ILLUSTRATIVE EXAMPLES OF SIMULATION FINDINGS OF THE MARS (Mutual Arms Reduction Scenarios)

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FOREWORD

For several years the Food and Agriculture Program (FAP) has worked closely with collaborating institutions in over 20 countries to develop a global system of linked national agricultural policy models. This system is now used for implementing applied studies. One of these studies is devoted to the liberalization of agricultural trade, and the other to hunger and development issues. Evaluation of alternative national and international policies that can help reduce the number of hungry and malnourished people in the world has been a major topic of the second study.

In this paper, Vladimir Iakimets describes the illustrative results of the scenario MARS (Mutual Arms Reduction Scenario) developed by him for exploring consequences of redirecting government expenditures from military to civil purposes on countries' economic development and reduction in hunger. These results show that redirection of even small amounts of funds now spent for military purposes, has an impact on the solution of problems of civil economy at both global and national levels.

Vitali Kaftanov
Deputy Director

ABSTRACT

In this paper the preliminary simulation results of the implementations of the Mutual Arms Reduction Scenarios (MARS), with the Basic Linked System (BLS) of national agricultural policy models, are described.

ACKNOWLEDGEMENT

I am very grateful to Kirit Parikh, Ferenc Rabar, and Janos Hrabovszky for fruitful discussions, to Günther Fischer and Gerhard Krömer for assistance with the programmed implementation of the MARS runs, and to Jan Morovic and Laszlo Zeold for plotting the results of simulation.

CONTENTS

Illustrative Examples of Simulation Findings of the MARS (Mutual Arms Reduction Scenarios)

V. Iakimets

1. Introduction

In three previous published papers written by the author (Iakimets 1985a, Iakimets 1985b, Iakimets 1985c), the main ideas for the development of the MARS (Mutual Arms Reduction Scenarios) for the Food and Agriculture Program's (FAP) study "Hunger, Growth and Equity" were described. In the first paper objectives of the MARS, its importance, assumptions for its construction, problems to be solved, as well as the description of its structure were given. The second paper contains the formal description of the hypotheses relating to desired dynamics of annual reduction in a country's military expenditure.

The third paper was devoted to a detailed consideration of two versions of the scenario's implementation with the BLS (MARS 1 and MARS 2) including methodological and formalized descriptions of variants for the solution of problems of the MARS implementation stated in the first paper (Iakimets, 1985a).

2. Preliminary Explanations

To begin the description of the MARS 1 and MARS 2 results we need to clarify the following items.

1. These results are based on simulation runs of the BLS under a set of hypotheses and assumptions of behavior of national models, and can be considered as completely illustrative ones.
2. Results described in the paper are related to the case when the values of the coefficients for annual reduction of military expenditures $\alpha(t)$ were accepted conditionally as fixed ones for $t = T$ for three categories of countries according to Table 1 in Iakimets (1985c).
3. For the MARS 2 the alternative version (different to Iakimets (1985c)) for calculation of a country's share in the Additional International Donation (AID) fund was used, namely

$$AID_j(t) = \gamma_j^o(t) \cdot AID(t) \tag{1}$$

with

$$\gamma_j^o(t) = \frac{w_j(t) \cdot pop_j(t)}{\sum_1 w_1(t) \cdot pop_1(t)}\ ; \tag{2}$$

where

$$w_j(t) = \begin{cases} \exp[-0.0023 \cdot GDP_j^c(t)], & \text{if } GDP_j^c(t) < 1000 \text{ US\$} \\ 0 \quad , & \text{if } GDP_j^c(t) > 1000 \text{ US\$} \end{cases} \tag{3}$$

According to this variant a country's share in the AID fund will be proportional to it's population, weighted by w_j where

$pop_j(t)$ is population of j-th country,

$GDP_j^c(t)$ is GDP per caput of j-th country,

$AID_j(t)$ is share of j-th country in total AID fund.

4. When comparing plots given in this paper we need to bear in mind that the only relative changes of corresponding indicators are used. In one case these are changes of indicator values under MARS 1 (or MARS 2) relative to such values for the reference scenario, and in another case these are changes of the above mentioned values under MARS 2 relative to those for MARS 1.
5. The following notations for distinction of results on the plots were accepted:

   A1 means MARS 1
   A4 means MARS 2
   R0 means reference scenario

   Finally, when comparing changes of indicators given on the plots, the differences in scales used should be taken into account.
6. The models of the regional country groups have number codes from 901 to 913. These were constructed using results of the FAO study, (FAO, 1981).
7. All details about the methodology for the construction and running of the BLS, developed by the FAP team, can be found in Fischer, et al. (forthcoming).

3. The Description of the MARS Results

3.1. Some notes about comparison of results for the reference and scenario runs

According to the FAP approach, two types of runs are discerned: the reference and scenario runs. By definition the reference run is when all national models simulate the behavior of countries' economies on the basis of relationships revealed for the historical period of 15 - 20 years. Within the reference run each model which is interlinked with other models of the BLS, has to reproduce as closely as possible observed values of a number of general and commodity-wise indicators for a country for this historical period and it has to produce such values for the period of simulation of the next 15-20 years under an assumption that no structural changes in its economy occur. Within the scenario run, each model interlinked with other models of the BLS has to generate "new" values of the same indicators reflecting corresponding changes of national and international policies according to the developed scenario.

When comparing the results of the reference and scenario runs one can see the impact of various policies on world and national economy. Such a comparison of results of simulation can be made in principle, both in quantitative and qualitative ways. However, the appropriate comparison of results of two runs is a qualitative one. It means that results of runs should be interpreted from the point of view of tendencies in changing of relative values of basic and commodity-wise indicators for a country and for the world as a whole. An appropriate approach to such a qualitative cross countries (or cross commodities) comparison seems to be the application of the ordering relation. In other words comparing results of runs one can use such types of ordering relations as "more-less", "better-worse", "faster-slower" and so on.

When describing the results of the MARS the above mentioned are kept in mind.

3.2. Categorization of the MARS results

It seems reasonable to classify the results of both MARS 1 and MARS 2 into 2 categories, namely, expected and counter-intuitive ones.

Expected results are those which can be predicted with a high level of certainty on the basis of traditional logical analysis of the possible behavior of national models under the impact of changes in policies given by the scenario. In a determined sense these results have little or no dependence upon the interaction of separate models.

Counter-intuitive results are those which strongly depend upon the interaction of national models for the simulation period and which cannot be predicted on the basis of traditional logical analysis or predictions of which are highly uncertain.

With the first category *trivial* and *interesting* expected results are discerned.

3.3. Expected trivial results

It is clear and self-evident, on the basis of traditional logical considerations, that redirecting resources used now for military expenditures into development-oriented investment would lead to improvement of basic economic and welfare indicators for separate countries and for the world economy as a whole. Moreover, there are a number of other studies which have already showed such results.

According to the scenario description we expected that values of such indicators as

- total gross world production as well as gross world production of agricultural and nonagricultural goods;
- world production of various agricultural commodities;
- gross domestic product of separate countries;
- calorie and protein supply per caput in countries ,

would be higher under various versions of the MARS than under the reference scenario.

All these trivial expected results are obtained as can be seen from Figures 1-15 where relative changes of some of the above mentioned basic indicators are given.

Thus the world production of each commodity for both versions of the MARS is higher than for the reference run (see Figures 2-5 and 9-12 for wheat, rice, and dairy commodities and for non-agriculture) and it is higher for the MARS 2 if compared to the MARS 1.

Absolutely the same tendencies of changes are obtained for such basic indicators as GDP and calories supply, per caput for separate countries (see Figures 6-8 and 13-15).

We expected also that a number of additional welfare indicators which are derivates from basic indicators (such as number of people in hunger, life expectancy at birth in years, infant mortality) will show positive changes for each country under the MARS in comparison with reference run. These expectations were also fulfilled (see Figures 16-19 for 4 selected countries).

3.4. Expected interesting results

Expecting the increase of world production of different commodities under the MARS relative to the reference scenario we could only guess for which commodity such an increase would be higher as well as what differences in world production of separate commodities would occur under different versions of the MARS.

When comparing the results we found, for example, that relative increase in world production of rice is high for both MARS 1 and MARS 2 in comparison with other agricultural commodities (see Figures 20-22 for wheat, rice and dairy). This interesting result could be explained as follows: most of the countries which received some share of the AID funds within the MARS are major rice-producing and rice-consuming countries. That is why it is natural that this aid received provides the increase of rice production in these countries (India, Indonesia, Pakistan, etc.), and in the world as a whole.

The other interesting result is that the world production of non-agricultural goods remains under the MARS 2 approximately the same as under the MARS 1 (see Figure 23). The interpretation of this result is the following. The increment of production of non-agricultural goods in countries which are the AID recipients under the MARS 2 is compatible with slight decreasing of such production for countries which are major donors to the AID under the MARS 2 in comparison with the MARS 1.

In some sense this interpretation is also confirmed if we compare relative changes in GDP for separate countries (see Figure 24). According to this figure such countries as New Zealand, Canada, Argentina and Australia, which are donors to the AID, will have under the MARS 2 approximately the same relative increment in GDP as under the MARS 1 (see also Figures 6 and 13). However, group B countries, which are major recipients from the AID (India and Indonesia) will have the highest relative increment in GDP under the MARS 2 in comparison with the MARS 1 (see Figure 24). The same data for other selected countries is given in Figure 25.

It is interesting that approximately the same ordering of countries from the point of view of relative increment of such indicators as calories supply per caput remains when results of the MARS 2 are compared with those for the MARS 1 (see Figure 26).

Of course we also expected that the LDC's under the MARS will have the highest relative increment in GDP, calorie and protein supply per caput etc., than DC's within the group of countries with the same value of annual reduction of military expenditures. This is obvious, for example, because the initial absolute values of GDP of those categories of countries are essentially different. However, it is interesting to see that ordering of selected countries by relative increment of the above mentioned indicators will be different in the case of the MARS 2 compared to the MARS 1 (compare corresponding Figures 6-8, 13-15). The interpretation is the following: economies of countries which change their places in ordering under the MARS 2 in comparison with the MARS 1, are sensitive to international aid. This expected interesting result about sensitivity of different countries to international aid is also confirmed if we compare tendencies in relative changes of so-called derivative indicator as "number of people in hunger" for selected countries under both versions of the MARS (see Figures 27-30).

Such countries as Indonesia and low income country grouping (Nepal, Burma, Sri Lanka, Bangladesh) are more sensitive than for example, Thailand, and high income food importing Latin American countries (Jamaica, Trinidad and Tobago, Chile, Peru, and Venezuela).

To give some idea about the distribution of AID fund among "poor" LDC's, see Figures 31, 32 and 33 which reproduce such data for 1990 and 2000.

3.5. Counter-intuitive acceptable results

Apparently the most interesting results for this scenario are those we called counter-intuitive acceptable results. As an example of such kind of results we consider in this paper, those concerning relative changes of world market prices and world net export of separate agricultural commodities and self-sufficiency ratio of countries in these commodities.

Thus when comparing results of both the MARS runs we found that world market prices of wheat and world net export of wheat are practically not different for both versions of the scenario from those for the reference scenario (see Figures 34-39). Values of those commodity-wise indicators for dairy commodities became slightly higher for both scenarios runs in comparison to the reference run (see Figures 40-43), and correspondingly higher for the MARS 2 in comparison to the MARS 1 (see Figures 44, 45). It is, however, strange that increases in the price of dairy coincides with the growth of net world export. However, the most essential changes of these indicators occur for rice (see corresponding Figures 46-51). The most interesting observation is that for MARS 1 we obtain the decreasing relative prices of rice (Figure 46) with practically unchanged world net export of this commodity. This means that utilization of their own released fund for internal purposes mainly affects the growth of domestic production of rice within major rice-producing countries, and leads to growth of volumes of rice on the world market keeping the value of net world export as it is in the reference run because the world market prices were decreased.

In the case of the MARS 2, when "poor" LDC's received their share of the AID, the world market prices went down further (see Figure 47), and net world export of this commodity increased (Figure 49). Corresponding plots for comparison of relative values of world market price, and net world exports for rice for MARS 2 relative to MARS 1 show more evidently that tendency (Figures 50 and 51).

This result can be interpreted as follows. The largest share of the AID is distributed among LDC's, which are the major rice-producing and rice-consuming countries (see Figures 32 and 33). These countries improve their own production of rice. Probably mainly due to this reason, the calories and protein supply per caput is also increased (see Figures 8, 15, 26). The world market price of rice is going down and net world export is going up.

It is interesting to note that such a tendency has a strong impact on relative values of the country-specific self-sufficiency ratio for rice (see Figures 52-53). Because the world market prices of rice go down, some major rice-consuming countries, apart from their own rice production, then also increase their imports and exports of rice. This leads to decreasing self-sufficiency ratio of this commodity for many such countries. It should be noted that for the MARS 2 (see Figure 53) such a tendency becomes more distinct (see also Figure 54 for comparison of results for MARS 2 relative to MARS 1).

It is a completely different case for wheat. For most countries self-sufficiency of wheat is higher for both versions of the MARS (see Figures 55-56), and there is practically no changes in values of this indicator between MARS 1 and MARS 2 (Figure 57). If we compare changes in this indicator for dairy, one can see that when many countries keep their self-sufficiency ratio for this commodity practically unchanged, there are countries where this indicator becomes better (Indonesia, Thailand, Kenya), and countries where this indicator is decreased (Nigeria, Egypt). (See corresponding plots on Figures 58-60.)

It is very interesting to compare also the behavior of countries from the point of view of their self-sufficiency ratio in non-agricultural production (see Figures 61-63). Two countries (India and Kenya) have opposite tendencies: for India one sees an increase of relative values for this indicator, and for Kenya vice versa. It should be mentioned that such tendencies remain for both versions of the MARS. At the same time all other countries have practically unchanged values for the indicator. One possible interpretation for additional investment in India is that it does not matter which source (own released fund or from AID) helps first of all for growth of non-agricultural production.

4. Conclusions

The main advantage of the BLS is probably that the results of its simulation allow to trace the dynamic changes of both general and agricultural commodity-wise indicators on national and international levels under various assumed national policies and transformations of the world market mechanism.

Experience of the MARS implementation with the BLS shows that this system is quite an appropriate tool for the study of corresponding complex applied economic issues like the world hunger problem.

Thus, the results called in this paper as expected trivial ones, illustrate the reasonable (from the point of view of traditional analysis) behavior of the interacting system of national agricultural policy models.

The so-called expected interesting results of the MARS show that models of individual countries react in different ways to the same rule in the creation and distribution of the Additional International Donation fund reflecting the differences in "current states" of its economies.

Results we called as counter-intuitive acceptable ones illustrate in some sense the "power" of the BLS as a tool for studying the complex economic issues because these results are mainly based on interactions of models and those could hardly be produced only on the basis of traditional analysis. Finally, we would like to point out once more that all the results of the BLS runs are illustrative ones which only show possible directions and tendencies in countries' reactions to reducing their military expenditures, because conditional and low shares of the GDP redirecting to civil purposes were accepted. For instance, if one takes data from SIPRI (1986), then the above tendencies are revealed more sharply. Hence the results described here should be considered as some theoretically induced simulation findings which can help in the better understanding of problems of real life and also for developing a more detailed version of the MARS.

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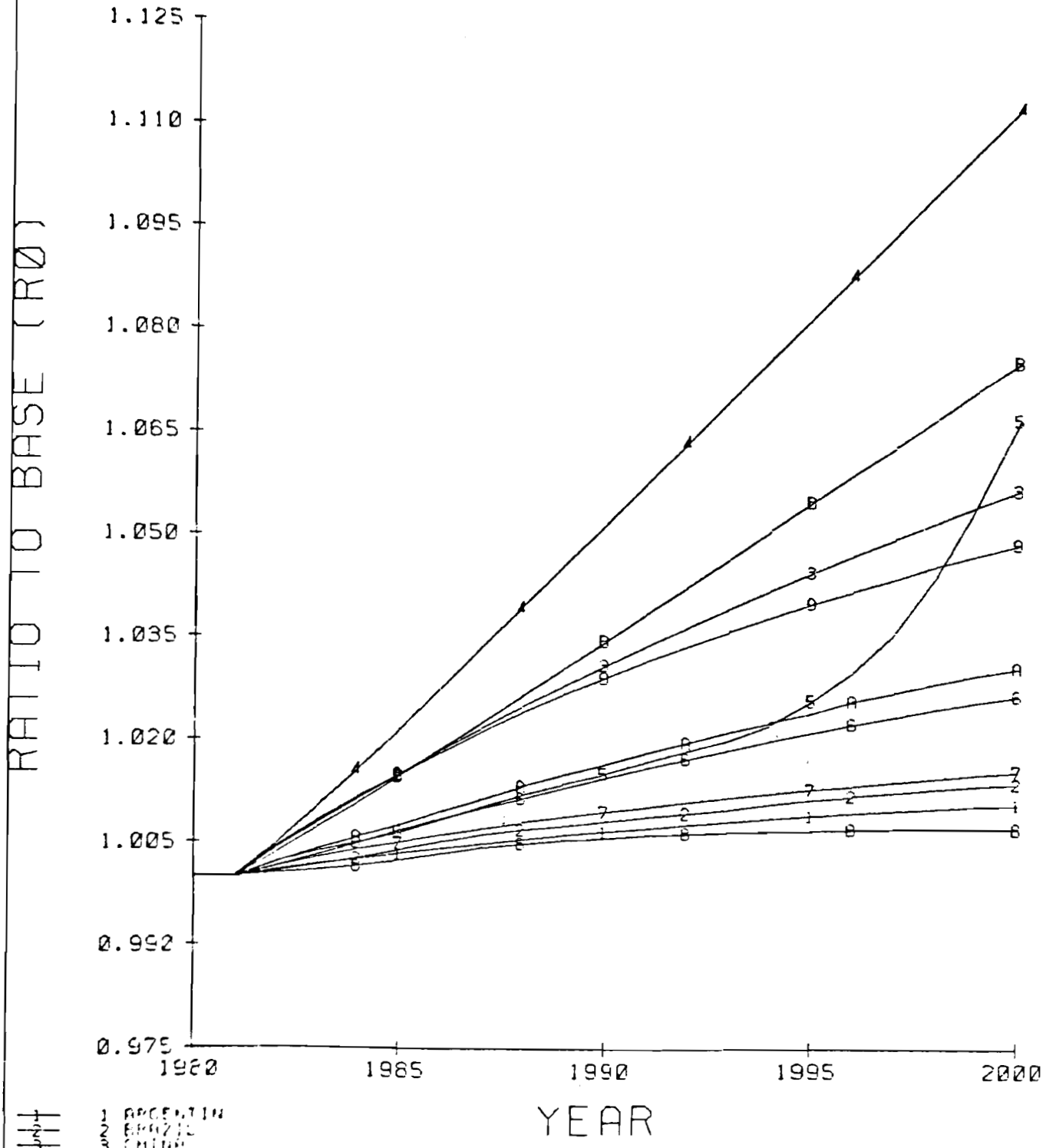
FIGURE 1

GDP/CAPUT

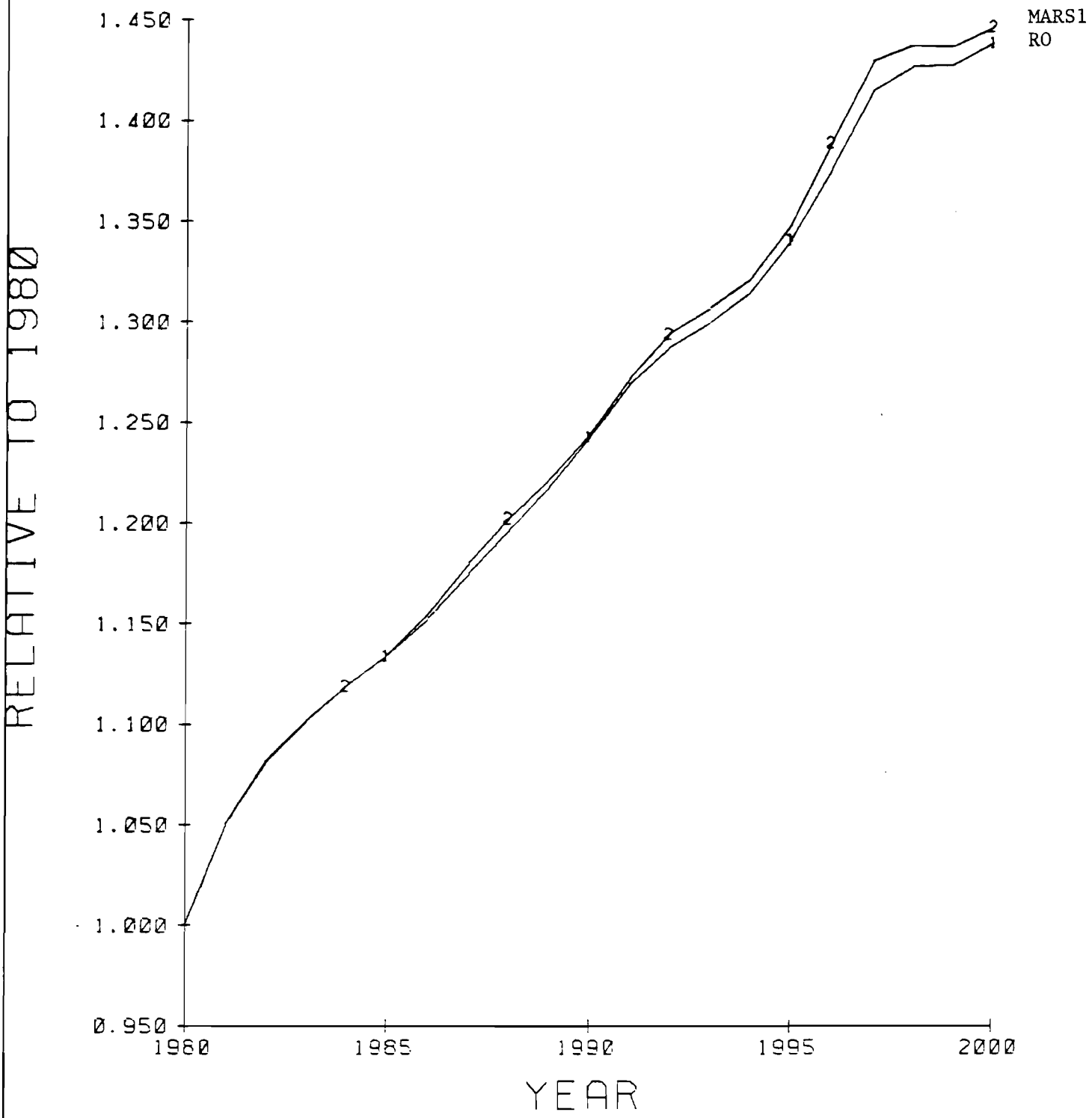
(MARS1 to RO)



A1 (V10

FIGURE 2

WORLD PRODUCTION WHEAT



[V02

FIGURE 3

WORLD PRODUCTION
RICE

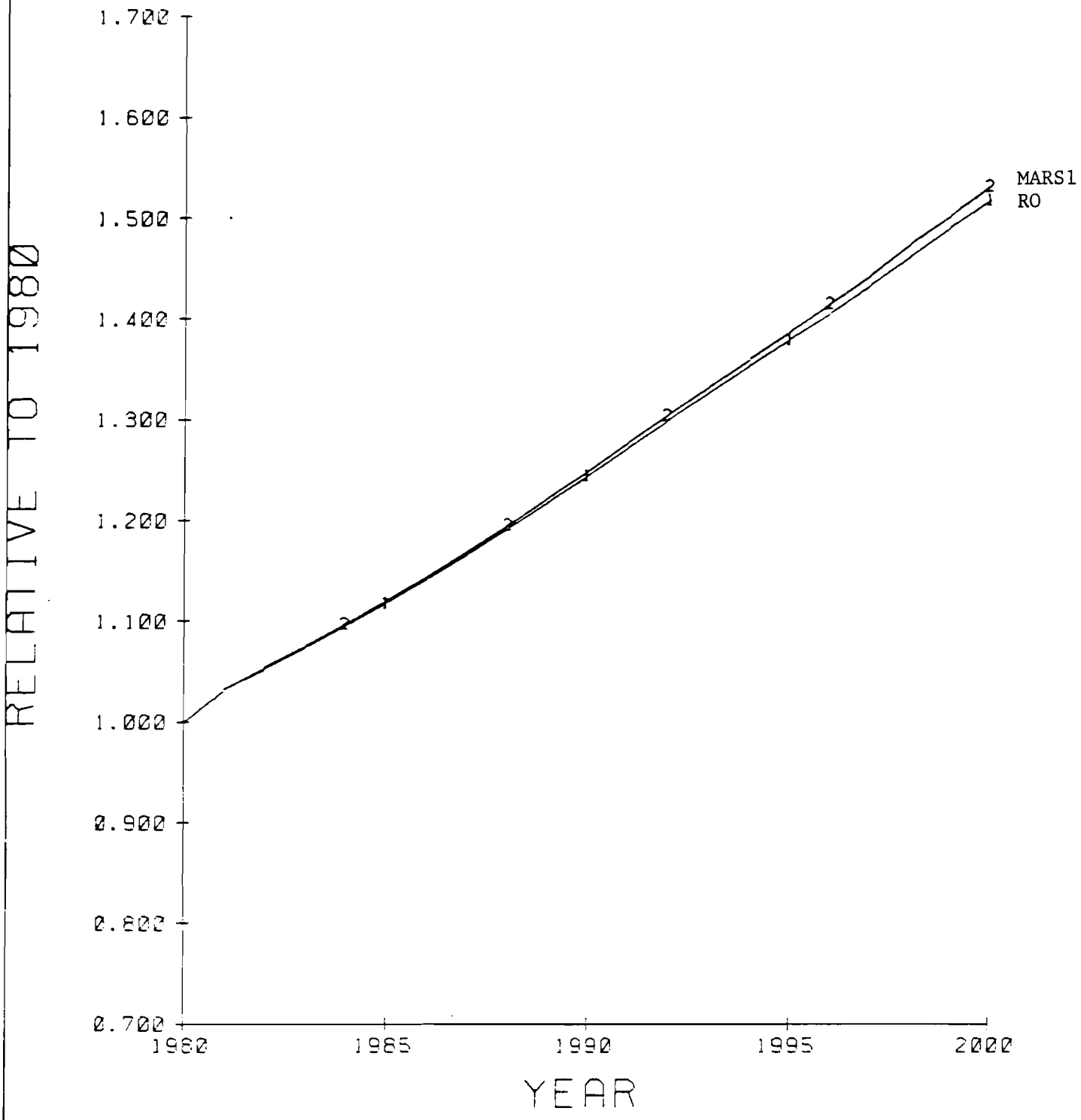


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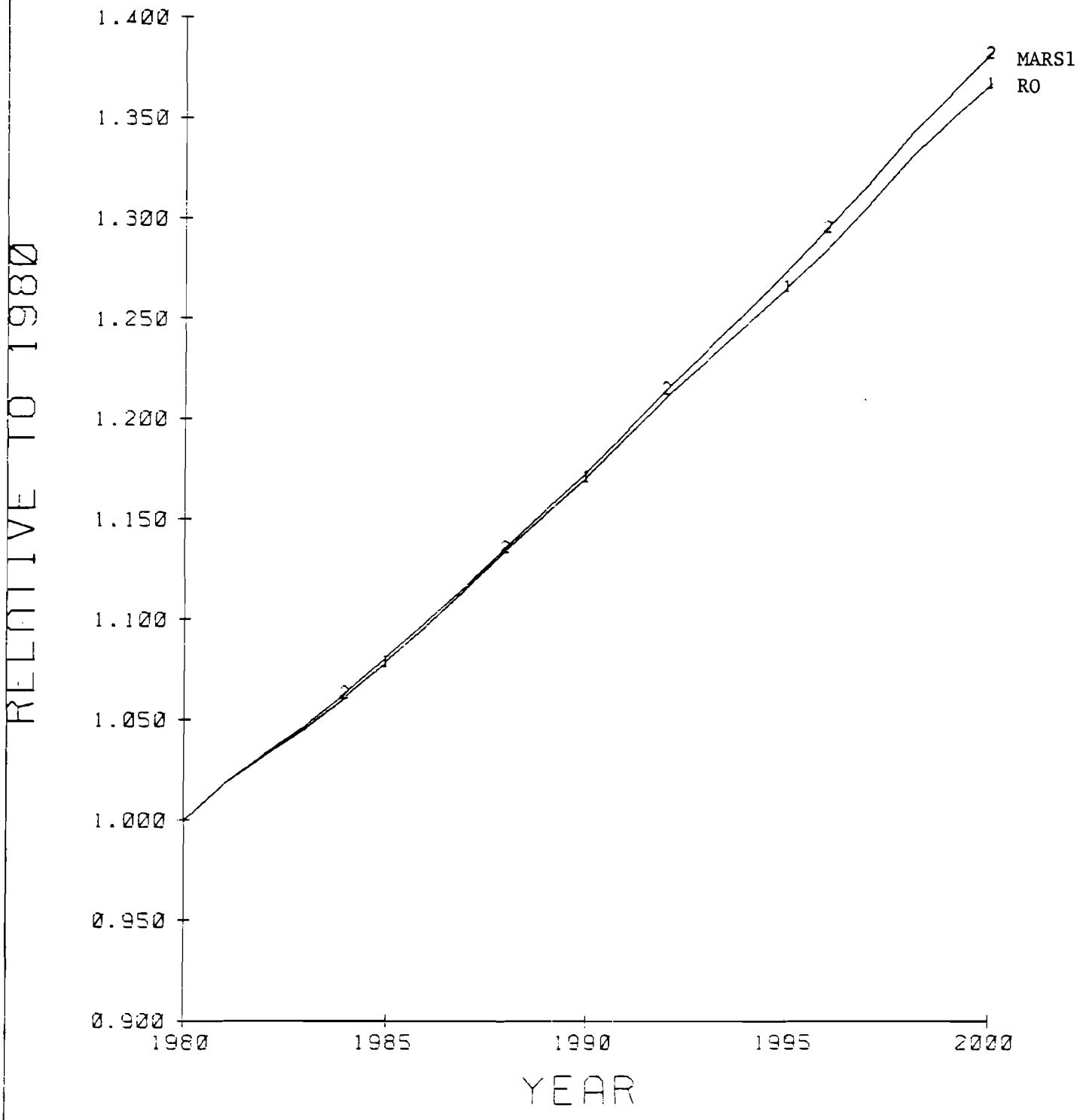
FIGURE 4

