AUSTRALIAN RESOURCES AND ENVIRONMENTAL ASSESSMENT (AREA) MODEL

A study by the Department of Science and the Environment in
consultation with Commonwealth departments and agencies

MODELLING AUSTRALIAN INTERNATIONAL
RELATIONSHIPS: AN APPROACH THROUGH
DYNAMIC SIMULATION

by

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and

Don MacRae

*The views expressed in this paper do
not necessarily reflect the opinions
of the Department of Science and the
Environment, nor of the
Australian Government.*

SARUM is a world econometric model developed by the System Analysis Research Unit of the UK's Department of the Environment, in which prices do not adjust to equilibrate supply and demand in each period, but rather recognise the many factors that inhibit instantaneous clearing of markets. The world can be regionalised into twelve regions and a number of industrial and agricultural activities.
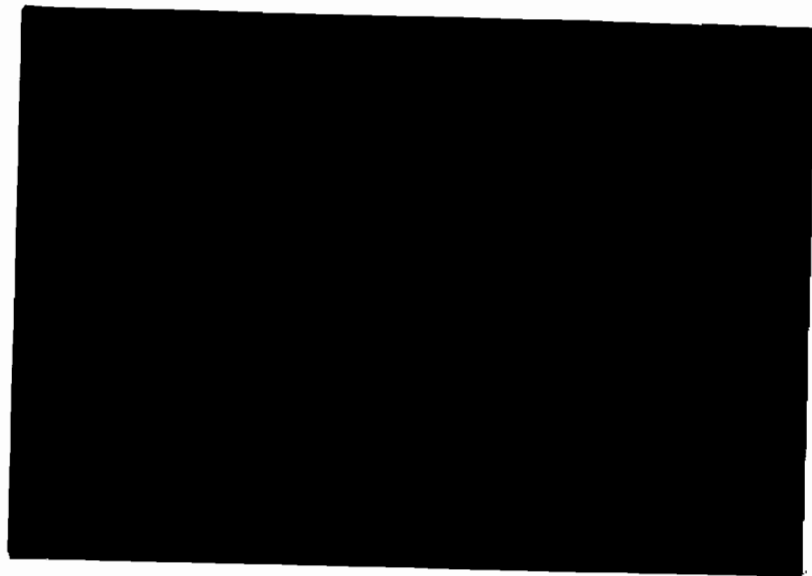
AREAM is the Australian version of SARUM for the analysis of Australian Resources and Environmental Assessment. The project was formulated in the light of a need to assess the impact of world change on the development of the Australian environment and its natural resources. In order to be able to look at environmental factors, SARUM is extended by the addition of an environment sector and the demographic sector is endogenised.

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ABSTRACT

In developing a case for the use of dynamic simulation models as a tool of prospective studies, illustrations are drawn from the results of an ongoing exploratory study to assess the utility of global models for prospective analysis within the policymaking framework of government. A global model is used to assess, in a highly exploratory manner, differences in national economic performance arising from a series of postulated trading patterns between Australia, New Zealand, Japan and the East and South East Asia. These patterns are evaluated within the context of a scenario of low economic growth postulated and analysed by a major global research project undertaken by the OECD.

1.   INTRODUCTION

        The use of dynamic simulation models in
prospective studies dealing with the long-term interplay
between global and national economic problems is
illustrated in this paper. The categorisation of models
which begins the paper provides a conceptual context
whereby dynamic simulation models may be linked to a wide
range of other types of models. A World-Australia
model is then used to illustrate the developing utility of
dynamic simulation models as a basis for prospective
analysis and evaluating policy options. This exploratory
work is in progress within the Australian Department of
Science and the Environment. It is being conducted in
collaboration with the UK Department of Environment, the
New Zealand Commission for the Future and the US East-West
Center.

