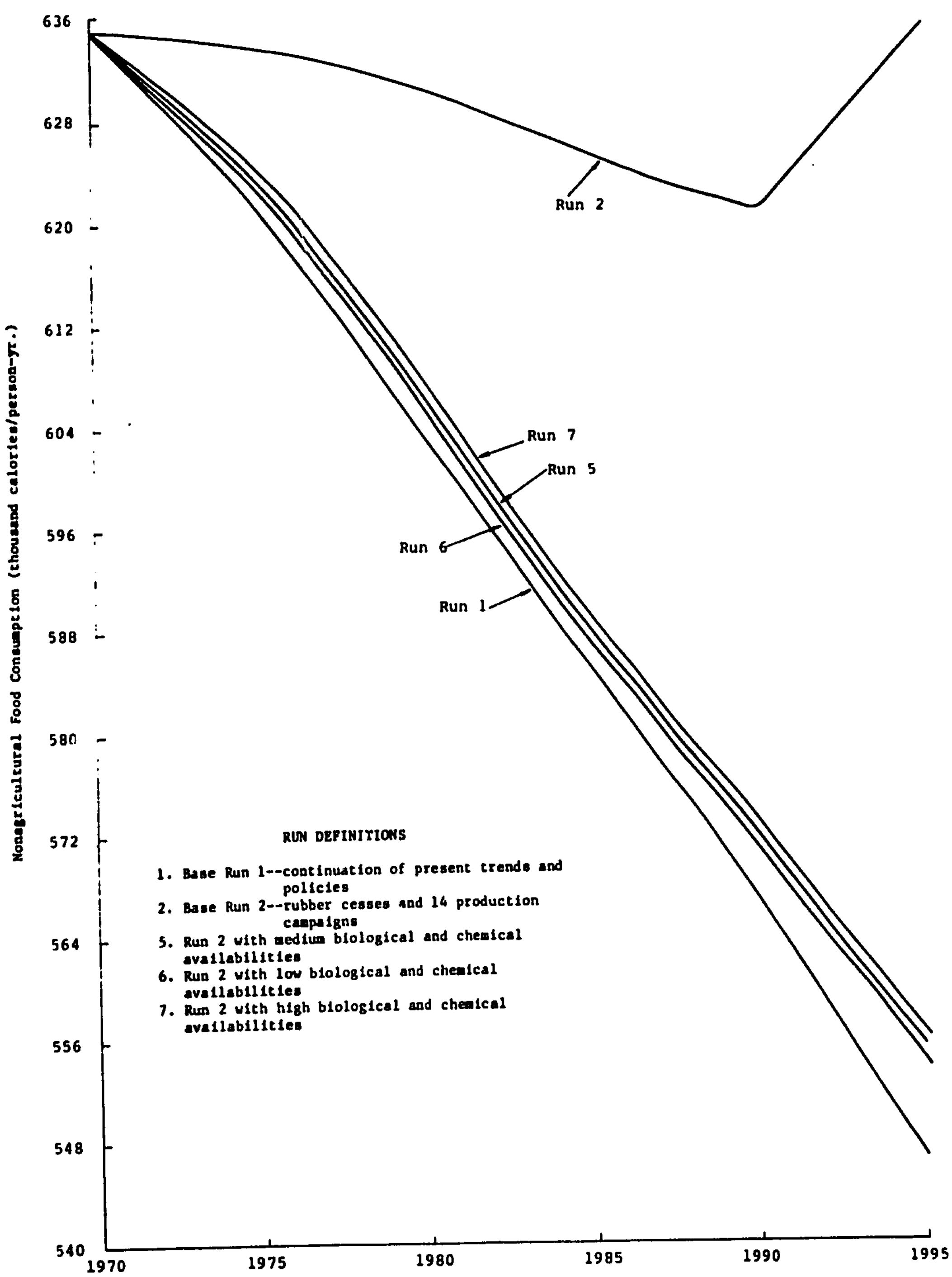

Fig. 19 Nonagricultural food consumption per capita (South), 1970-1995, with three levels of combined input constraints.

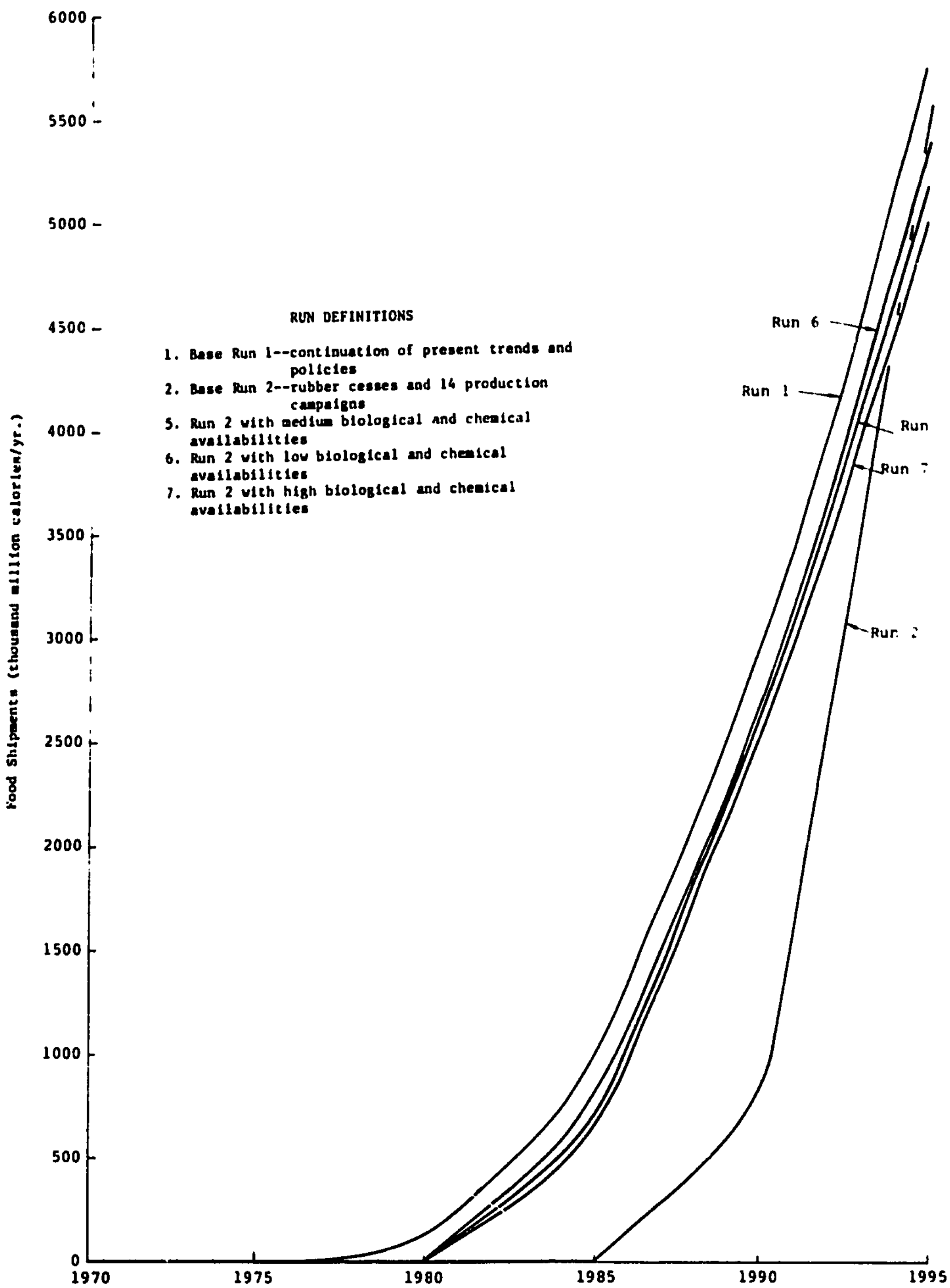

Fig. 20 Interregional food shipments (North to South), 1970-1995, with three levels of combined input constraints.

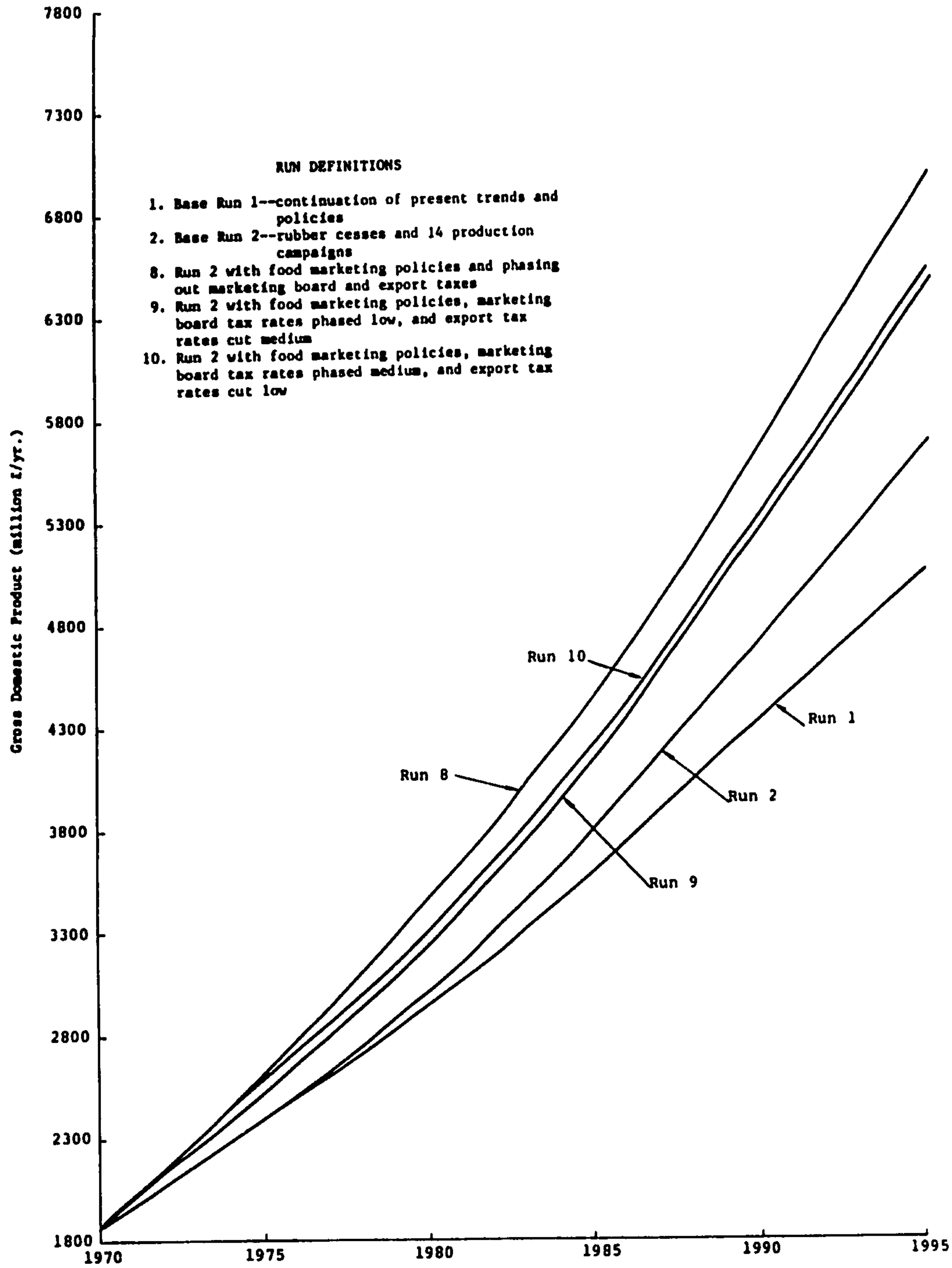

Fig. 21 Gross domestic product (assuming tax revenues are not put to productive use), 1970-1995, with three levels of marketing board and export tax reductions.

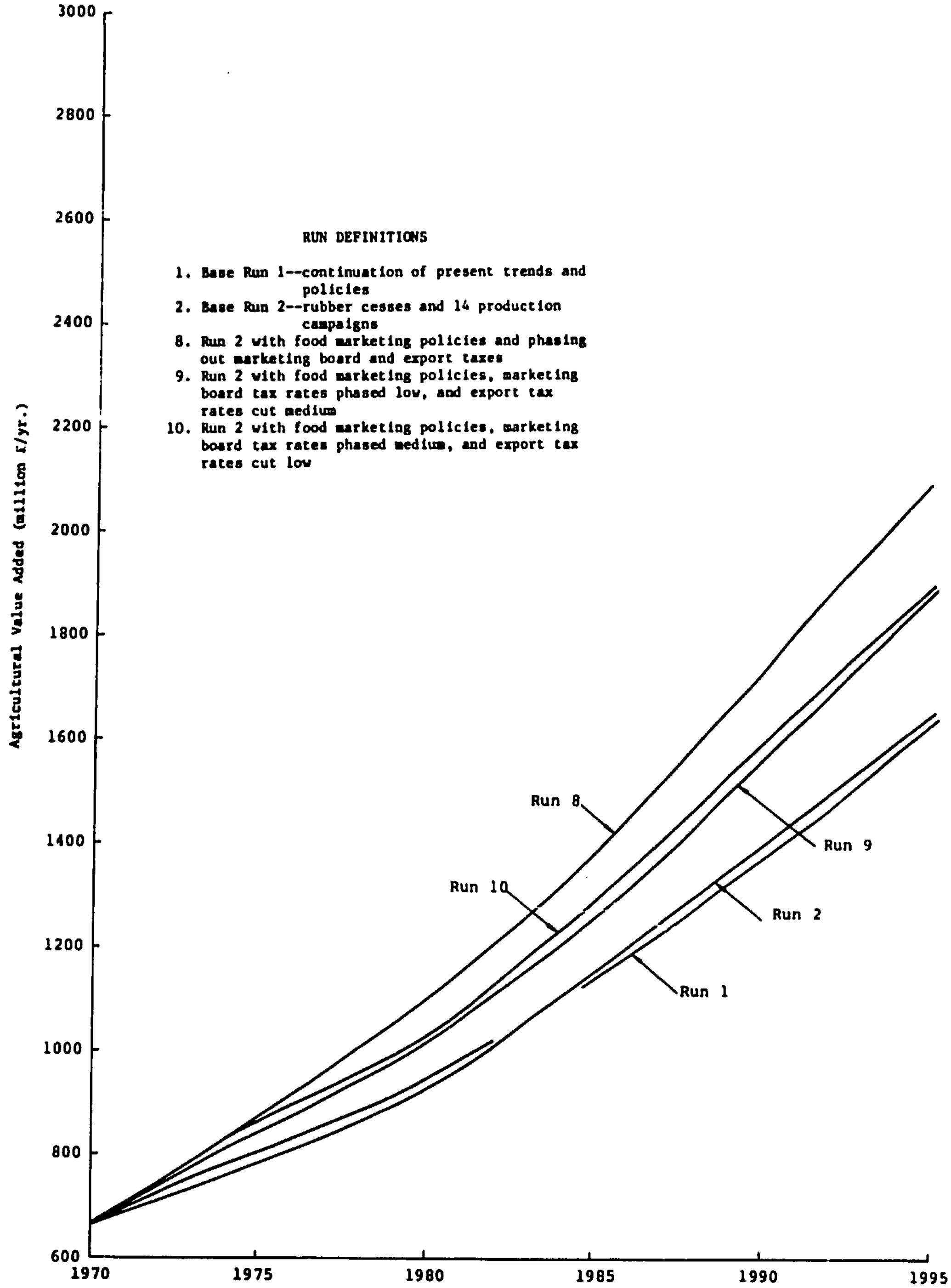

Fig. 22 Value added in agriculture, 1970-1995, with three levels of marketing board and export tax reductions.

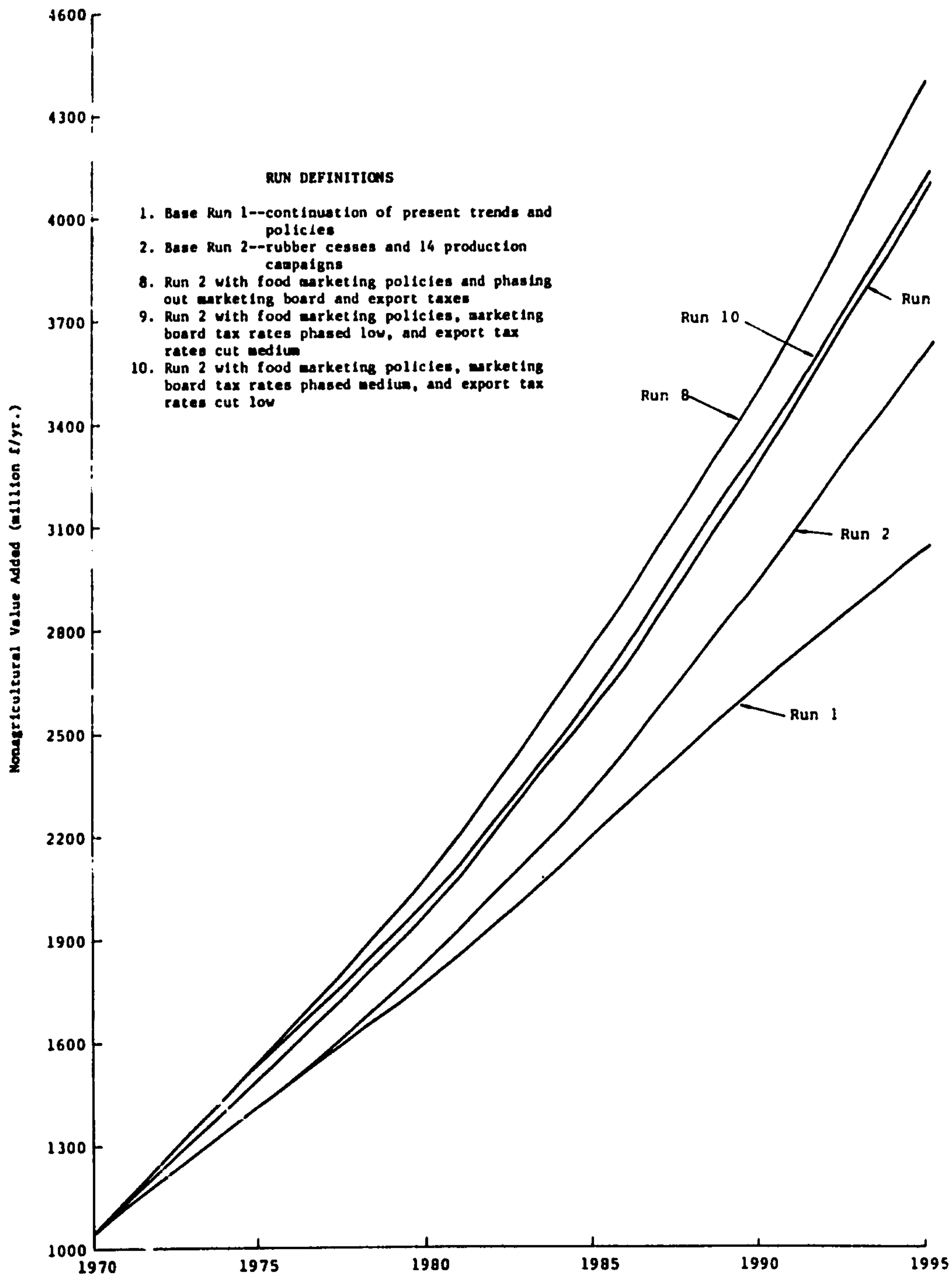

Fig. 23 Value added in nonagriculture, 1970-1995, with three levels of marketing board and export tax reductions.