WORLD PRODUCTION DAIRY



[V02

FIGURE 5

WORLD PRODUCTION NON-AGRICULTURE

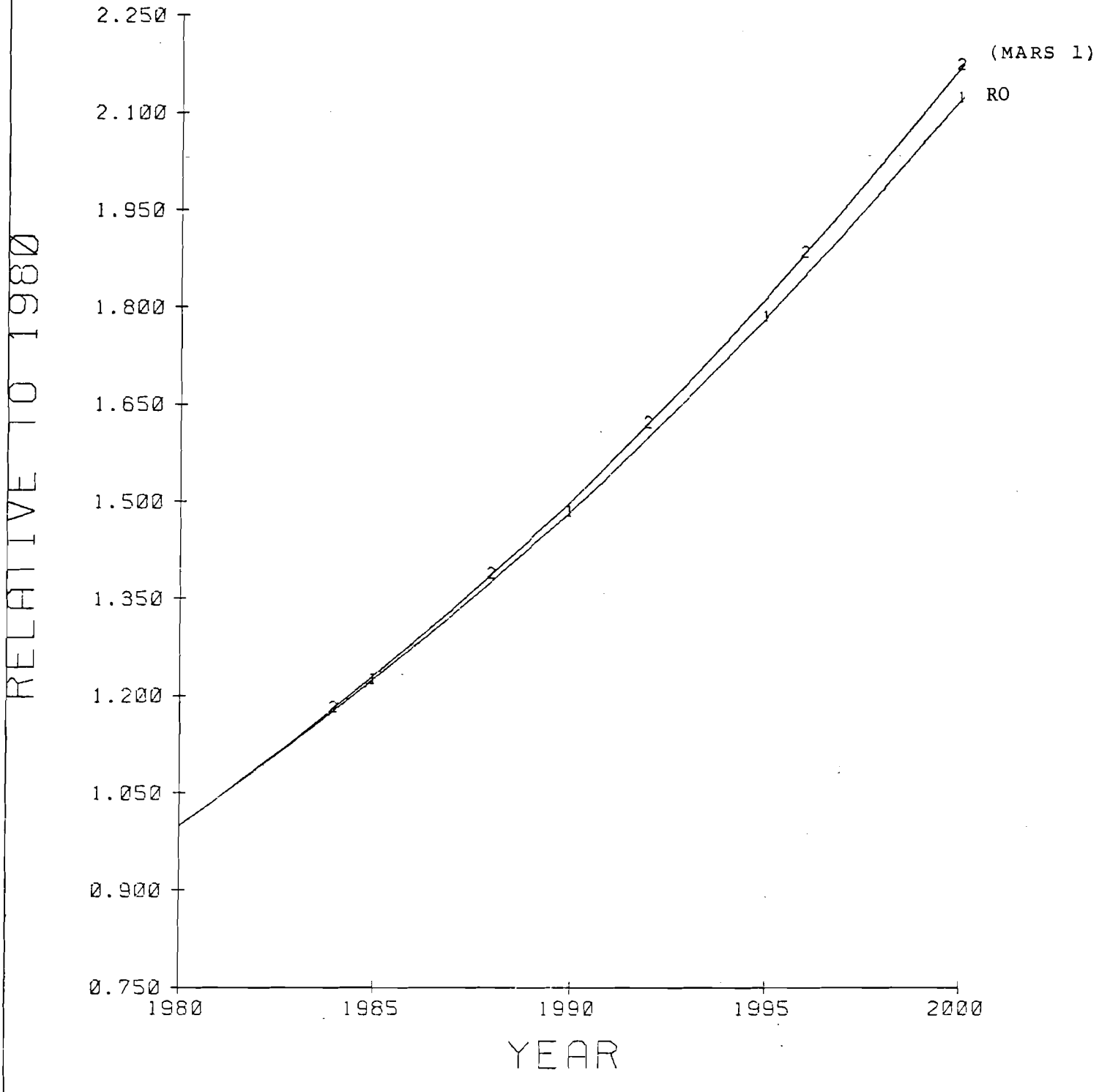


FIGURE 6

GDP-70

(MARS1 to RO)

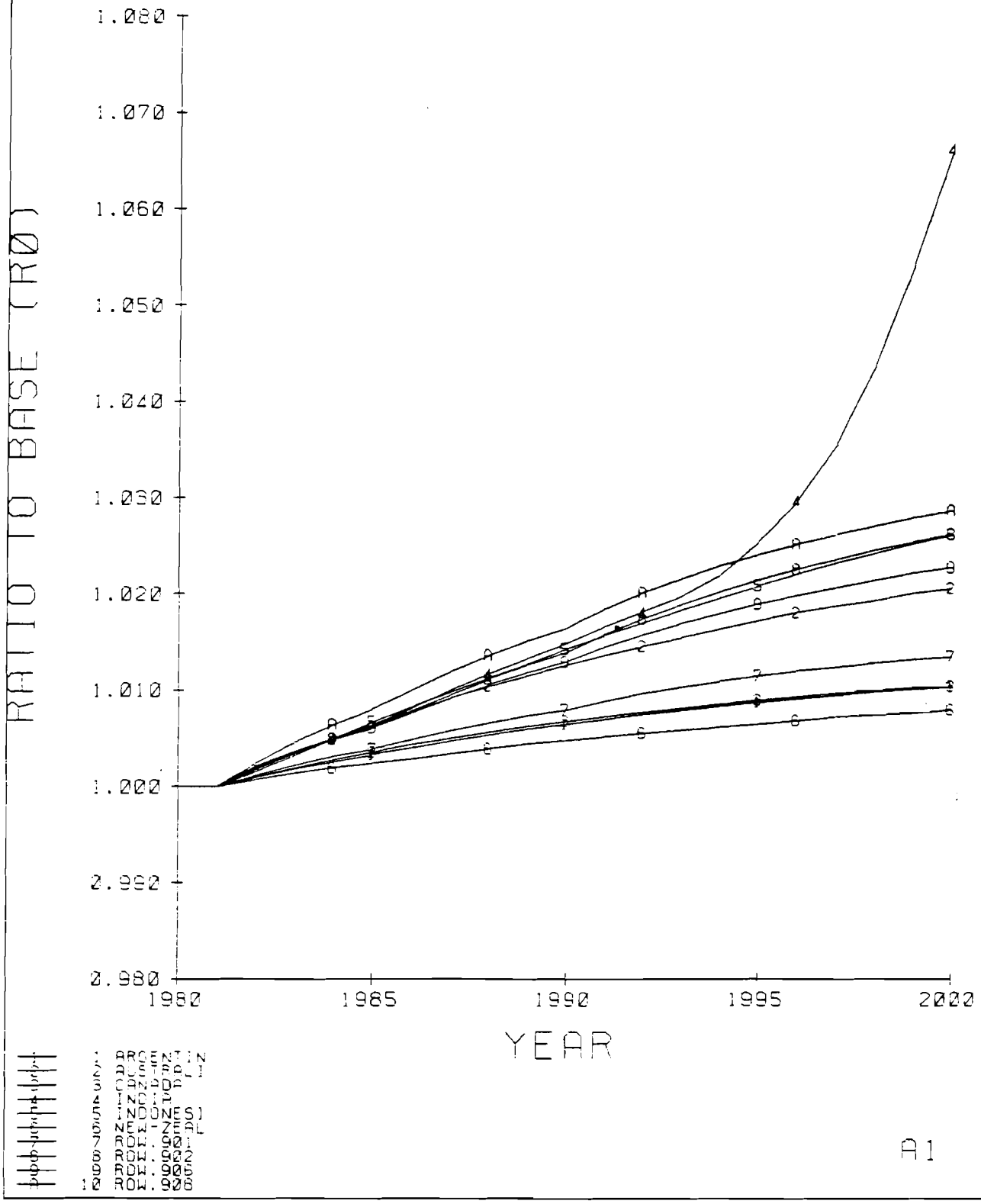


FIGURE 7

GDP-70

(MARS1 to RO)

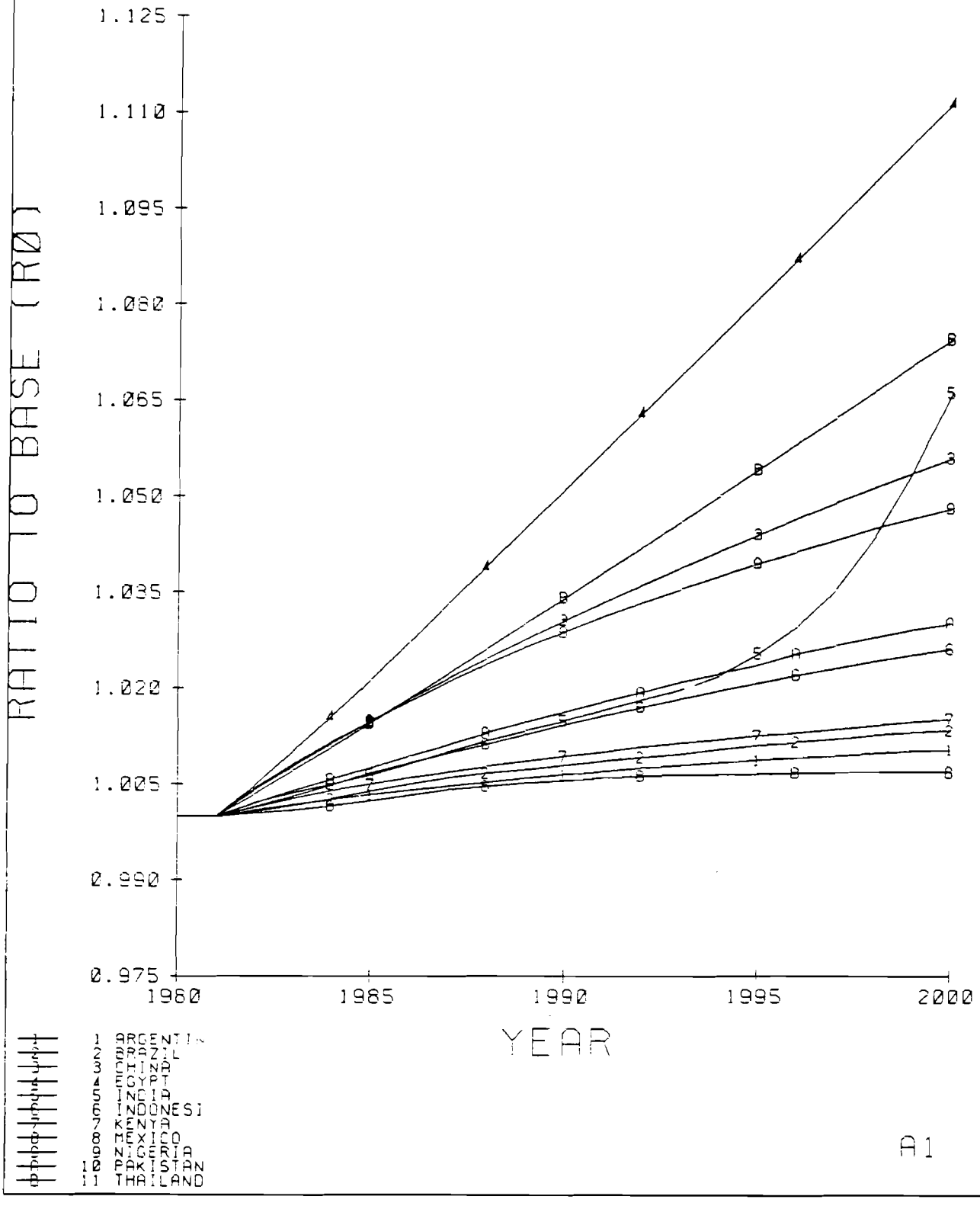
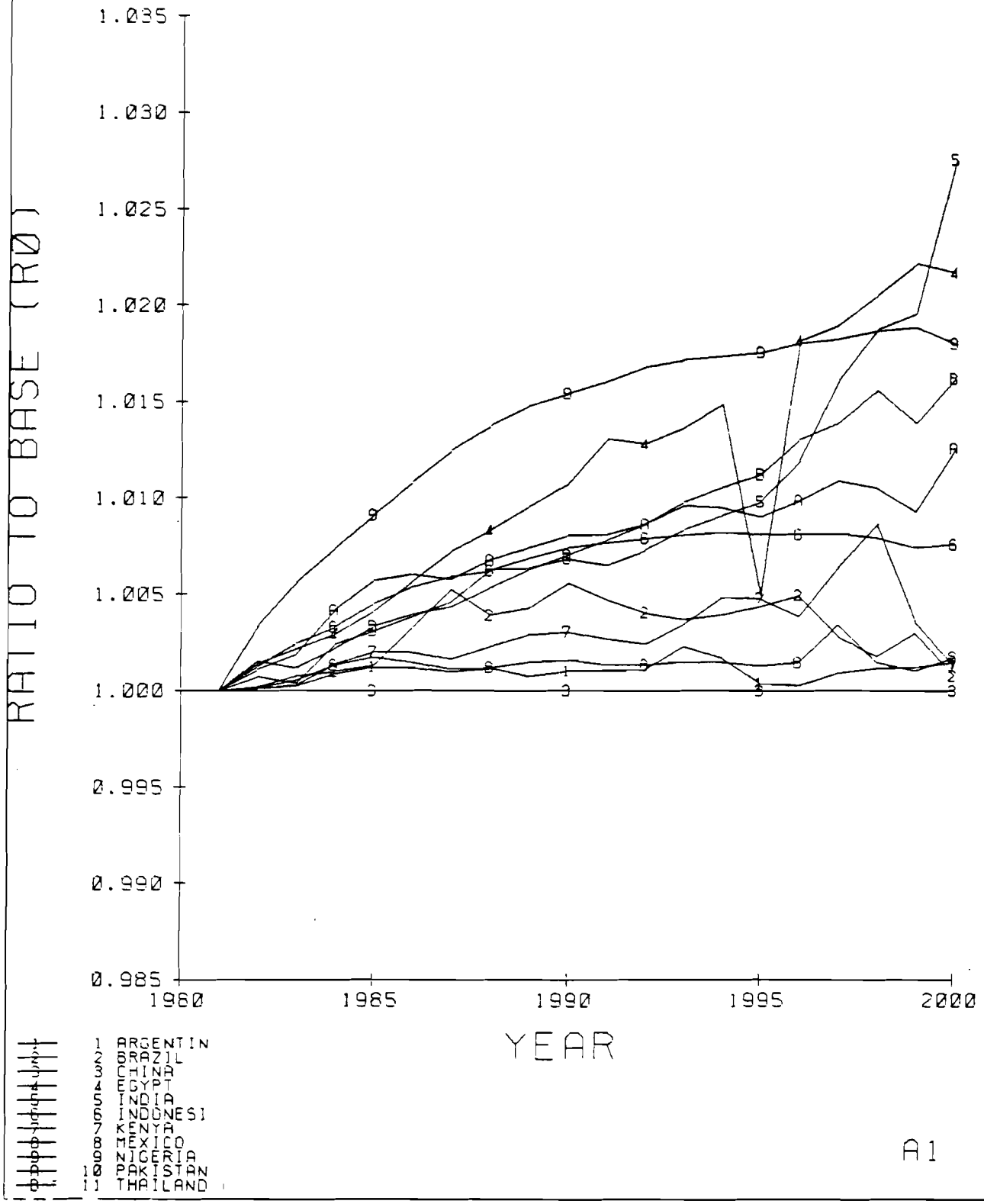


FIGURE 8 CALORIES PER CAPUT

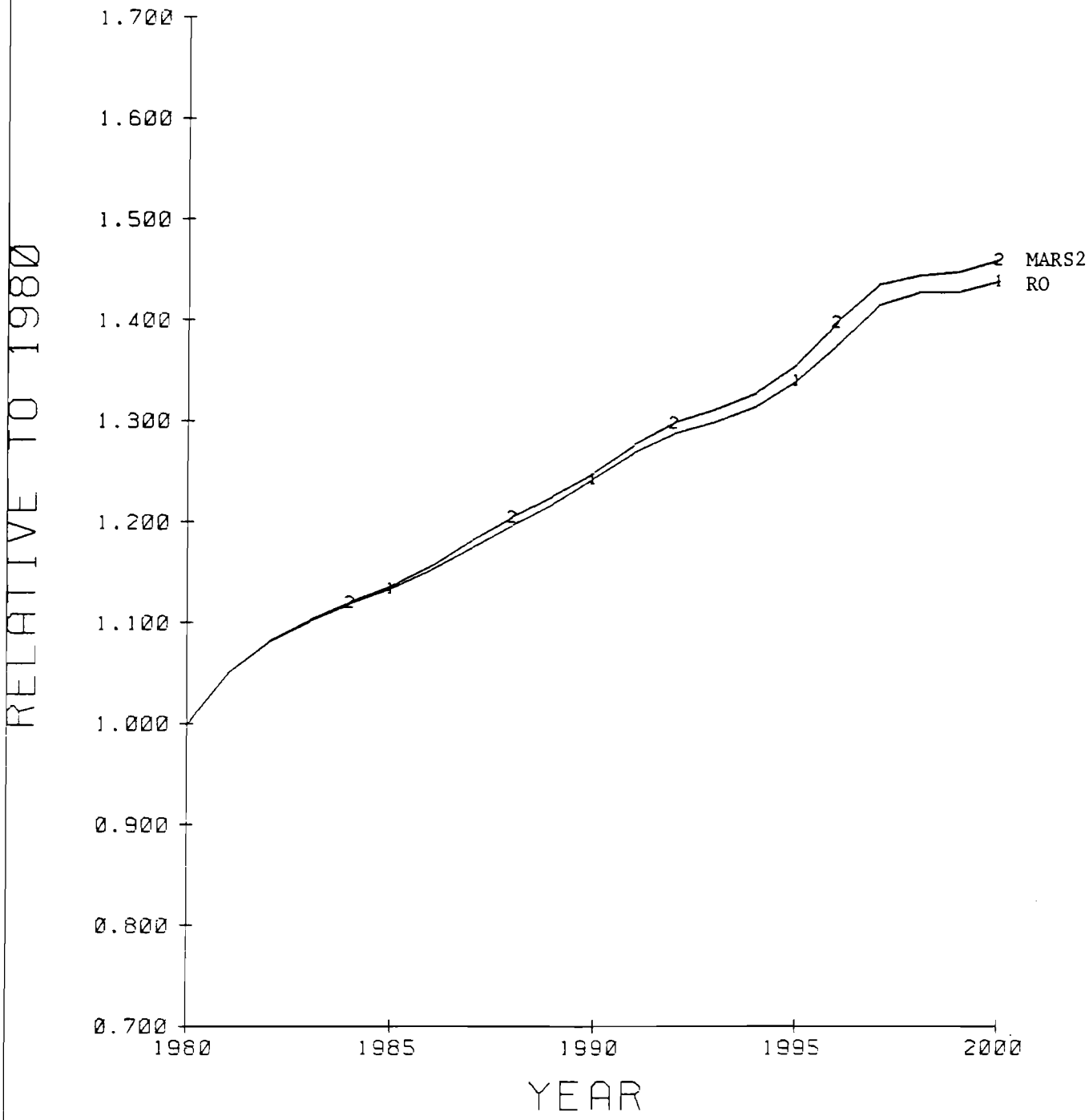
(MARS1 to RO)



A1 (\37)

FIGURE 9

WORLD PRODUCTION
WHEAT



(V02)

FIGURE 10

WORLD PRODUCTION
RICE

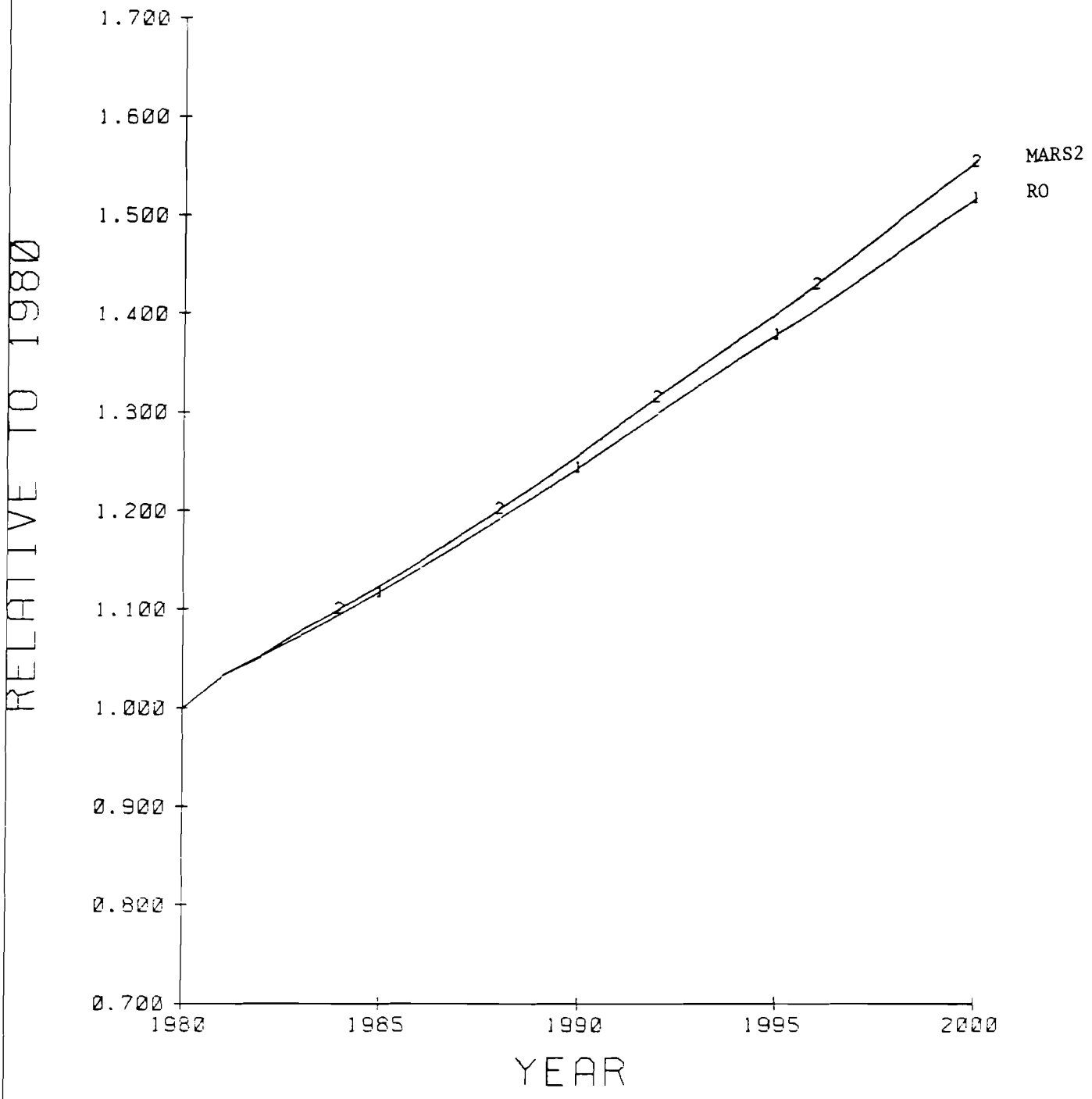


FIGURE 11

WORLD PRODUCTION
DAIRY

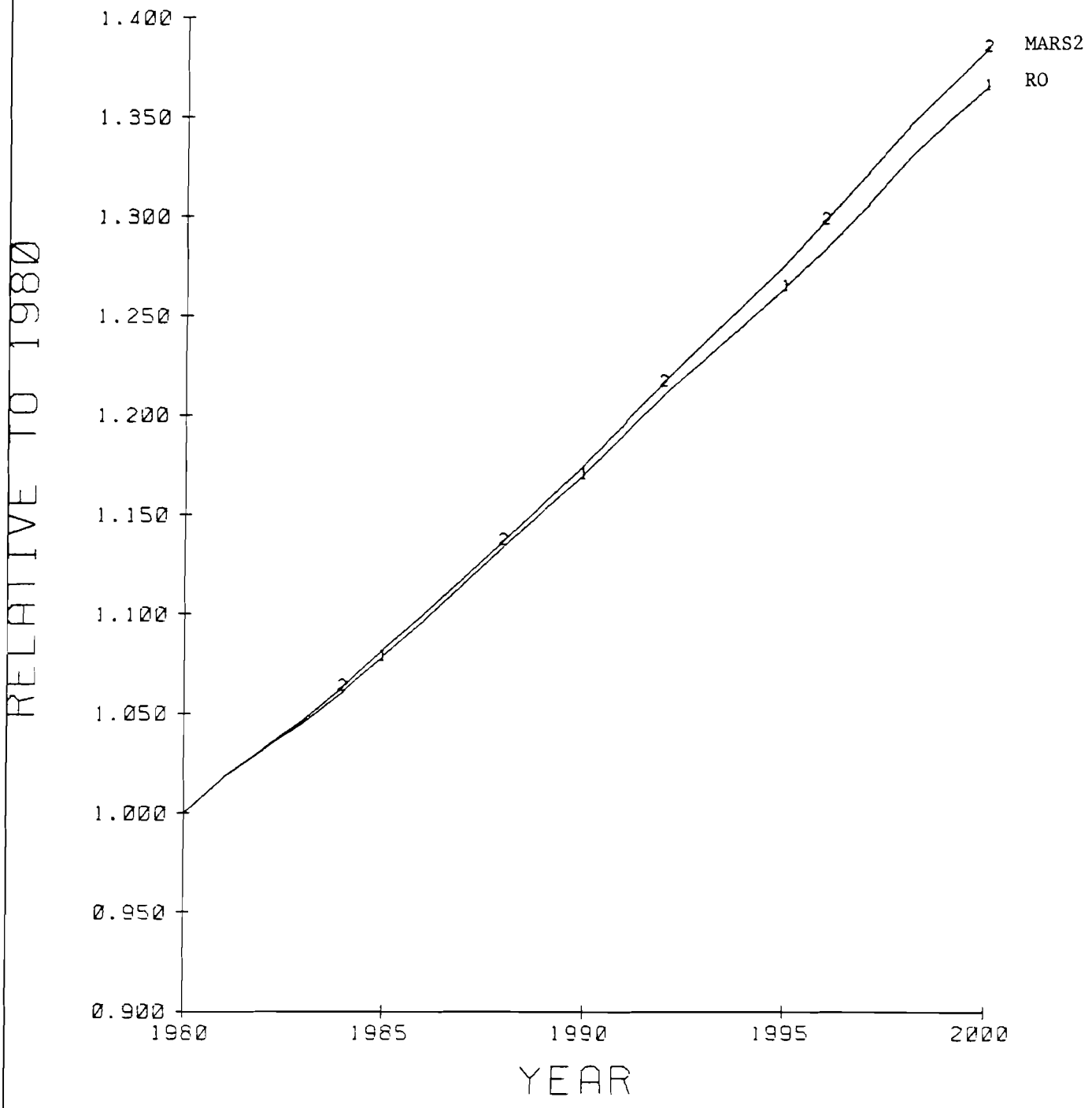


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FIGURE 12

WORLD PRODUCTION NON-AGRICULTURE

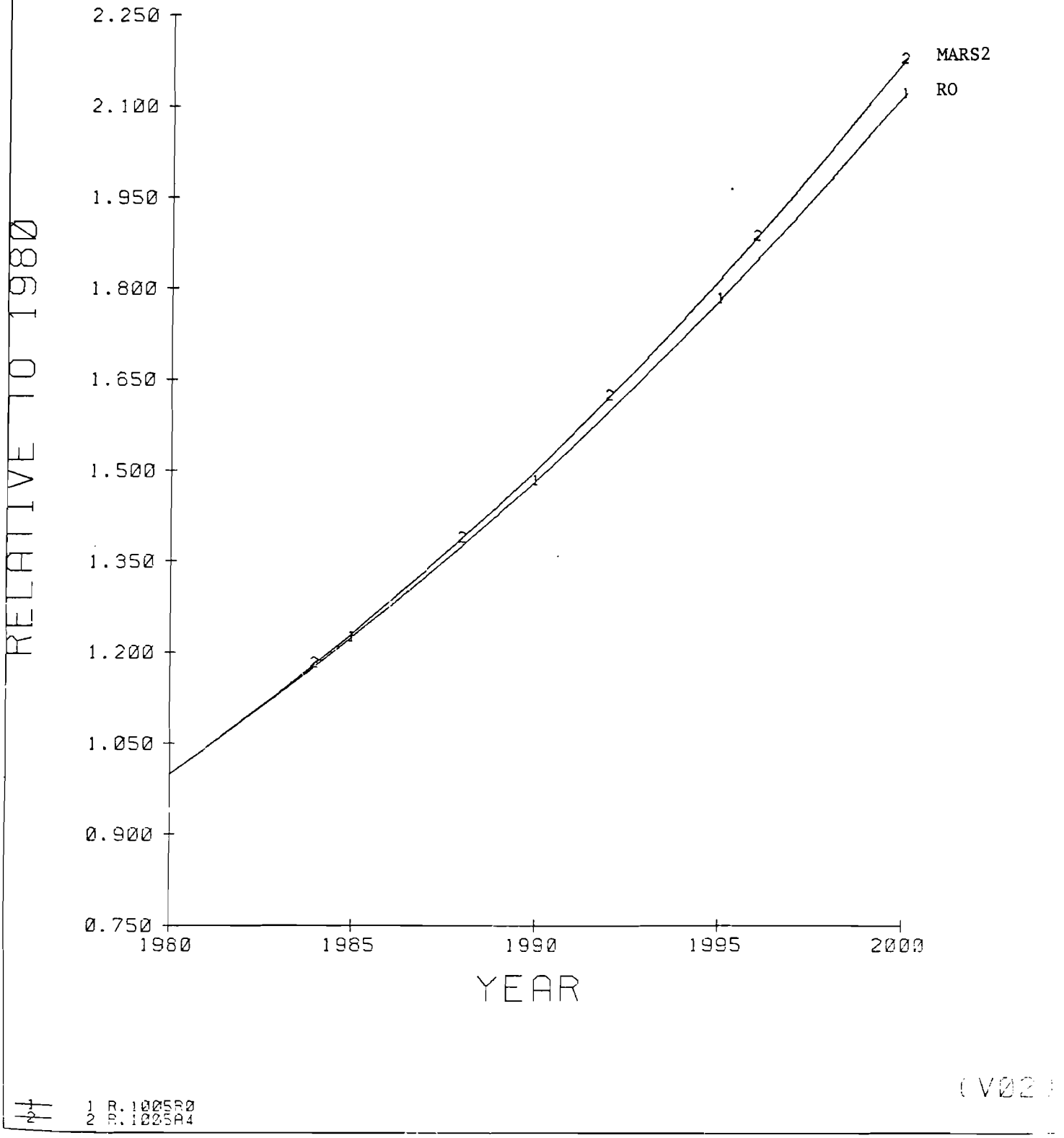
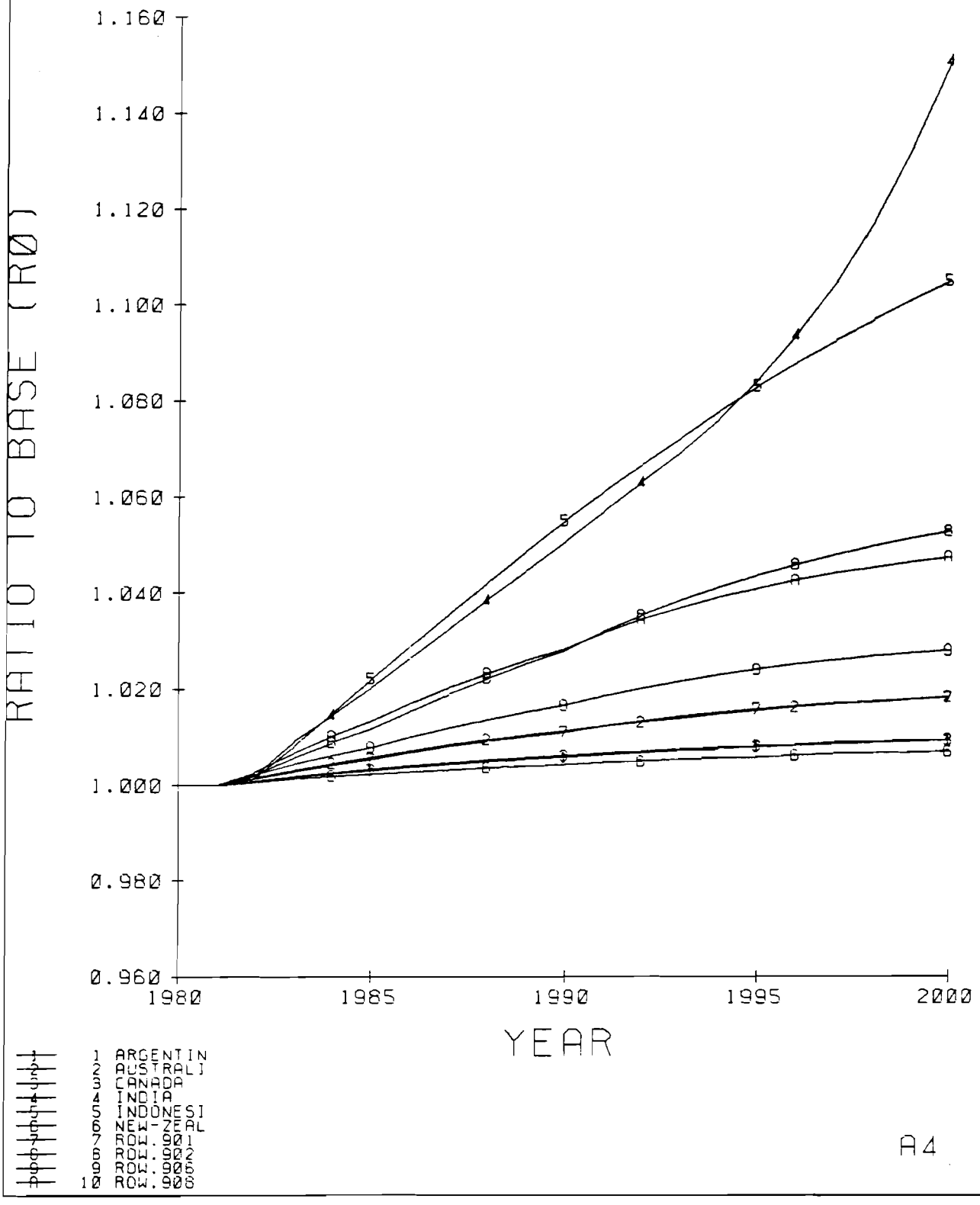