        This World-Australia model is used to evaluate,
in a highly exploratory way, a series of variations to a
scenario of low economic growth postulated and evaluated
recently by the OECD. The variations posed allow
comparisons of the relative economic performance of three
different economic communities comprising Australia, New
Zealand, Japan and East and South East Asia. Aspects of
energy, minerals and food trading futures for these
communities are considered. Finally, we address some of
the employment implications of these possible futures.

2.   DYNAMIC SIMULATION MODELS

In developing an understanding of how models and modelling reflect reality we have to go back to first principles.[1] A model is defined as a representation or abstraction of an actual object or situation. It shows the relationships (direct and indirect) and the interrelationships of action and reaction in terms of cause and effect. Since a model is an abstraction of reality, it may appear to be less complex than reality itself. The model, to be complete, must be representative of those aspects of reality that are being investigated.

One of the basic reasons for developing models is to discover which variables are the important or pertinent ones. The discovery of the pertinent variables is closely associated with the investigation of the relationships that exist among the variables. Quantitative techniques such as those resulting from statistical theory and simulation modelling are utilized to investigate the relationships that exist among the many variables in a model.

A system may be defined as two or more elements or components acting together; these elements or components are dependent upon each other. A system is, however, our perception of some part of reality. If we assume that reality is everything in existence, then a system is simply the way we perceive that part of reality which we are examining. In fact the only way in which we can learn about reality is by developing mental models of it. Even if we were to express a system symbolically our translation would be less than perfect. But as Starr explains, this may suffice:[2]

> Because it is a perception of reality, a system can take on
> meaning only through the observations, interpretations, and
> values of the persons defining it, whether they use verbal

> *expression or mathematical symbols, their translation*
> *of reality will always be incomplete. But incomplete does*
> *not mean unsatisfactory. Each system is identified for*
> *a particular purpose, and even though perfection is*
> *impossible the purpose may be satisfied by far less than*
> *perfection.*

A system may be viewed as being some part of reality while
a model is a subset of the perceived system. Before any
physical (as distinct from mental) model can be built the
system must be specified.

Although mental models are necessary, they
must be converted into either verbal or physical models
for them to be useful. Verbal models are all familiar
to us in the utterances of daily life and they are
disadvantaged by the deficiencies inherent in the language
used. On the other hand, physical models do not rely on
words, but may be in either a concrete or abstract form;
concrete in the sense that it physically exists, you can
see and touch it. Abstract normally means the mathematical
form or some form of symbolic, logical representation.

Physical models may be classified by
structure, uncertainty, function and time. Within the
structural dimension there are three model types; iconic
which looks like the system it represents, eg photograph,
sculpture and painting, and in this sense is truly physical;
analogue which diagramatically represent reality, eg a network
of water pipes to represent the flow of electricity; and
the one of interest to us, symbolic. Symbolic models employ
symbols to represent the components of the system and the
relationships among them. These symbols are generally
mathematical or logical in character. An equation is, in
a sense, the universal language of mathematical models.

Models may be categorised as deterministic
and stochastic in nature. The first type are formulated
when uncertainty in the data and structural basis of the

model is viewed as insignificant. Stochastic models specifically allow for uncertainty of the foregoing types through the application of probability theory and analysis. The classification termed *function* may be defined as the mode of action by which a model fulfills its purpose. For example, a *descriptive* model describes the relationships that exist among the variables and parameters in the system but does not attempt to identify the optimal behaviour of the system or derive optimal solutions. When a model is heuristic in character we have developed a capability which may generate feasible but not necessarily optimal solutions to a problem. Optimization is possible when we can construct models consisting of sets of analytic equations which can be reduced to generate optimal solutions from a range of feasible solutions.

Descriptive models may be further subdivided into analytic and simulation categories. Analytic models comprise equations which can be reduced and solved to produce a unique solution. Simulation models include those models whose equations or rules do not admit analytic solution in general form but that nevertheless produce numerical values. The models are based on step-by-step sequential calculation methods descriptive of the workings of large-scale problems or systems. The input data in a simulation model may be real or generated data.