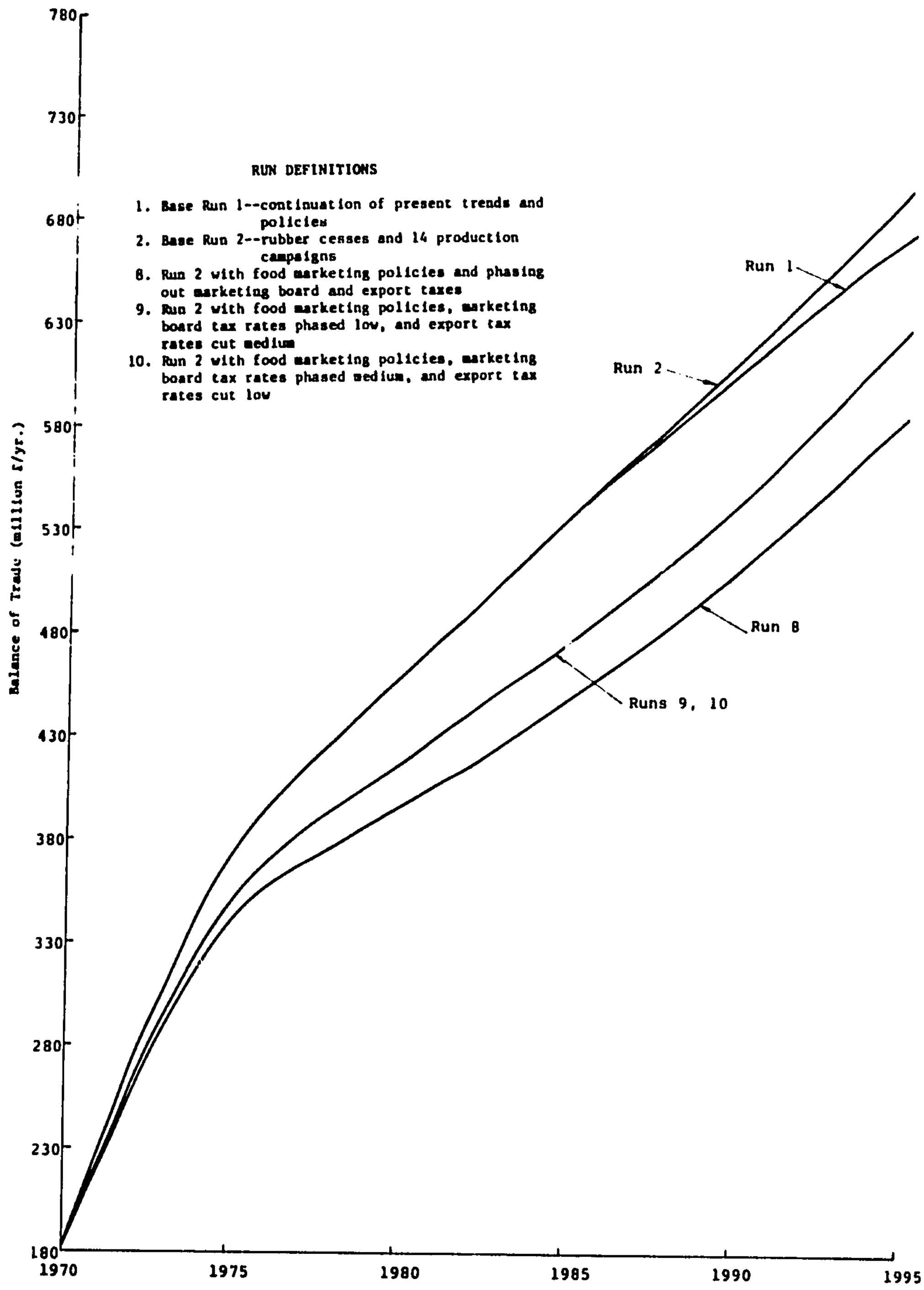

Fig. 24 Balance of trade, 1970-1995, with three levels of marketing board and export tax reductions.

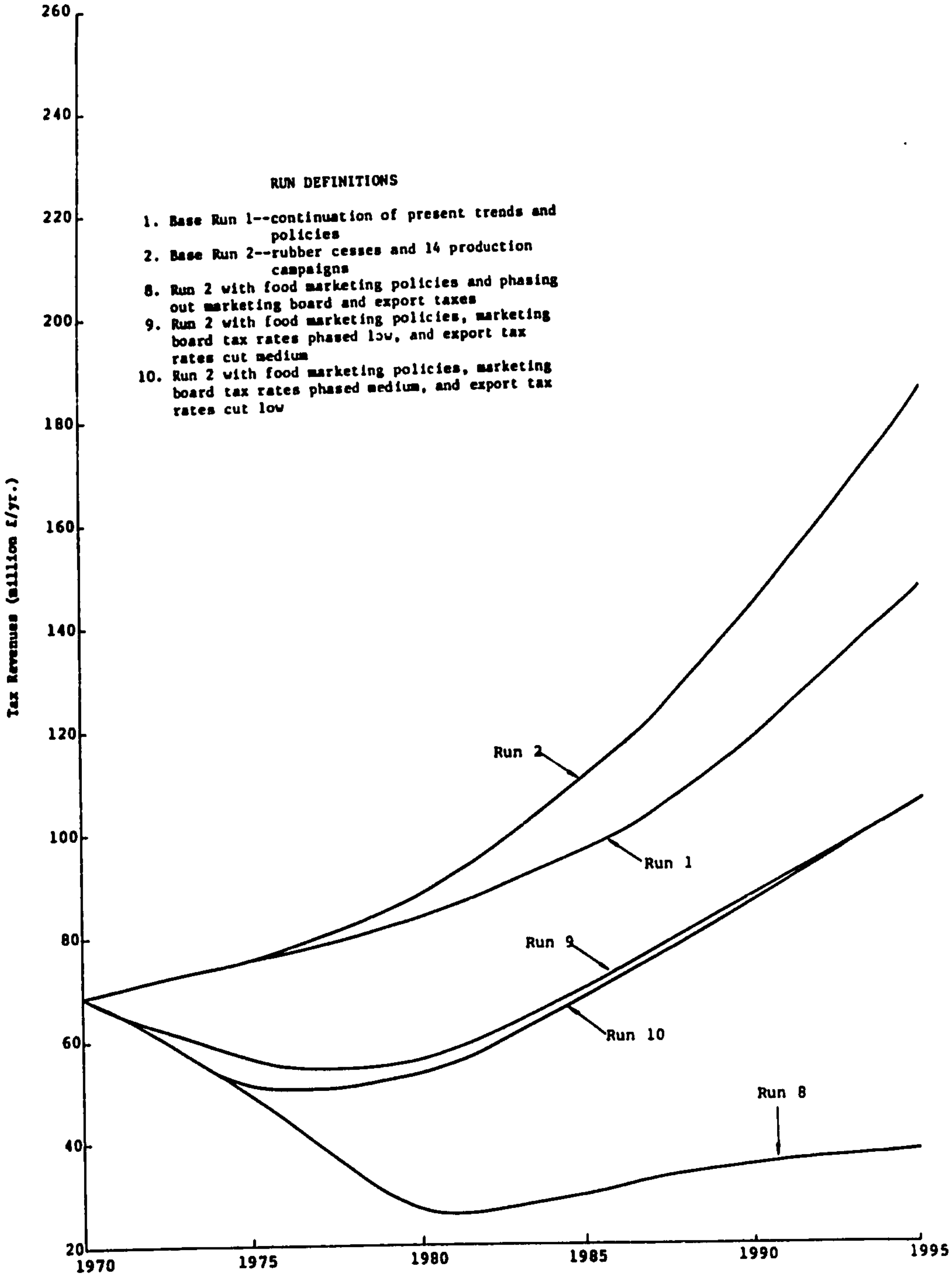

Fig. 25 Agricultural sector tax revenues, 1970-1995, with three levels of marketing board and export tax reductions.

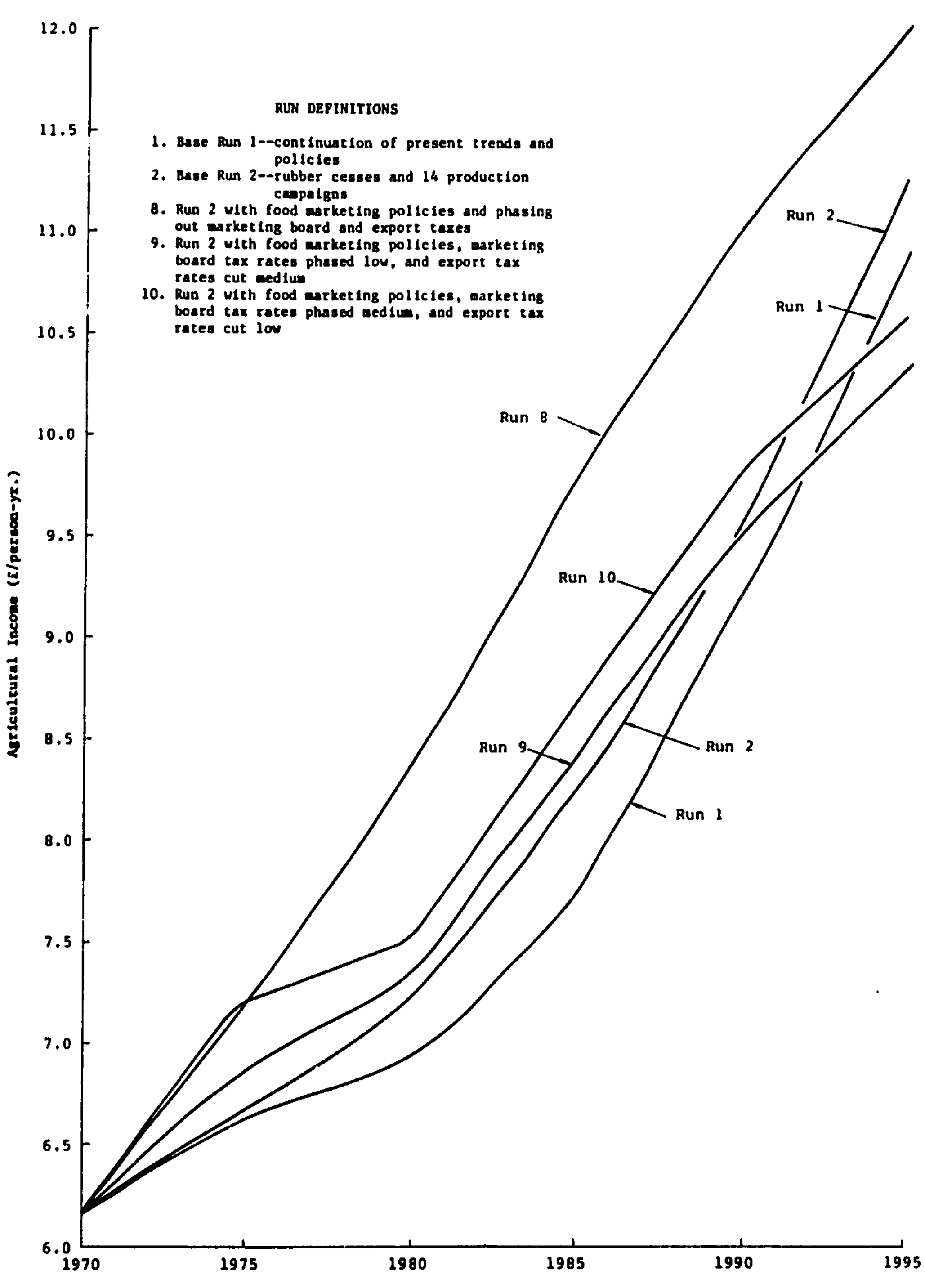

Fig. 26 Agricultural income per capita (North), 1970-1995, with three levels of marketing board and export tax reductions.

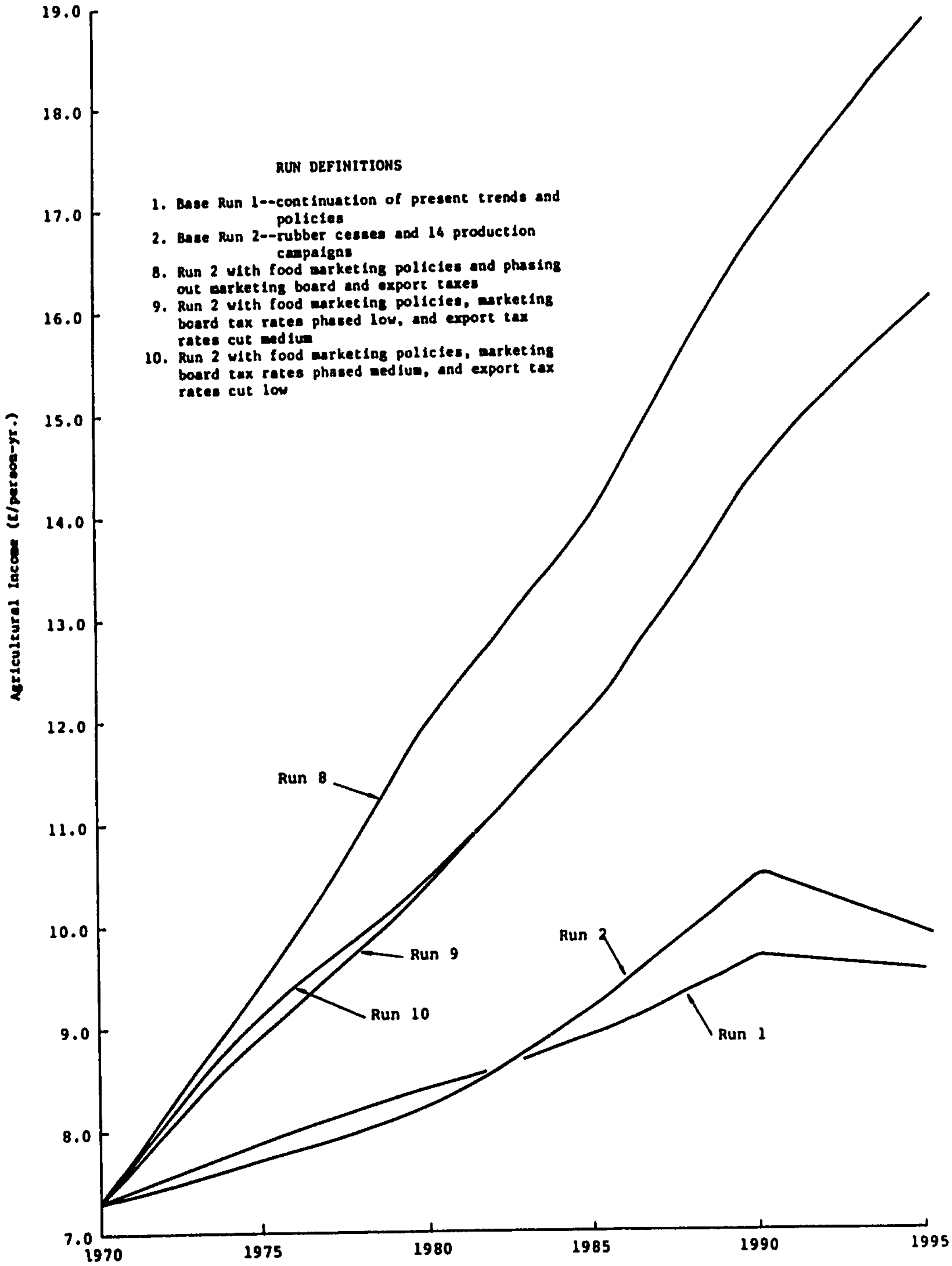

Fig. 27 Agricultural income per capita (South), 1970-1995, with three levels of marketing board and export tax reductions.

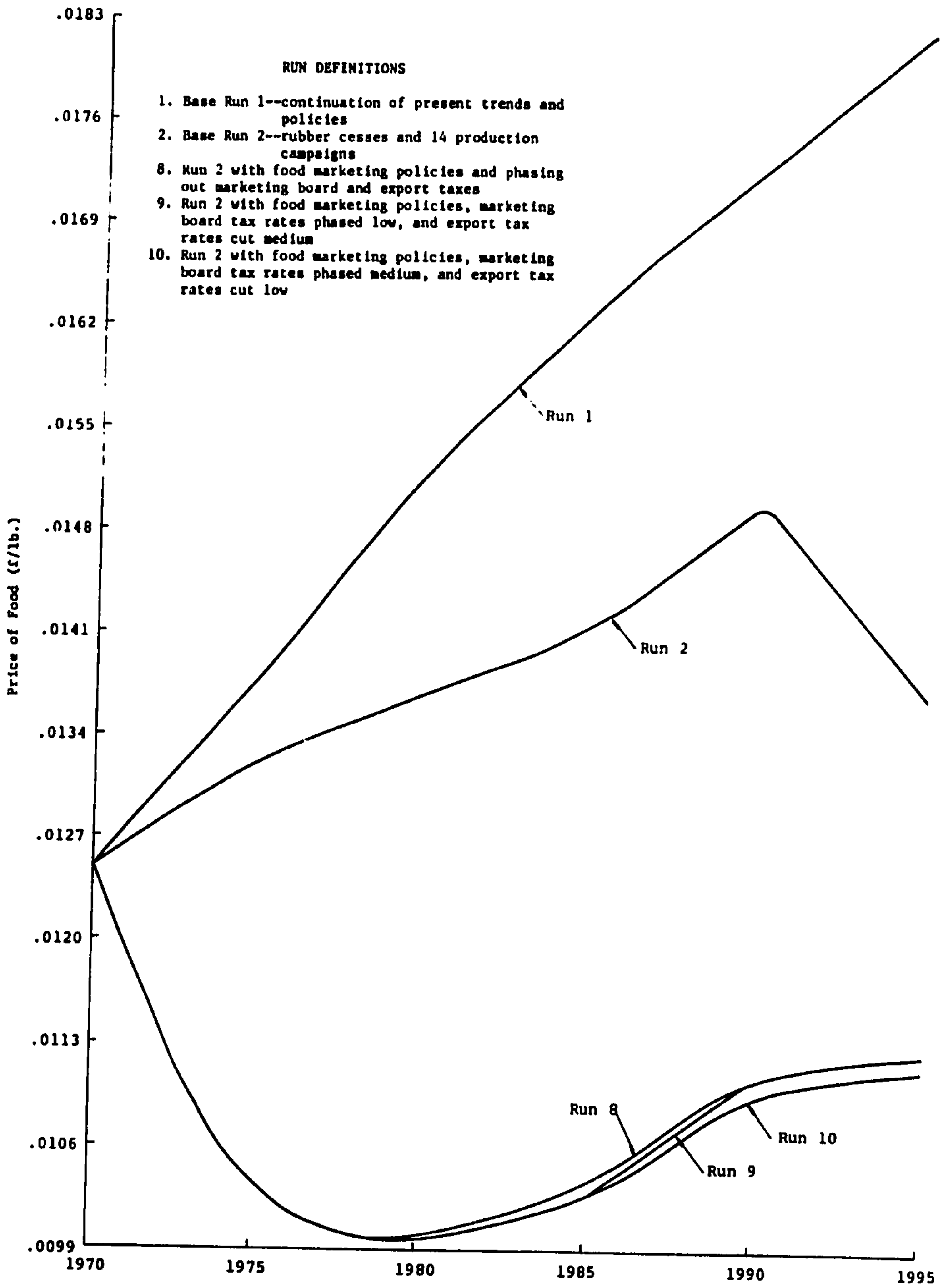

Fig. 28 Market price of food (South), 1970-1995, with three levels of marketing board and export tax reductions.