FIGURE 13

GDP-70

(MARS2 to RO)

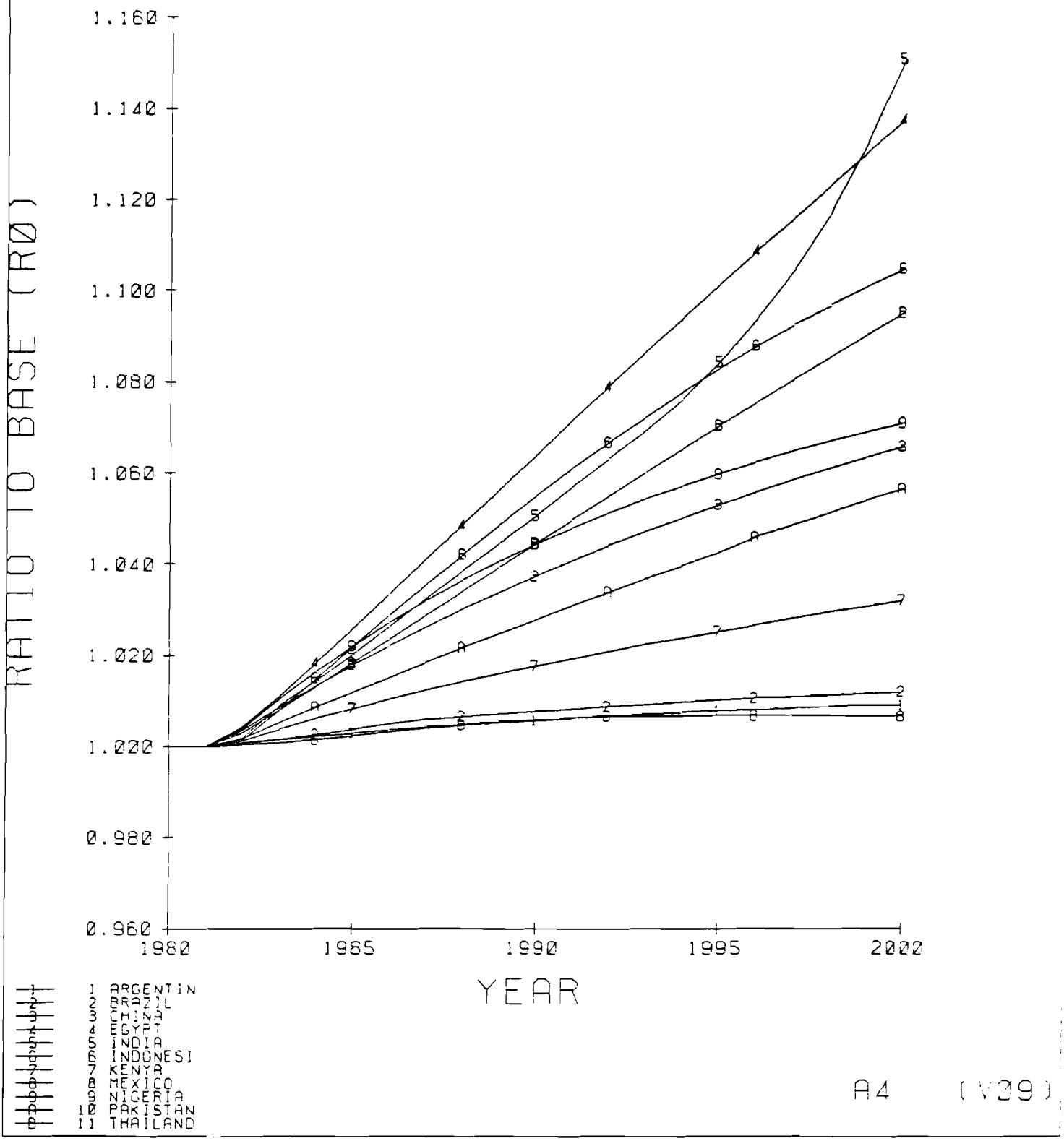


A4 (V11)

FIGURE 14

GDP-70

(MARS2 to RO)

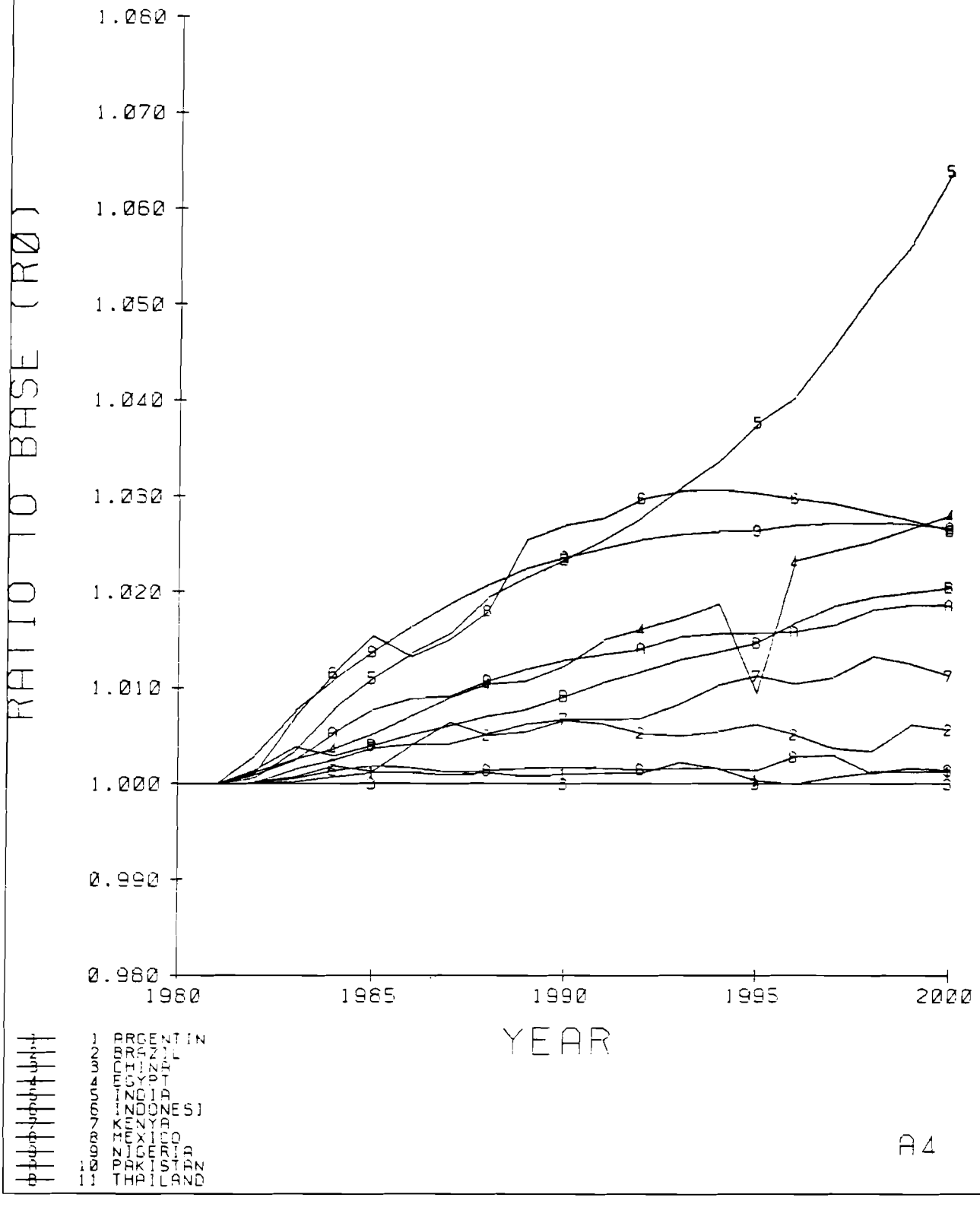


A4 (V39)

FIGURE 15

CALORIES PER CAPUT

(MARS2 to R0)

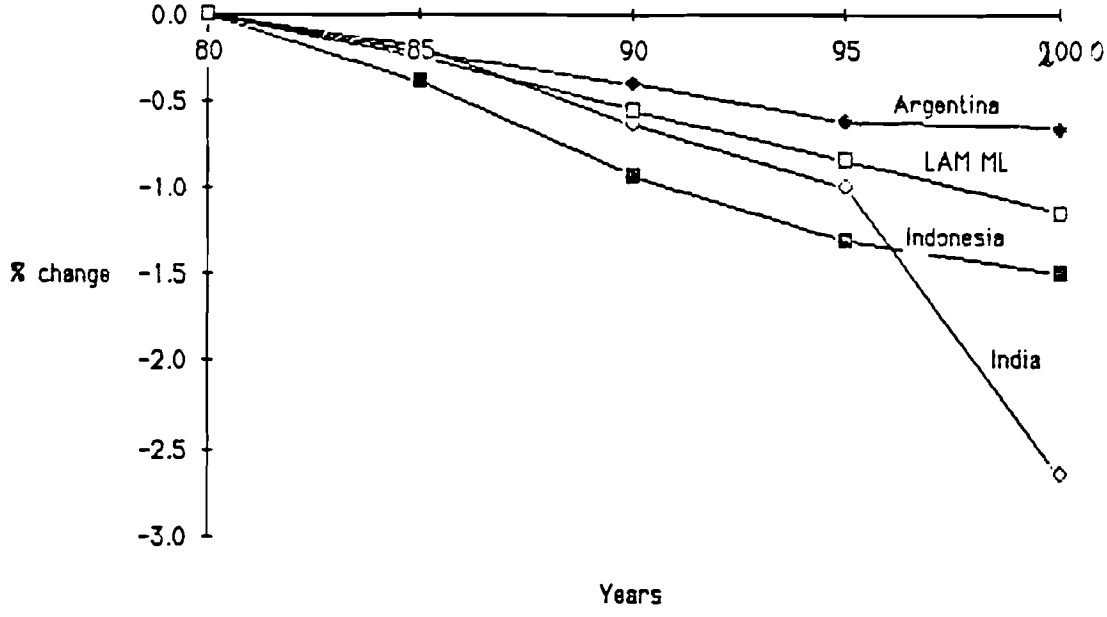


A4 (V07)

FIGURE 16

Infant Mortality (MARS 1 to RO)

AI



FIGUPE 17

Life Expectancy at Birth in years (MARS 1 to RO)

AI

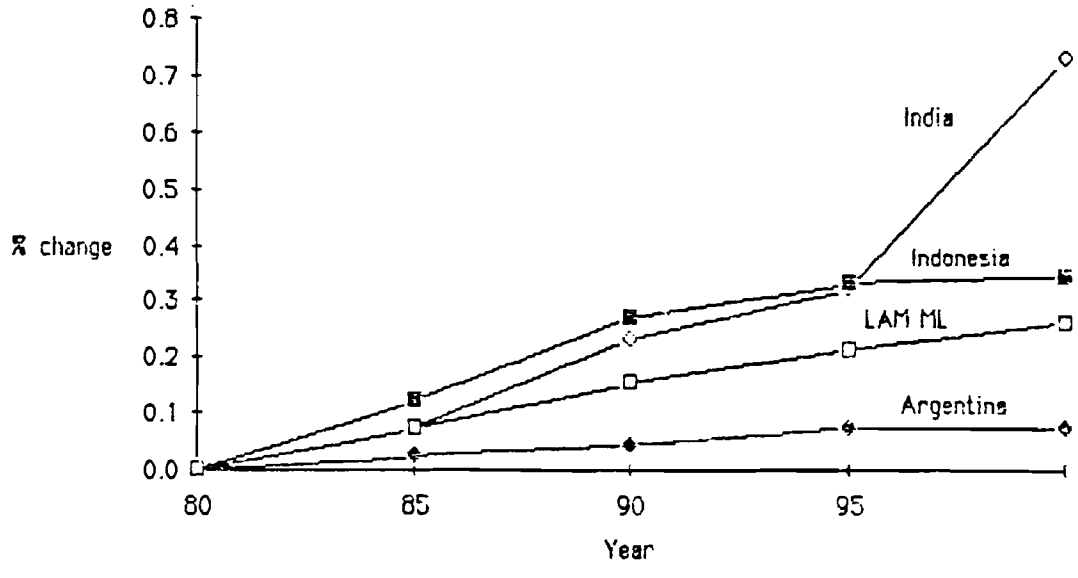


FIGURE 18

Equivalent Income Indicator (MARS 1 to R0)

A1

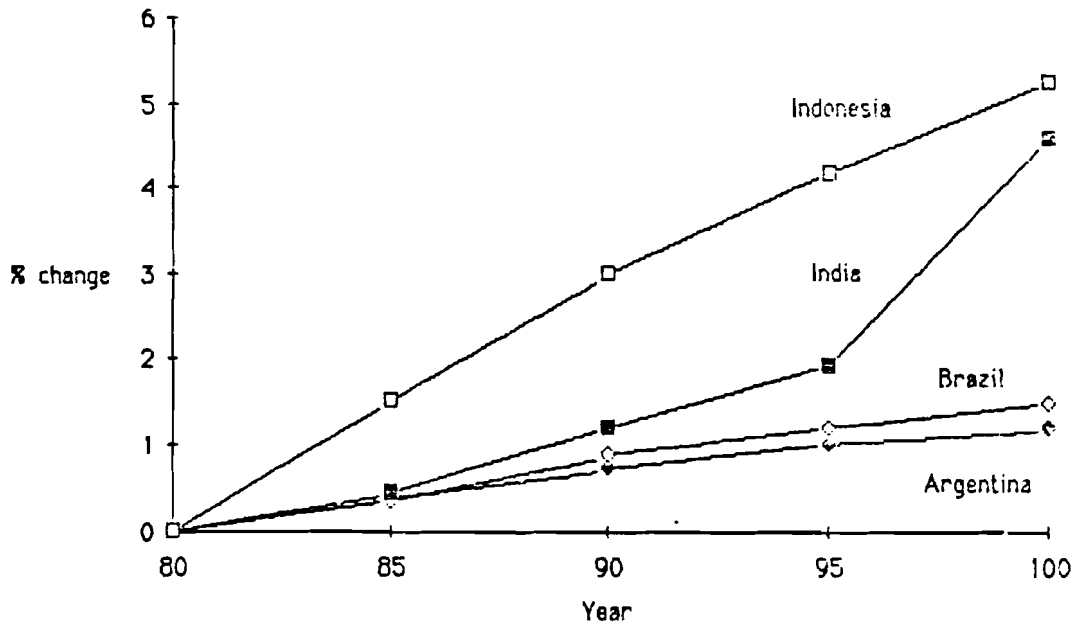


FIGURE 19

Number of People in Hunger (MARS 1 to R0)

A1

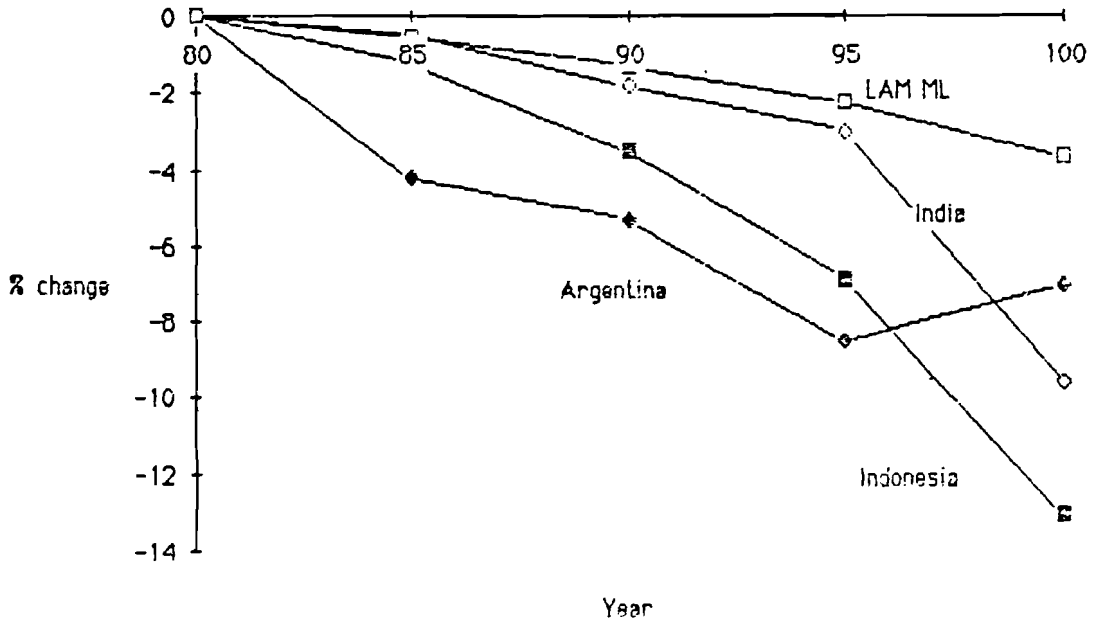
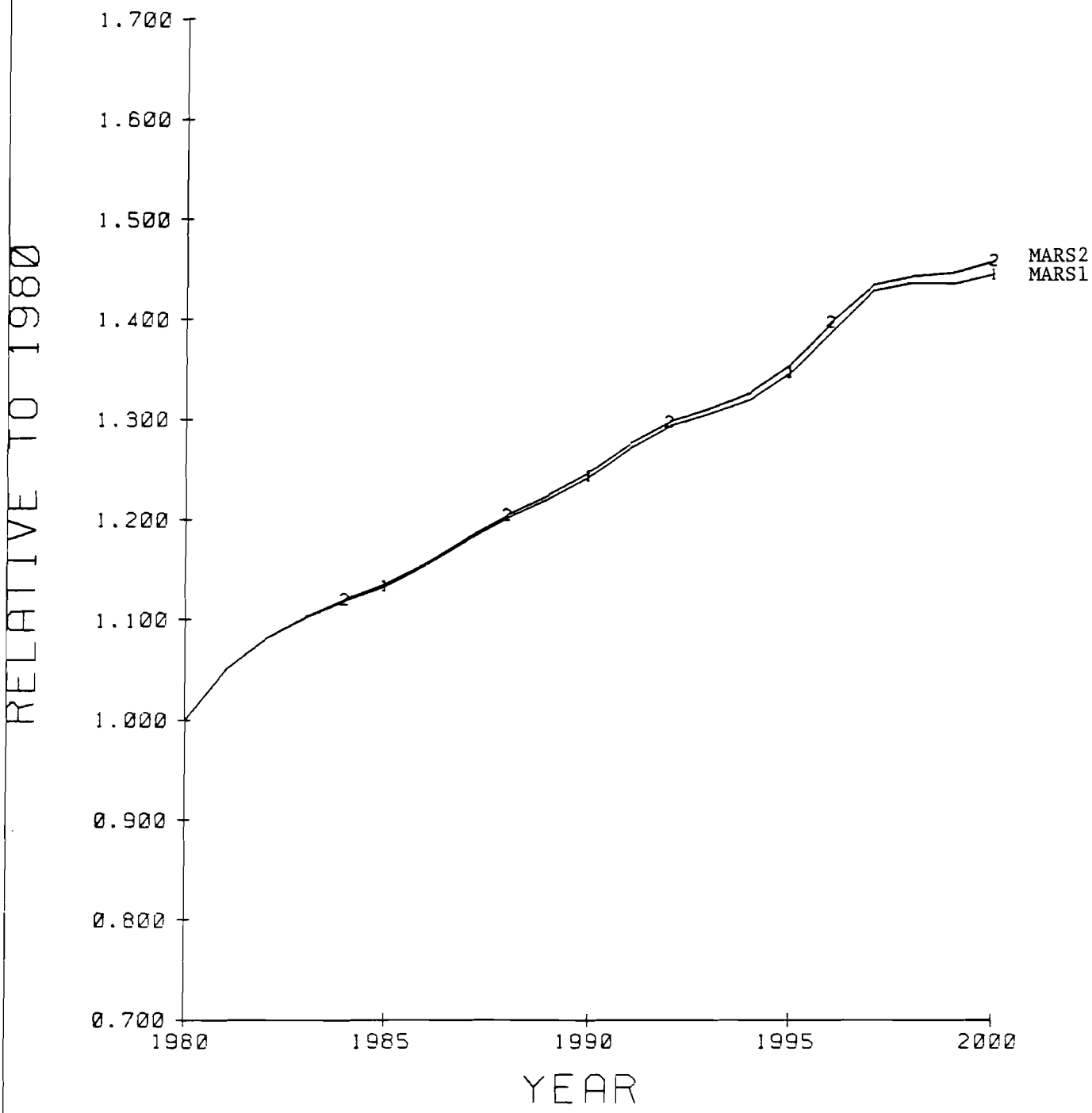


FIGURE 20

WORLD PRODUCTION
WHEAT



(V02)

FIGURE 21

WORLD PRODUCTION
RICE

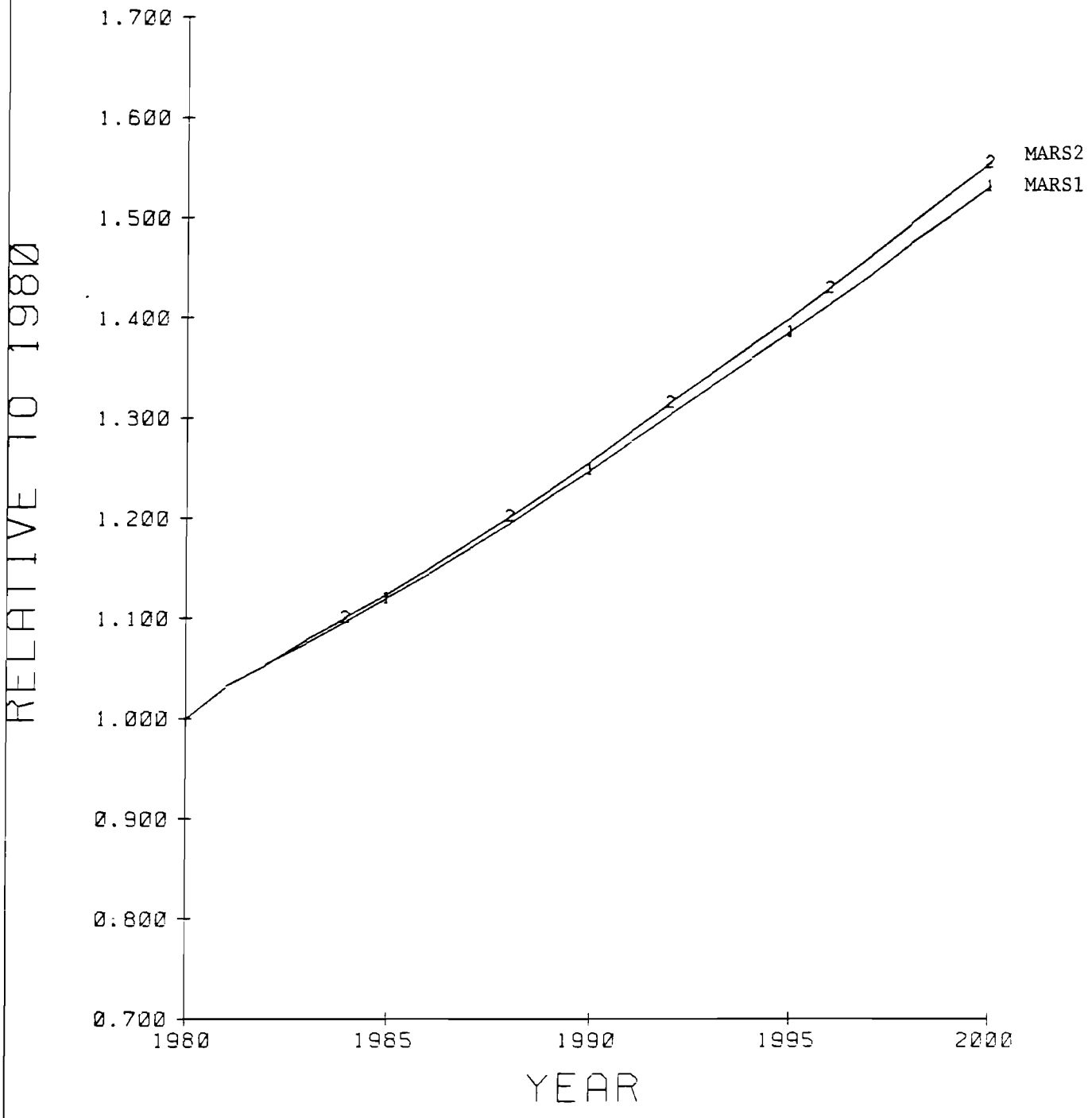
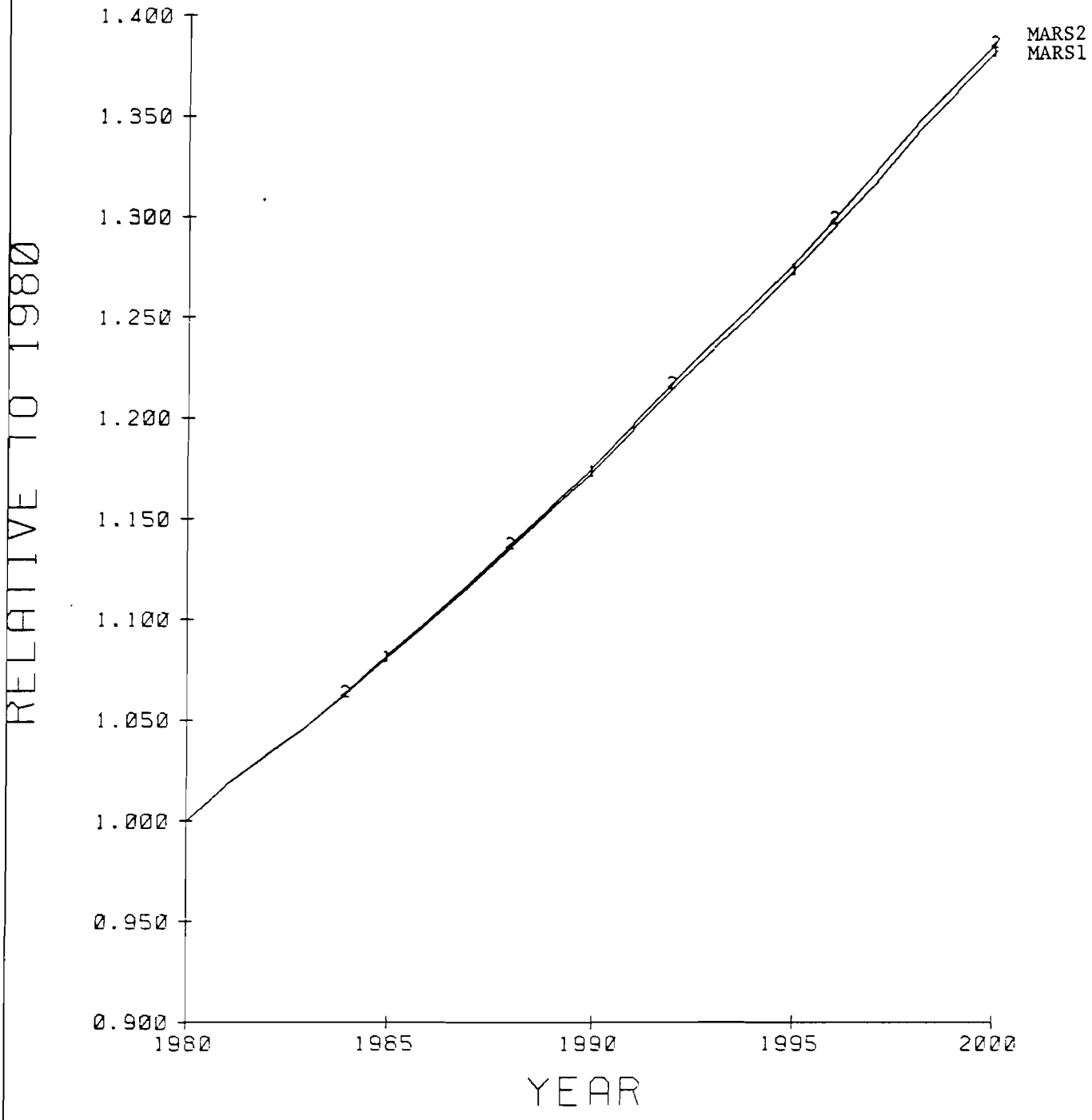