Finally, models may be static or dynamic. The former may provide solutions for a specified time period but do not allow for changes in parameters during that period. A dynamic model, on the other hand, has time as one of its fundamental parameters; it is concerned with changes over time or with delays or lags. Forrester further subdivides dynamic models into stable and unstable categories.[3] The time factor plays an essential role in

the sequence of decisions. Regardless of what the prior
decisions have been, the dynamic model enables one to
seek optimal decisions for the periods that still lie
ahead.

The description of large systems such as
national and global economies may be achieved through
dynamic simulation models. Prior to the upsurge of
interest in modelling at this scale most national economic
models were static, very detailed and used in relation
to short time periods. Dynamic models to describe
national systems were developed in response to a perceived
need to include in the model description an assessment
of changing influences and impacts external to the national
system. This led eventually to the development of highly
aggregative models of economic systems which were
essentially global in character.

In the illustration of a dynamic simulation
model which follows we will consider the case of a World-
Australia model. The linking of this type of model with
static models of the national economy (usually input-output
in structure) to generate a more detailed economic
assessment at the national level subject to the resource
depletion and other constraints determined through time
by the dynamic model is the subject of further research.[4]

3.   OUTLINE OF A WORLD-AUSTRALIA MODEL

The model used here to illustrate the potential
of dynamic simulation methods for prospective analysis
is a dynamic simulation model of the global economy based
on neo-classical economic principles. It comprises variable
numbers of world regions and economic sectors within each
region. Current work is dealing with the following
regions: North America, Japan, Australia, New Zealand,

European and Asian COMECON, other Europe and Asia Minor, Latin America and the Caribbean, South Asia, East and South East Asia and Oceania, China, West Asia and North Africa, and other Africa. Economic sectors currently within each region deal with energy, minerals, manufactures, machinery, construction, fertilizers, water, land development, land pool, food, services and natural products.

A sector recently added to this configuration provides a means of assessing the level of stress imposed on the environment by the activities of the other sectors. The development of a further sector is drawing on existing behavioural modelling studies to describe the dynamics of demographic change in Australia internal to the Australian region of the model.

By modelling the trade between the sectors of the various world regions the model can be used to address problems relating to the way regions interact with each other. In trade transactions the model accounts explicitly for factors which inhibit the functioning of a free market. This is achieved by applying a matrix of *trade biases*[5] to each commodity traded in order to modify the prices perceived by the importer depending on the source. The biases reflect economic factors such as tariff barriers and distance and factors due to differences of a political, strategic and cultural nature. In developing a population sector internal to Australia a mechanism similar to that for applying trade biases is being examined as a means of describing the underlying flow of migration. In the model aid flows from one region to another. As yet there is no attempt to model the international money markets.

4. A REFERENCE SCENARIO

A reference scenario is required to assess the effects of policy changes as evaluated by a model such as the World-Australia model considered here. It suits our present purposes to use as a reference the scenario of low economic growth world-wide proposed by the large-scale global research study, termed the INTERFUTURES Project,[6] commissioned and recently completed by the OECD. Since this OECD Project used the same model as we are considering here the available global analysis of this low growth scenario[7] provides a detailed context for the following analysis of Australia and New Zealand development relative to alternative economic communities within the Pacific Basin.

Major assumptions underlying this scenario of low economic growth include:

- zero recovery with respect to the productivity losses incurred during the early years of this decade
- an annual rate of 1.5 per cent in long term productivity in the USA
- a gradual convergence in the long term productivity of the other OECD countries to the USA levels
- a rate of population growth equivalent to the UN medium level projections and relative to these projections a constant rate of labour force participation.

Over the 25 years to the year 2000 this yields an average rate of growth in GDP of 3.4 per cent for all OECD countries, with Australia and New Zealand registering 3.3 per cent and 2.7 per cent respectively.