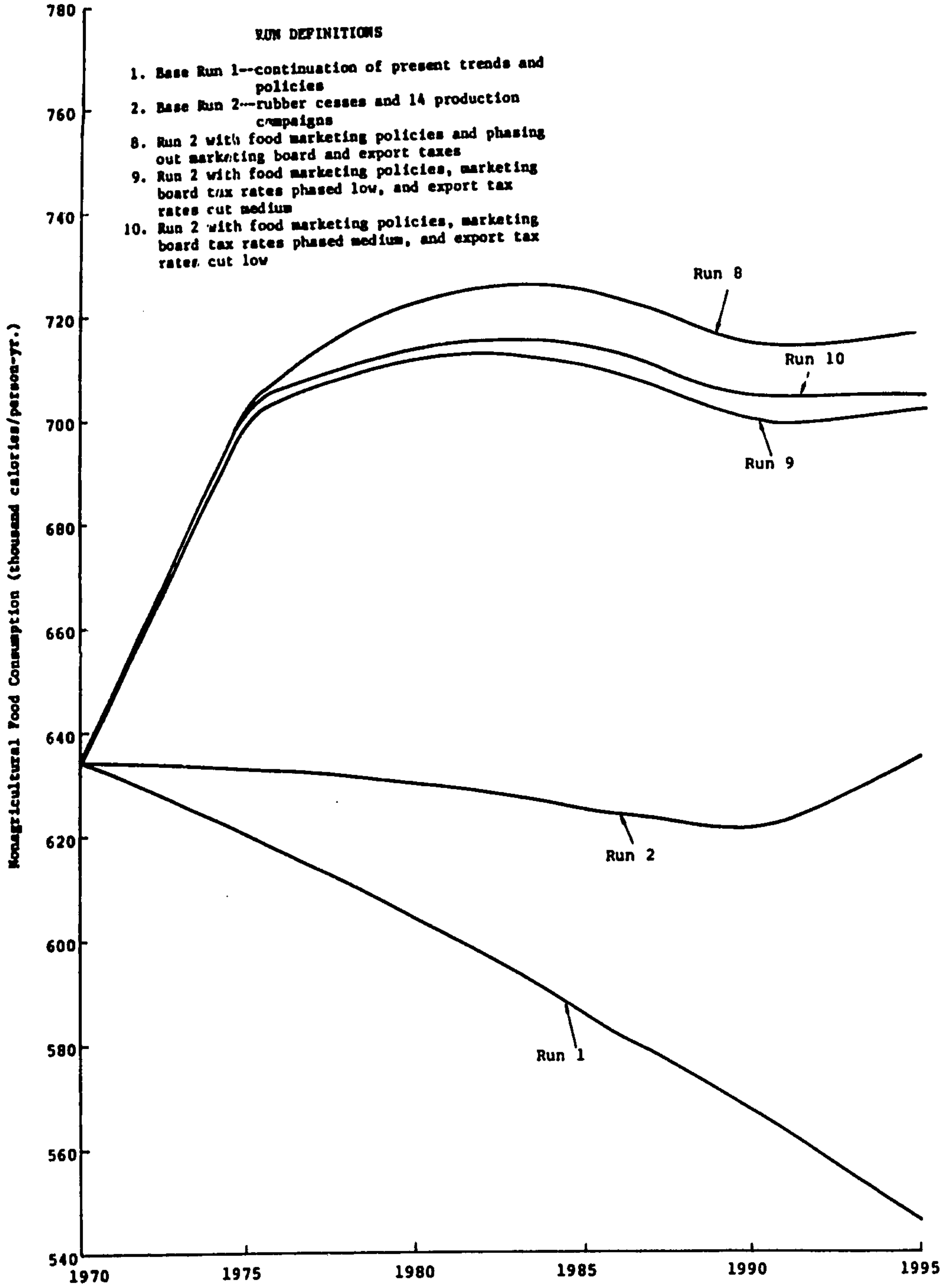

Fig. 29 Nonagricultural food consumption per capita (South), 1970-1995, with three levels of marketing board and export tax reductions.

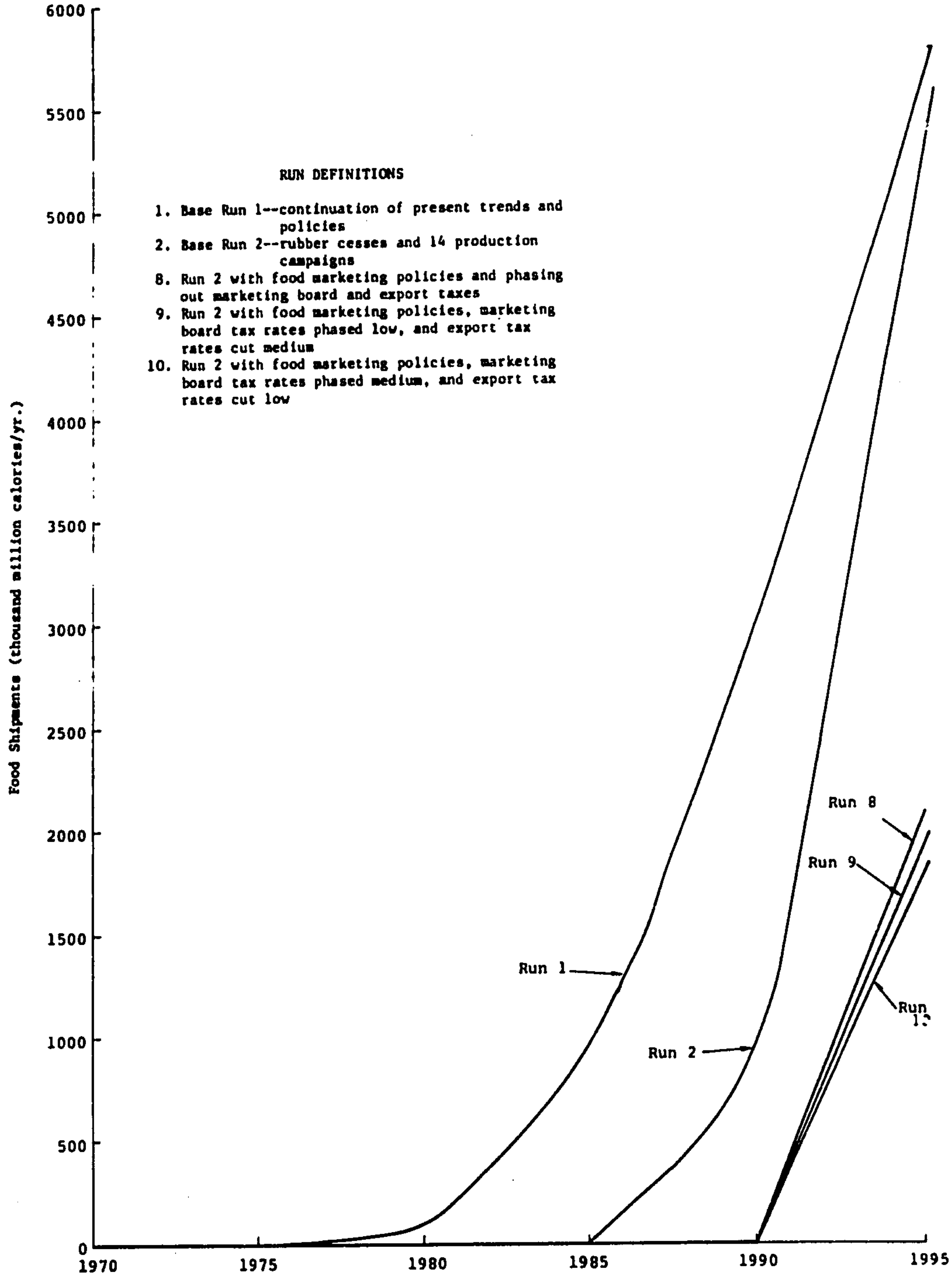

Fig. 30 Interregional food shipments (North to South), 1970-1995, with three levels of marketing board and export tax reductions.

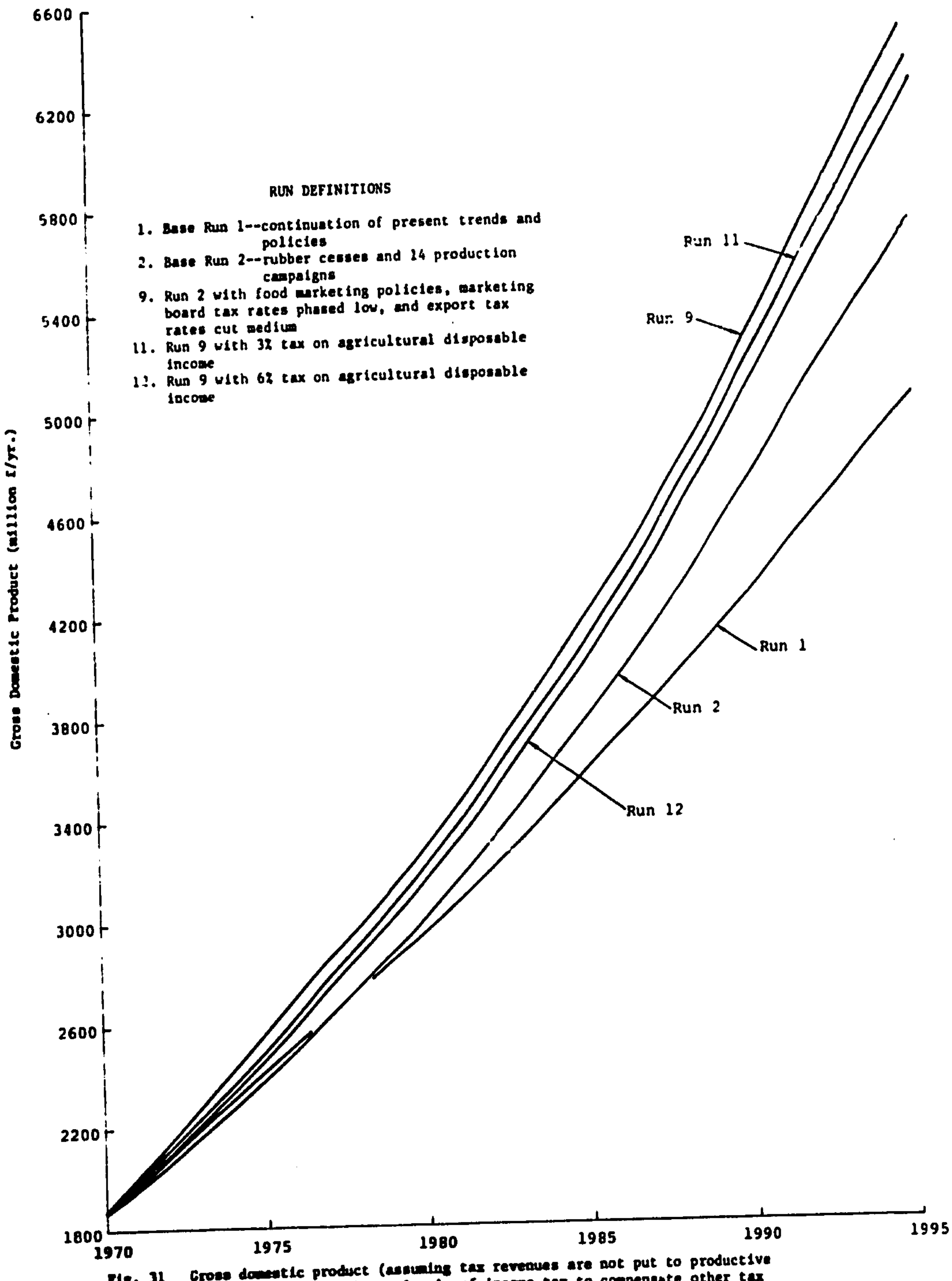

Fig. 31 Gross domestic product (assuming tax revenues are not put to productive use), 1970-1995, with two levels of income tax to compensate other tax reductions.

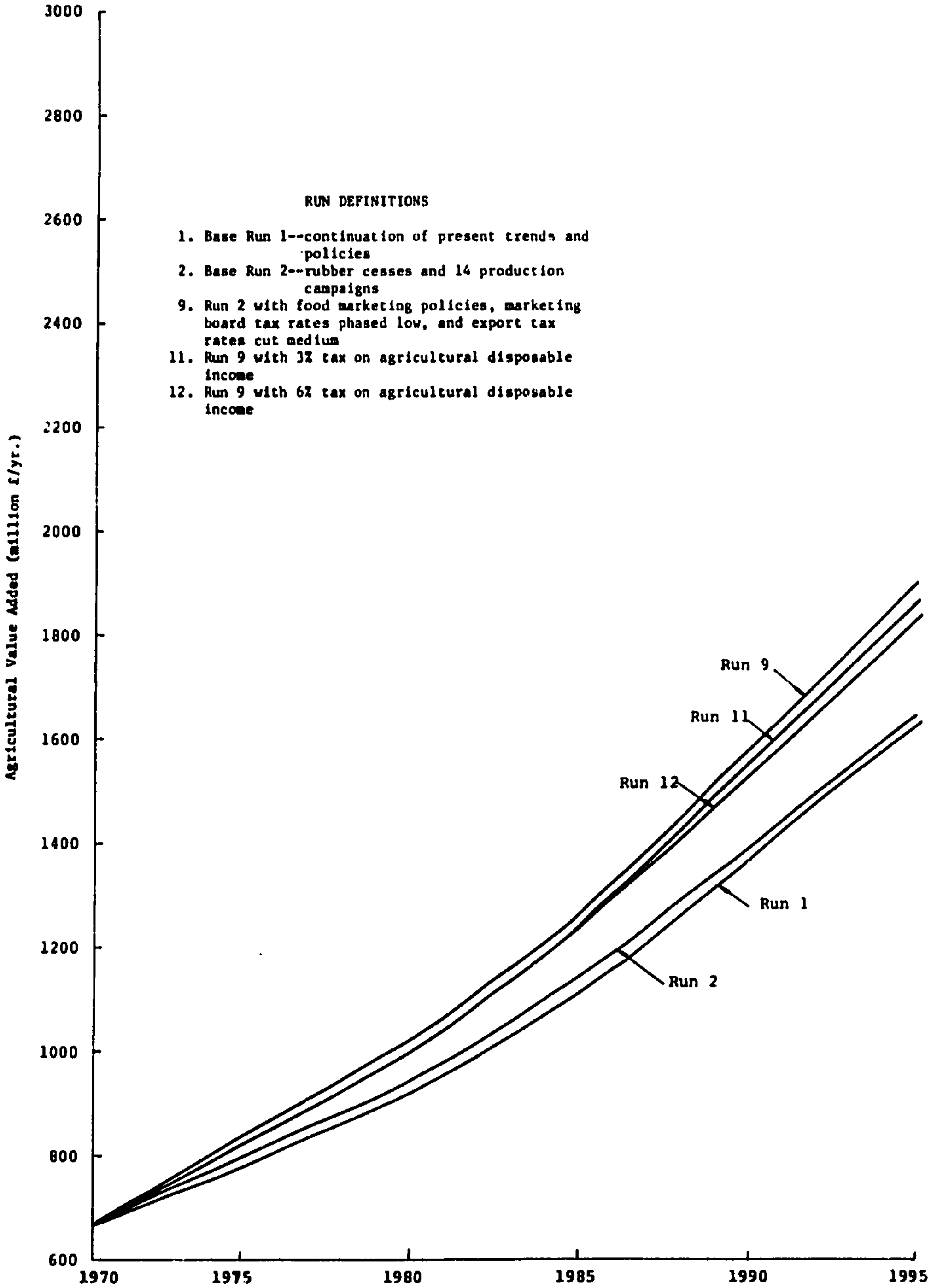

Fig. 32 Value added in agriculture, 1970-1995, with two levels of income tax to compensate other tax reductions.

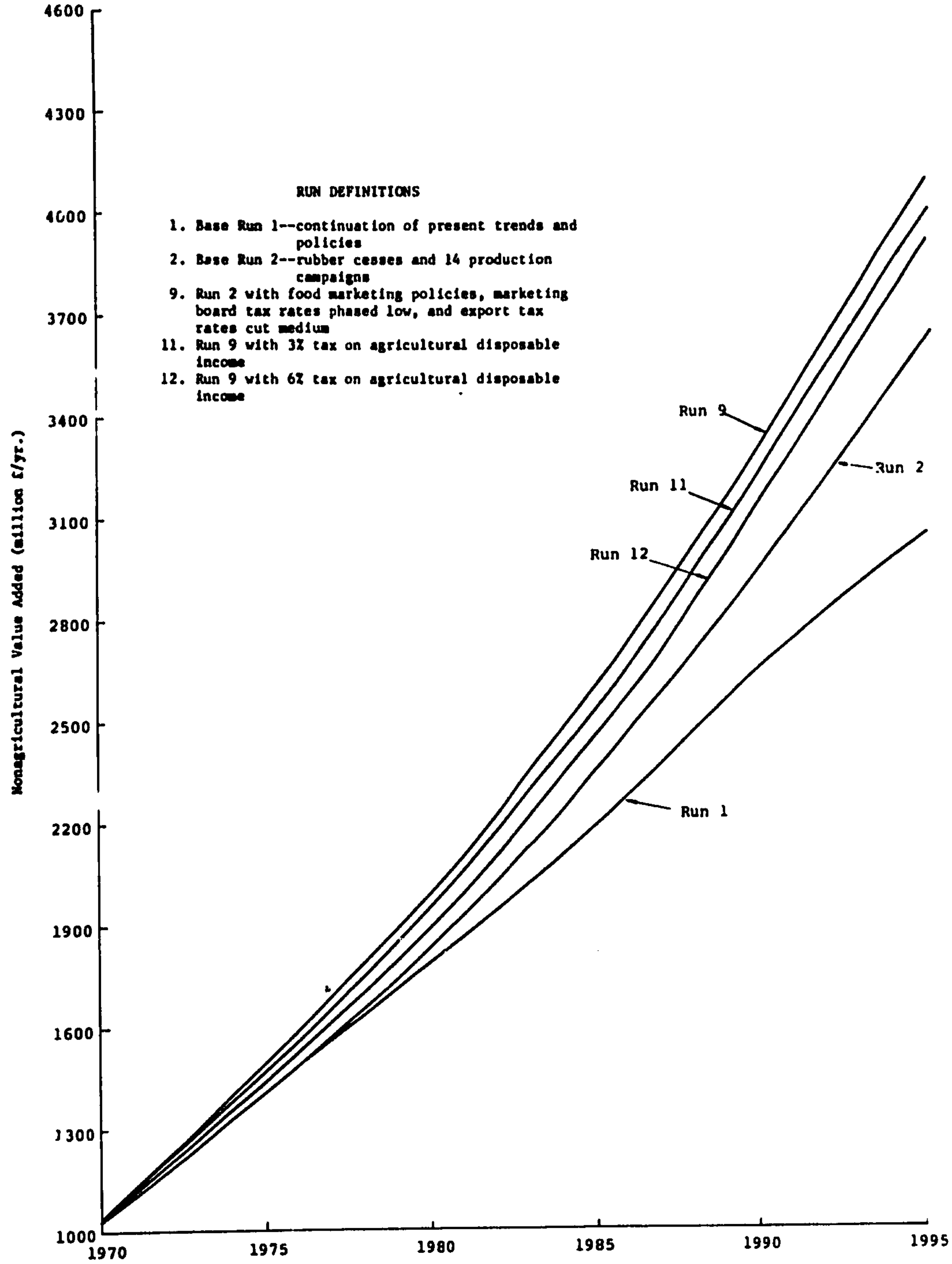

Fig. 33 Value added in nonagriculture, 1970-1995, with two levels of income tax to compensate other tax reductions.

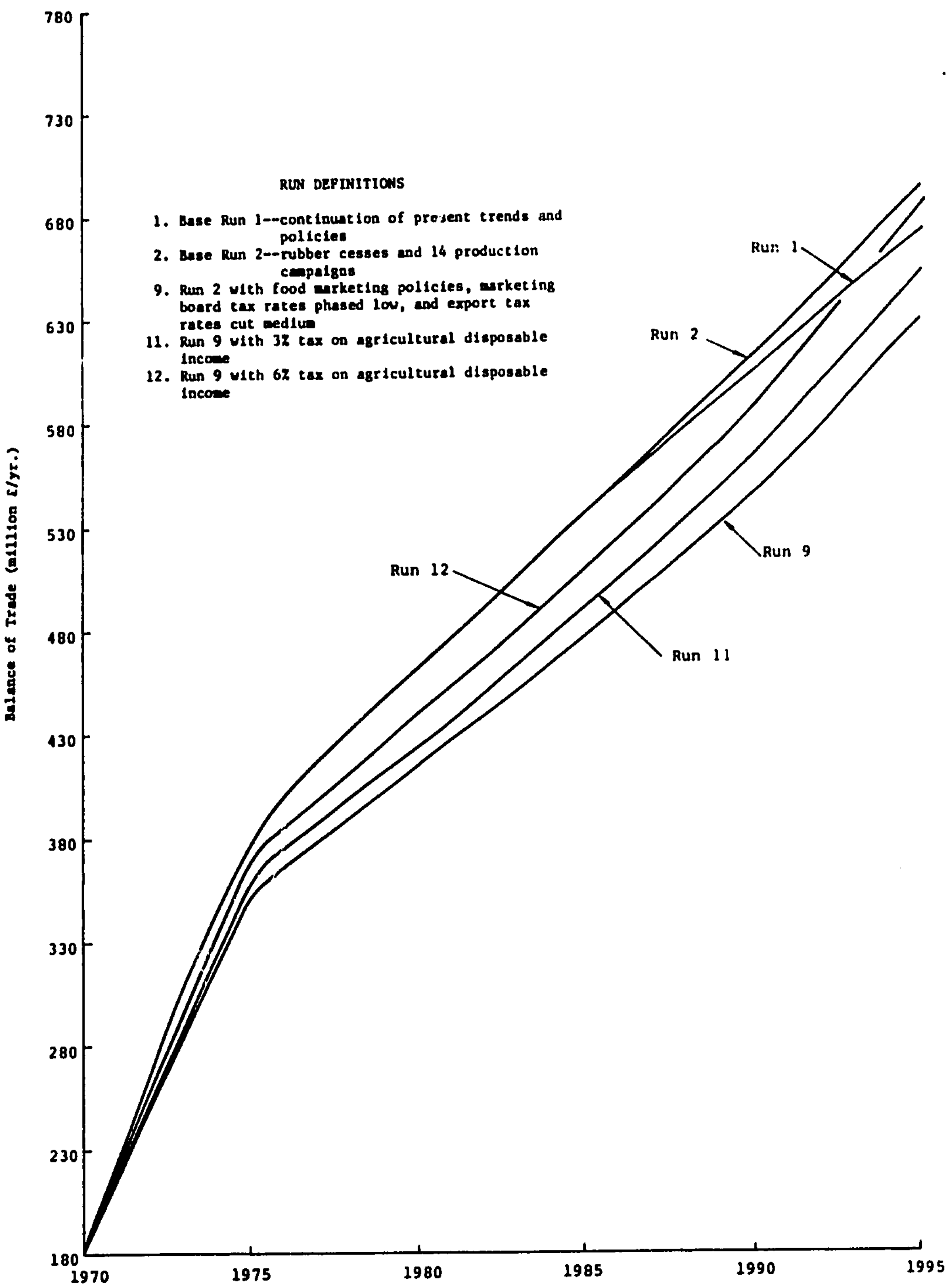

Fig. 34 Balance of trade, 1970-1995, with two levels of income tax to compensate other tax reductions.