FIGURE 22

WORLD PRODUCTION
DAIRY

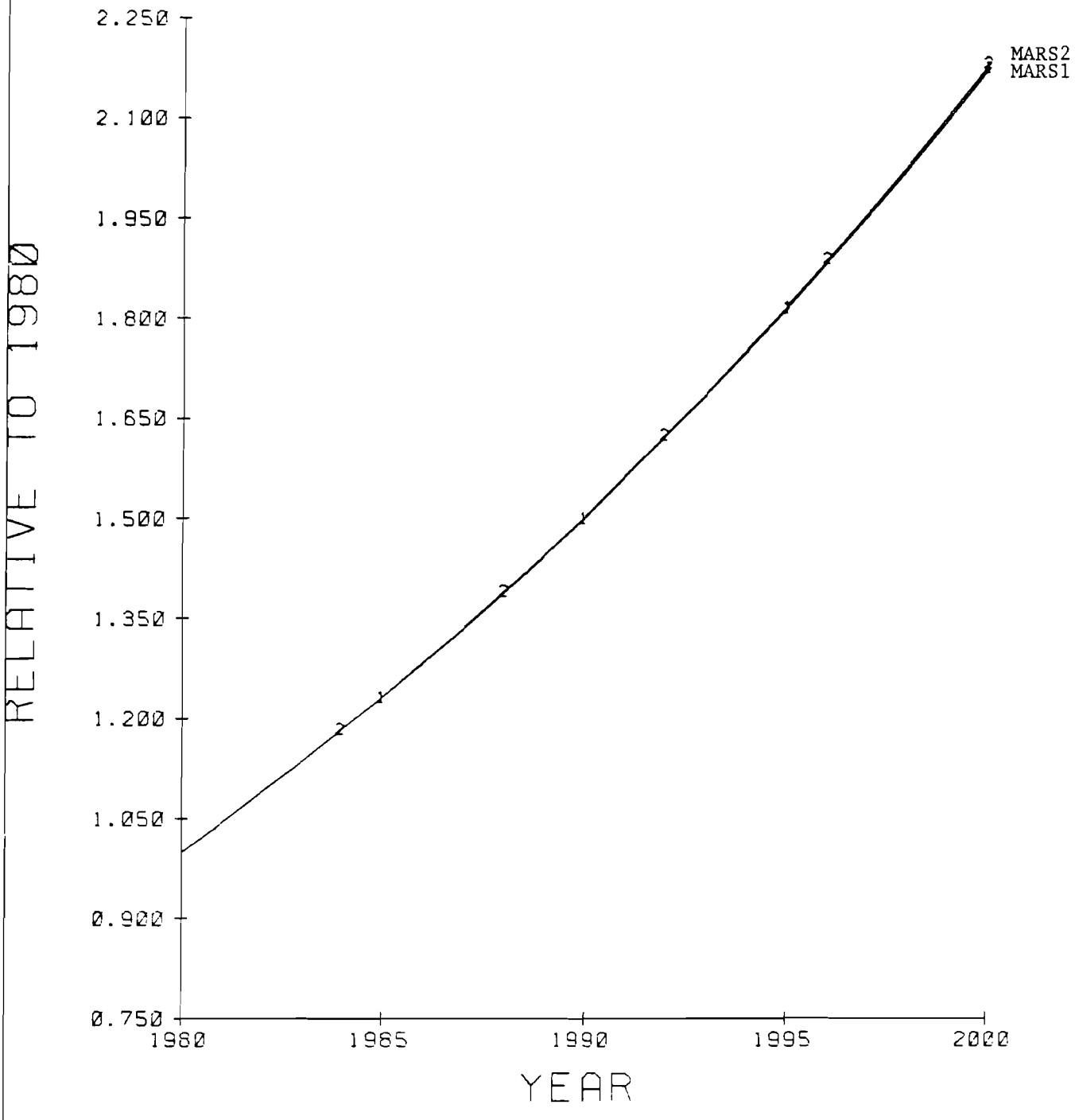


(V02)

1 R.1005A1
2 R.1005A4

FIGURE 23

WORLD PRODUCTION NON-AGRICULTURE

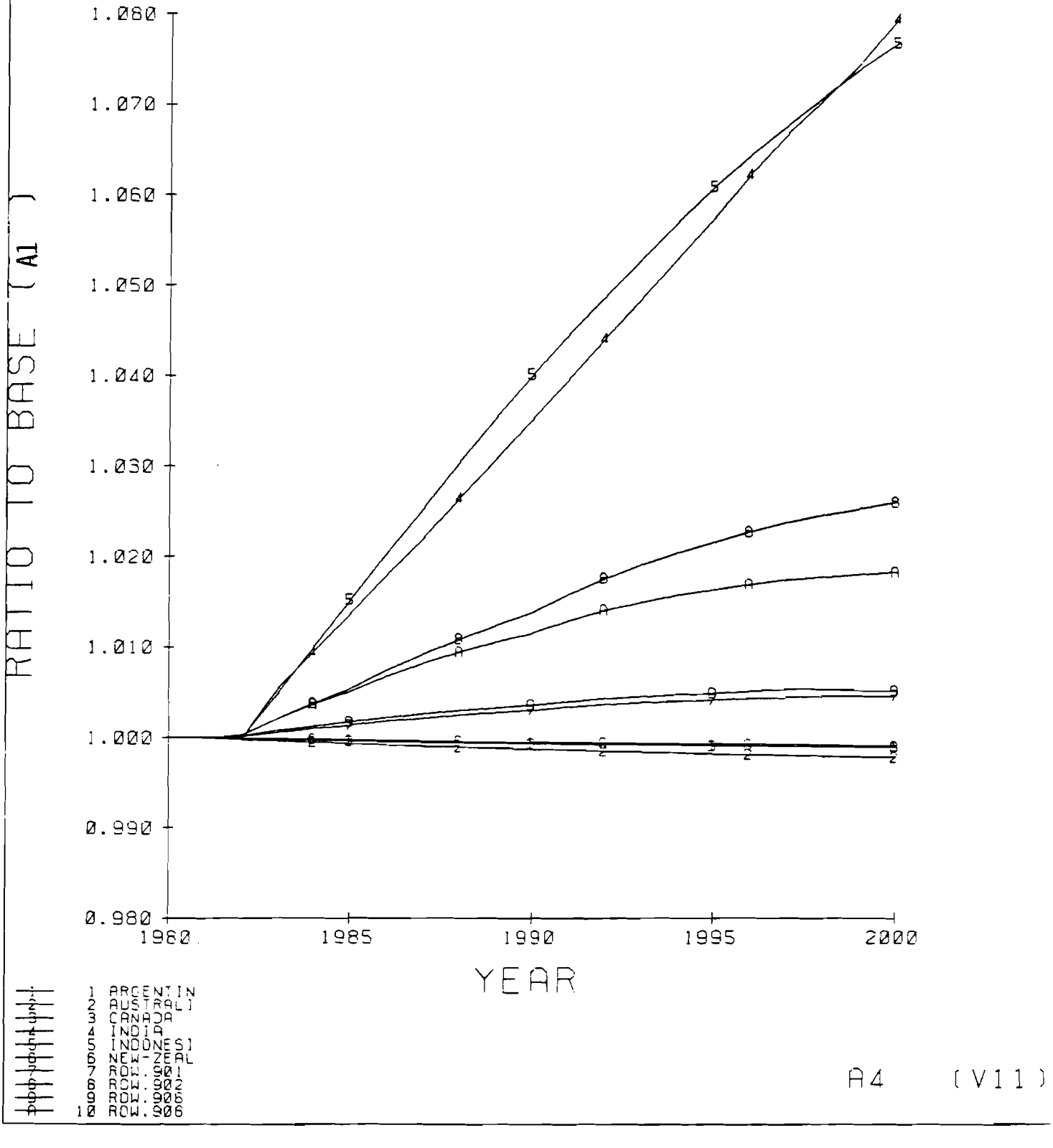


(V02)

FIGURE 24

GDP-70

(MARS2 to MARS1)



A4 (V11)

FIGURE 25

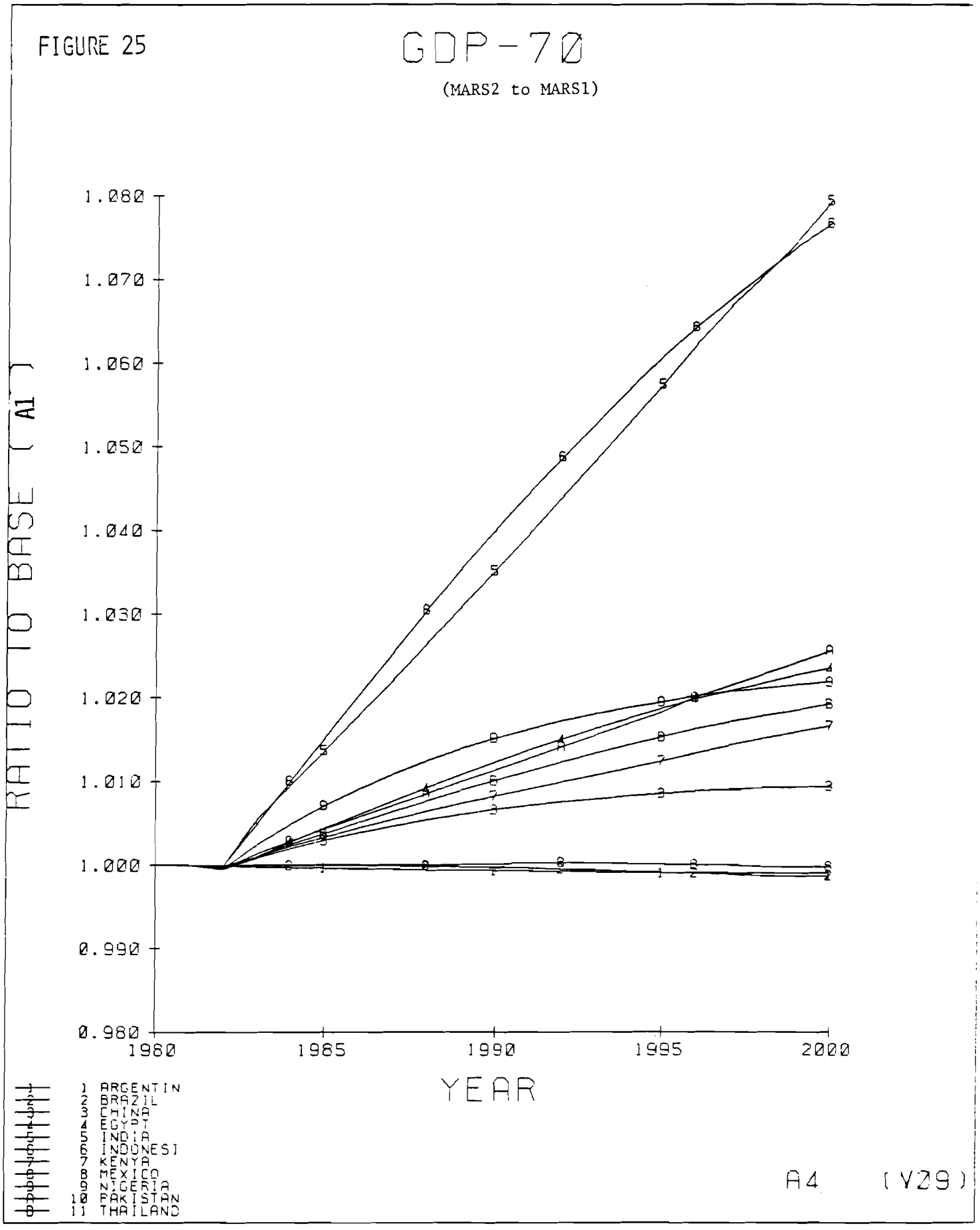
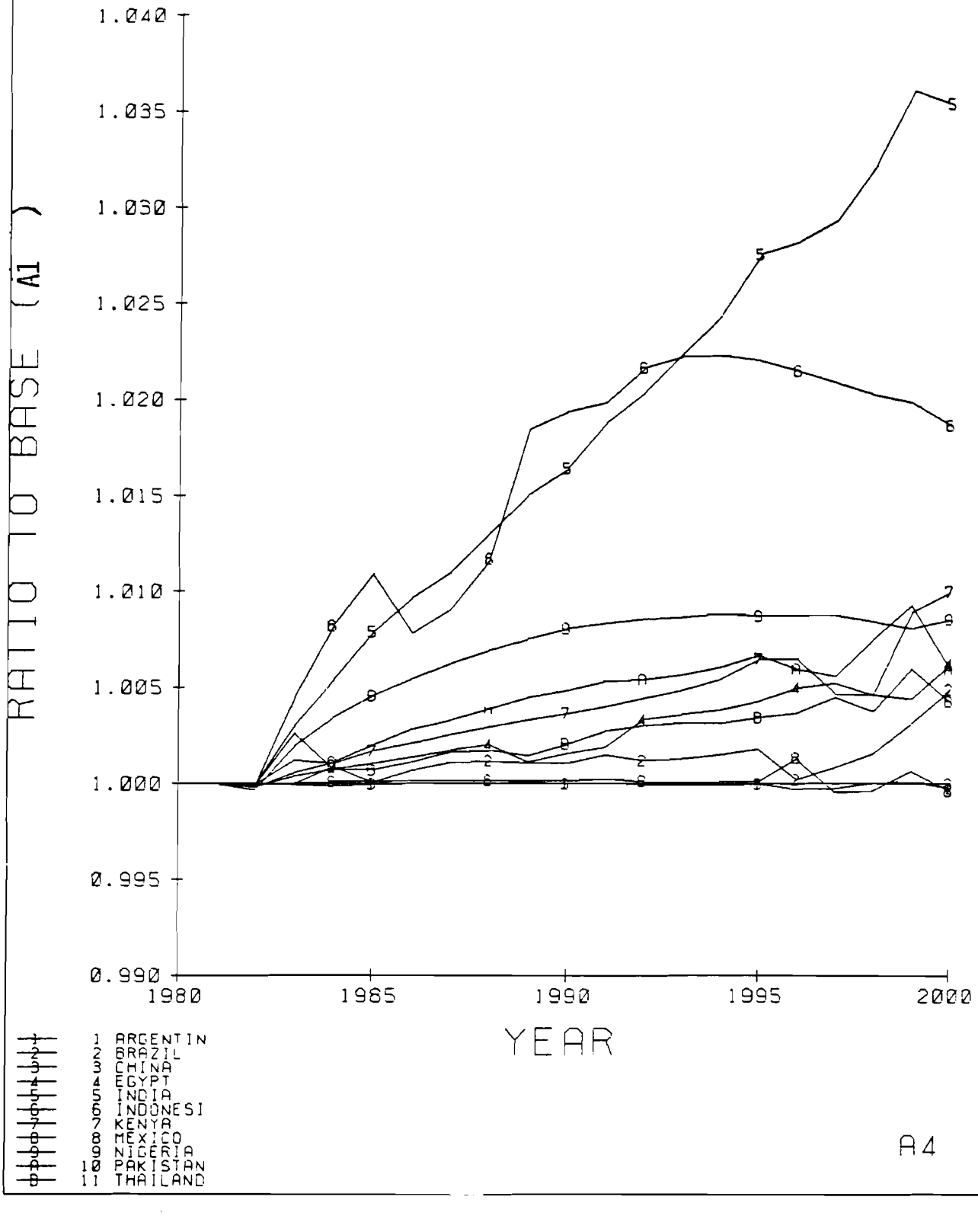

GDP-70
(MARS2 to MARS1)
RATIO TO BASE (A1)
1.080
1.070
1.060
1.050
1.040
1.030
1.020
1.010
1.000
0.990
0.980
1980
1985
1990
1995
2000
YEAR
1 ARGENTIN
2 BRAZIL
3 CHINA
4 EGYPT
5 INDIA
6 INDONESI
7 KENYA
8 MEXICO
9 NIGERIA
10 PAKISTAN
11 THAILAND
A4 (V29)

FIGURE 26 CALORIES PER CAPUT

(MARS2 to MARS1)



A4 (V07)