The reference scenario used here resembles
the INTERFUTURES scenario for low economic growth in
all aspects except the following:

.   through the trade bias matrices, trading patterns
     are set according to the historical experiences
     of the early 1970s, such as the OPEC cartel
     action of 1973
.   removal of conditions set to liberalise trade
     between North and South
.   removal of conditions set to create a flow of
     official aid from developed to developing
     countries.

5.   A MECHANISM FOR EFFECTING TRADE LIBERALISATION

Earlier, mention was made of the methodology used
for modelling trade between the various sectors of the
world regions. The mechanism which describes how free
market conditions or trade liberalisation is induced
is based on the use of the trade biases referred to
earlier. By adjusting the elements of the trade bias
matrix of each of the commodities considered here we are
able to use the model to evaluate trade policies,
relating to the levels of liberalisation and protectionism
over time which a region might wish to pursue in the
context of a specific economic scenario.

The trade policies considered in this paper
relate to reduction in the tariff barriers between various
regions in the Pacific Basin. The word liberalisation
is used because a perfect *'free-trade'*   agreement would
mean that trade biases would be eliminated and in our
methodology would have a value of unity. This would imply
that imported commodities can compete perfectly with home
produced goods. Since the biases subsume the barrier of

distance this would mean that the transportation costs
are non-existent or negligible, which is not the real
world situation. For this reason alone, if no other, the
biases do not fall to one but to the lowest observed
values in 1970 in Australia and New Zealand. These
ranged from 2 to 4 depending on the particular commodity.

Again to mirror the real world situation, we
did not introduce this liberalisation overnight. Time
is needed to introduce such policies and to phase them
in over the various sectors of the economy. In order to
do this, a policy was introduced in 1980 whereby the bias
fell at the rate of ten per cent per annum to approach
the lowest observed value of the particular commodity.
This is the rate at which barriers fell among the
countries of the European Economic Community. Thus
by the year 2000 the bias would have dropped to about
11 per cent of its original value.

In an endeavour to gain some insight into
how different regions would react to liberalisation
of trade, we decided to run various simulations so
that each region could be introduced separately into a
trading union. The effect of the introduction would
then be measured against the region's previous position
of not being in the grouping of regions and subsequent
positions of being in other groupings. The next section
sets out the economic communities considered.

6. PACIFIC ECONOMIC COMMUNITIES

To-date experiments have been conducted which
have evaluated the reference scenario (and other
INTERFUTURES scenarios) for a series of economic
communities in the Pacific Basin or Pacific Economic
Communities (PECs) as follows:

```
PEC-0       Australia and New Zealand (ANZ)
PEC-1A      ANZ + Japan
PEC-1B      ANZ + East and South East Asia (ESEA)
PEC-1C      ANZ + Japan + ESEA
PEC-2       ANZ + Japan + ESEA + China
PEC-3       ANZ + Japan + ESEA + China + NORAM
PEC-4       ANZ + North America (NORAM)
```

Given the resource potential of regions of the Pacific
Basin, the question of whether the economic potential
of the Basin in total and for each region would increase
through the development of economic communities PEC-0 to 4
is posed and addressed in an earlier paper.[8] Briefly, from
among these seven configurations, the grouping of regions
which maximised the lot of Australia and New Zealand by
the end of the simulation period occurred for PEC-1C
(ANZ + Japan + ESEA). Of the six configurations PEC-1 to 4
listed above the same grouping, PEC-1C, also maximises
the GDP per capita of ESEA. A detailed account of
PEC-0 is provided elsewhere.[9] In this paper the
reference scenario is evaluated subject to regional
economic communities PEC-1A, PEC-1B and PEC-1C.