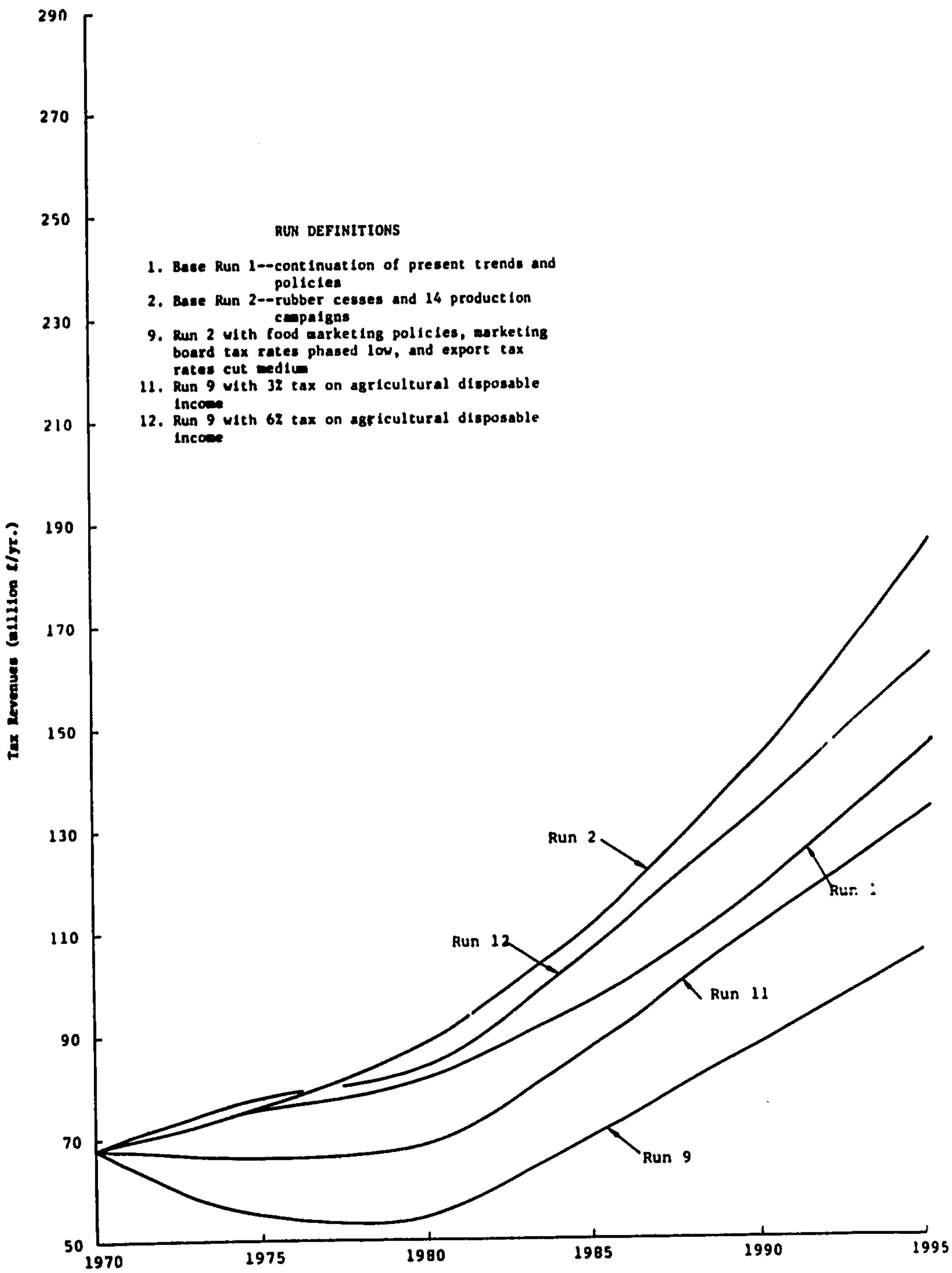

Fig. 35 Agricultural sector tax revenues, 1970-1995, with two levels of income tax to compensate other tax reductions.

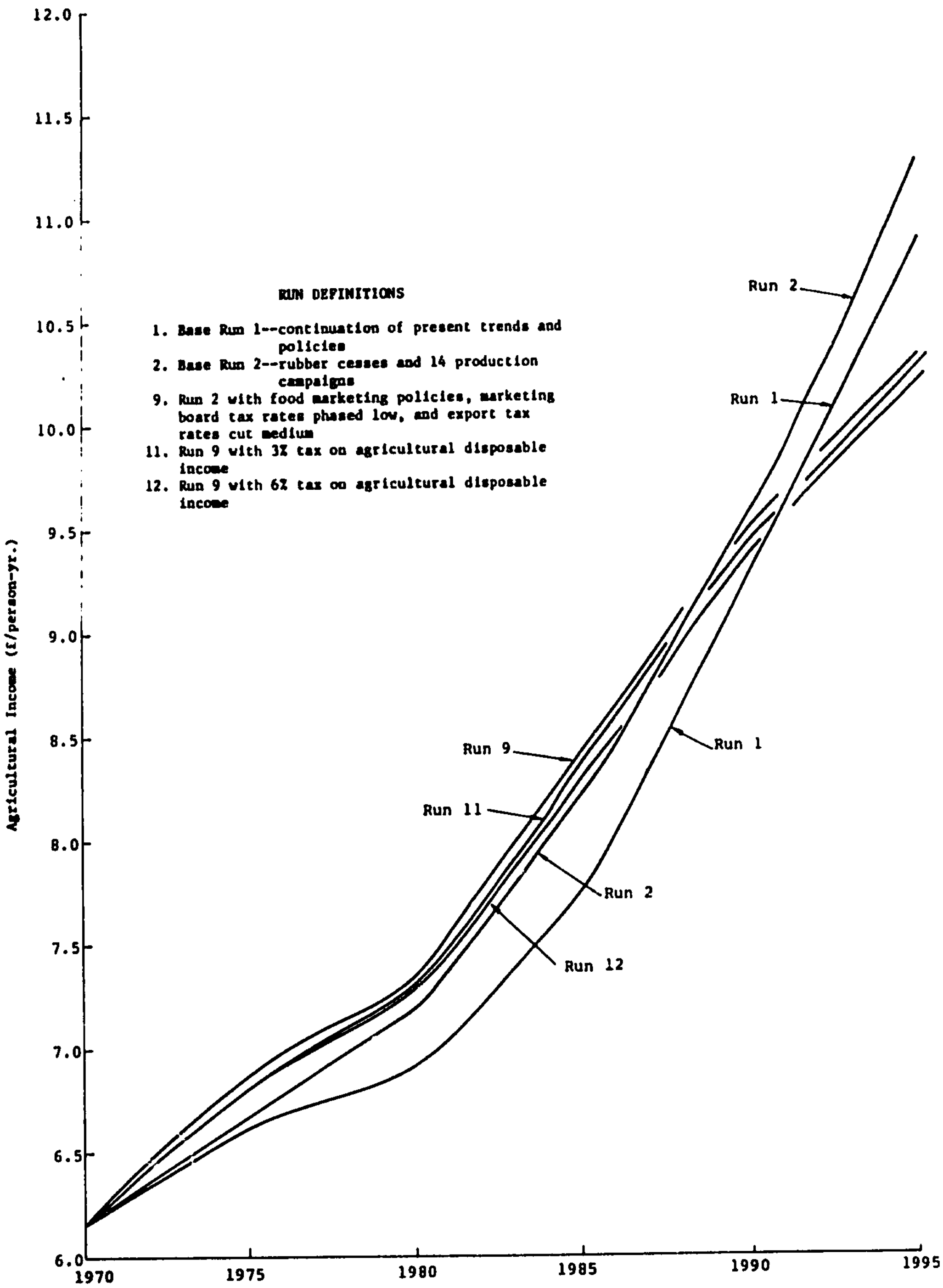

Fig. 36 Agricultural income per capita (North), 1970-1995, with two levels of income tax to compensate other tax reductions.

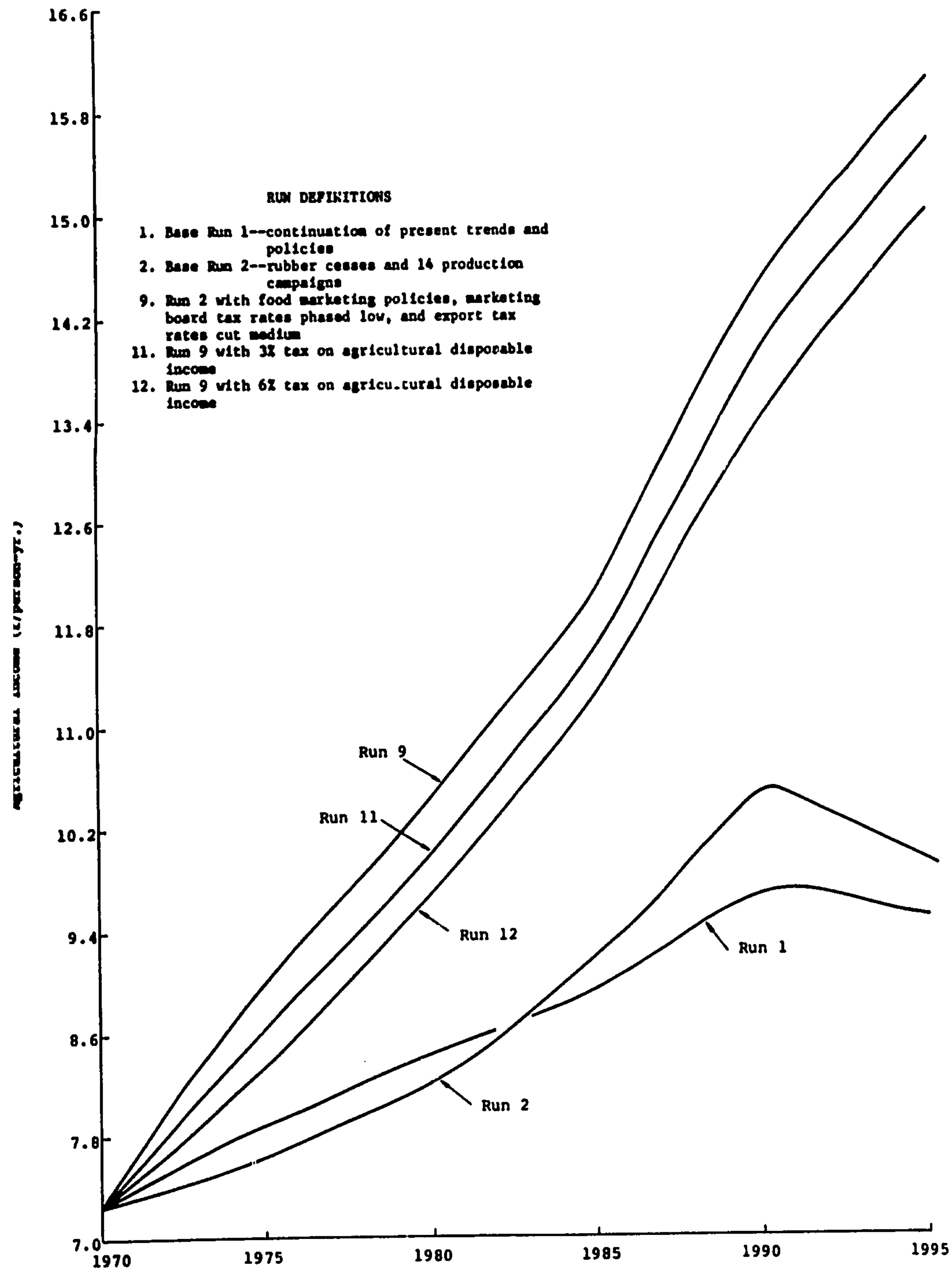

Fig. 37 Agricultural income per capita (South), 1970-1995, with two levels of income tax to compensate other tax reductions.

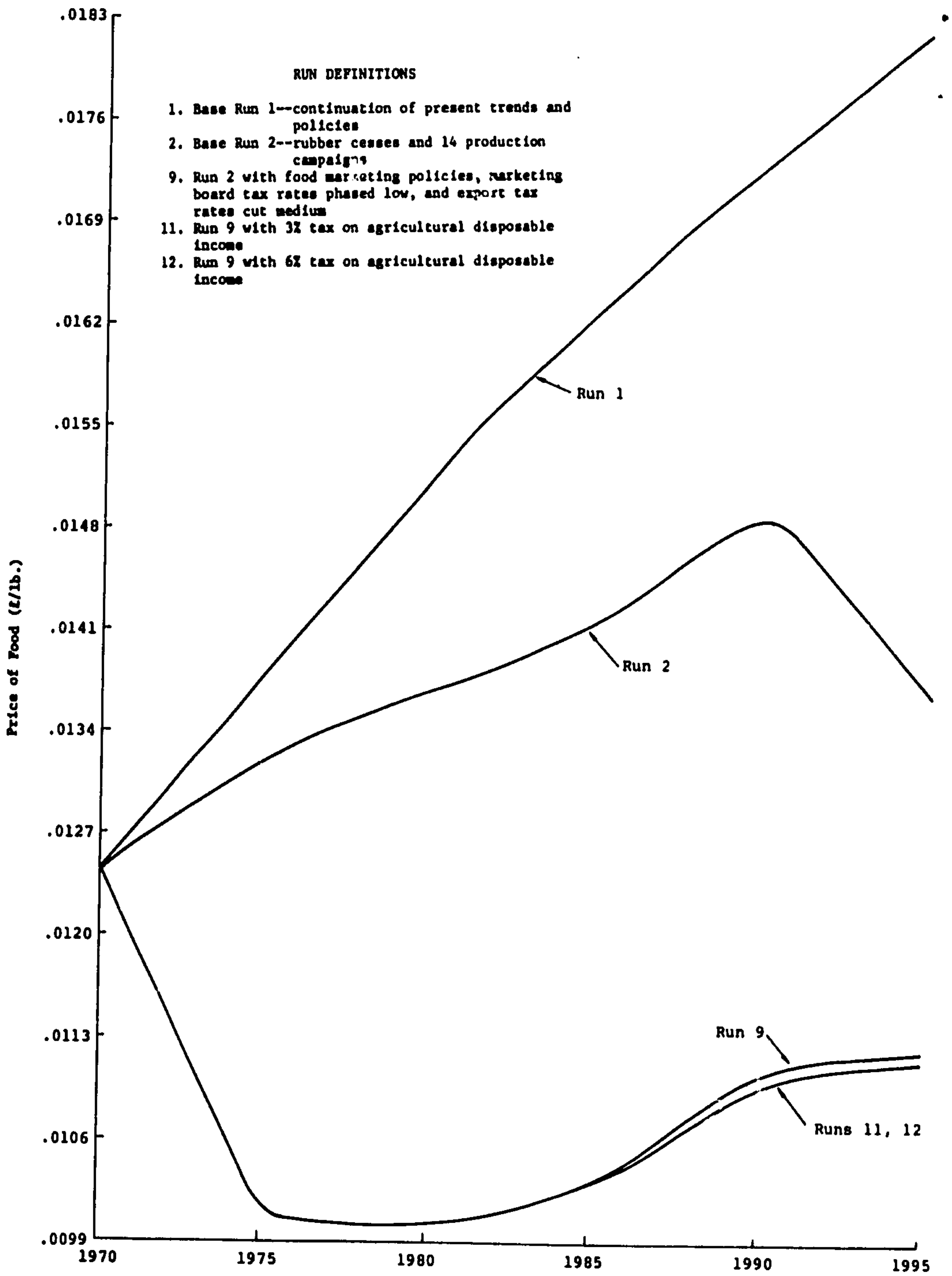

Fig. 38 Market price of food (South), 1970-1995, with two levels of income tax to compensate other tax reductions.

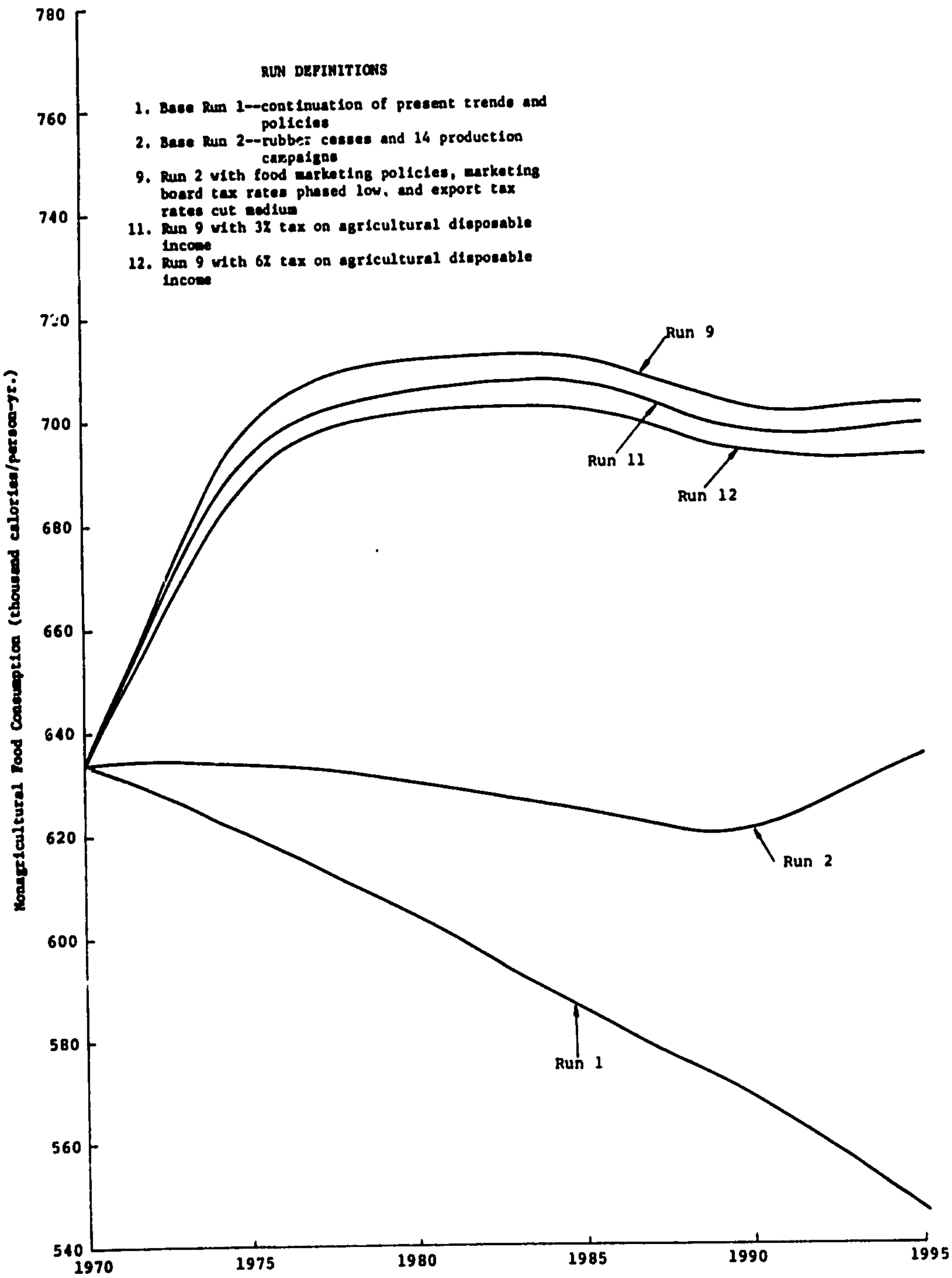

Fig. 39 Nonagricultural food consumption per capita (South), 1970-1995, with two levels of income tax to compensate other tax reductions.