FIGURE 27

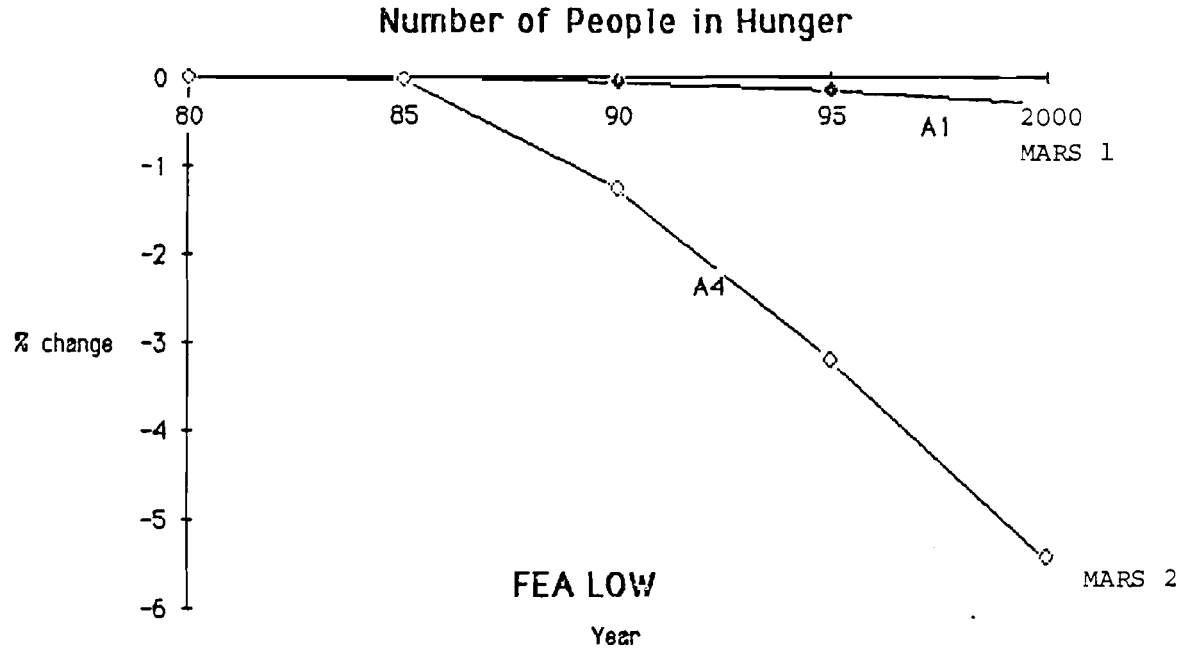


FIGURE 28

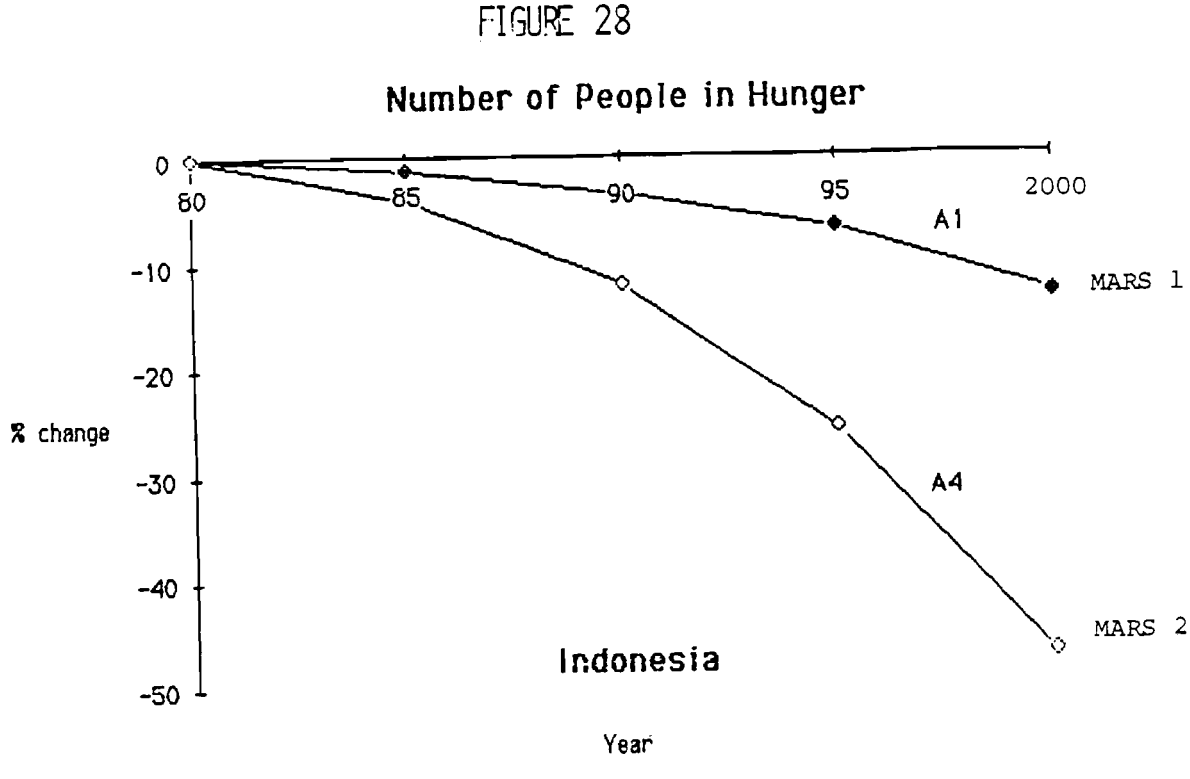


FIGURE 29

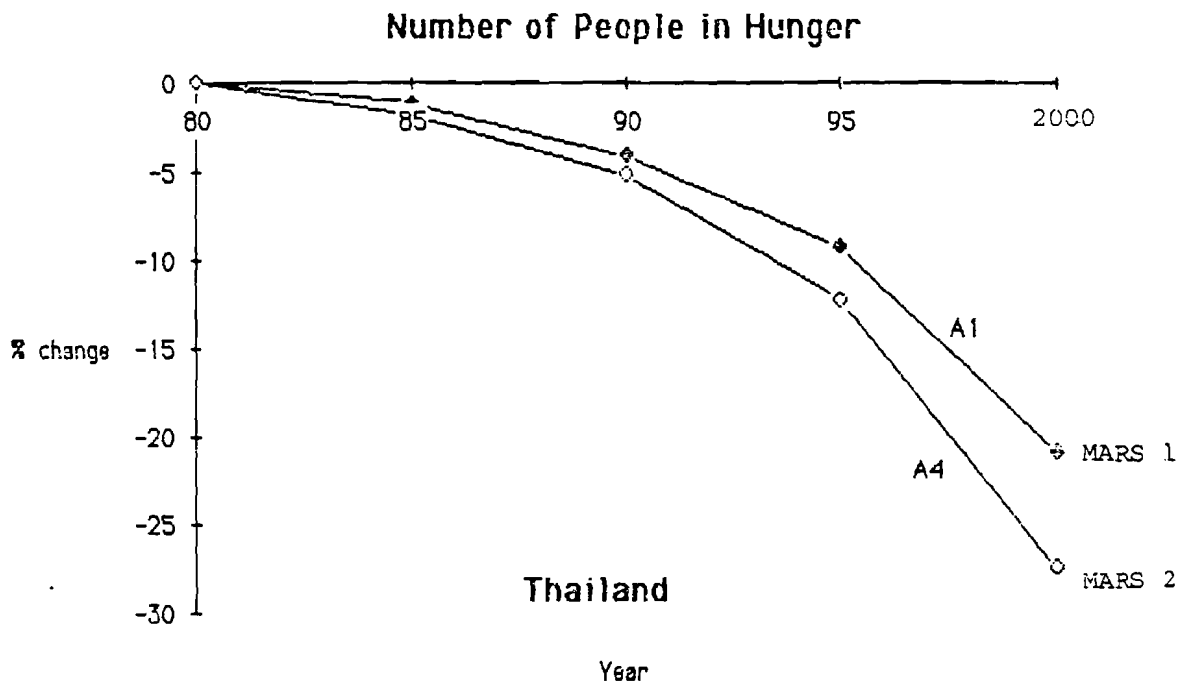


FIGURE 30

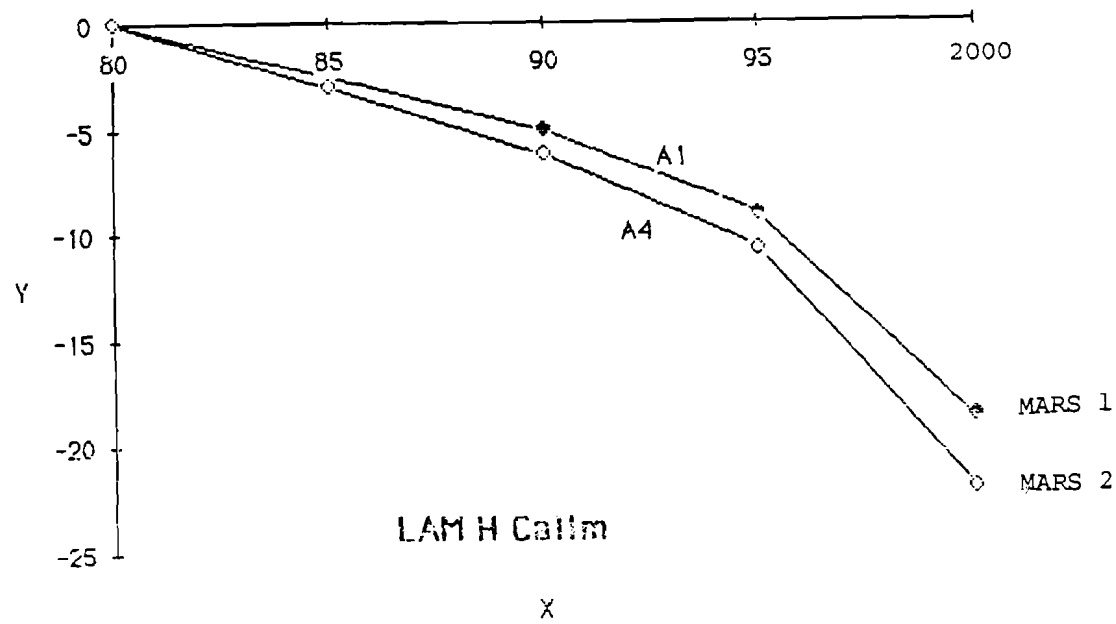


FIGURE 31

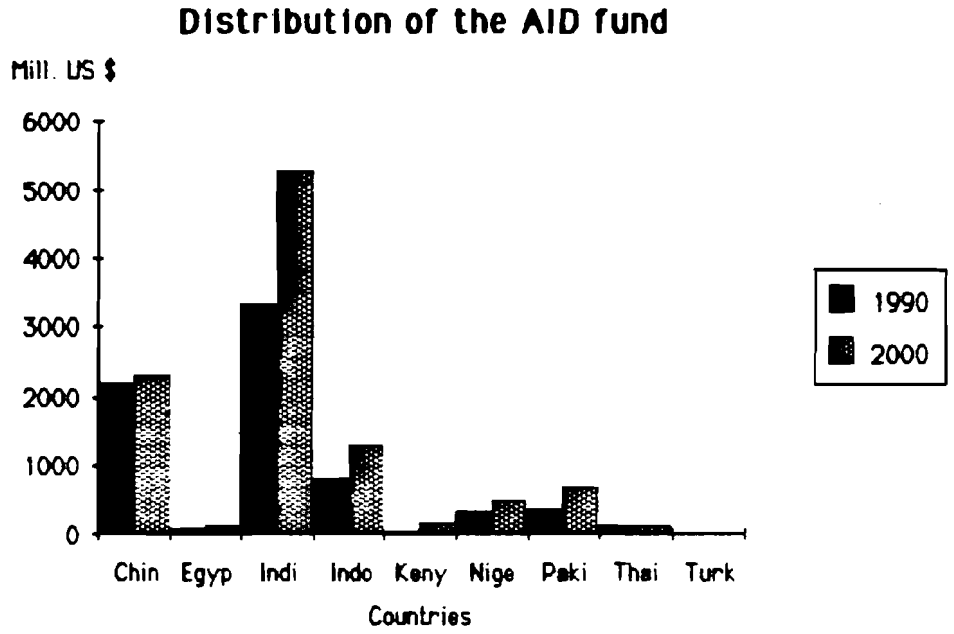


FIGURE 32

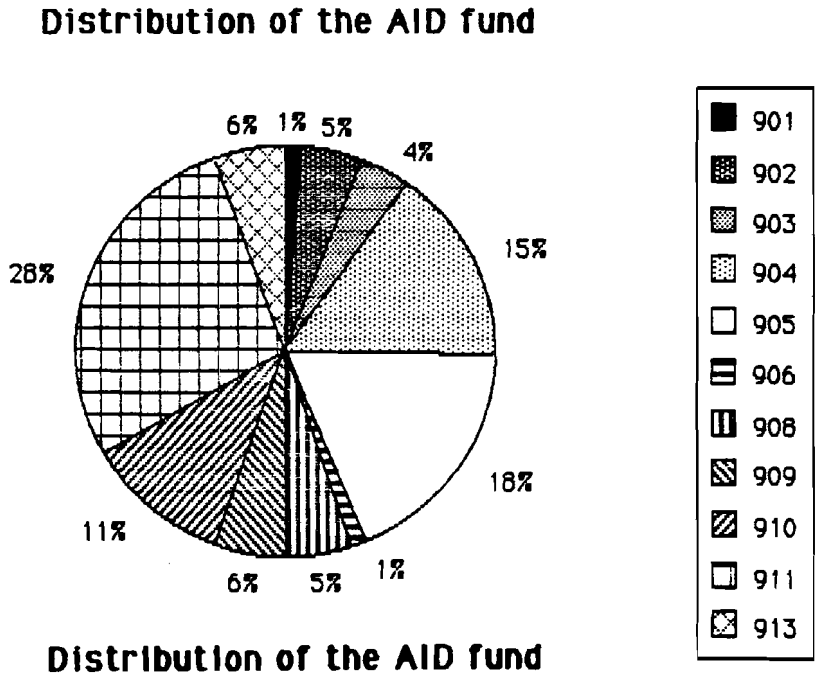


FIGURE 33

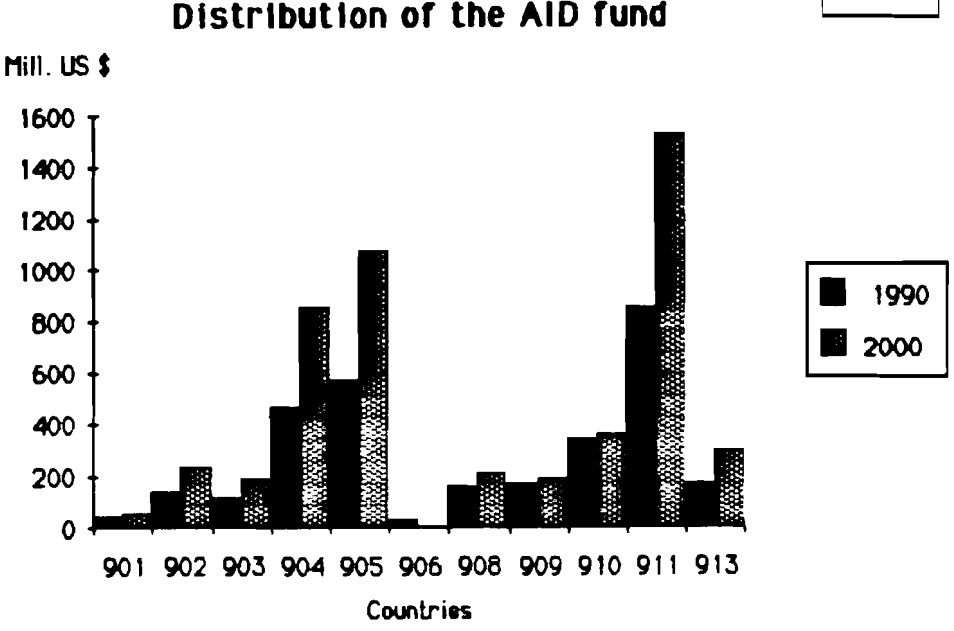
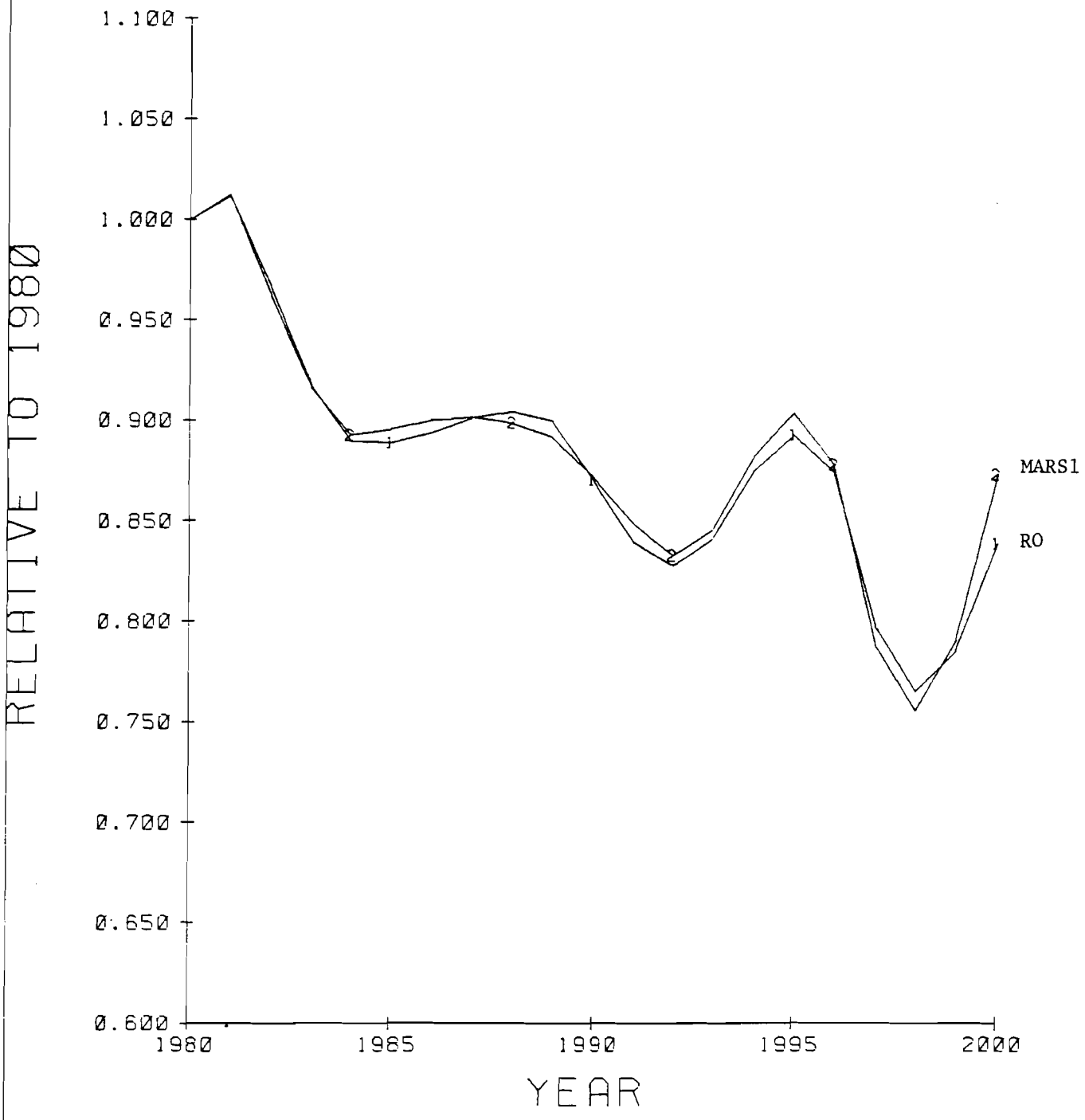


FIGURE 34

WORLD PRICES / WORLD NONAGR. PRICE WHEAT



(V05)

1 R.1005R0
2 R.1005A1

FIGURE 35

WORLD PRICES / WORLD NONAGR. PRICE WHEAT

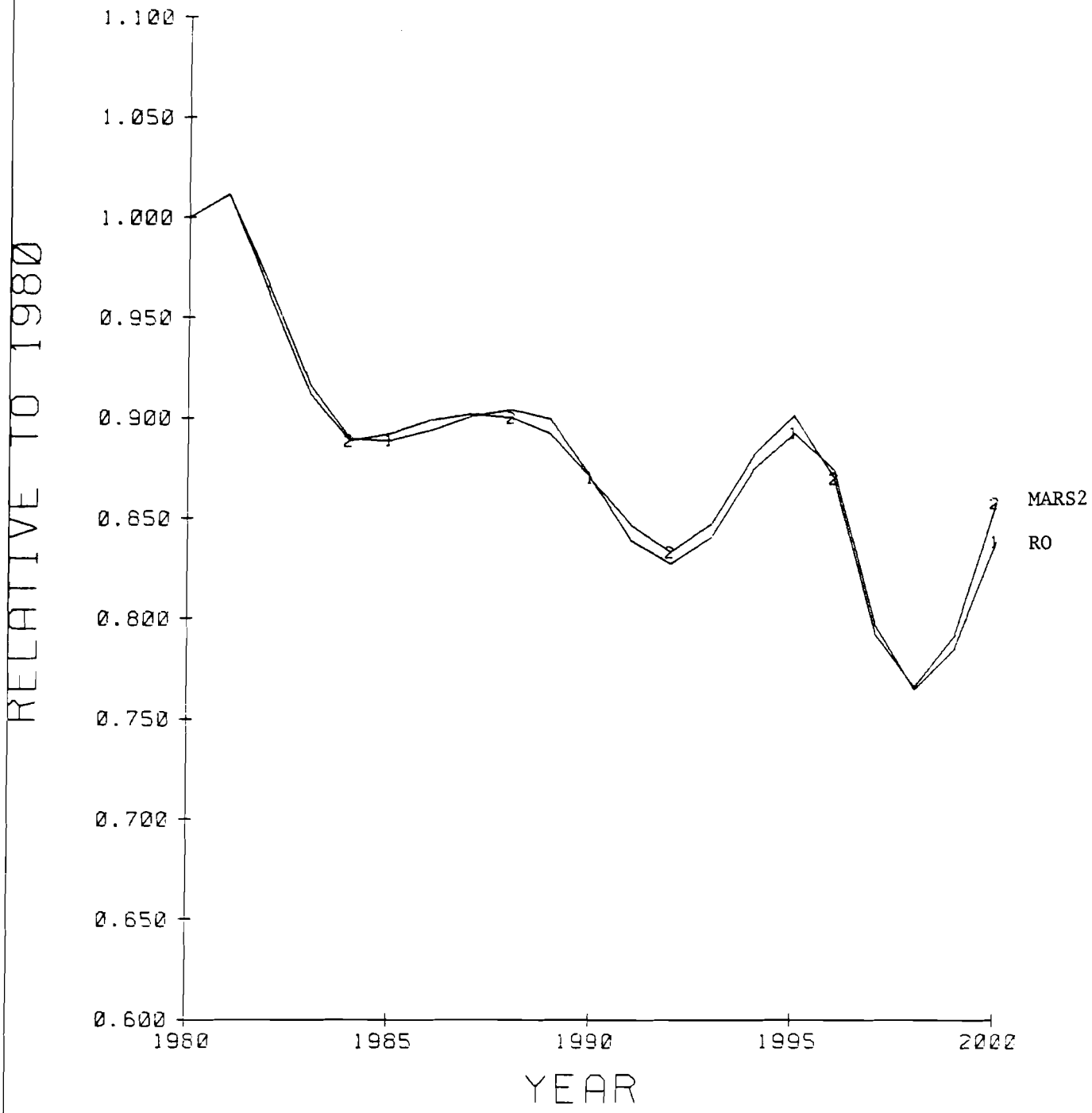


FIGURE 36

WORLD EXPORTS
WHEAT

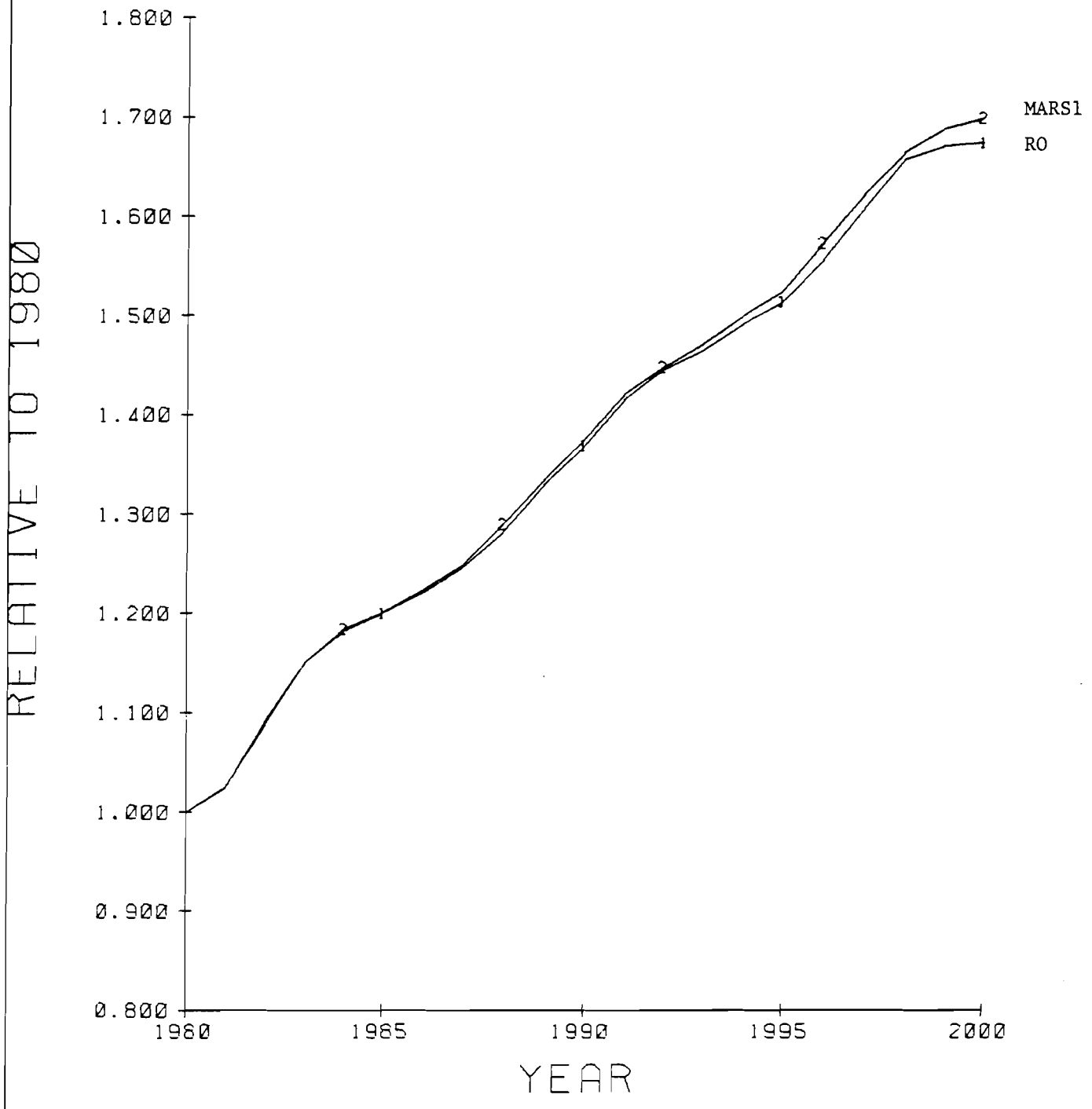
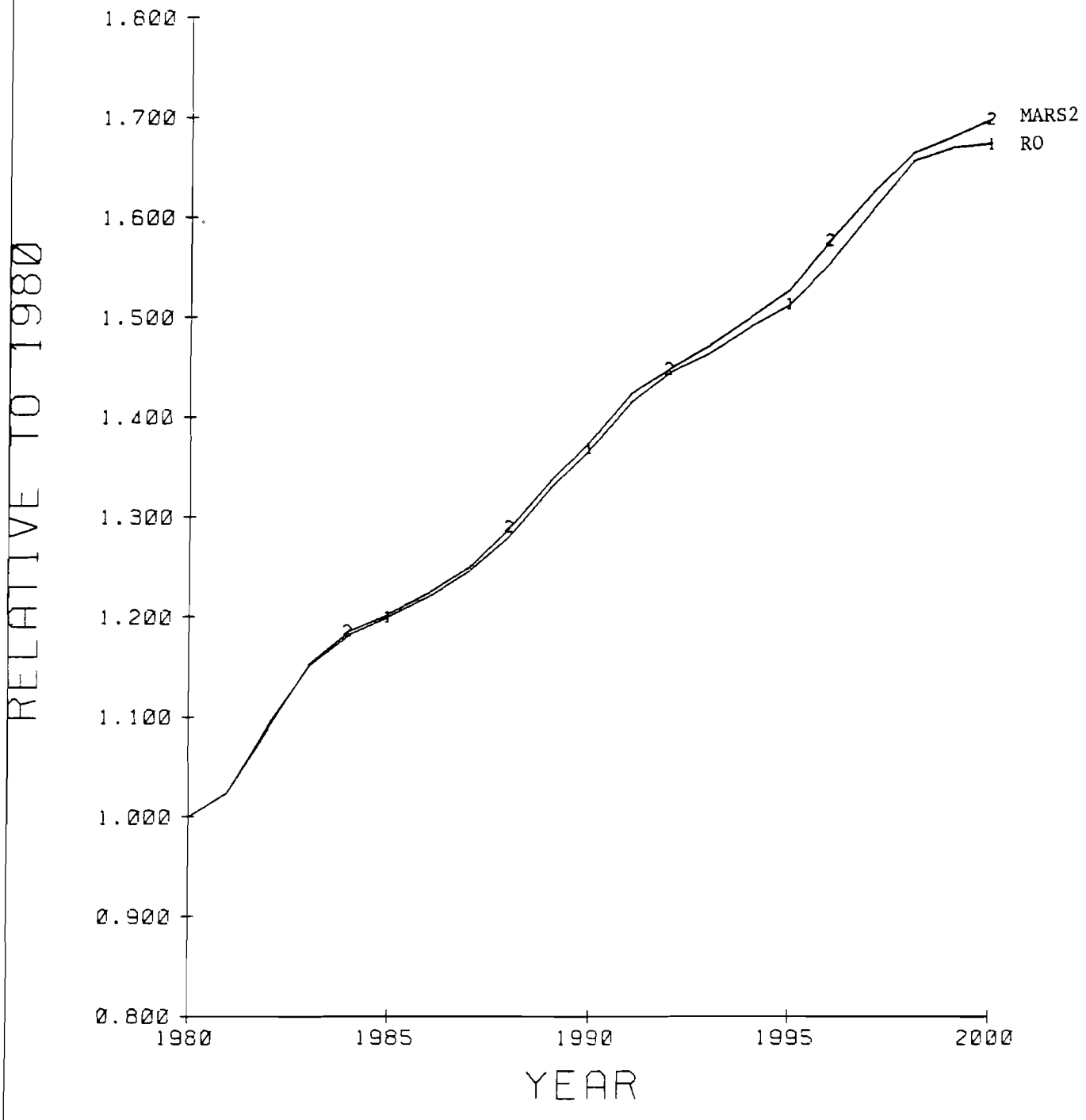


FIGURE 37

WORLD EXPORTS
WHEAT



(V03)

FIGURE 38

WORLD PRICES / WORLD NONAGR. PRICE WHEAT

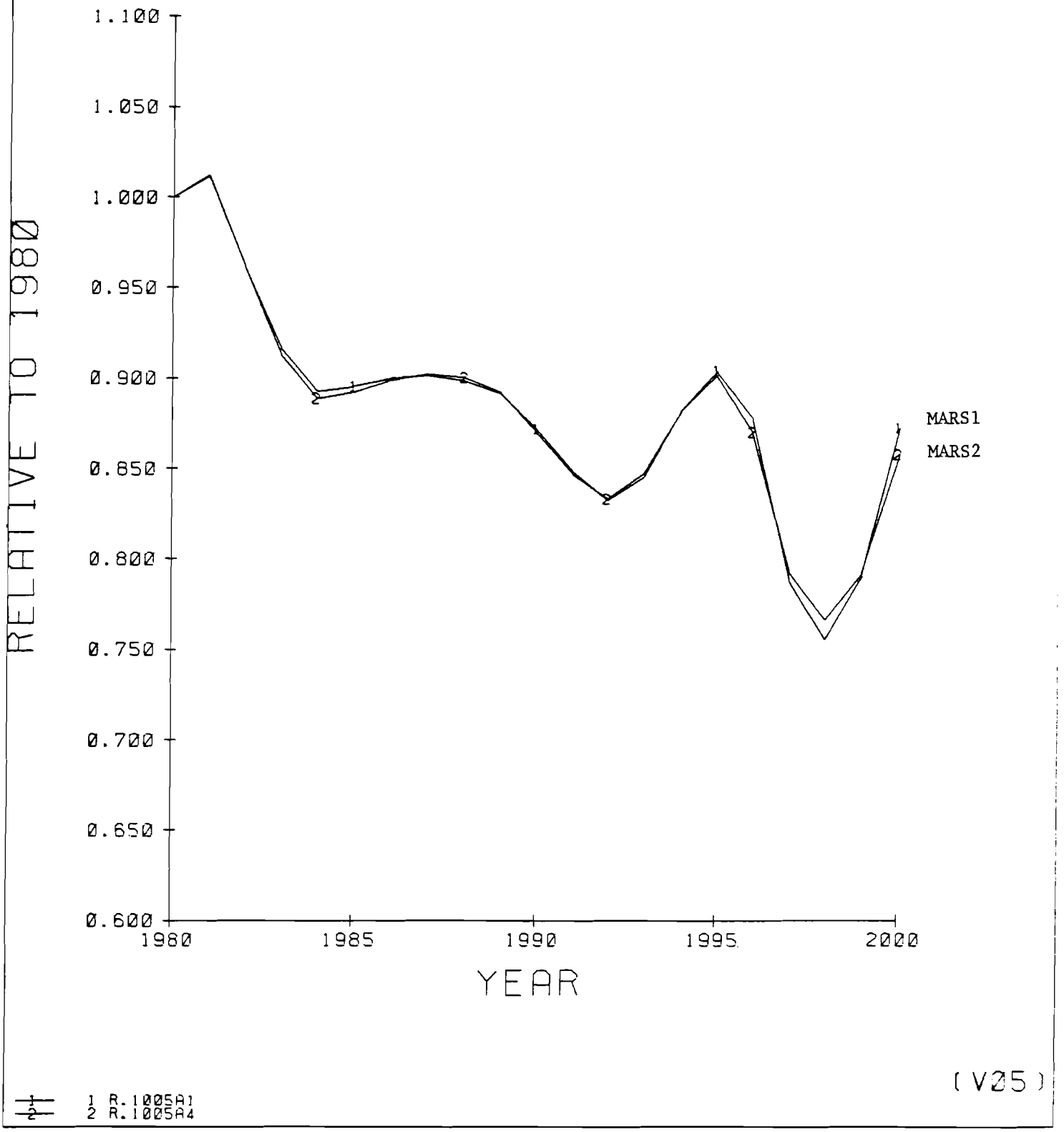
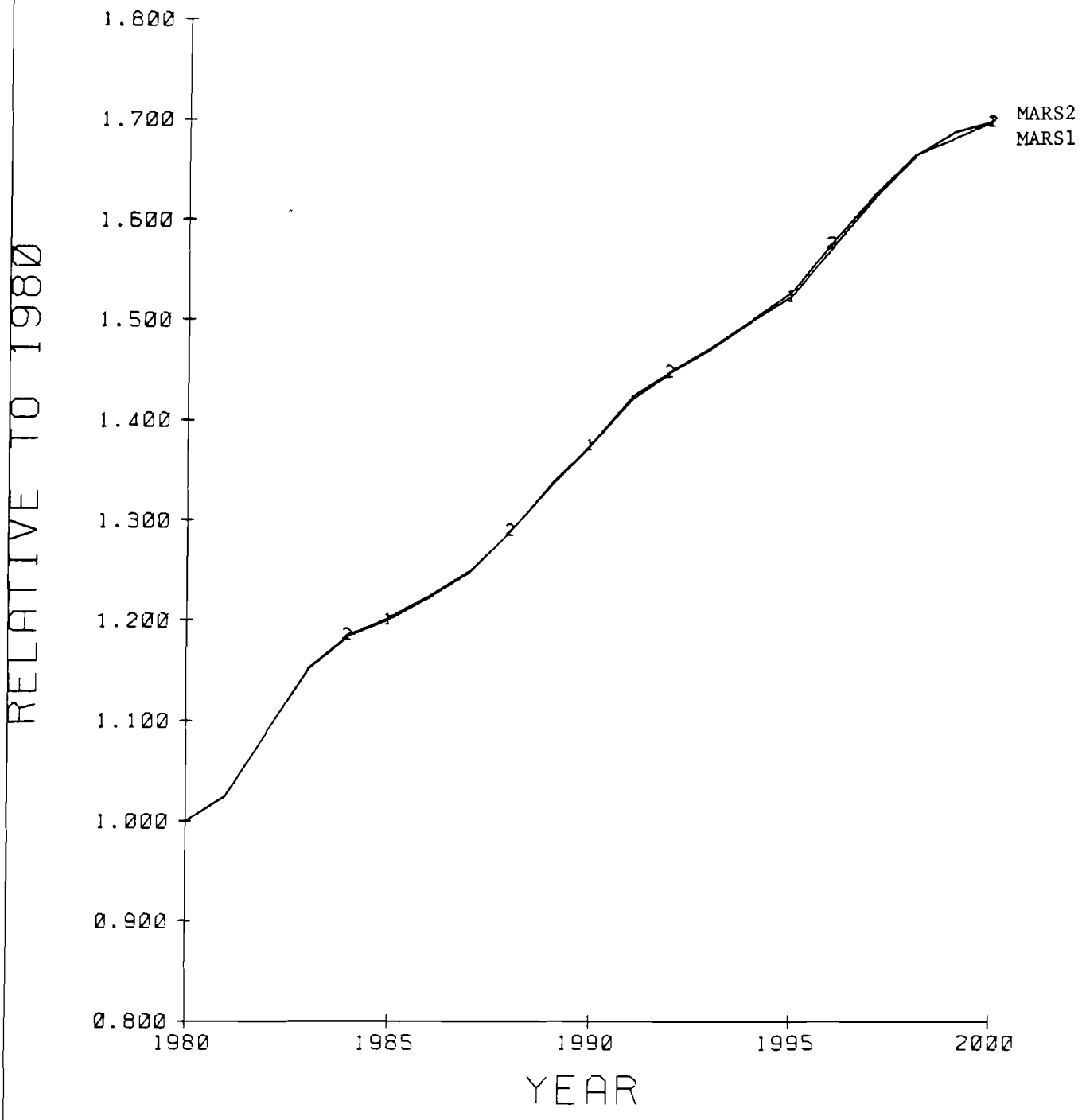


FIGURE 39

WORLD EXPORTS
WHEAT



(V03)