          Using the measure of GDP per capita, expressed
in standard 1970 US dollars, as a surrogate for standard
of living we see from Figure 1 that in the fifty year
period to 2020, model evaluation of the reference
scenario generates changes with respect to this measure
in the ranking of the twelve world regions considered
here. The levels of GDP by region shown in Figure 2
dwarf the values for the economically tiny regions of
Australia and New Zealand. GDP levels for Australia,
New Zealand, Japan and ESEA for each of PEC-1A, 1B and 1C
are shown in Table 1. While both Australia and New Zealand
fare best in the four region case, they differ in how they
are affected in the other two groupings. Australia's
strong minerals and energy tie with Japan alone generates

                           10

FIGURE 1
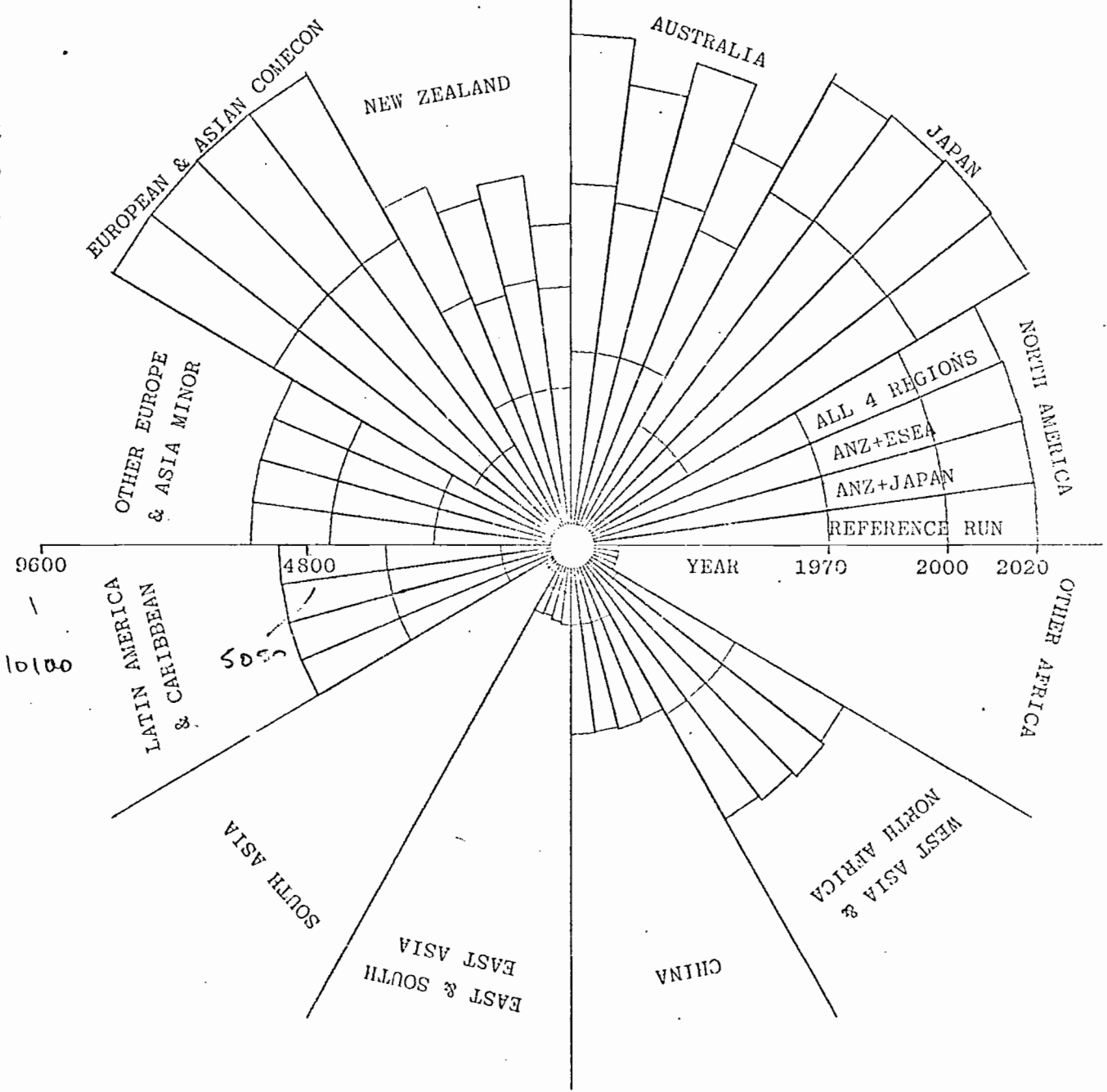GROSS CONSUMPTION/CAPITA BY REGION
STD DOLLARS/HEAD/YEAR

FIGURE 2
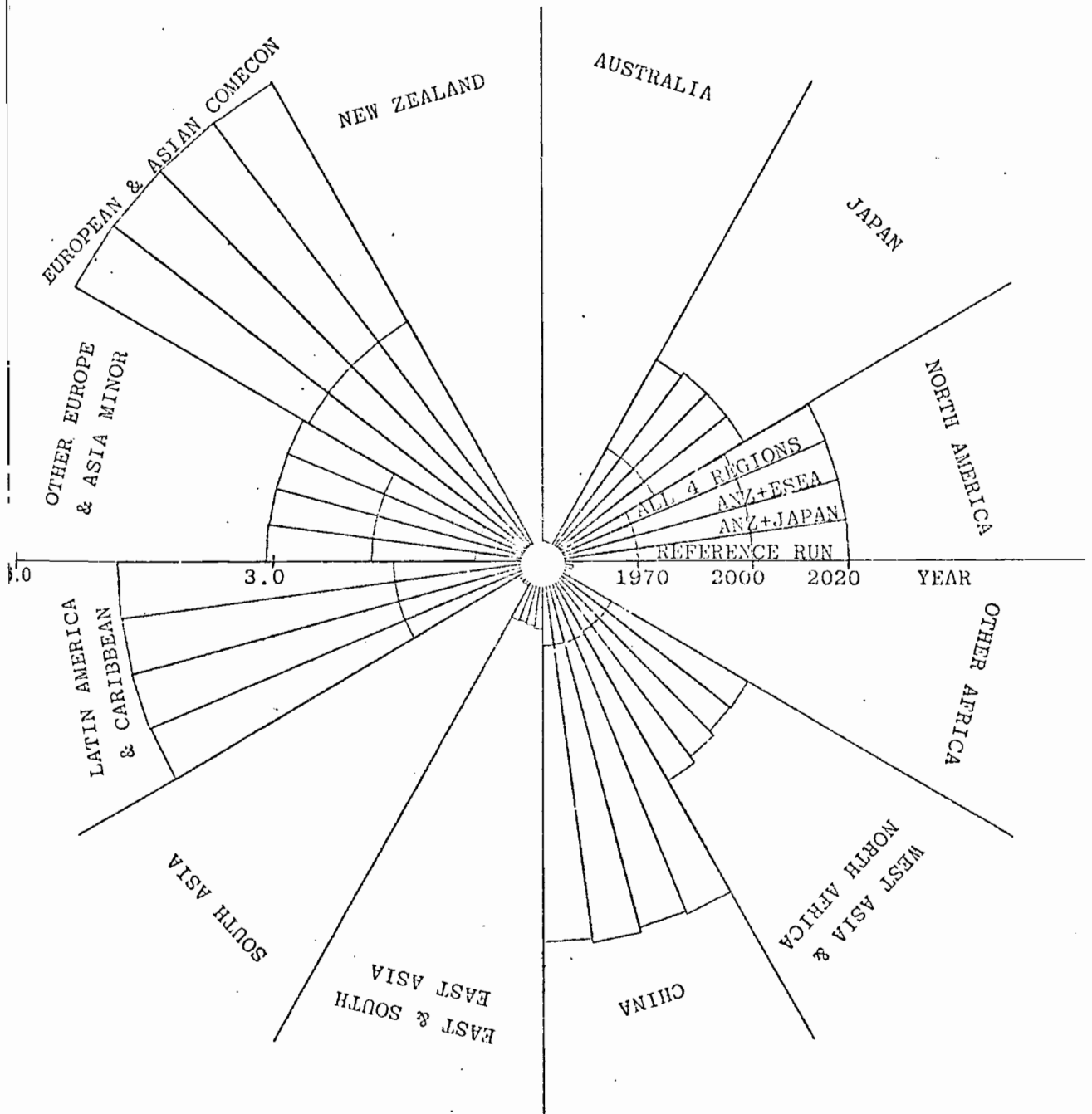GROSS DOMESTIC PRODUCT, BY REGION
BILLIONS STD DOLLARS/YEAR

TABLE 1

GDP BY REGION GENERATED BY 2020

(Expressed in Billions of Standard Dollars)

Region	Reference (1970 levels)	PEC-1A ANZ+Japan	PEC-1B ANZ+ESEA	PEC-1C ANZ+Japan+ESEA
Aust	192(37)	212	211	226
NZ	26(6)	29	31	32
Japan	2580(201)	2575	2510	2525
ESEA	701(59)	690	708	735

a higher GDP than trade liberalisation with only ESEA.
On the other hand, the economic food producing
capability of New Zealand is utilized more fully in the
case of free trading with ESEA. Only Japan does not
fare best in the case where all four regions are grouped.
By and large this arises from the keener competition in
the production of manufactured goods between Japan and
ESEA.