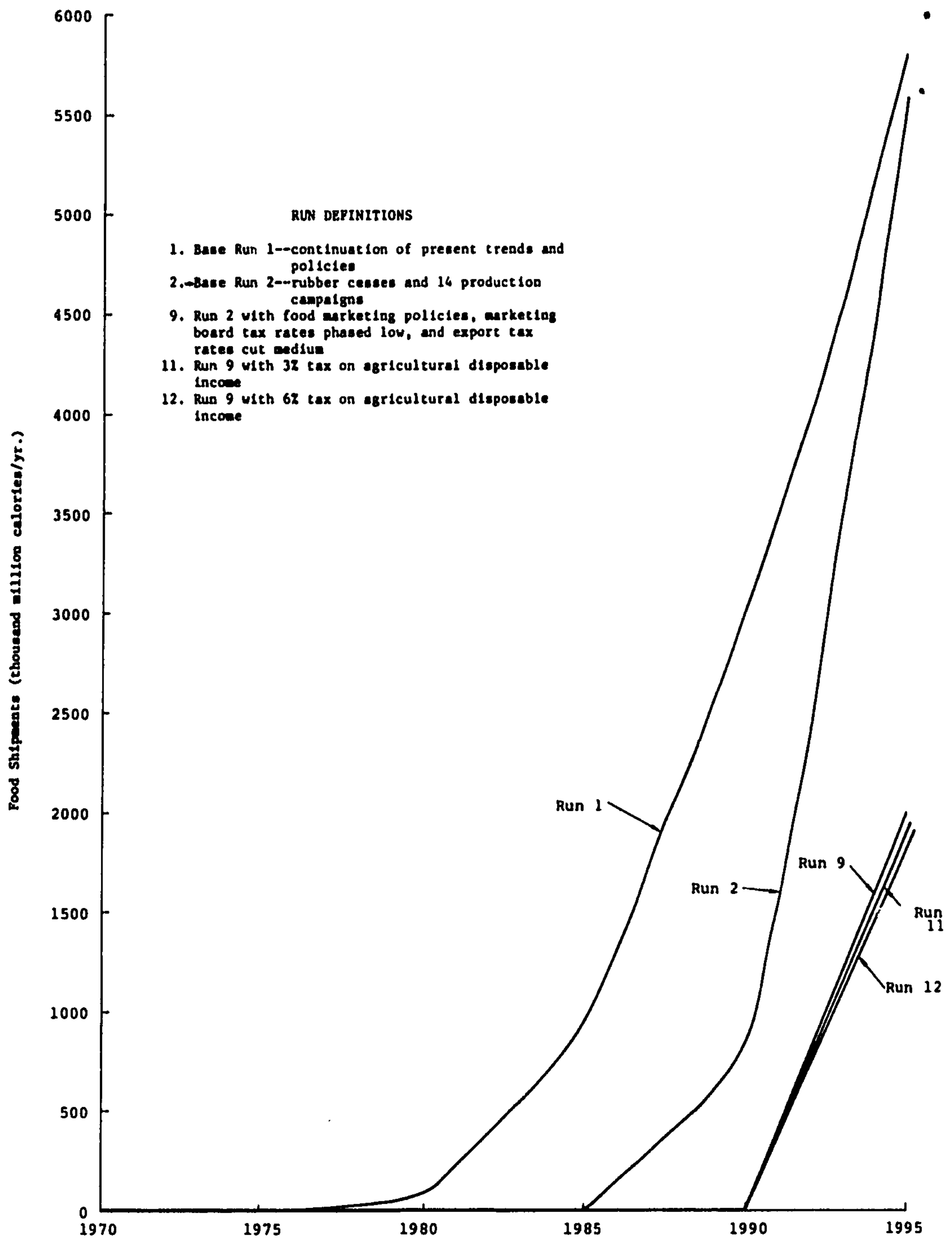

Fig. 40 Interregional food shipments (North to South), 1970-1995, with two levels of income tax to compensate other tax reductions.

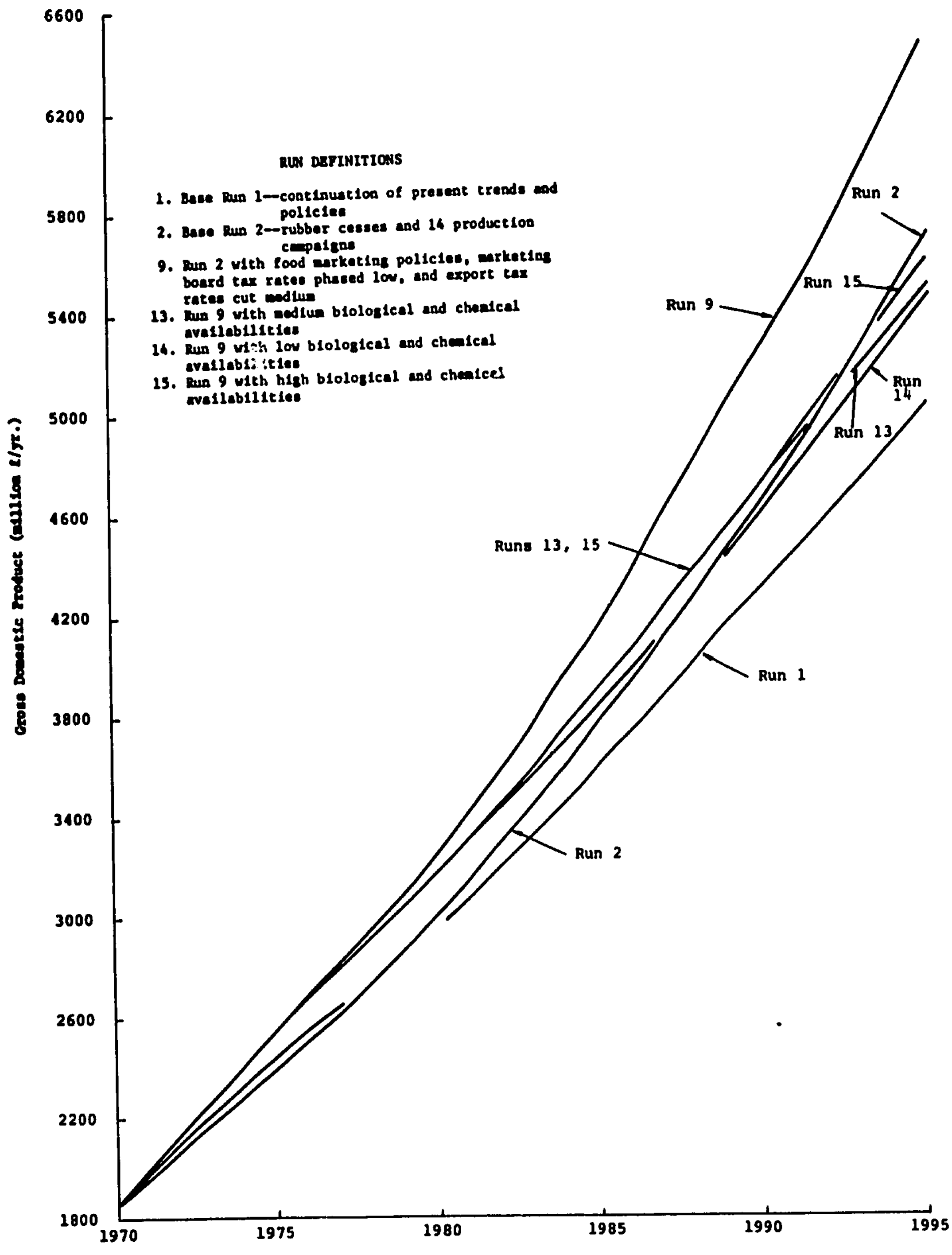

Fig. 41 Gross domestic product (assuming tax revenues are not put to productive use), 1970-1995, with three levels of combined input constraints with tax reductions.

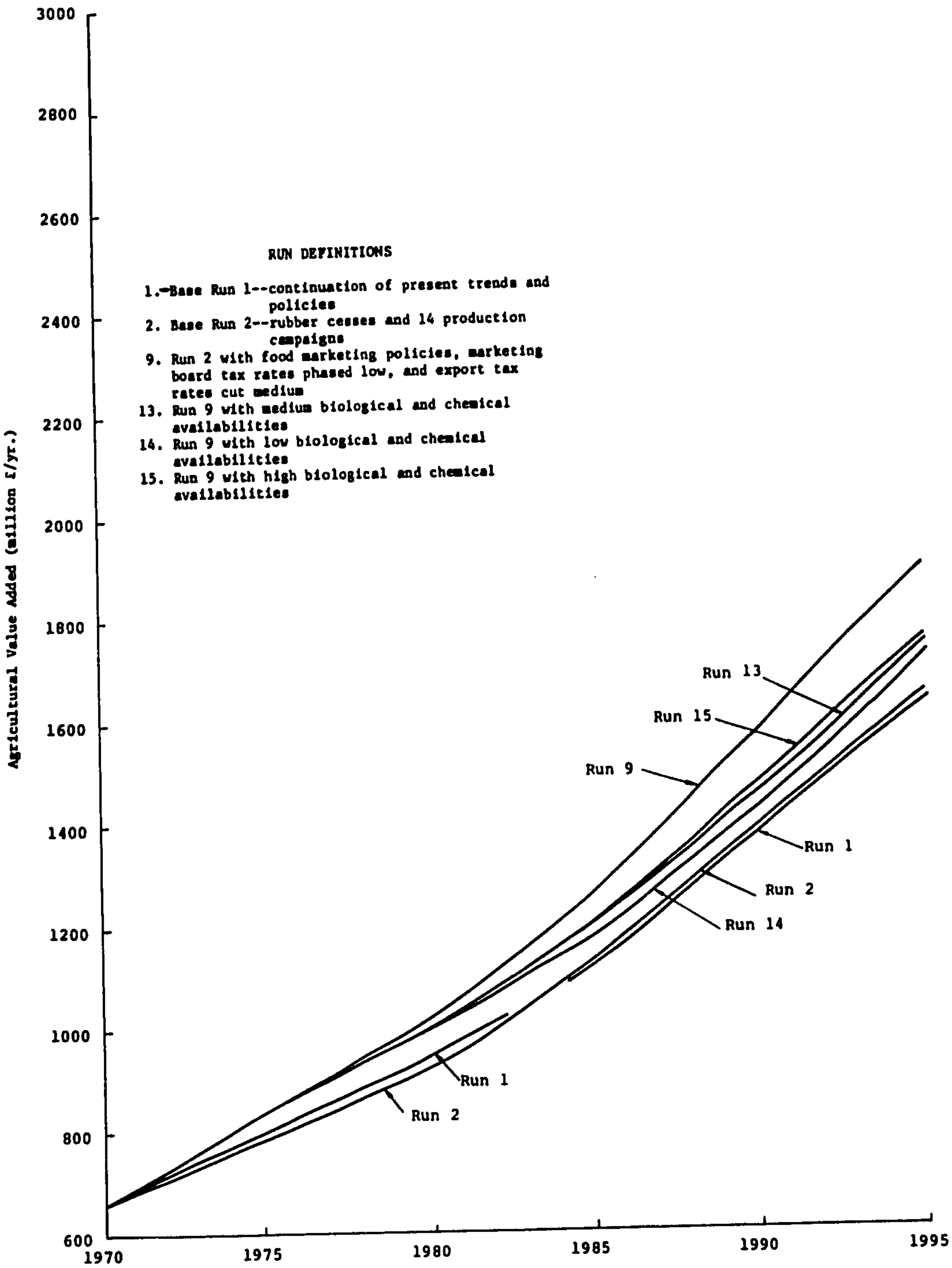

Fig. 42 Value added in agriculture, 1970-1995, with three levels of combined input constraints with tax reductions.

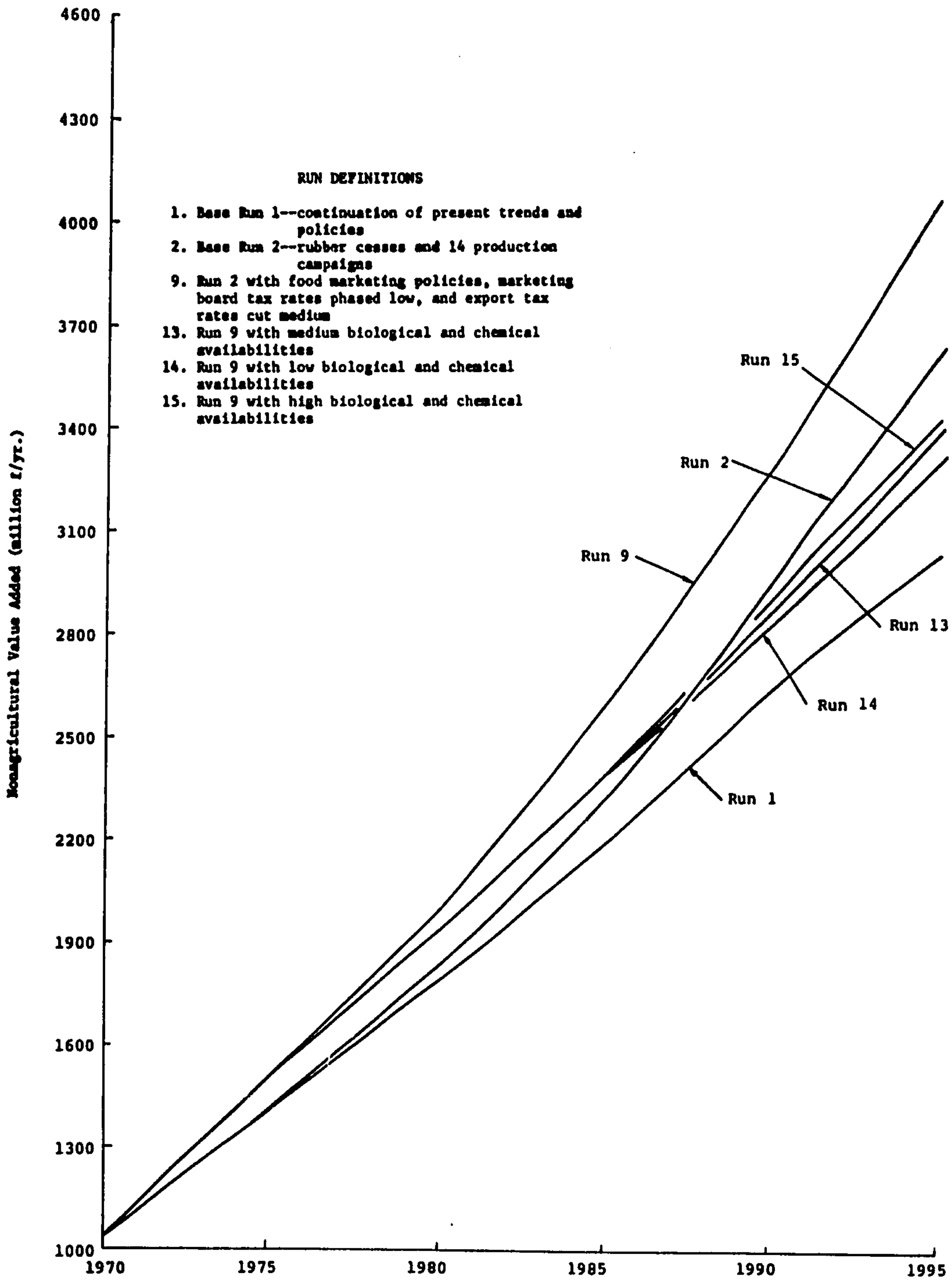

Fig. 43 Value added in nonagriculture, 1970-1995, with three levels of combined input constraints with tax reductions.

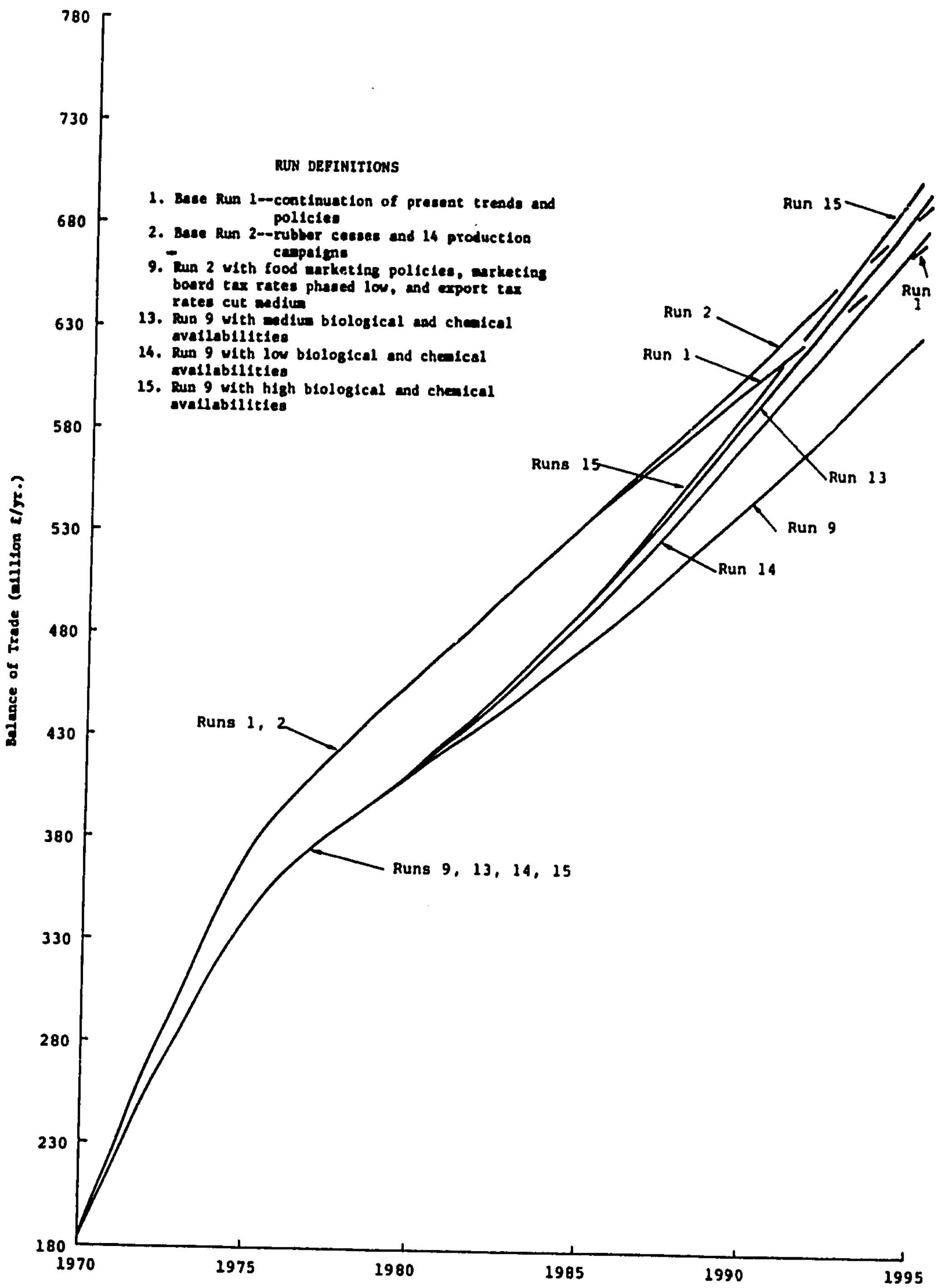

Fig. 44 Balance of trade, 1970-1995, with three levels of combined input constraints with tax reductions.