FIGURE 40

WORLD PRICES / WORLD NONAGR. PRICE DAIRY

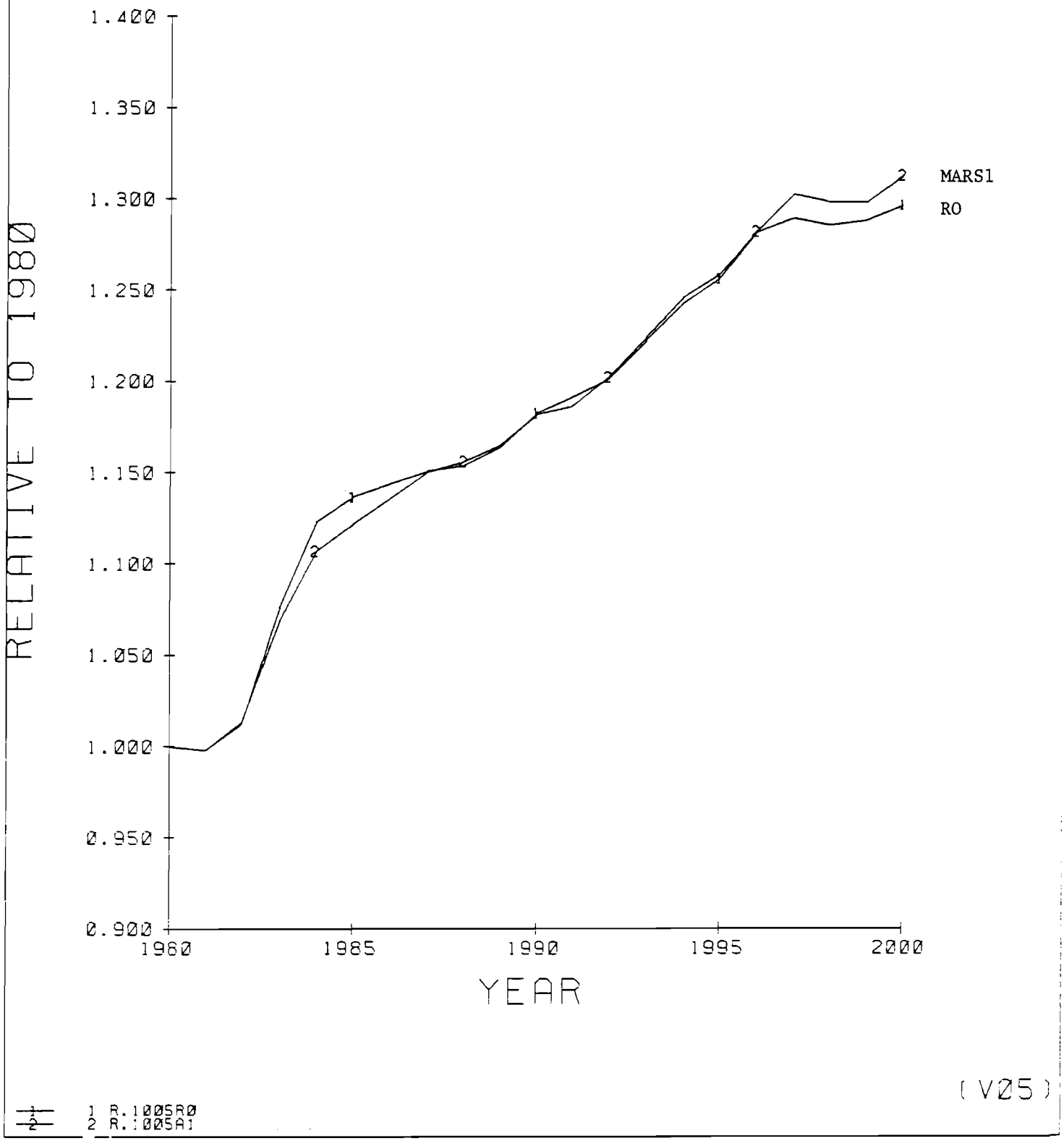


FIGURE 41

WORLD PRICES / WORLD NONAGR. PRICE DAIRY

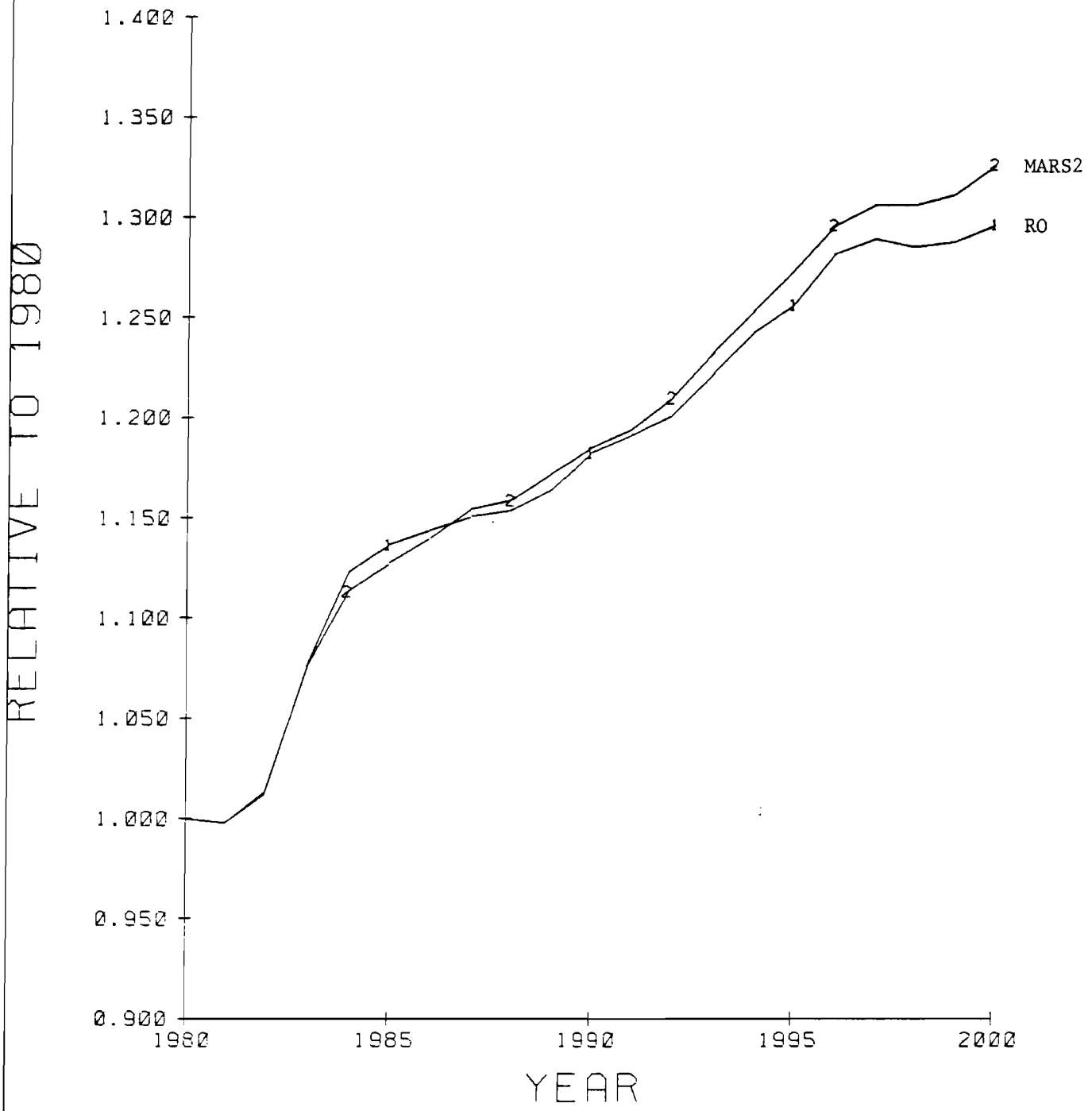


FIGURE 42

WORLD EXPORTS
DAIRY

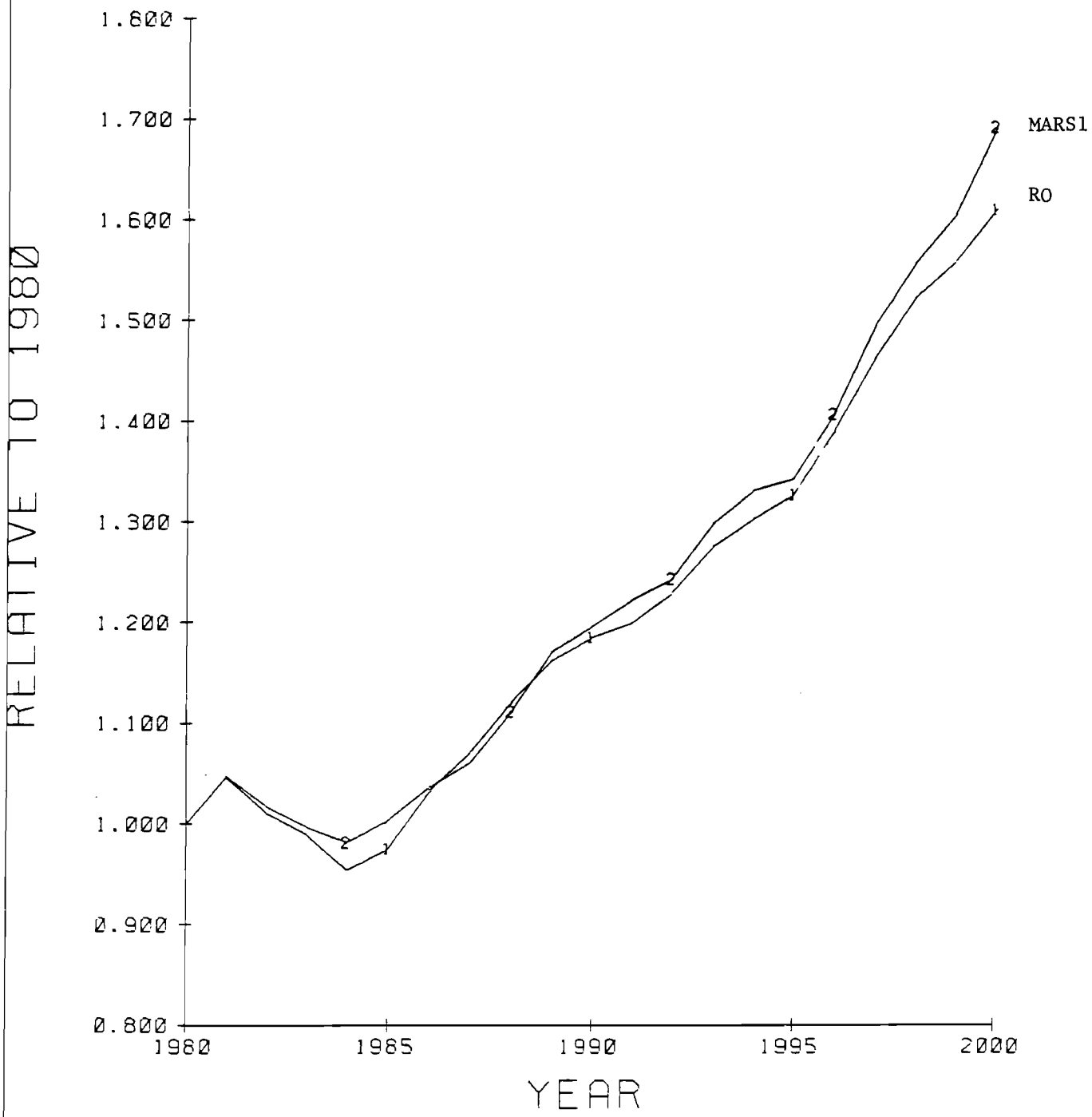
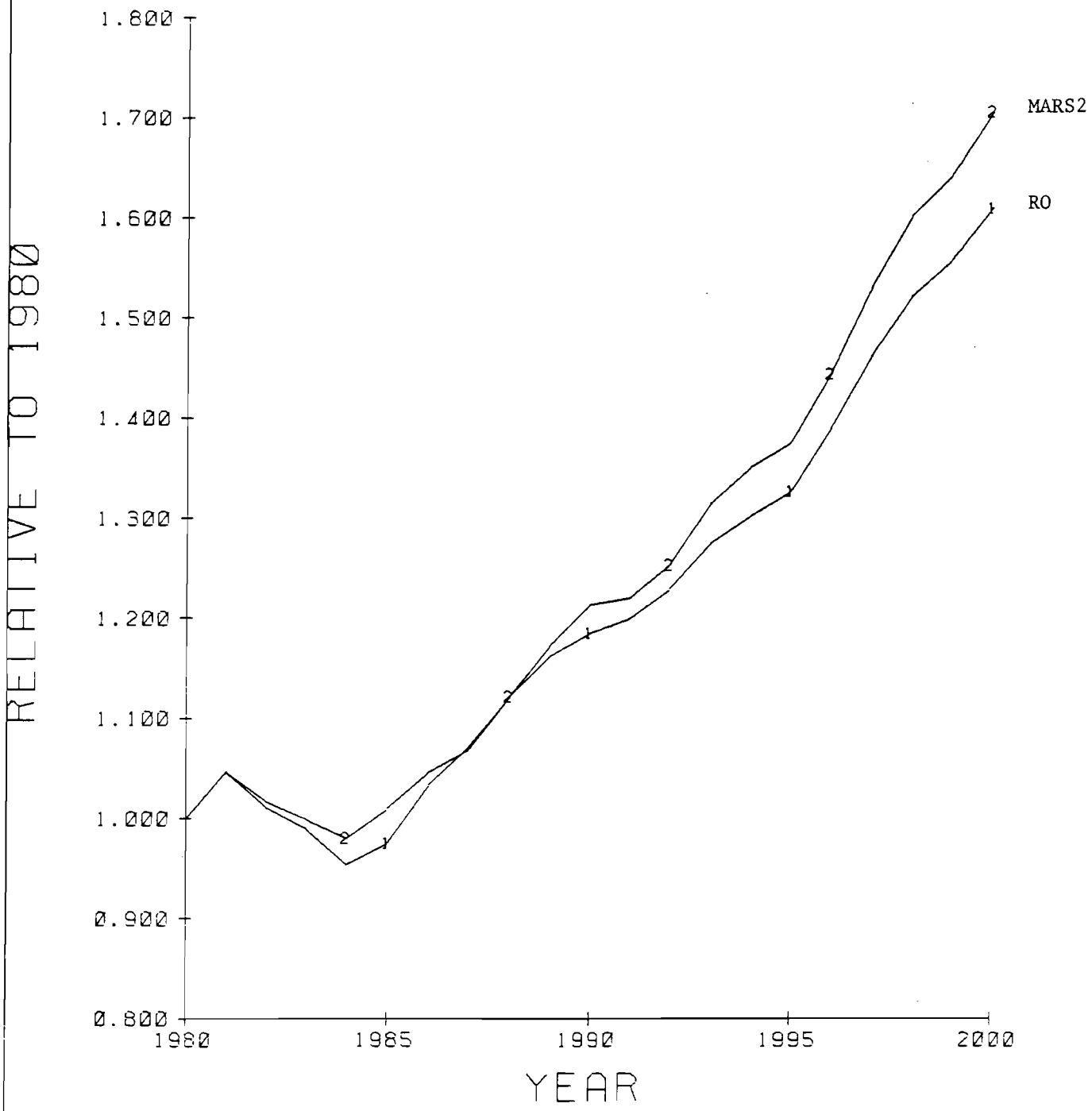


FIGURE 43

WORLD EXPORTS
DAIRY



[V03]

FIGURE 44

WORLD PRICES / WORLD NONAGR. PRICE DAIRY

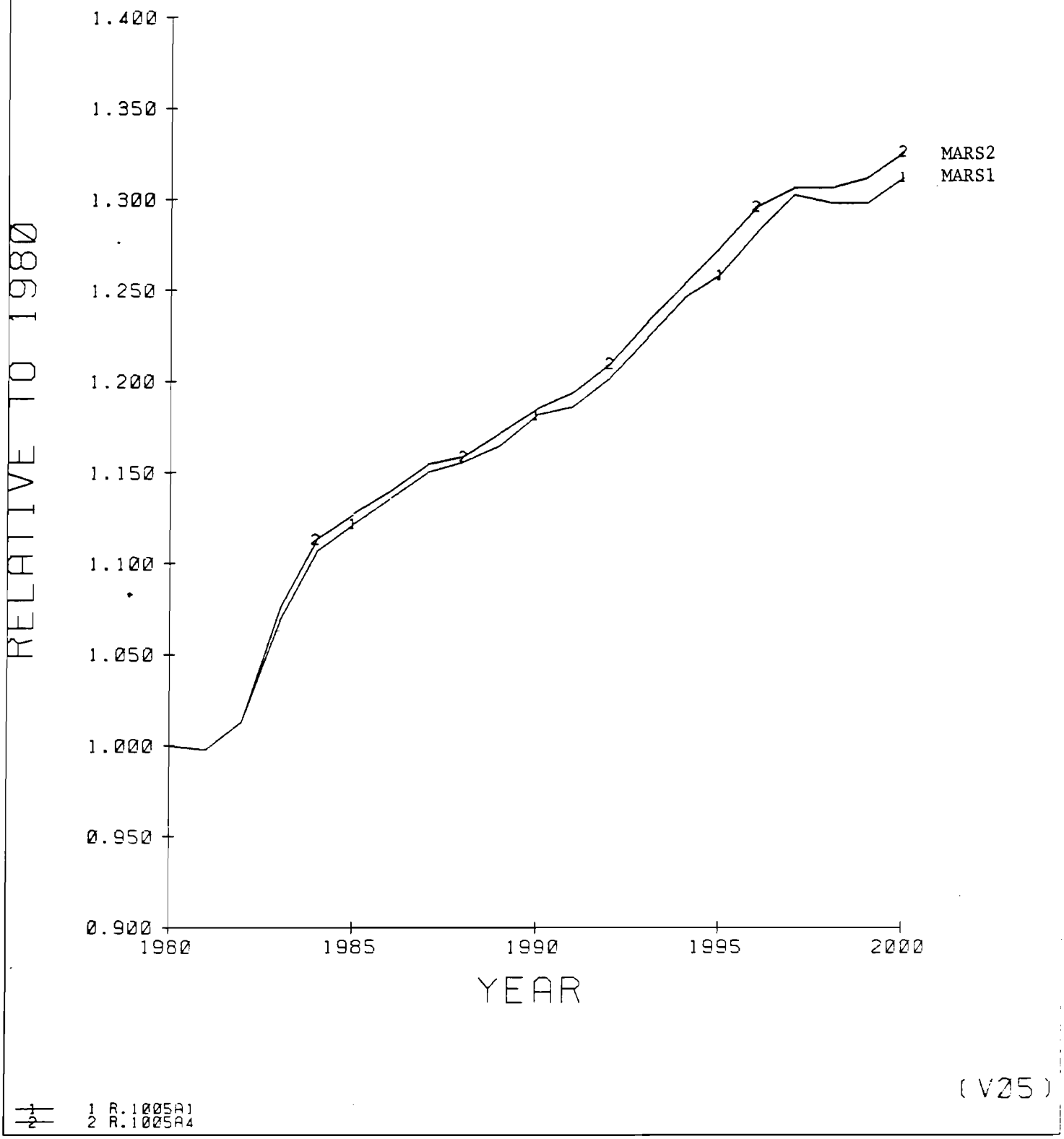
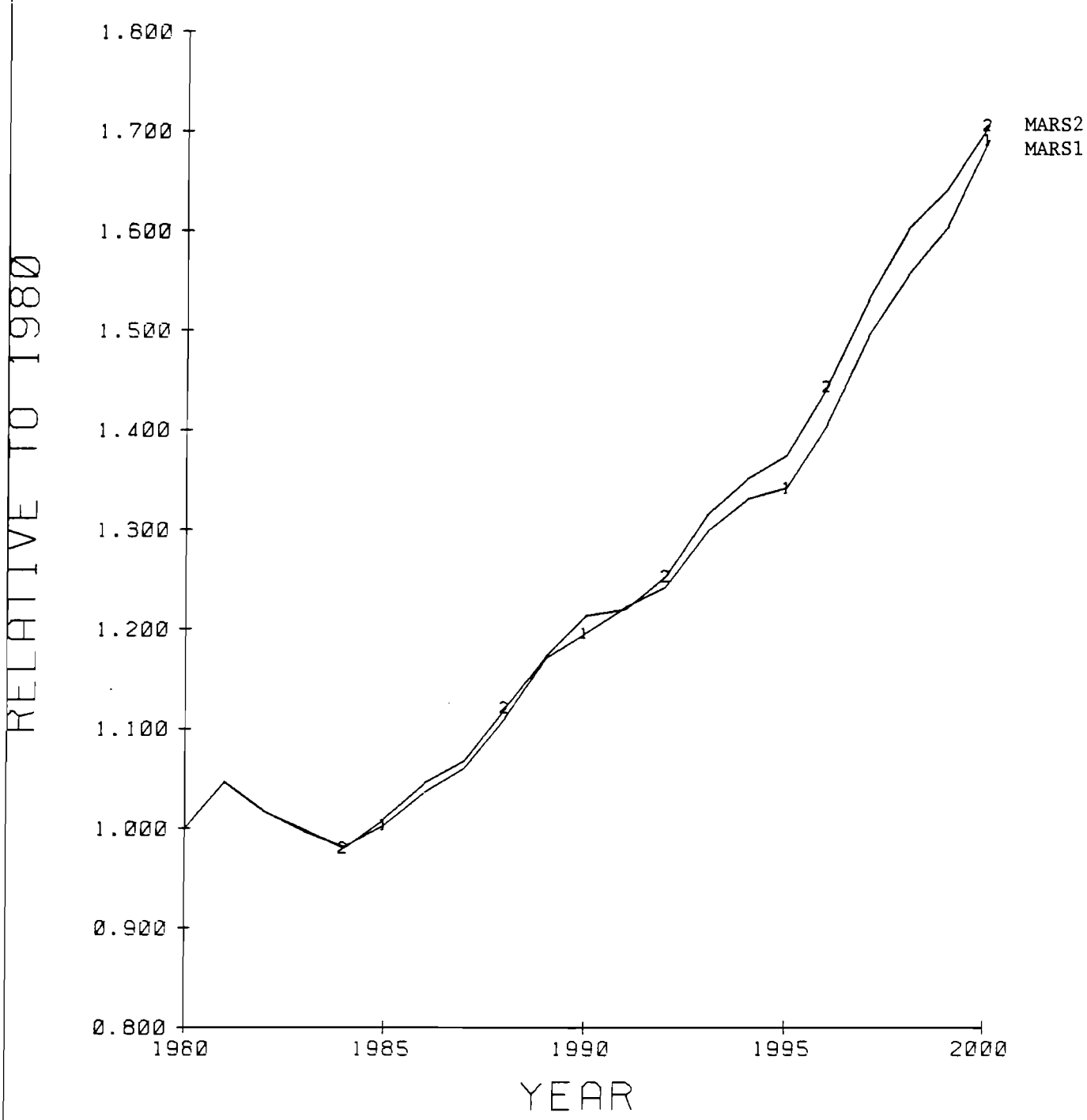


FIGURE 45

WORLD EXPORTS
DAIRY



(V03)

FIGURE 46

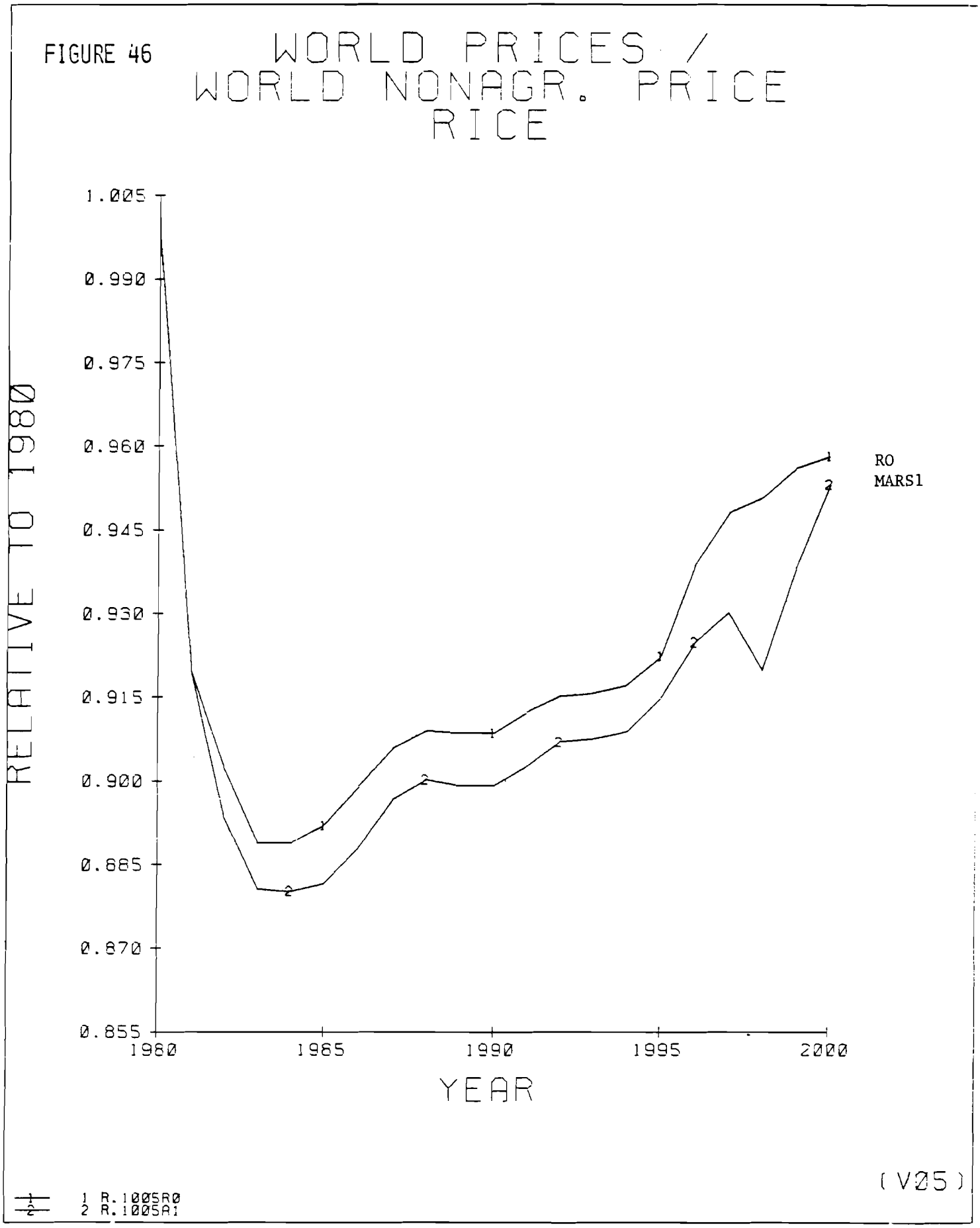

WORLD PRICES /
WORLD NONAGR. PRICE
RICE
RELATIVE TO 1980
1.005
0.990
0.975
0.960
0.945
0.930
0.915
0.900
0.885
0.870
0.855
1980
1985
1990
1995
2000
YEAR
RO
MARS1
1 R.1005R0
2 R.1005A1
(V05)