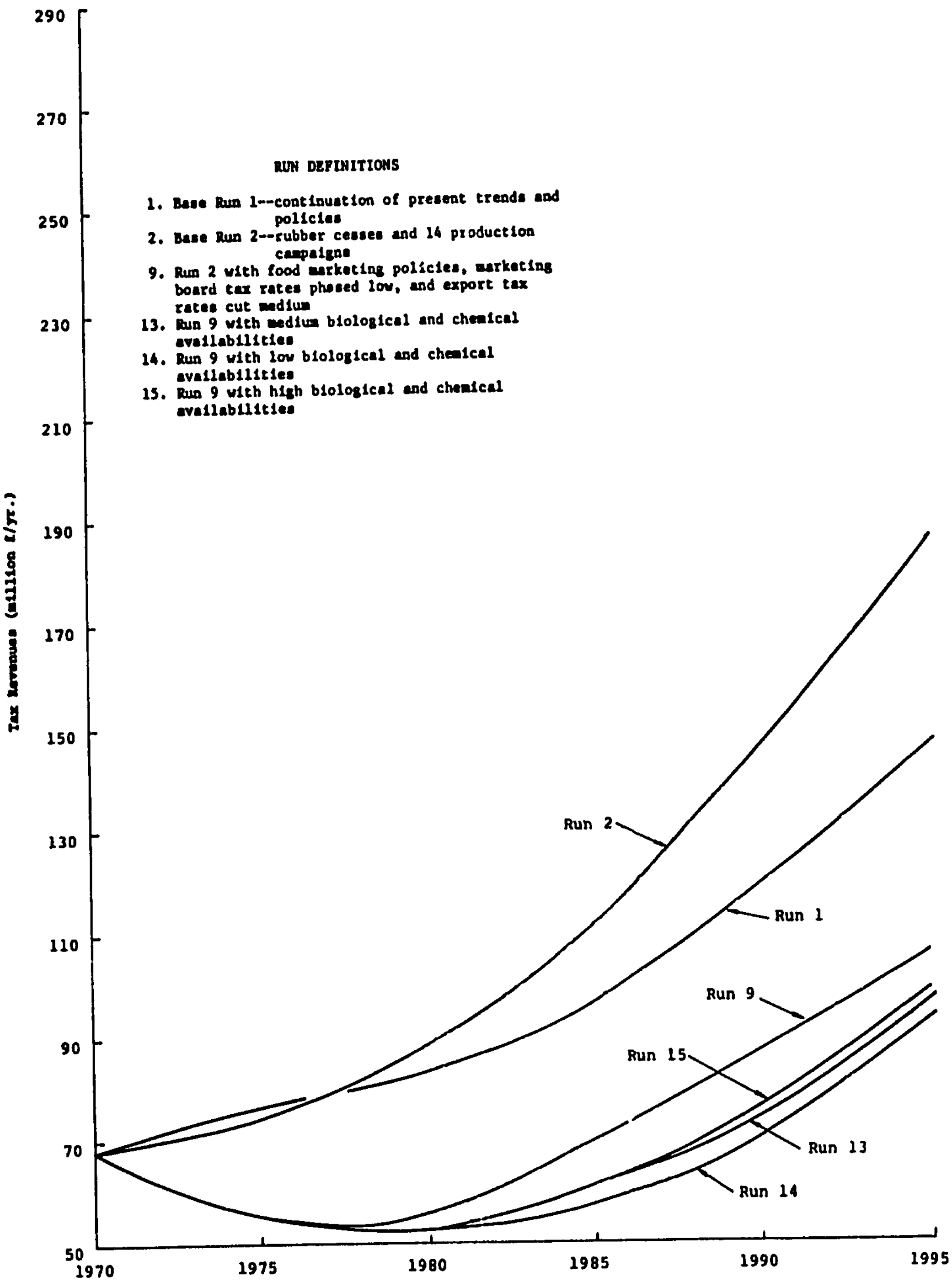

Fig. 45 Agricultural sector tax revenues, 1970-1995, with three levels of combined input constraints with tax reductions.

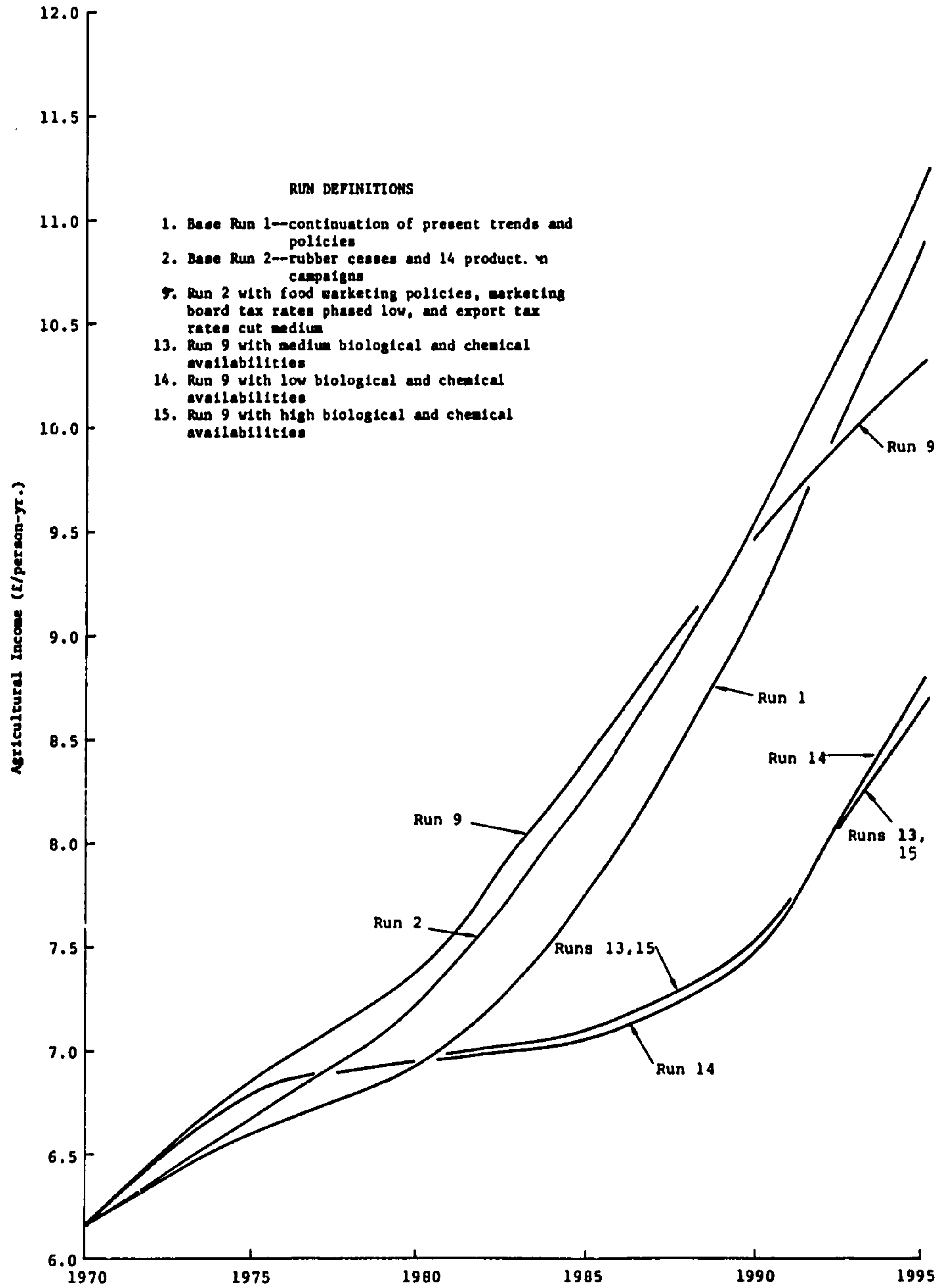

Fig. 46 Agricultural income per capita (North), 1970-1995, with three levels of combined input constraints with tax reductions.

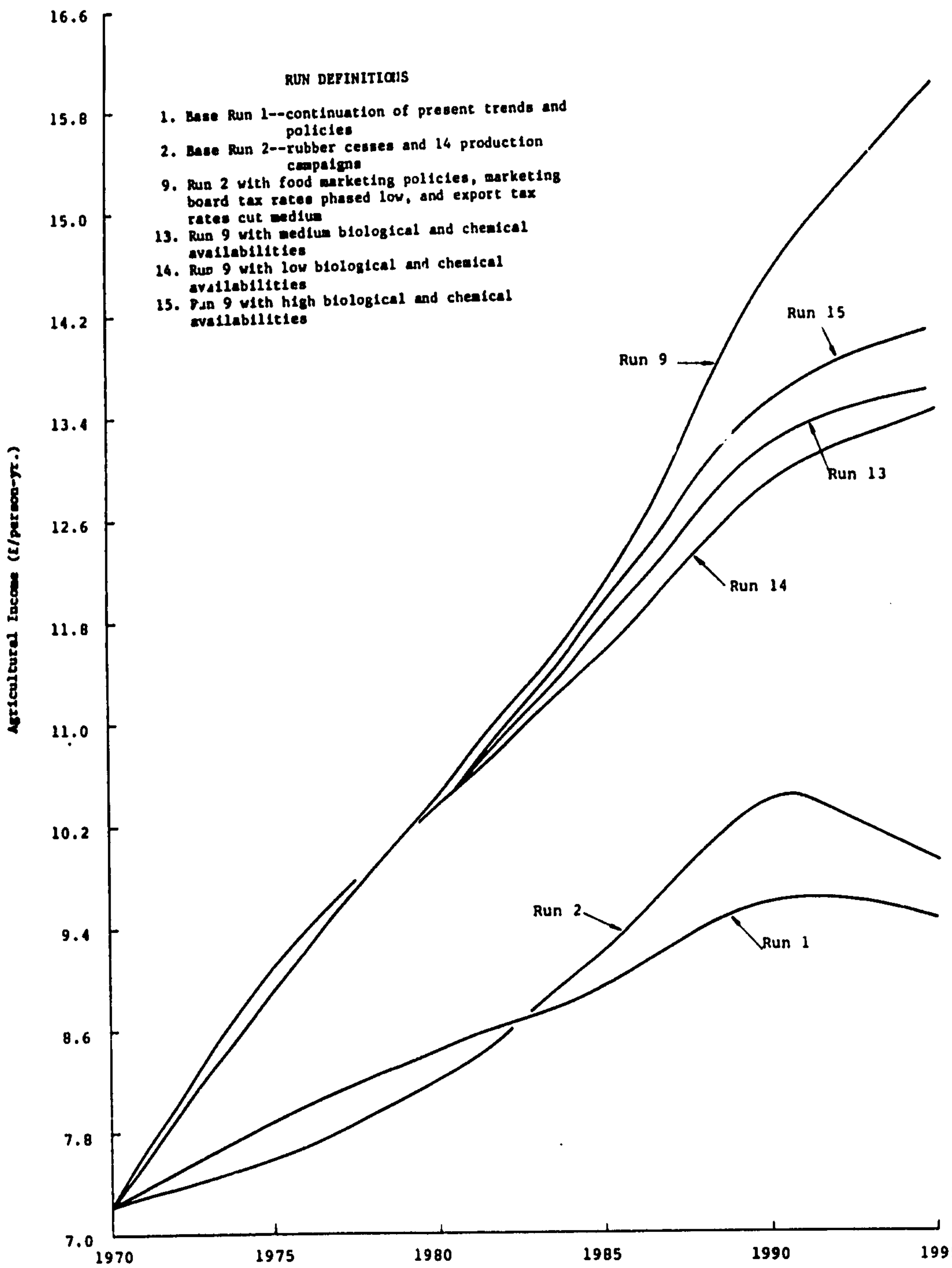

Fig. 47 Agricultural income per capita (South), 1970-1995, with three levels of combined input constraints with tax reductions.

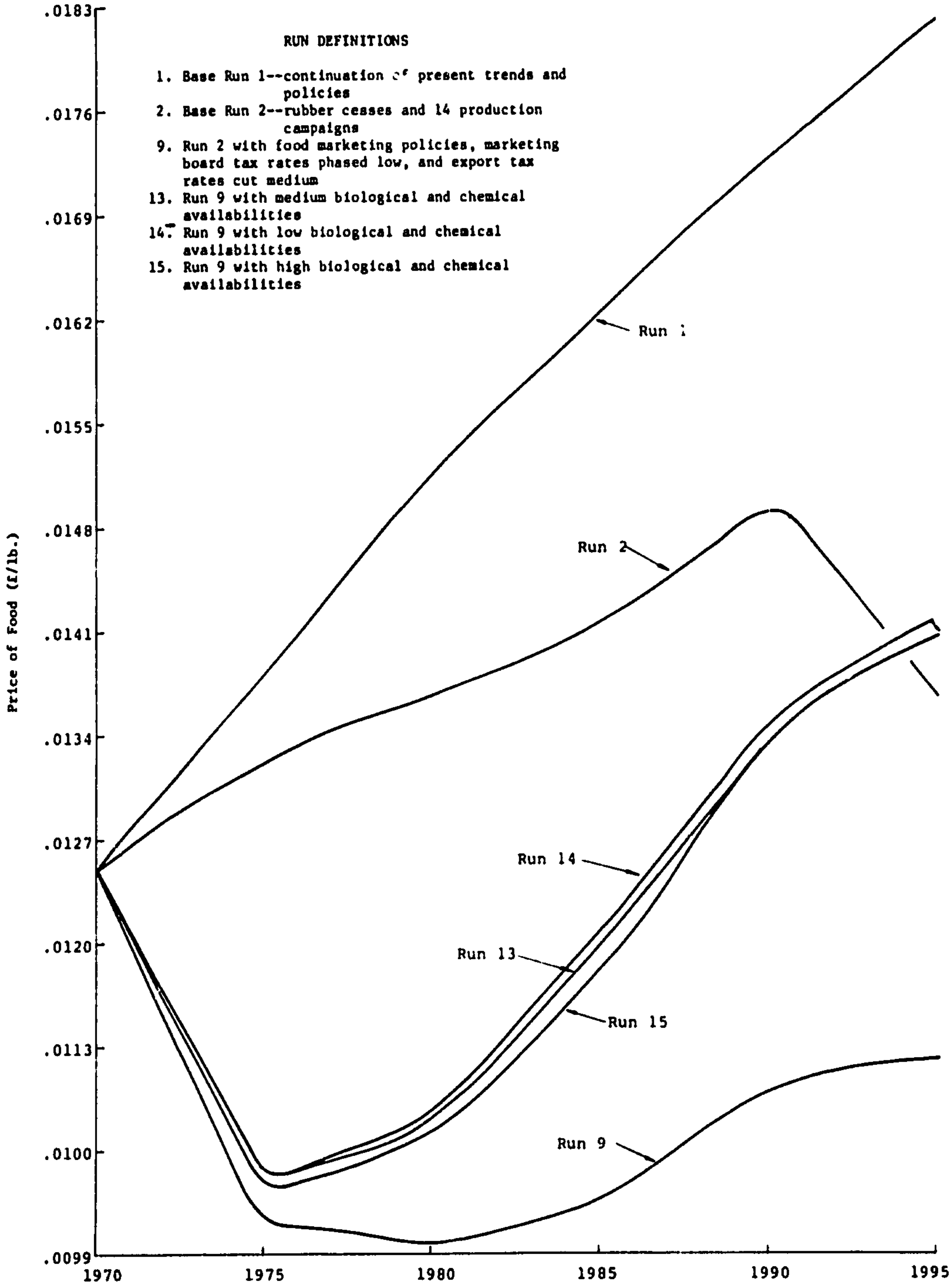

Fig. 48 Market price of food (South), 1970-1995, with three levels of combined input constraints with tax reductions.

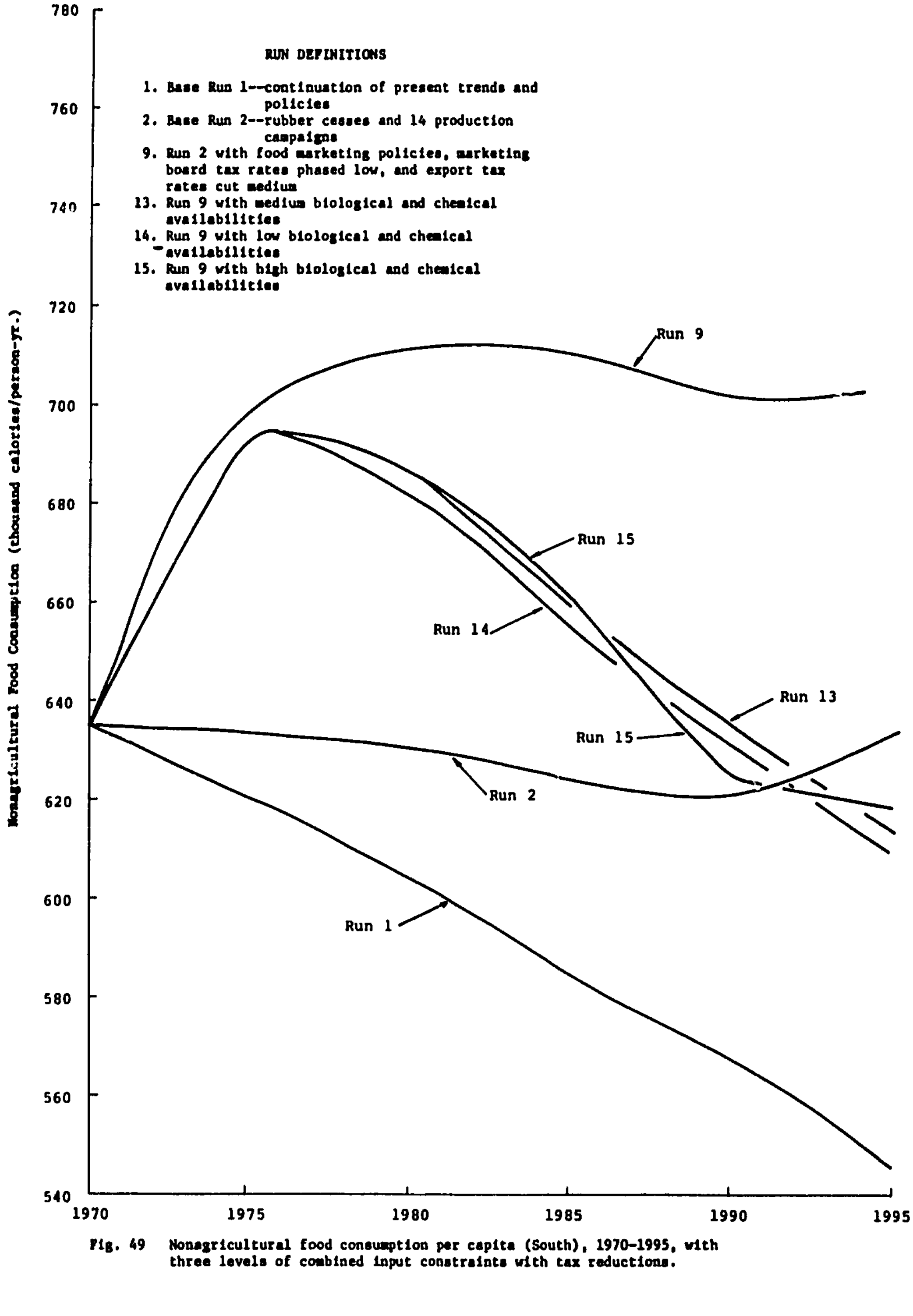

Fig. 49 Nonagricultural food consumption per capita (South), 1970-1995, with three levels of combined input constraints with tax reductions.

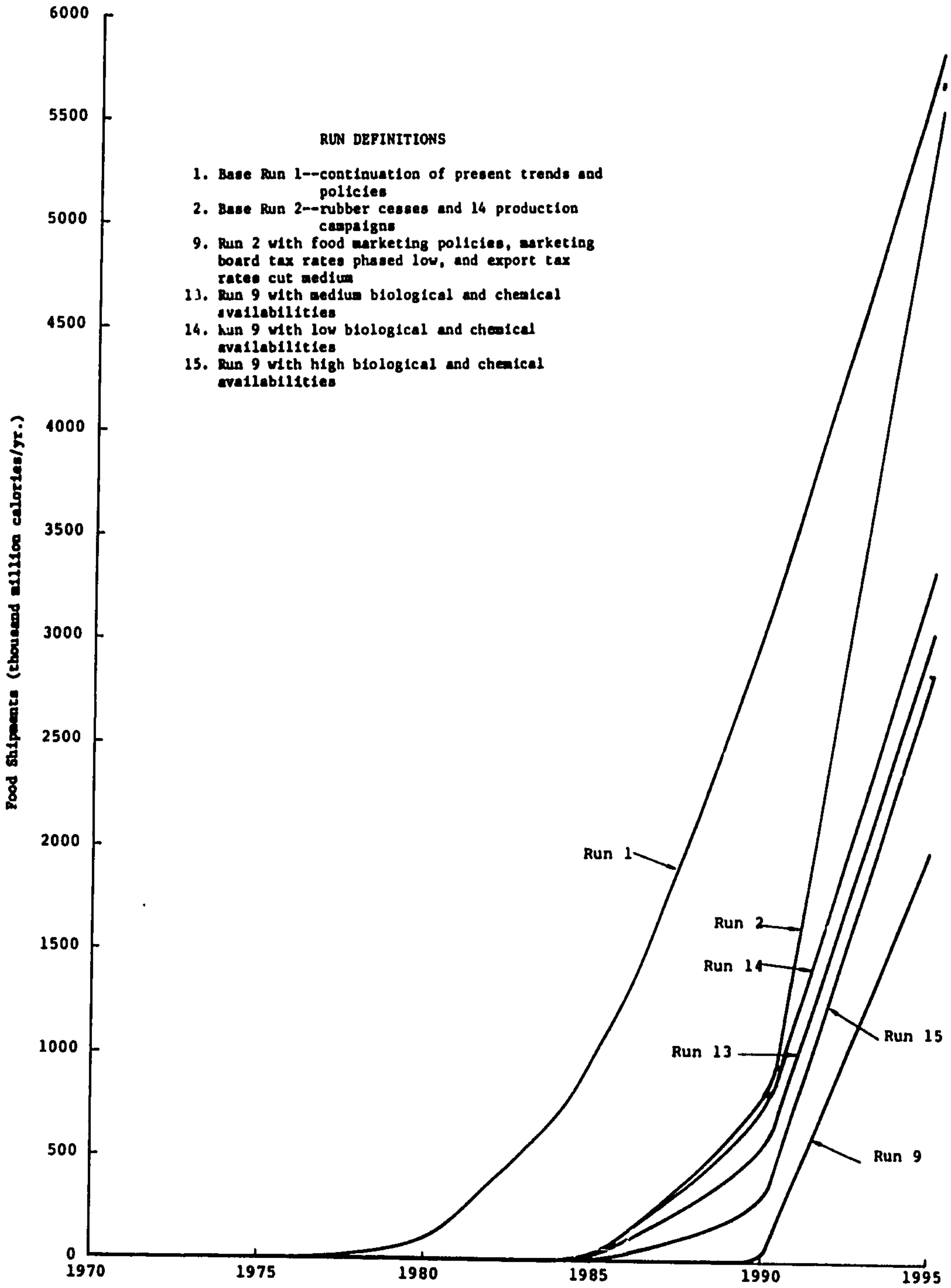

Fig. 50 Interregional food shipments (North to South), 1970-1995, with three levels of combined input constraints with tax reductions.

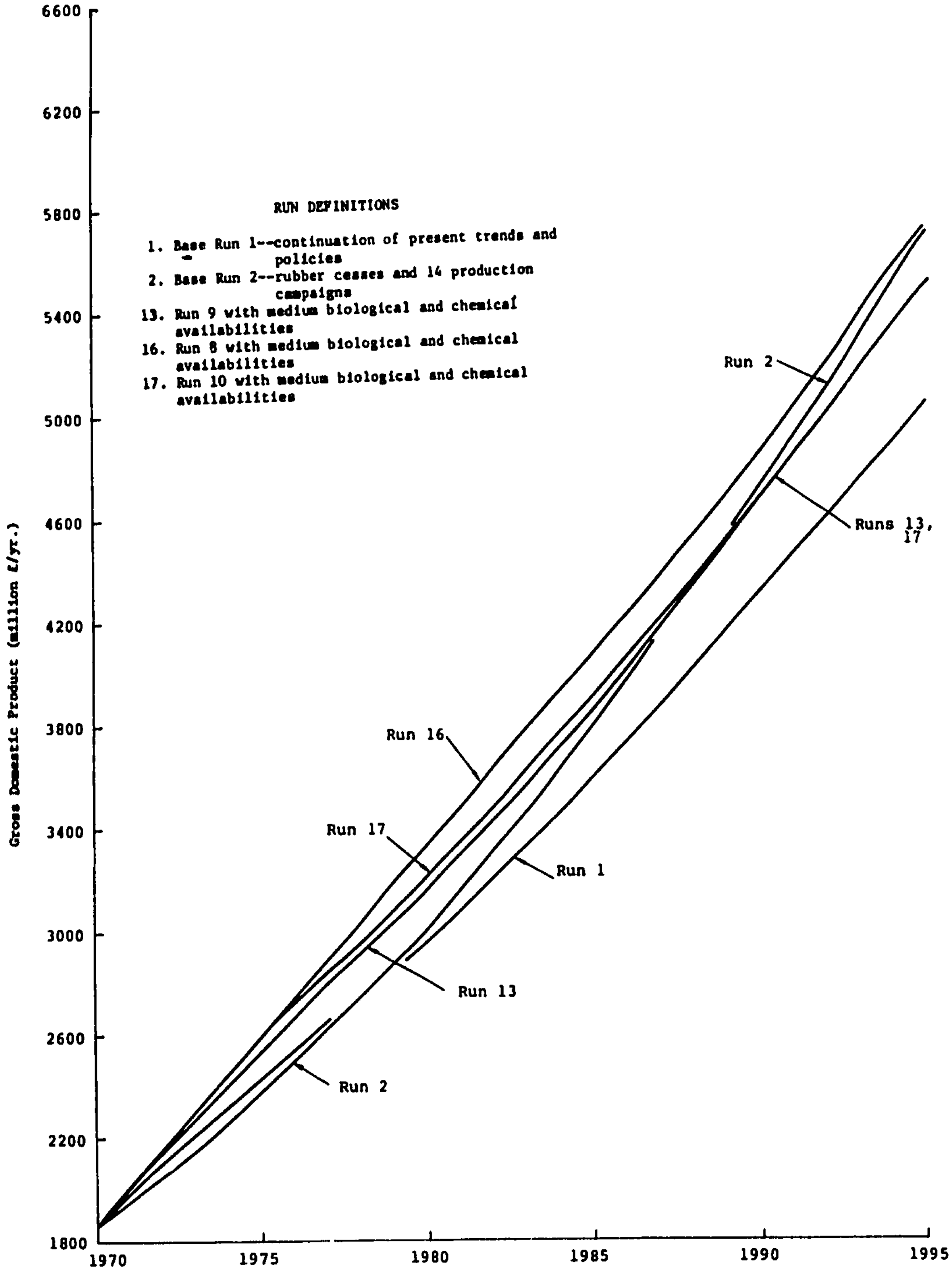

Fig. 51 Gross domestic product (assuming tax revenues are not put to productive use), 1970-1995, with three levels of tax reductions with combined input constraints.

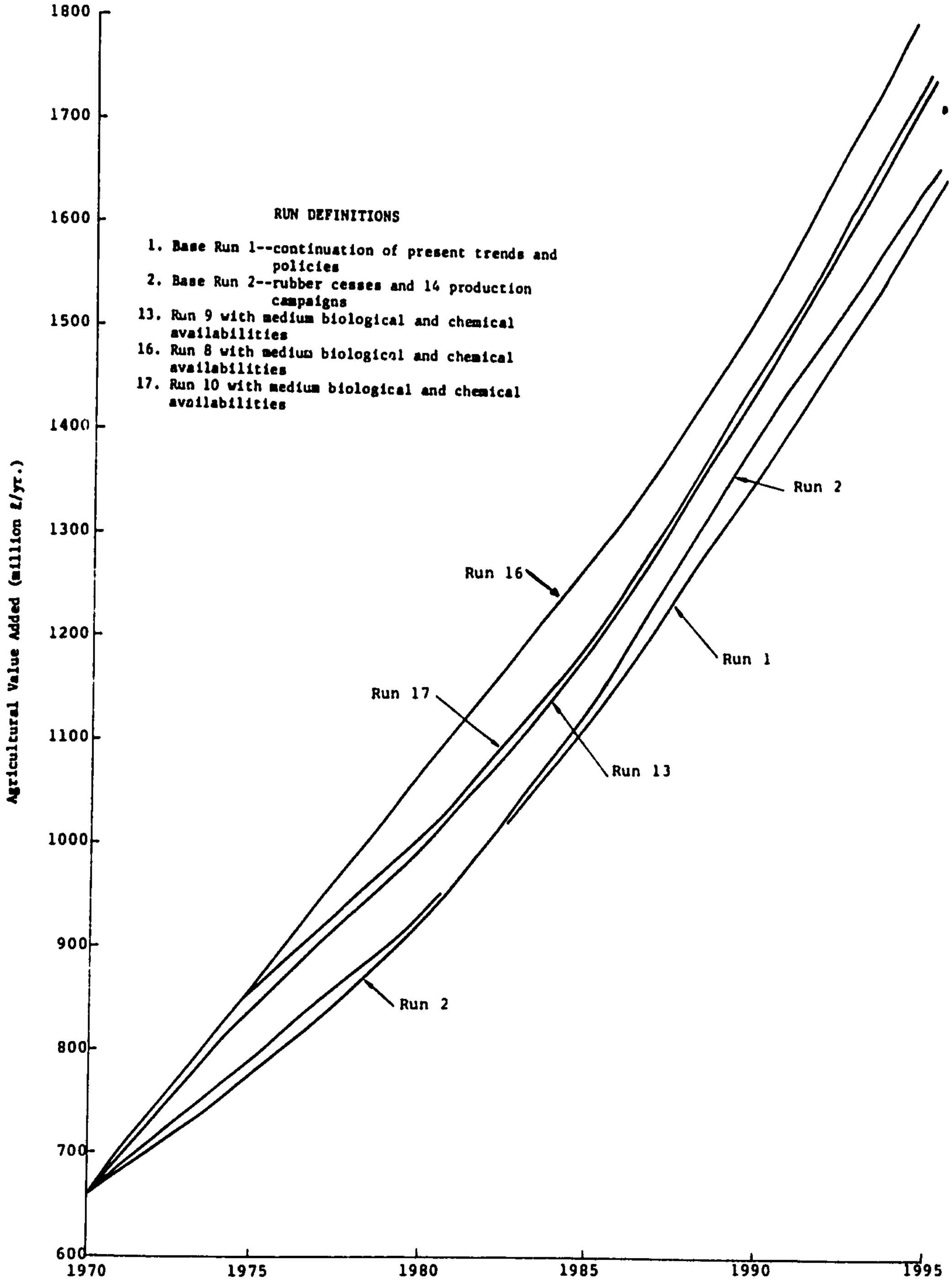

Fig. 52 Value added in agriculture, 1970-1995, with three levels of tax reductions with combined input constraints.

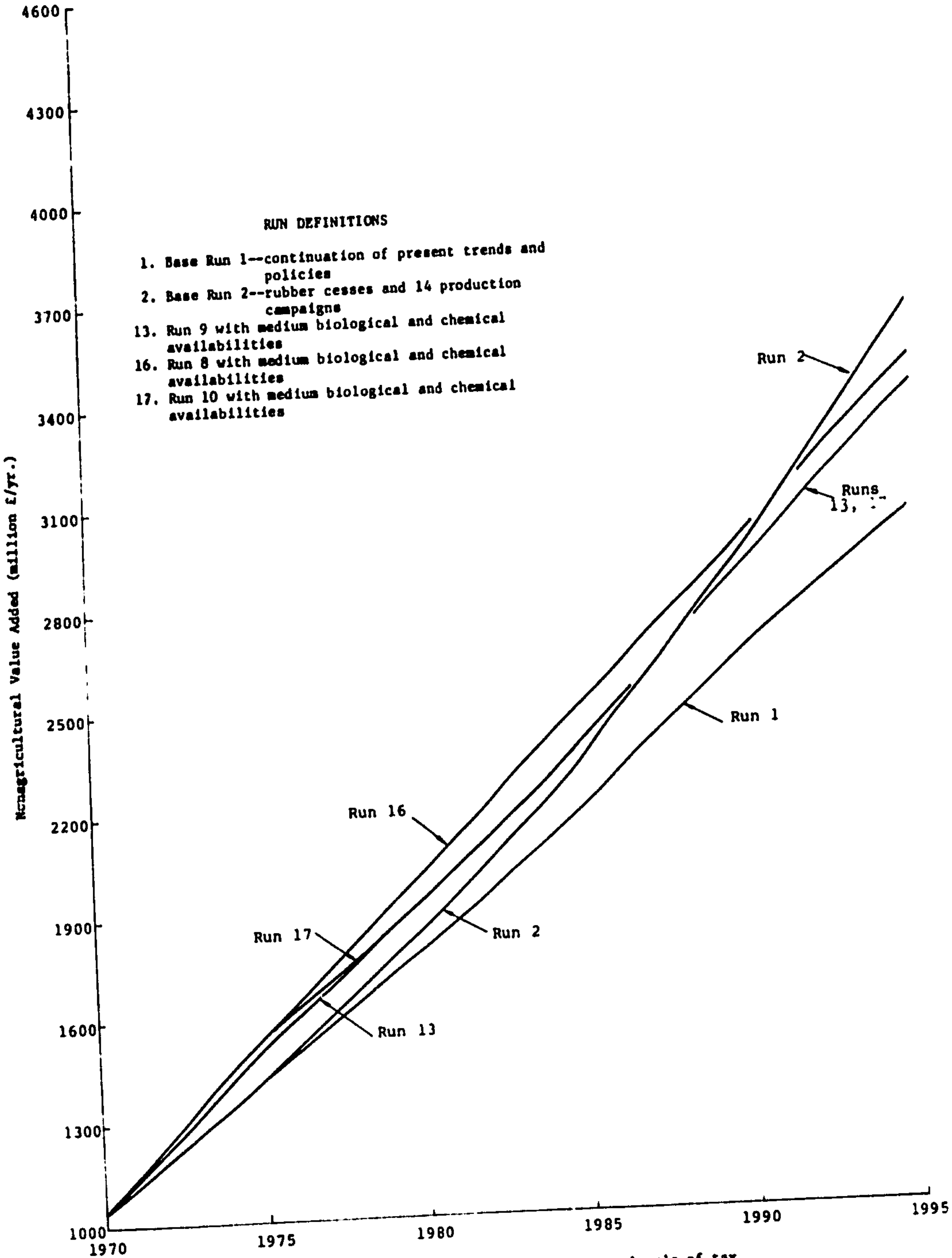

Fig. 53 Value added in nonagriculture, 1970-1995, with three levels of tax reductions with combined input constraints.

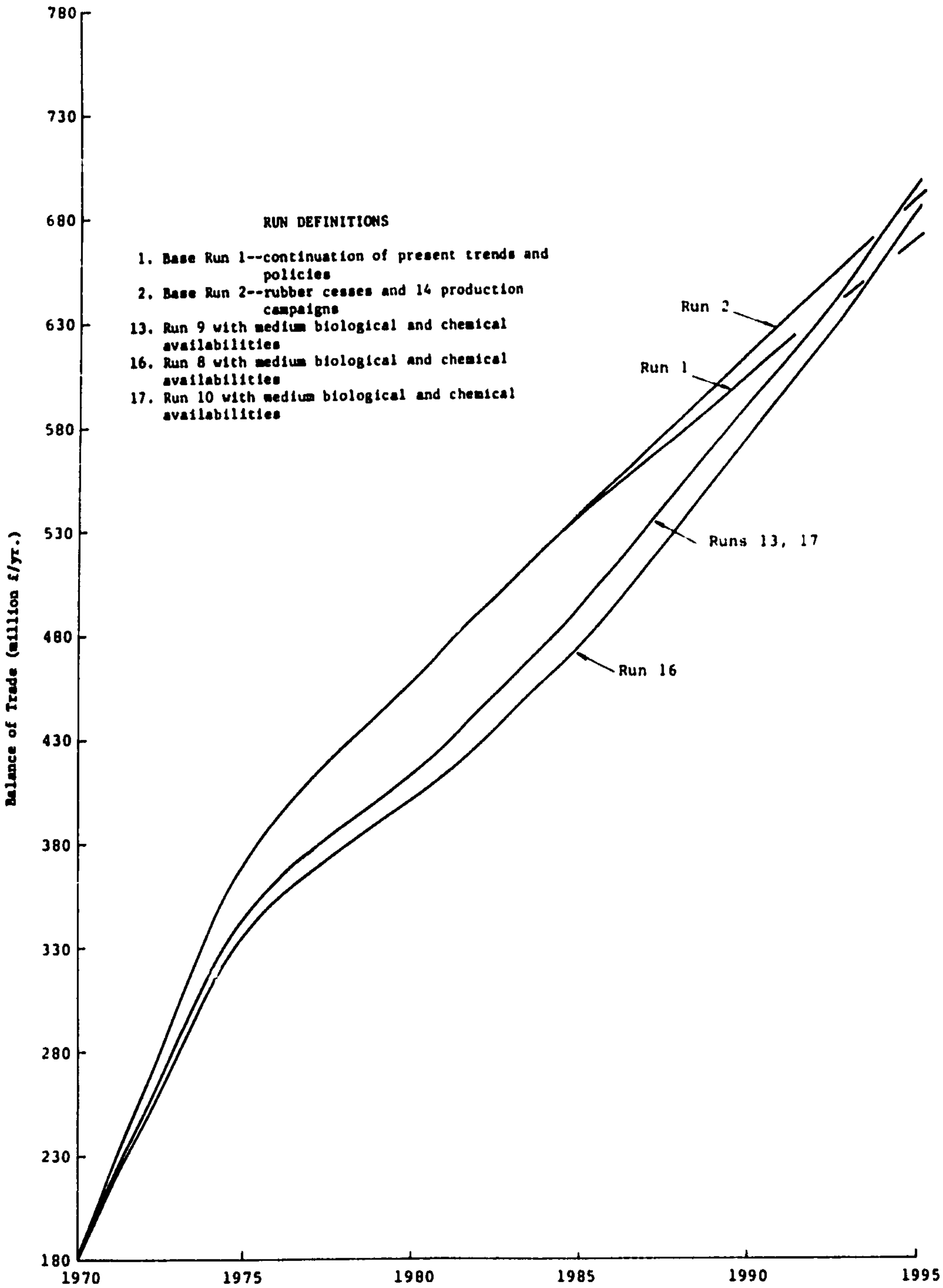

Fig. 54 Balance of trade, 1970-1995, with three levels of tax reductions with combined input constraints.

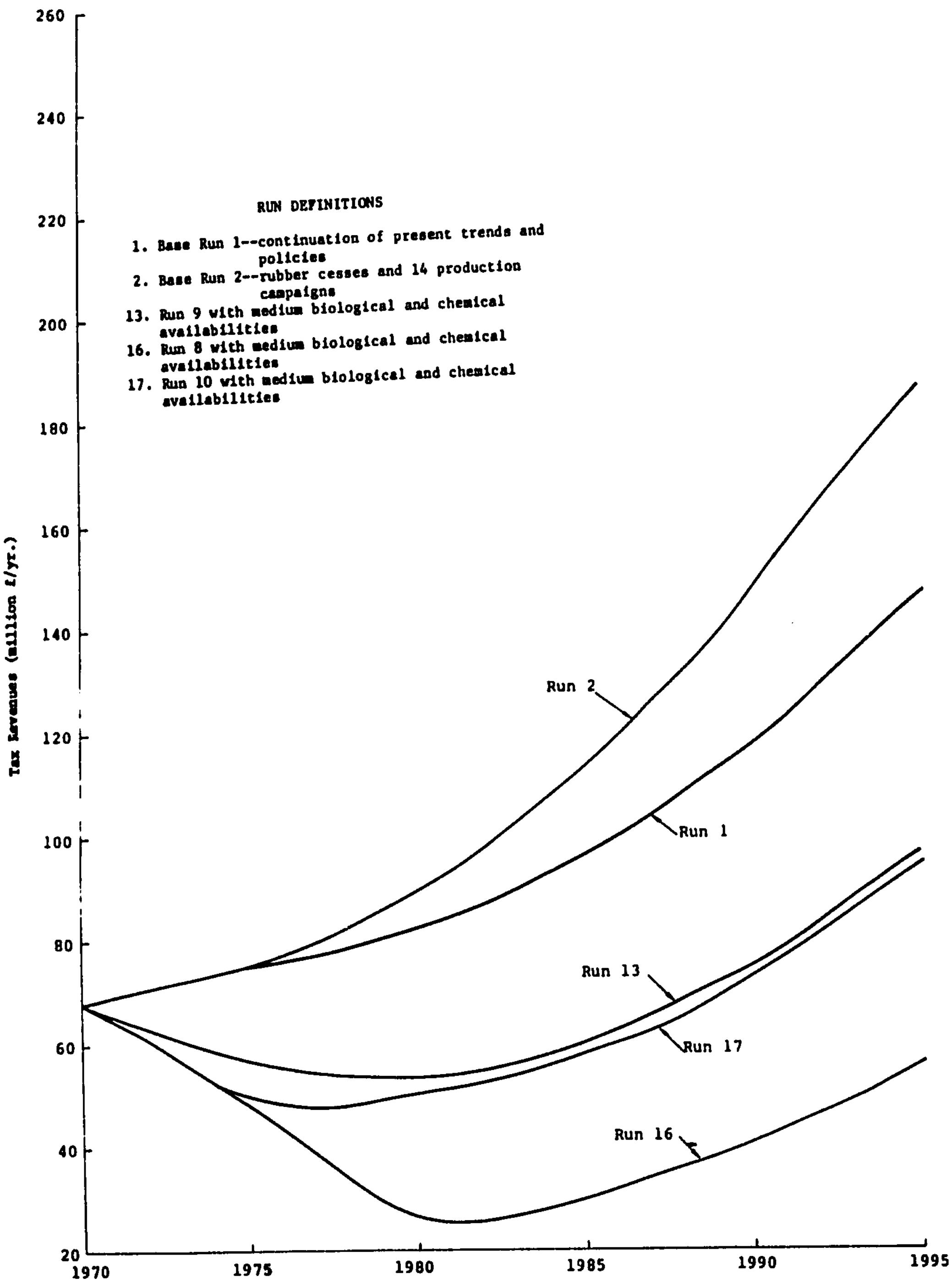

Fig. 55 Agricultural sector tax revenues, 1970-1995, with three levels of tax reductions with combined input constraints.