FIGURE 47

WORLD PRICES / WORLD NONAGR. PRICE RICE

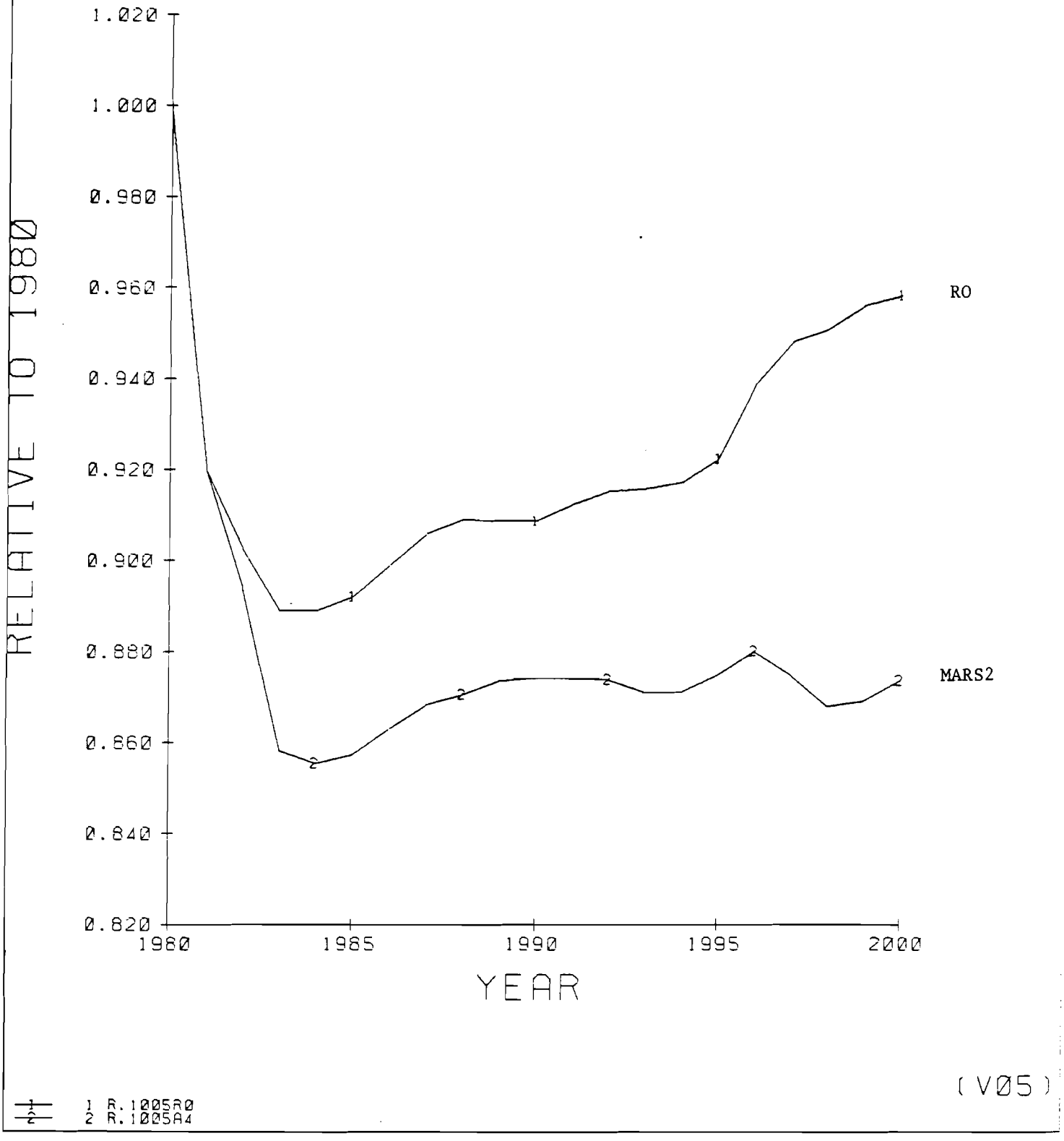


FIGURE 48

WORLD EXPORTS
RICE

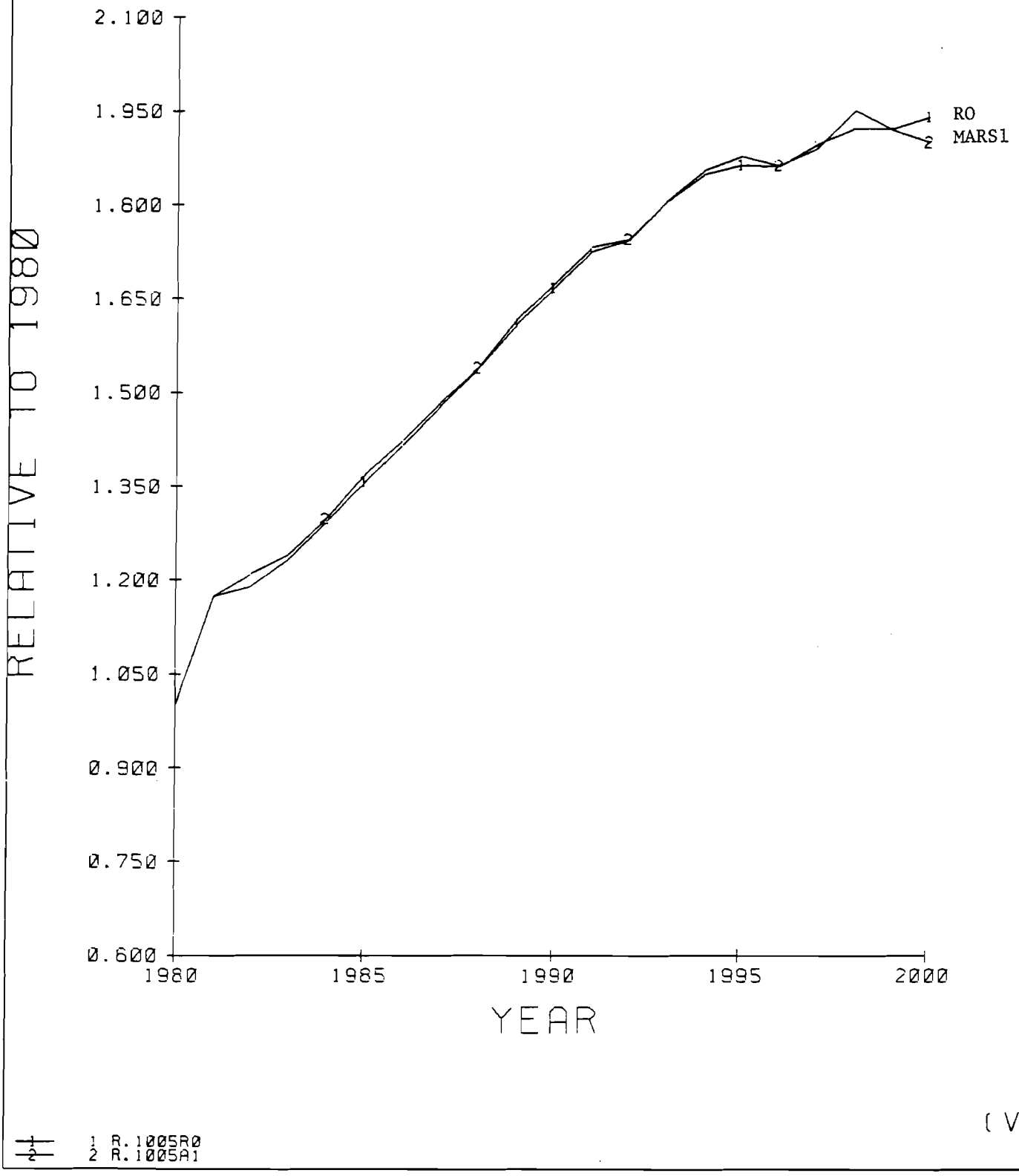


FIGURE 49

WORLD EXPORTS
RICE

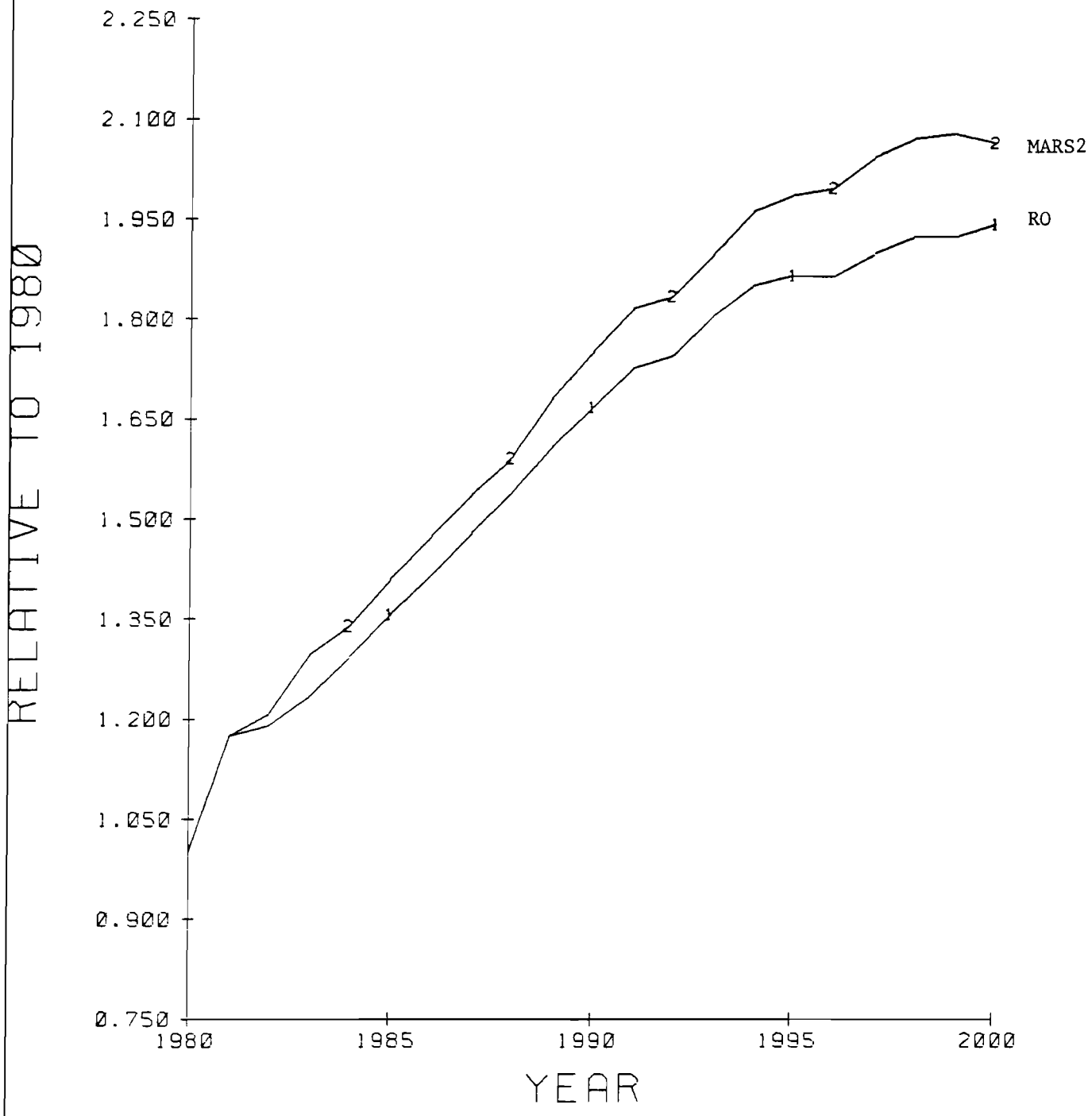


FIGURE 50

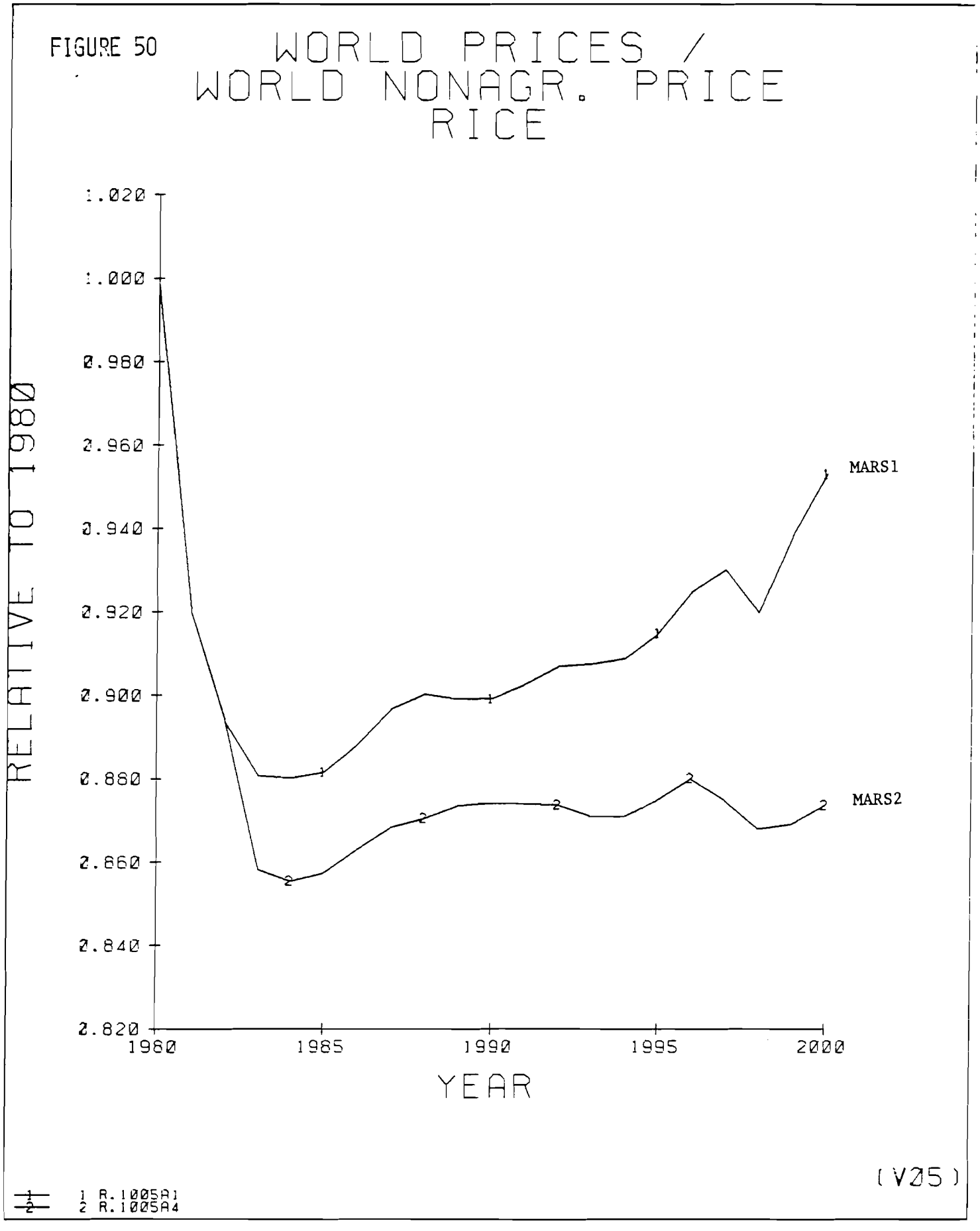

WORLD PRICES /
WORLD NONAGR. PRICE
RICE
RELATIVE TO 1980
1.020
1.000
0.980
0.960
0.940
0.920
0.900
0.880
0.860
0.840
0.820
1980
1985
1990
1995
2000
YEAR
MARS1
MARS2
(V05)
1 R.1005A1
2 R.1005A4

FIGURE 51

WORLD EXPORTS
RICE

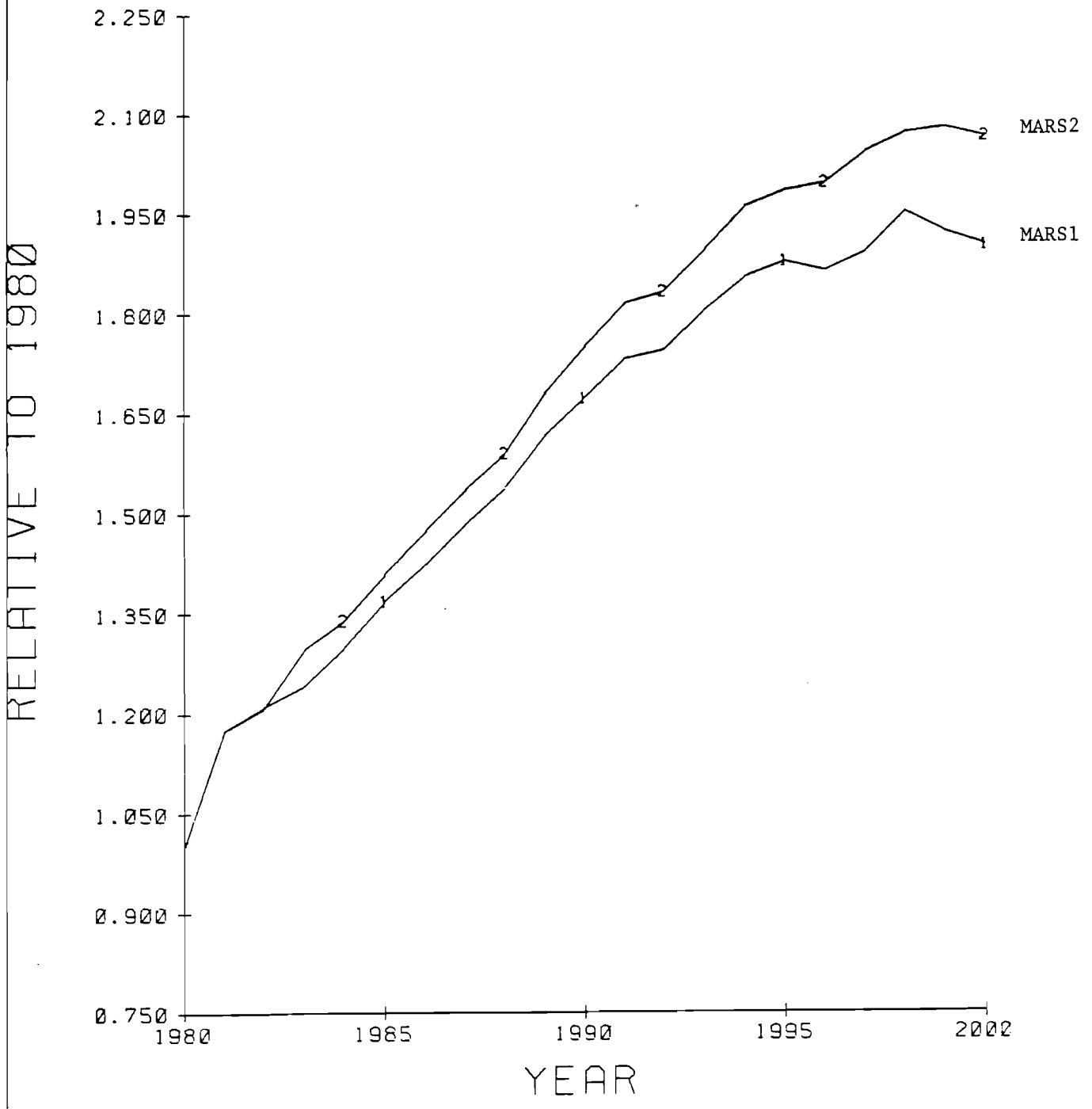


FIGURE 52

SSR RICE

(MARS1 to RO)

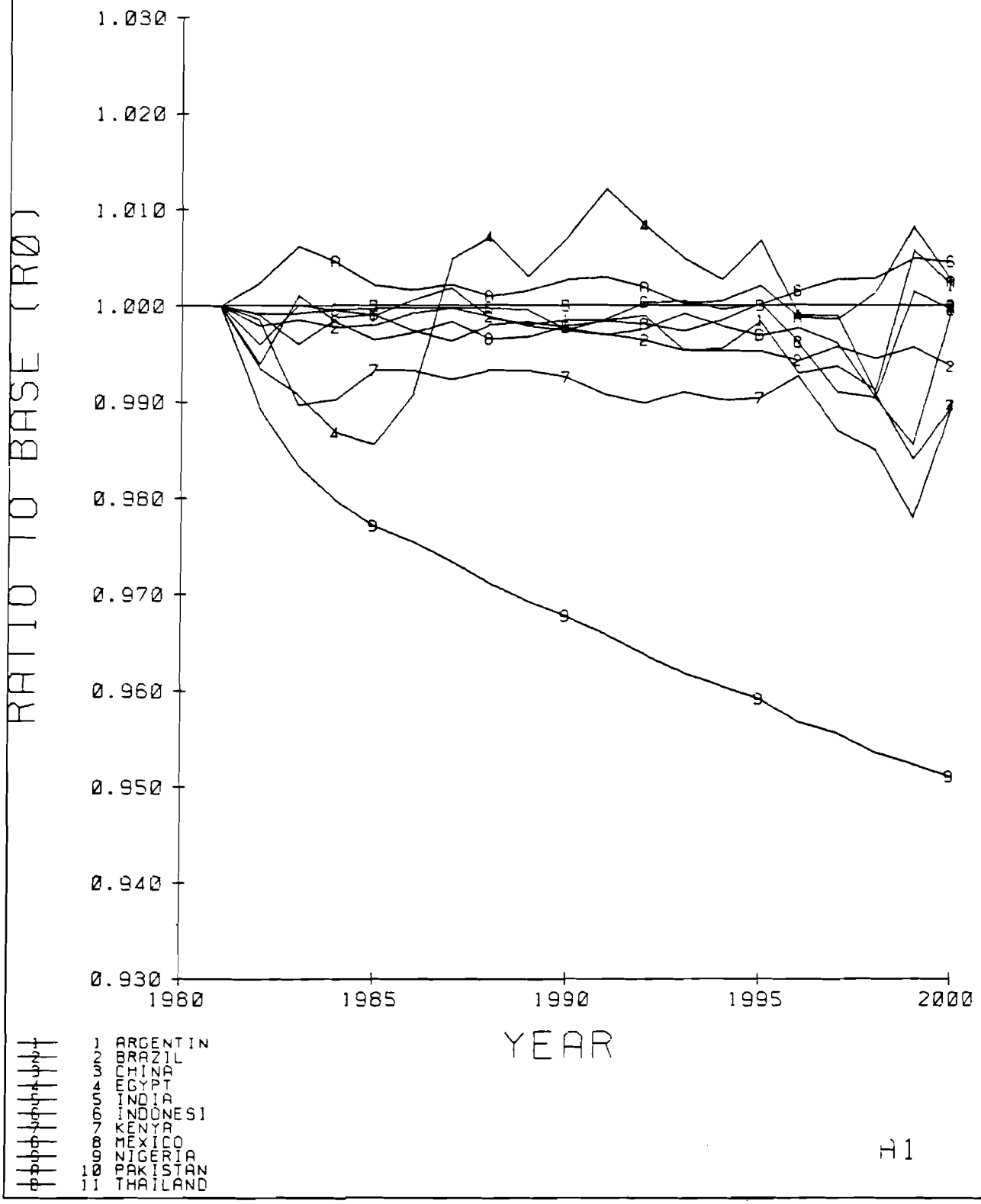
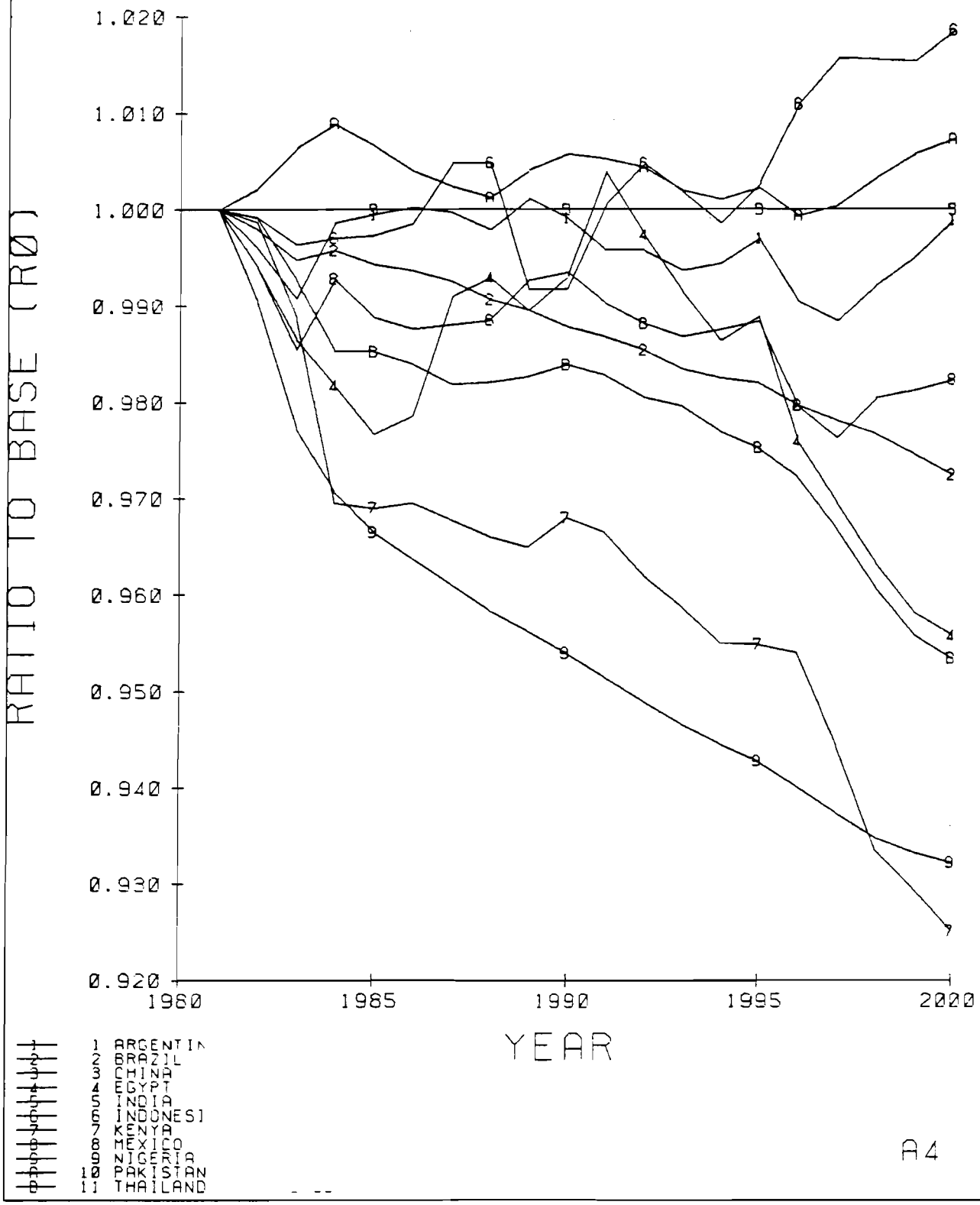


FIGURE 53

SSR RICE

(MARS2 to R0)

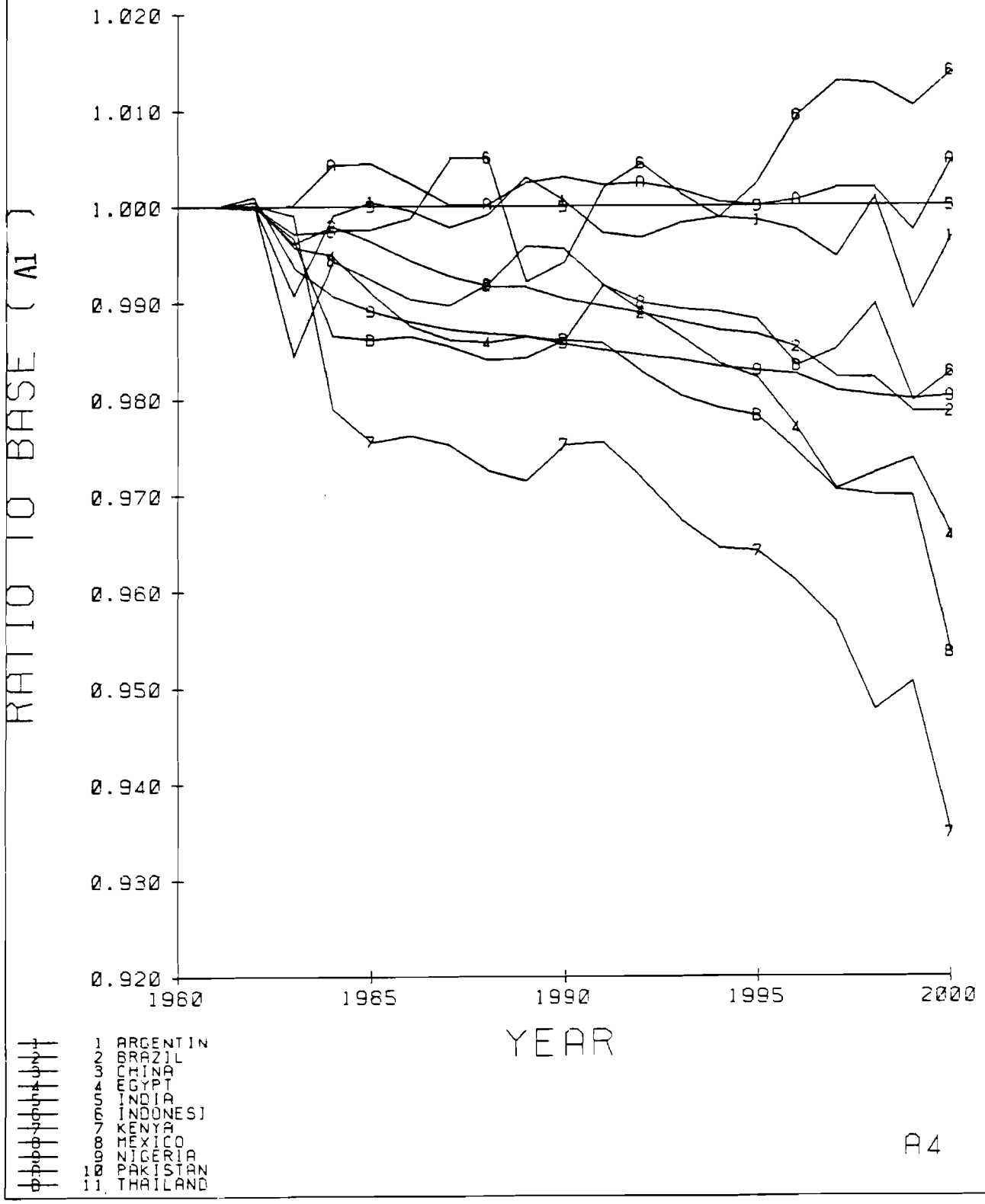


A4 (V12)

FIGURE 54

SSR RICE

(MARS2 to MARS1)



A4 (V12)

FIGURE 55

SSR WHEAT

(MARS1 to RO)

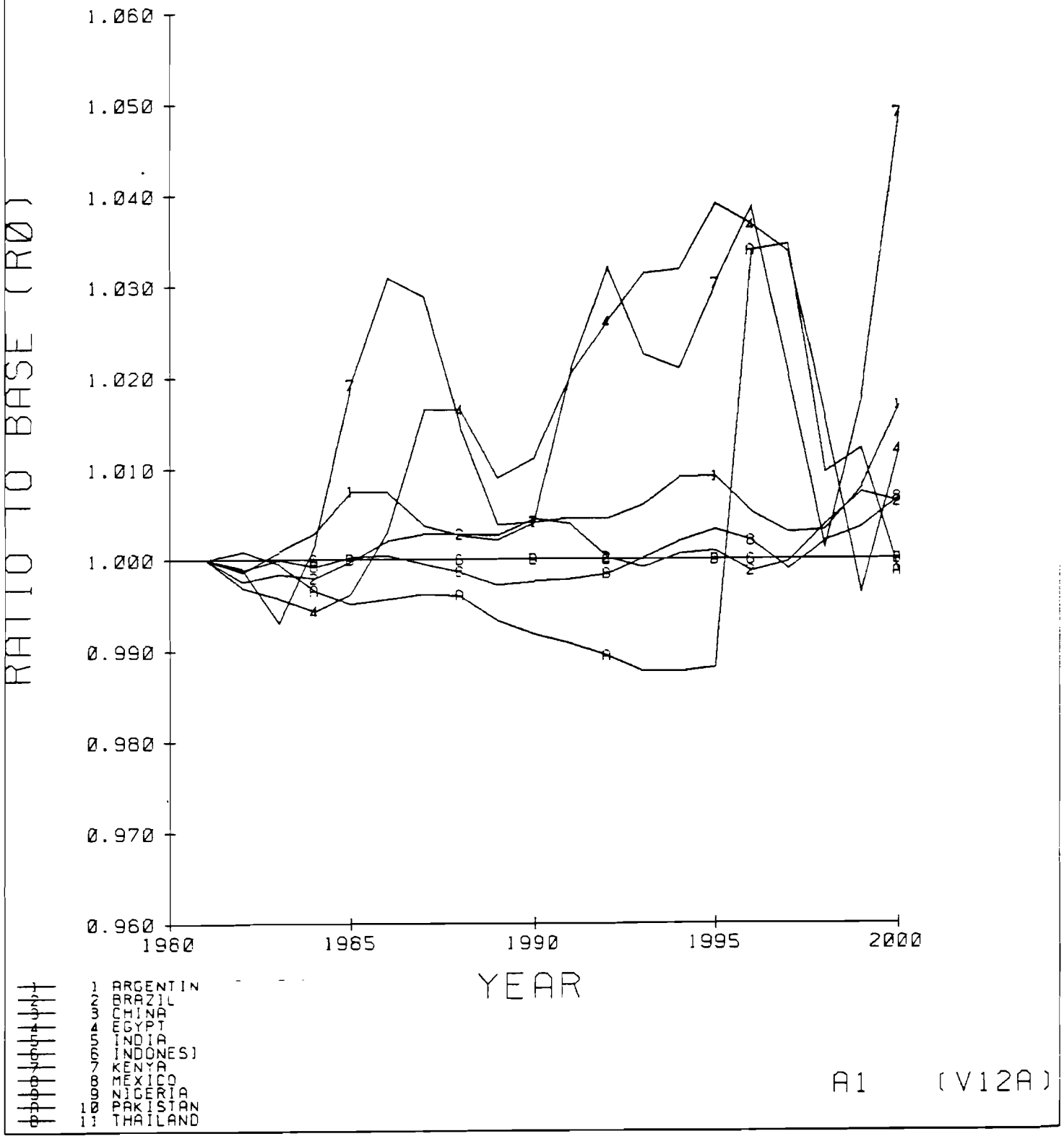
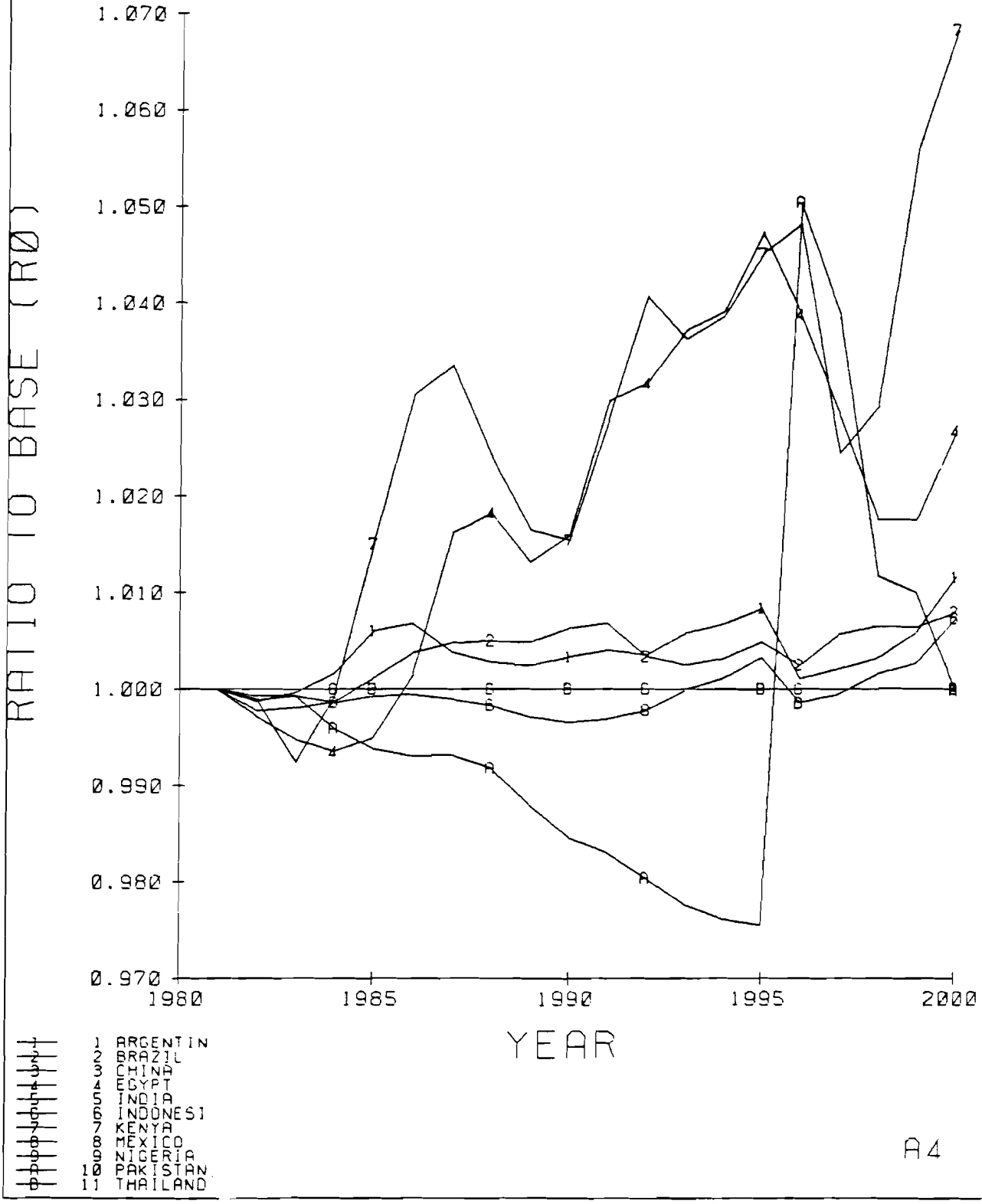