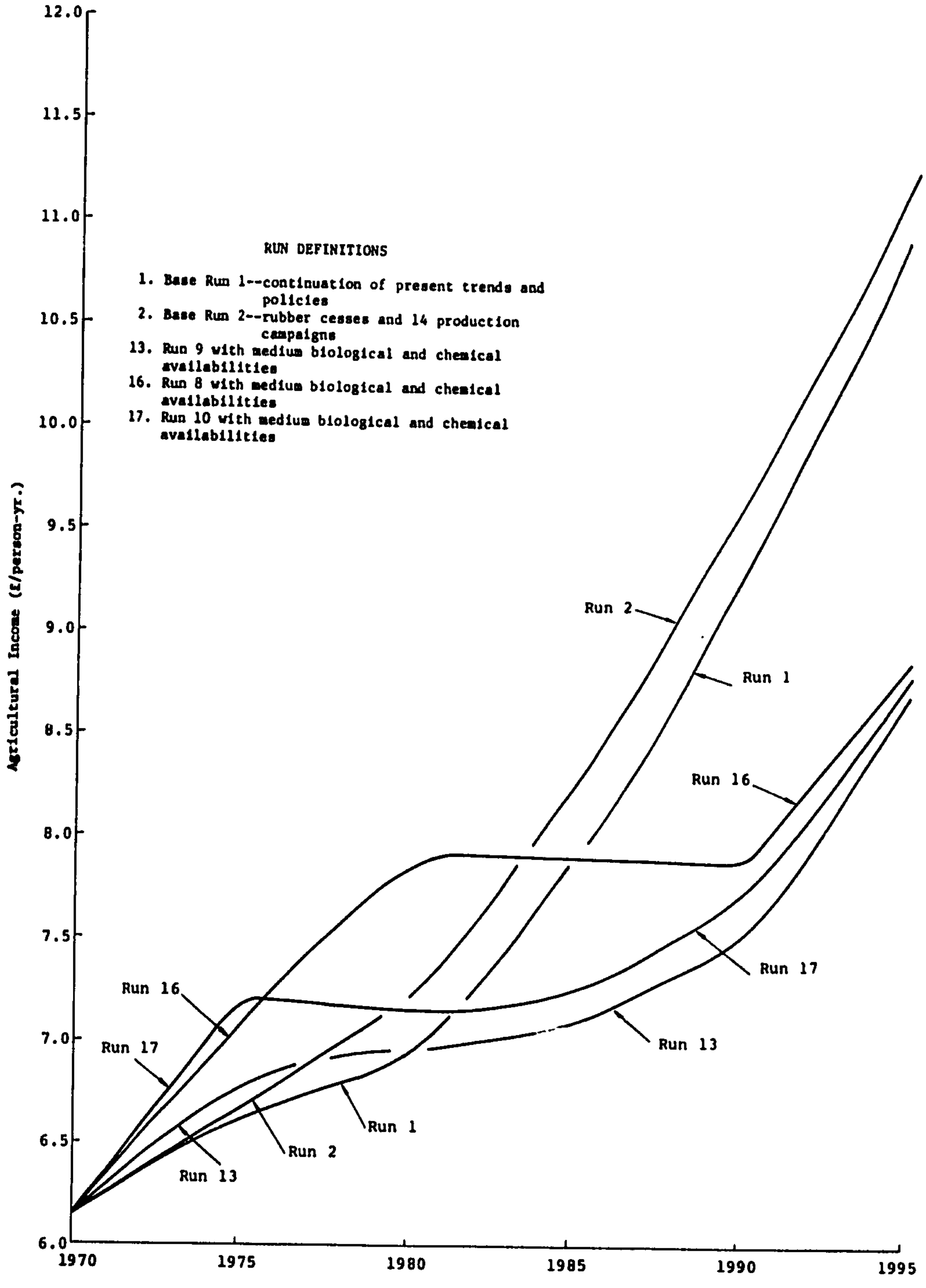

Fig. 56 Agricultural income per capita (North), 1970-1995, with three levels of tax reductions with combined input constraints.

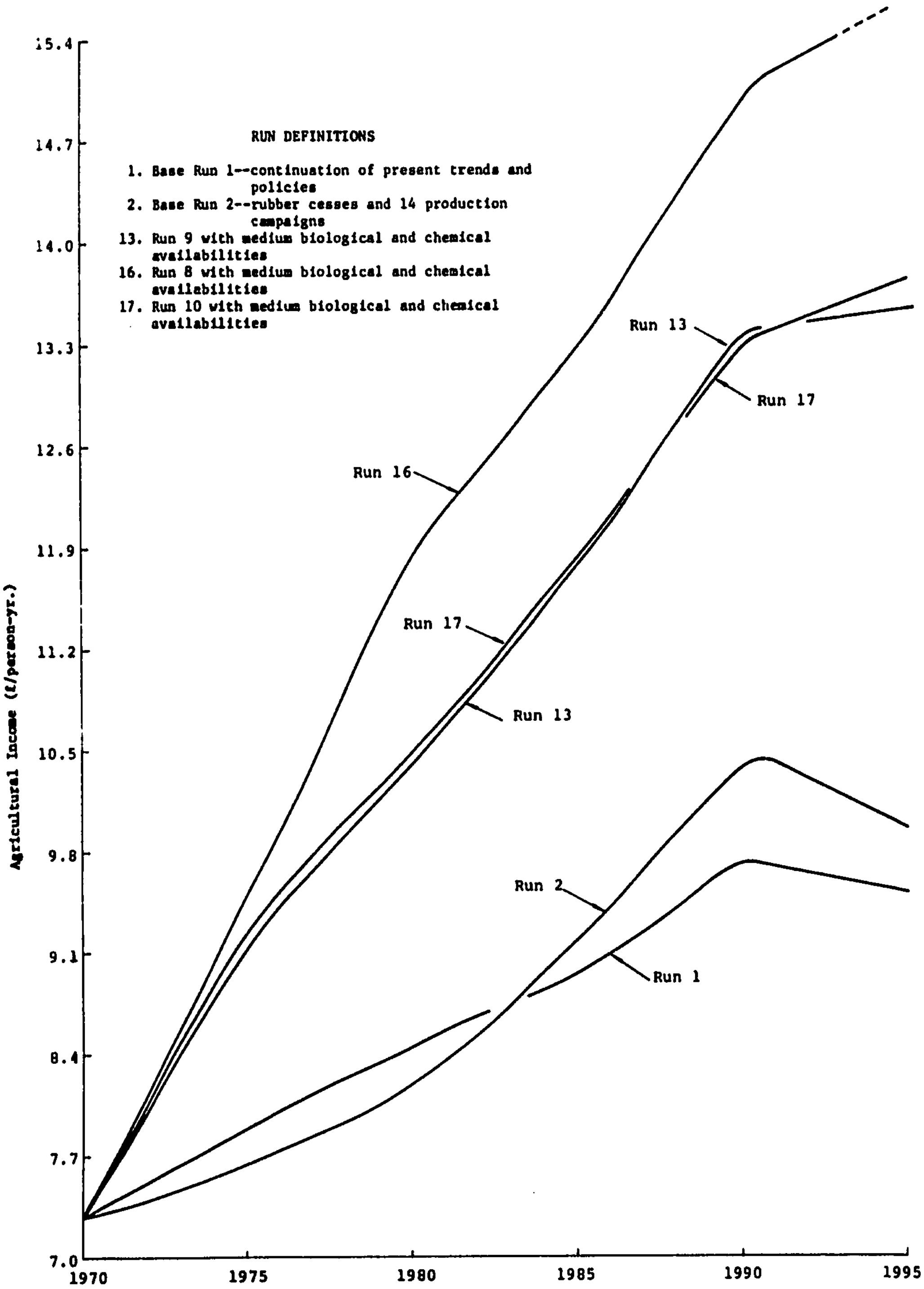

Fig. 57 Agricultural income per capita (South), 1970-1995, with three levels of tax reductions with combined input constraints.

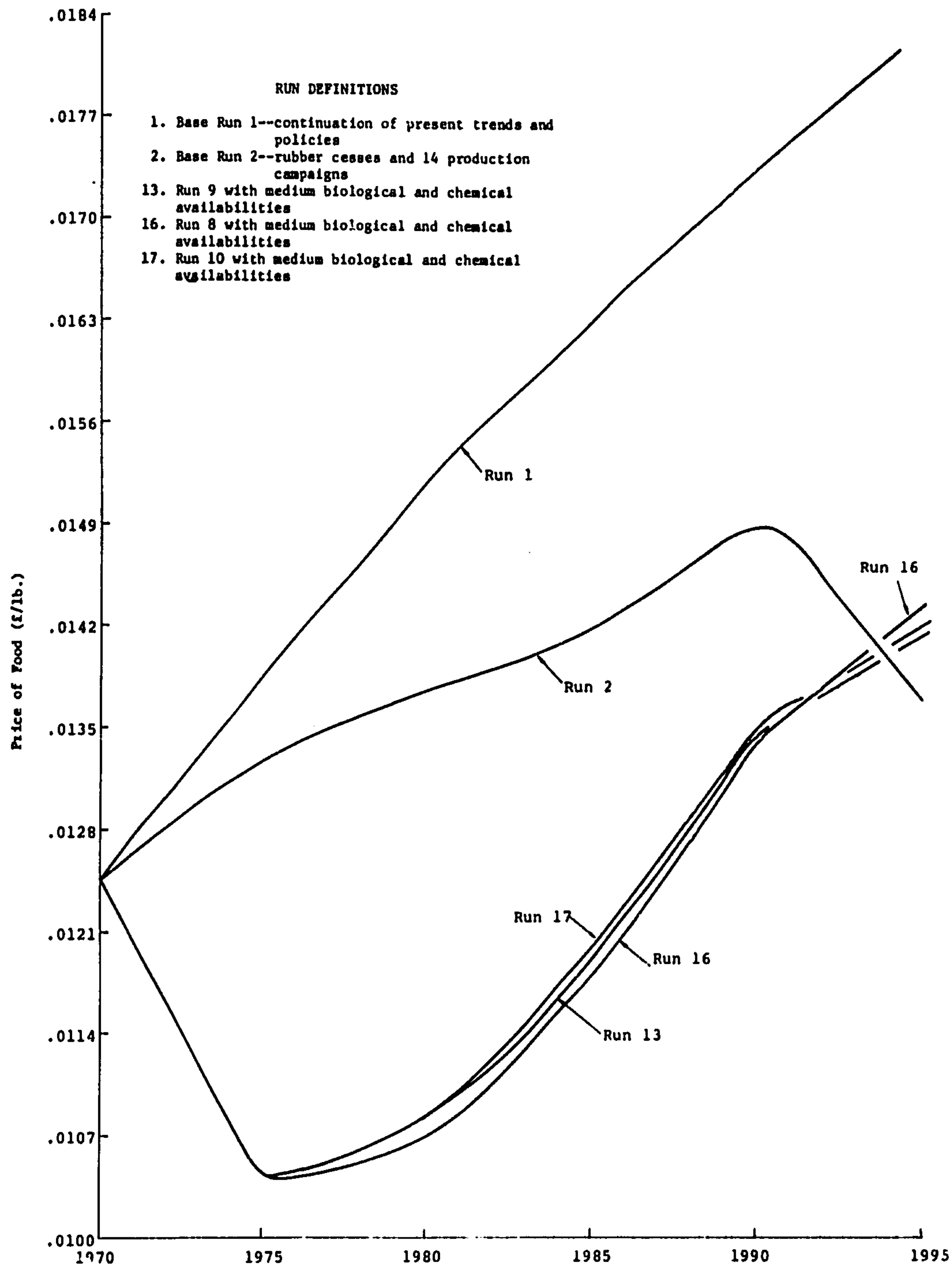

Fig. 58 Market price of food (South), 1970-1995, with three levels of tax reductions with combined input constraints.

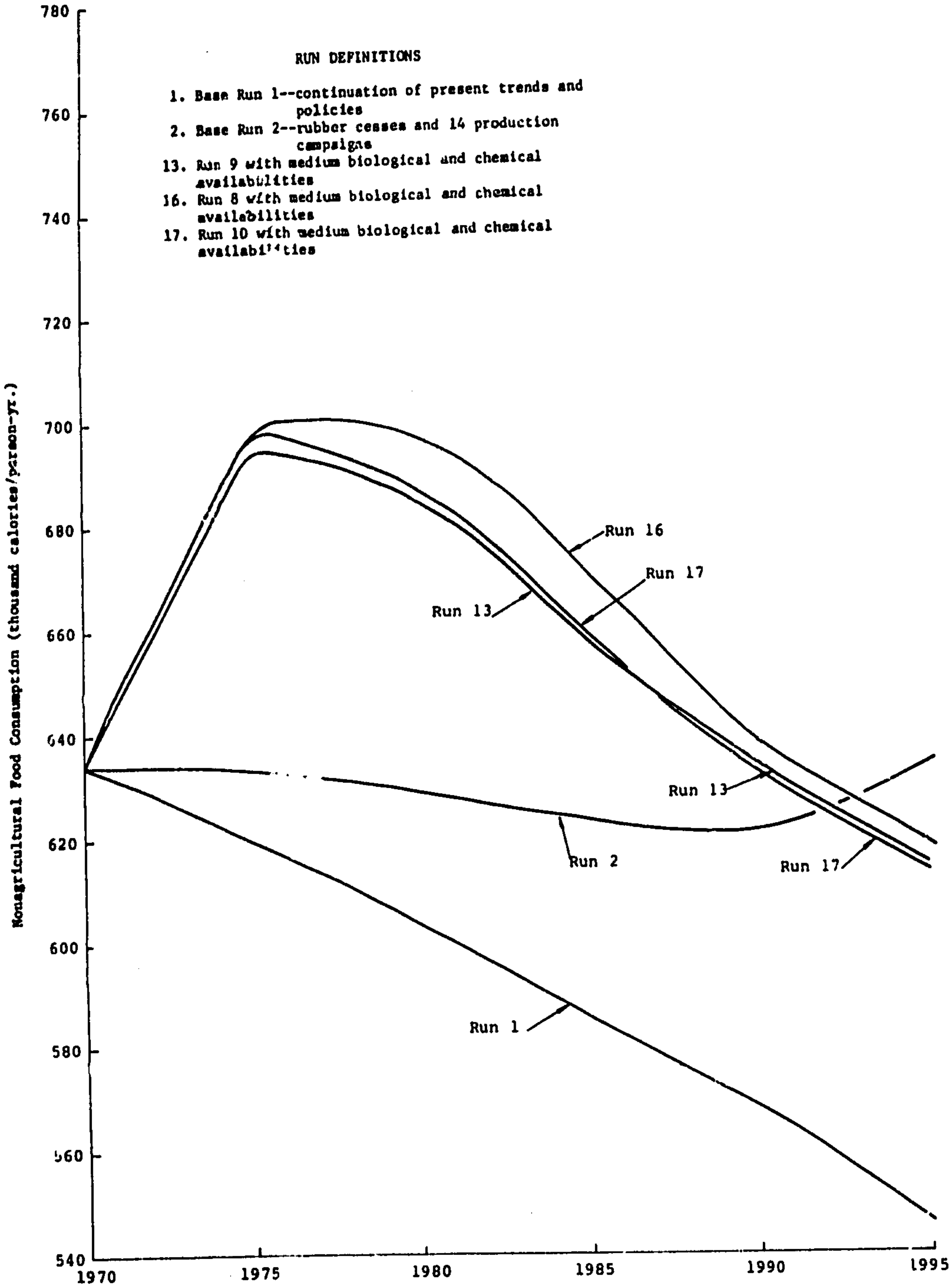

Fig. 59 Nonagricultural food consumption per capita (South), 1970-1995, with three levels of tax reductions with combined input constraints.

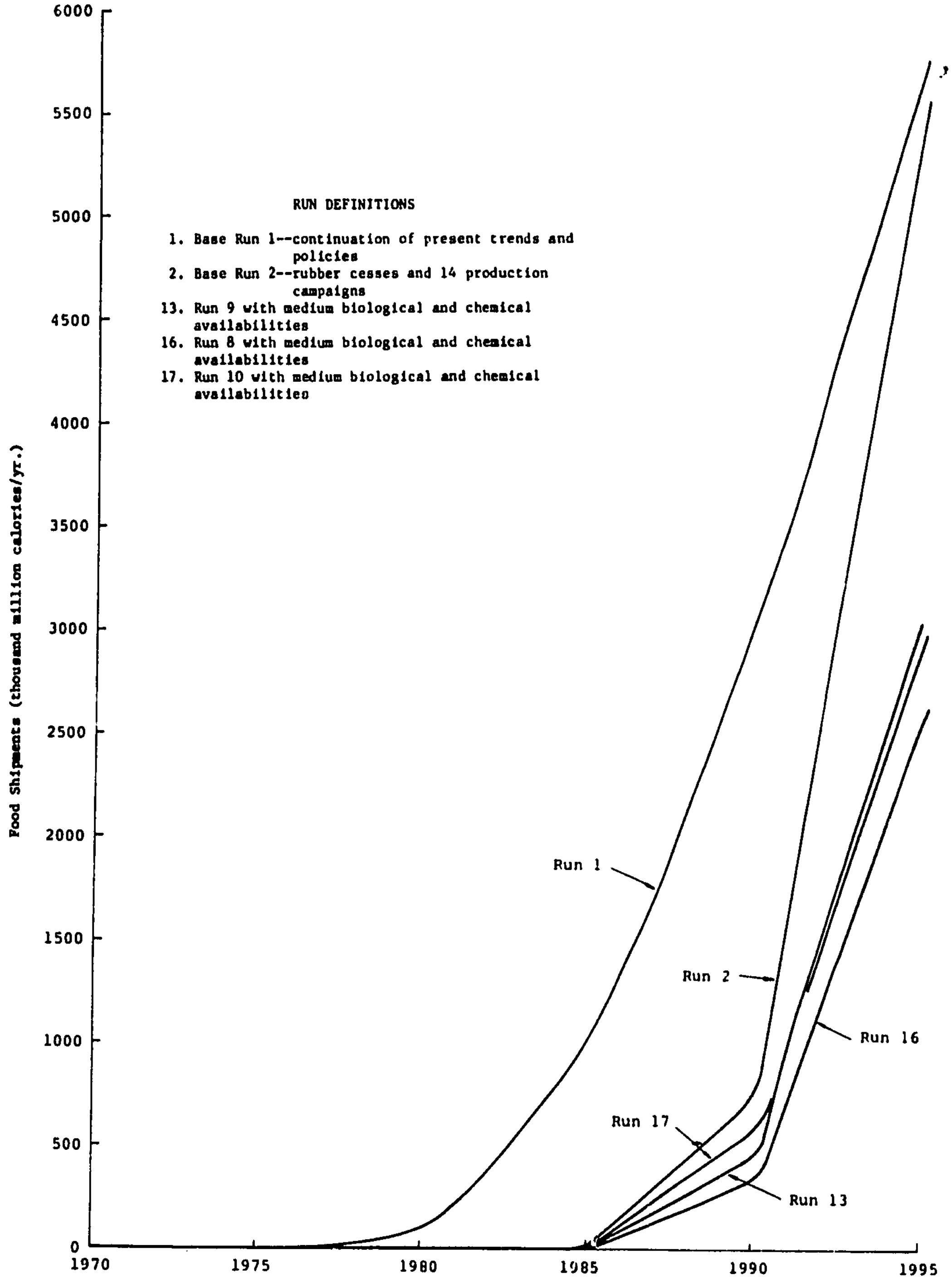

Fig. 60 Interregional food shipm-nts (North to South), 1970-1995, with three levels of tax reductions with combined input constraints.