FIGURE 56

SSR WHEAT

(MARS2 to RO)



A4 (V12)

FIGURE 57

SSR WHEAT

(MARS2 to MARS1)

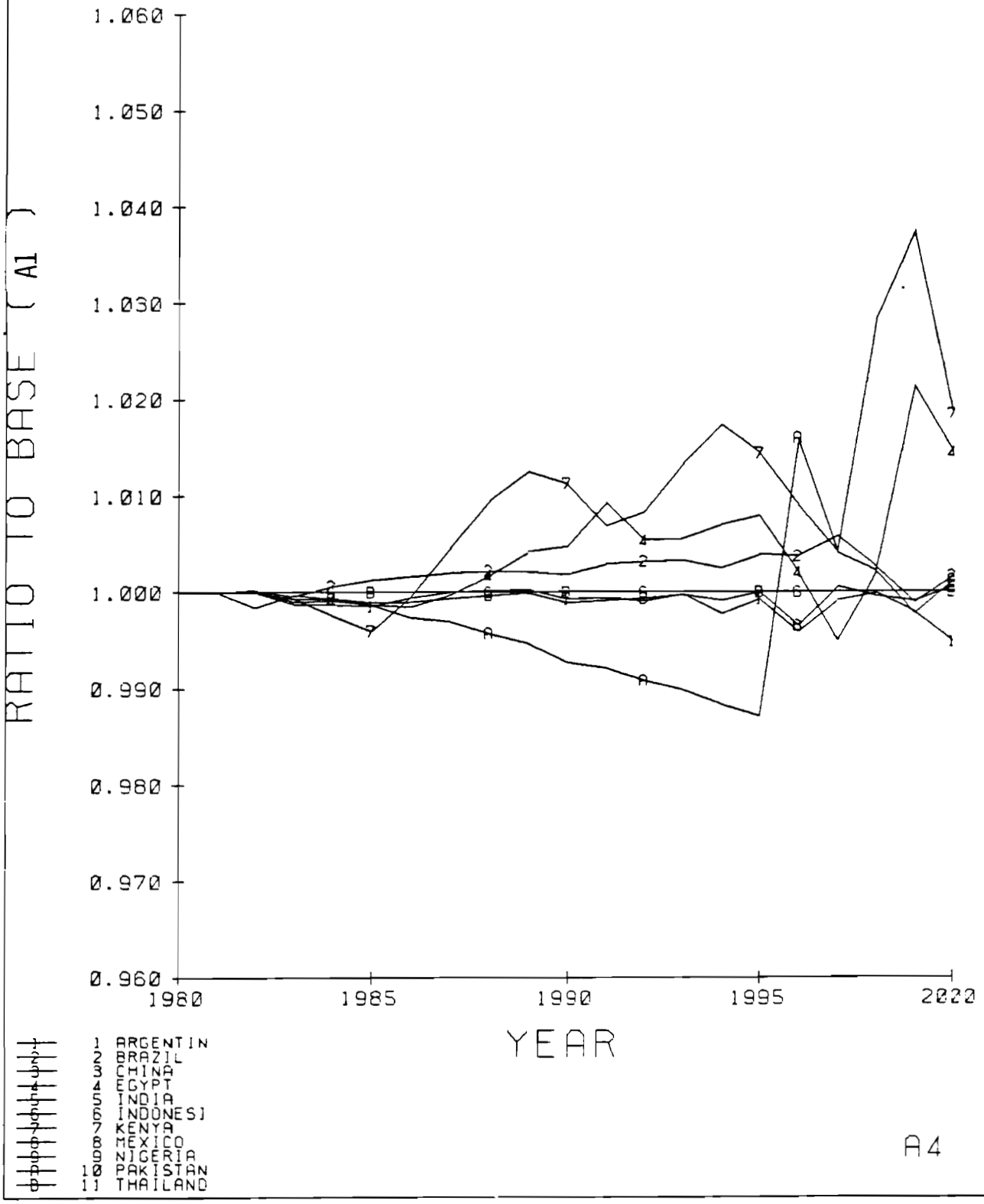


FIGURE 58

SSR DAIRY

(MARS1 to RO)

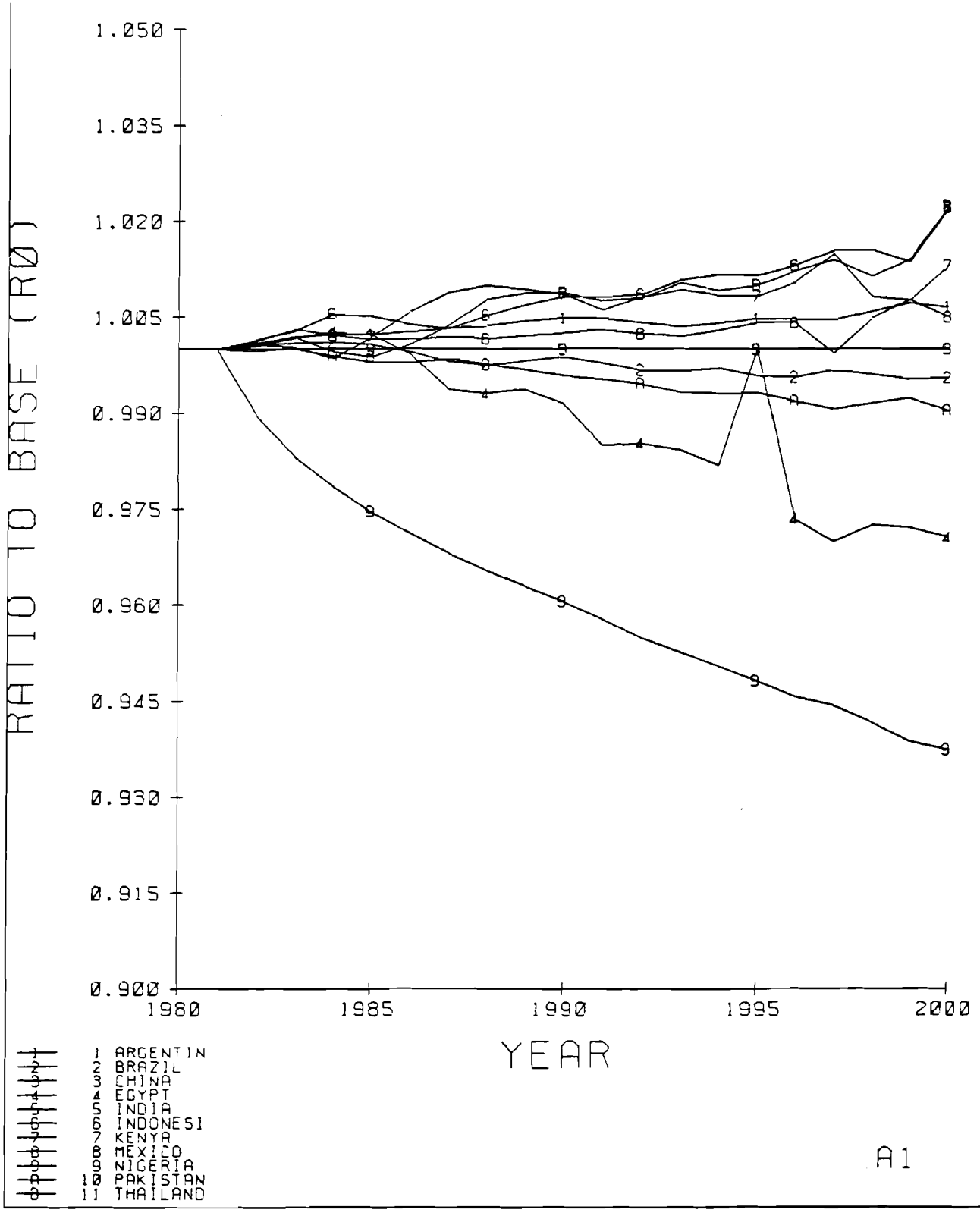


FIGURE 59

SSR DAIRY

(MARS2 to R0)

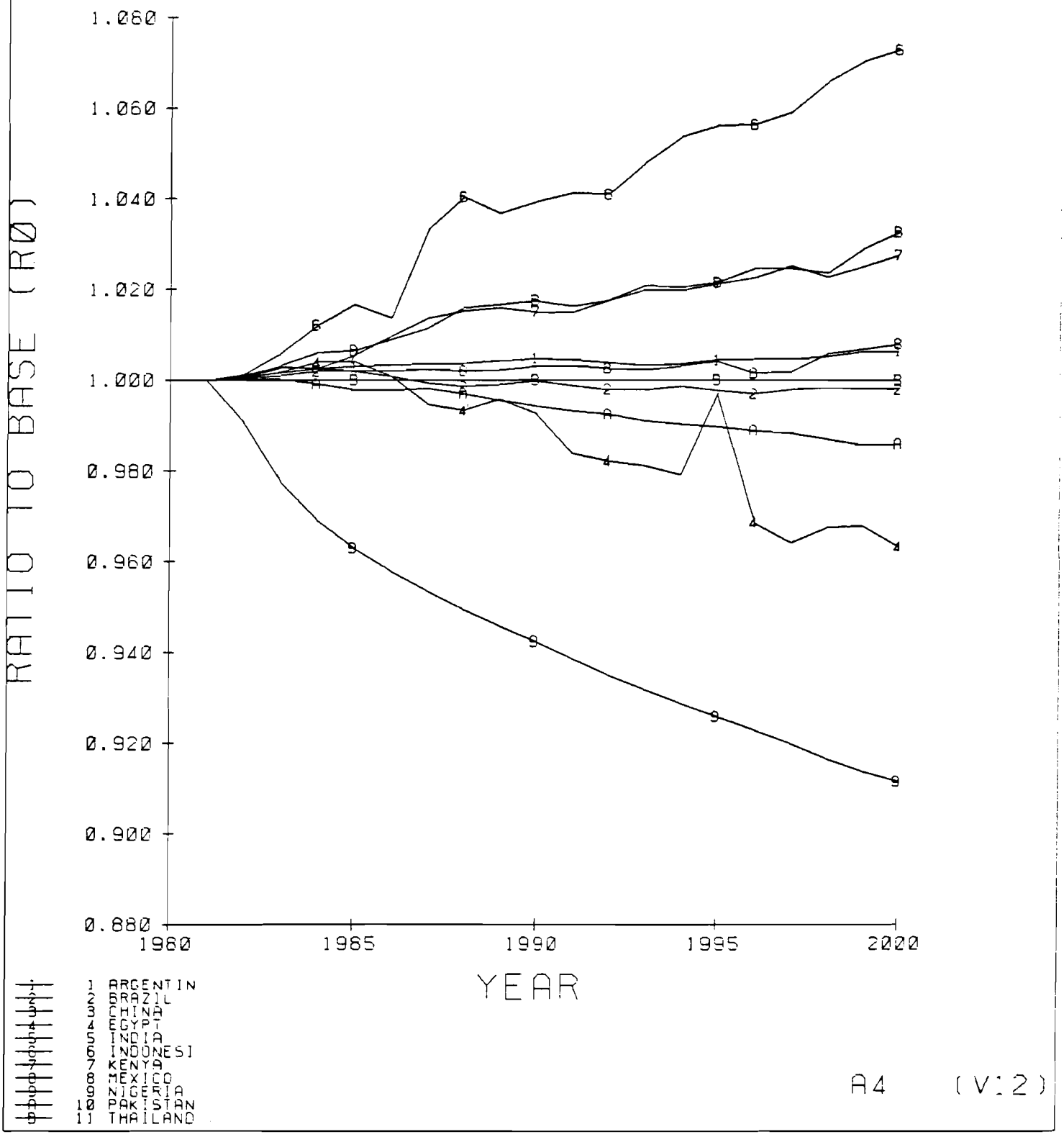
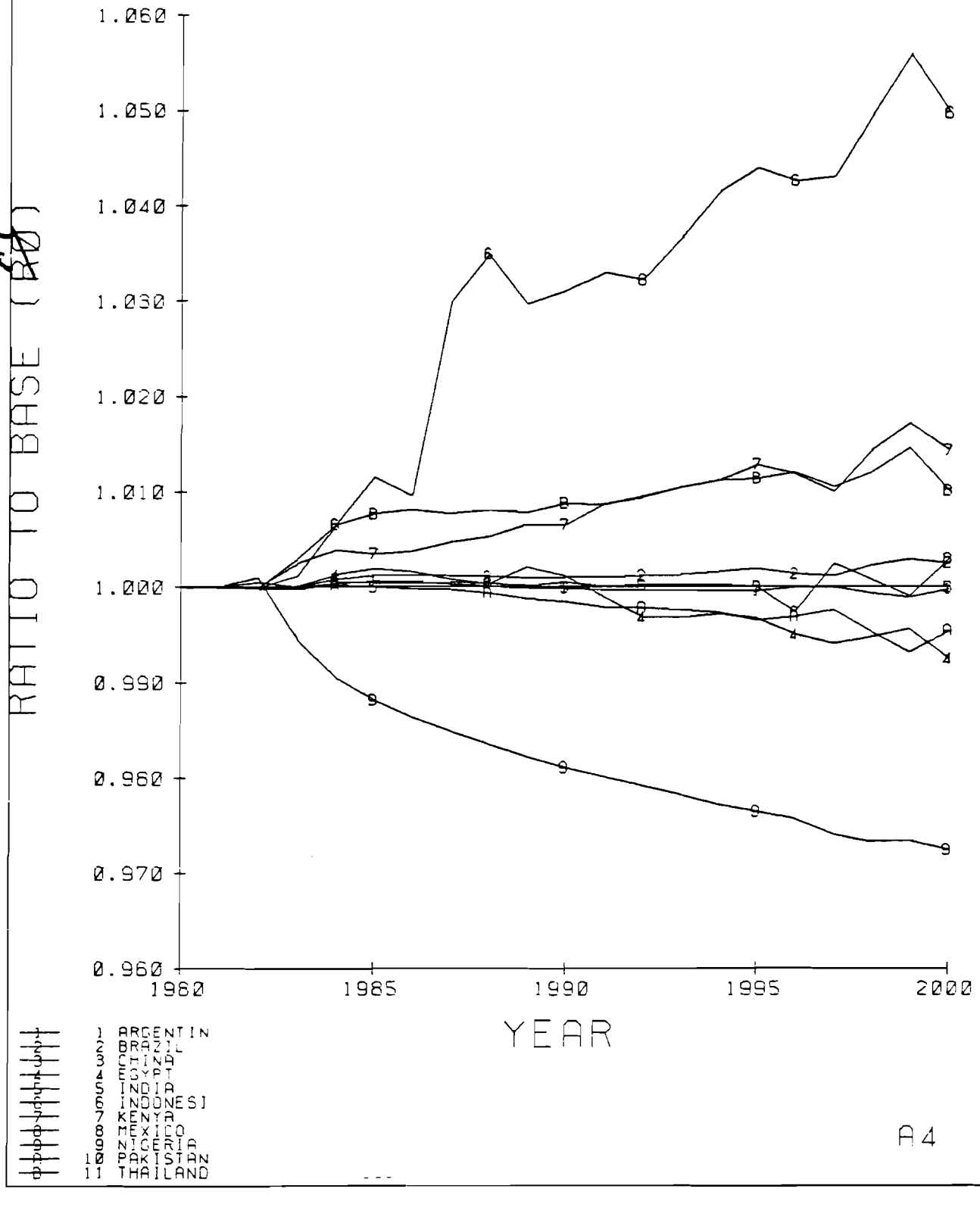


FIGURE 60

SSR DAIRY

(MARS2 to MARS1)



A4 (V12)

FIGURE 61

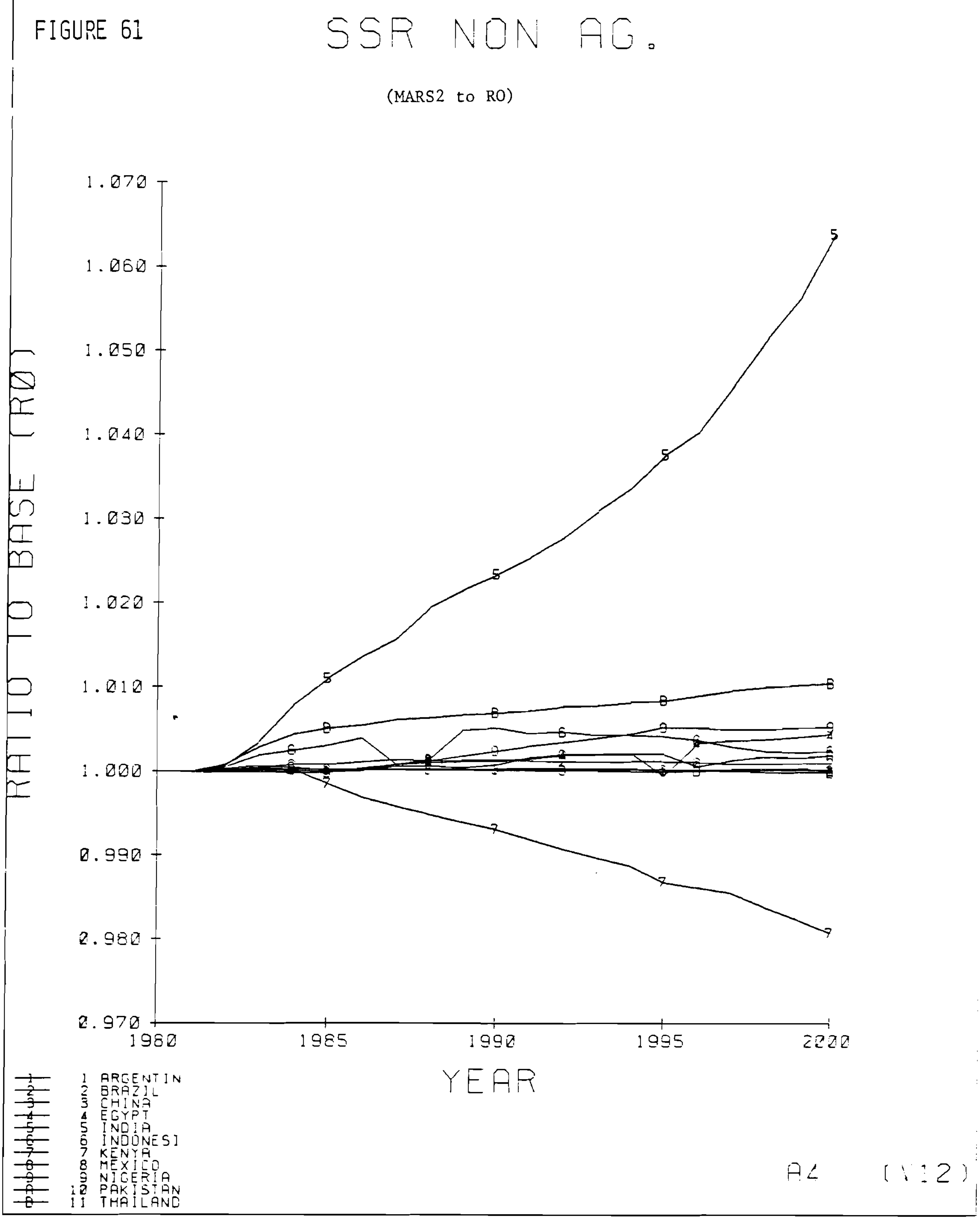

SSR NON AG.
(MARS2 to RO)
RATIO TO BASE (RØ)
1.070
1.060
1.050
1.040
1.030
1.020
1.010
1.000
0.990
0.980
0.970
1980
1985
1990
1995
2000
YEAR
1 ARGENTIN
2 BRAZIL
3 CHINA
4 EGYPT
5 INDIA
6 INDONESI
7 KENYA
8 MEXICO
9 NIGERIA
10 PAKISTAN
11 THAILAND
A4
(V12)

FIGURE 62

SSR NON AG.

(MARS1 to RO)

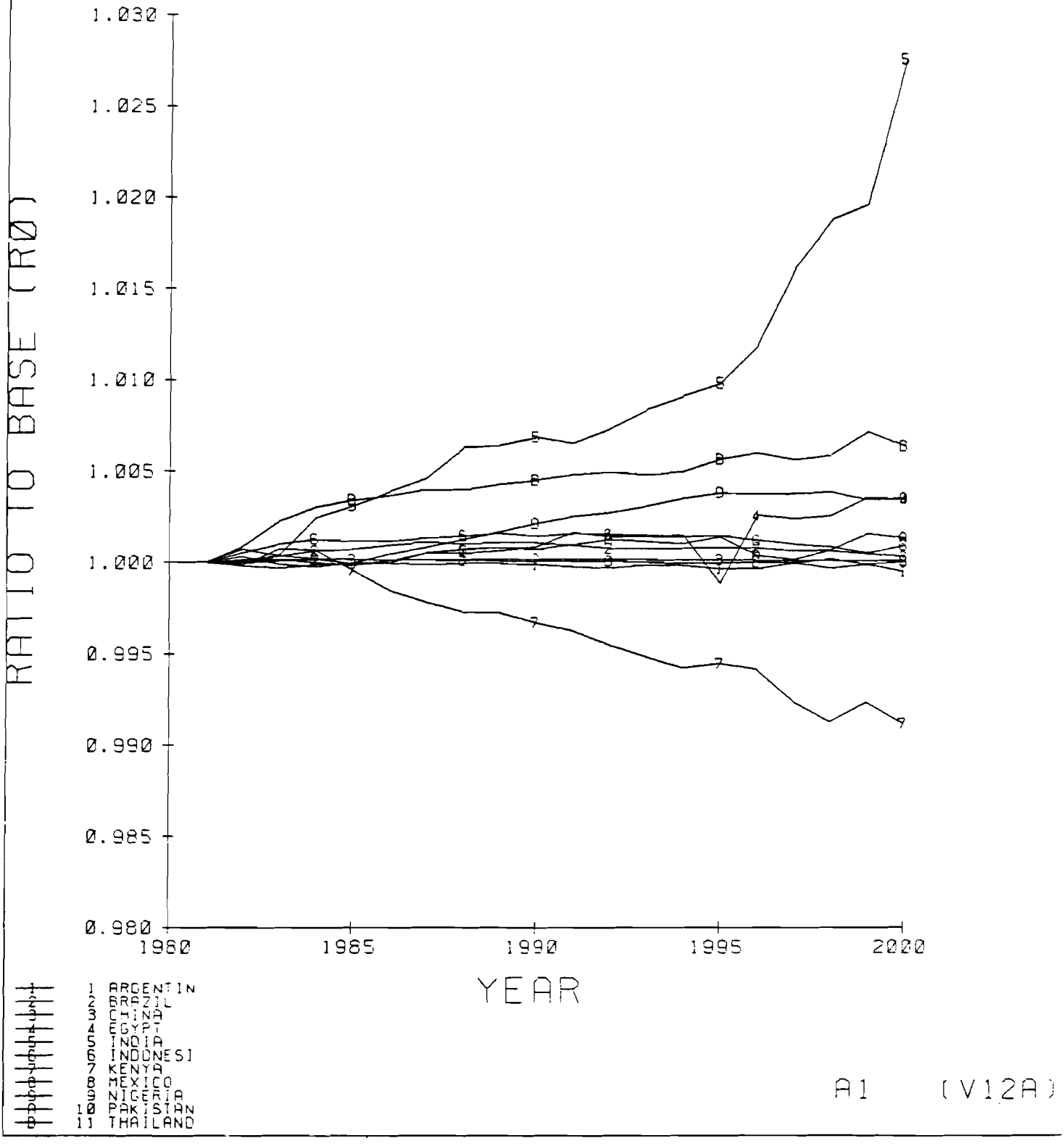
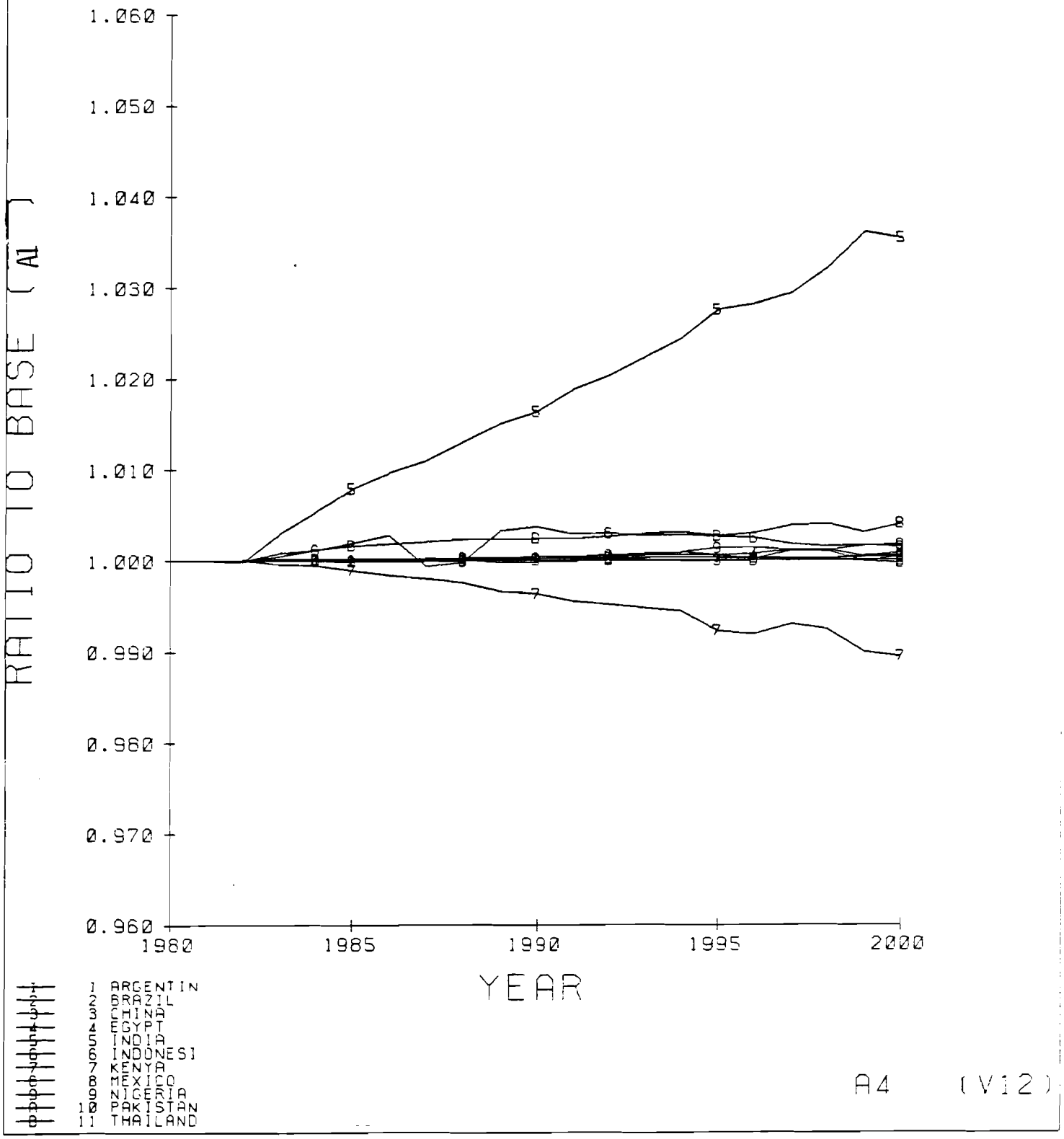


FIGURE 63

SSR NON AG.

(MARS2 to MARS1)



Appendix 1 - Simplified Country Grouping Models (901-913)

901	AFR Oil Exp	africa, oil exporters
902	AFR M CAL Ex	africa, medium income/calorie exporters
903	AFR M CAL Im	africa, medium income/calorie importers
904	AFR L CAL Ex	africa, low income/calorie exporters
905	AFR L CAL Im	africa, low income/calorie importers
906	LAM H CAL Ex	latin america, high income/calorie exporters
907	LAM H CAL Im	latin america, high income/calorie importers
908	LAM LM	latin america, low-medium income
909	FEA MH CAL Ex	far east asia, medium-high income calorie exporters
910	FEA MH CAL Im	far east asia, medium-high income calorie importers
911	FEA LOW	far east asia, low income
912	NEA Oil Exp	near east asia, oil exporters, high income
913	NEA LM	near east asia, low-medium income