FIGURE 3   RANKING BY GROSS DOMESTIC PRODUCT FOR
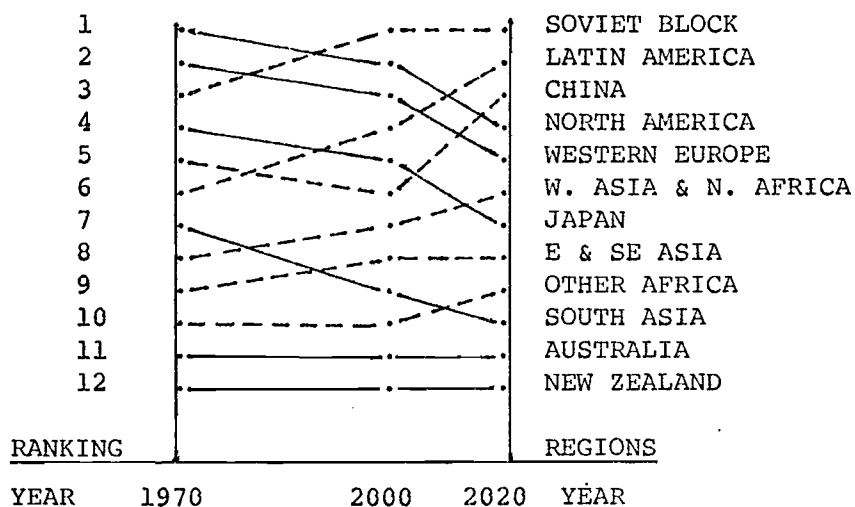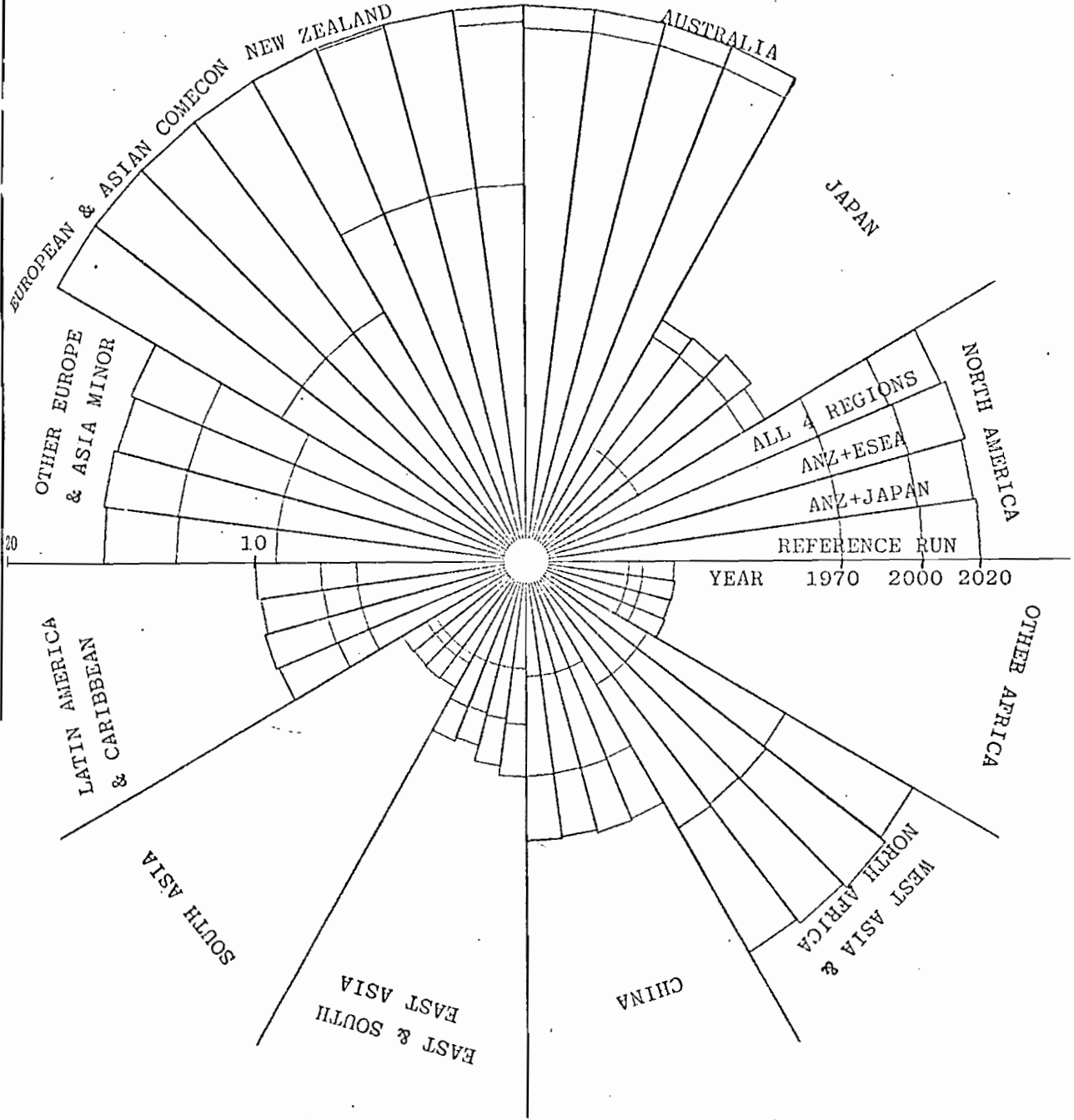   REFERENCE RUN - 1970, 2000, 2020

1	SOVIET BLOCK
2	LATIN AMERICA
3	CHINA
4	NORTH AMERICA
5	WESTERN EUROPE
6	W. ASIA & N. AFRICA
7	JAPAN
8	E & SE ASIA
9	OTHER AFRICA
10	SOUTH ASIA
11	AUSTRALIA
12	NEW ZEALAND

RANKING   REGIONS

YEAR   1970   2000   2020   YEAR

13

FIGURE 4
FOOD CONSUMPTION/CAPITA BY REGION
GIGAJOULES/PERSON/YEAR

From Figure 3 we see that China is ranked fifth
at the beginning of the simulation period, falls to sixth
in the following thirty years and then dramatically
reverses this trend by rising to third place in the twenty
years to 2020. Food consumption per capita is shown in
Figure 4 to be highest in Australia, reaching the $glut^{10}$
limit early in the simulation period. Increasing wealth
in ESEA leads to a doubling of food intake per head,
measured in cereal equivalents, over the period 1970 to
2020. We see that the greater the access they have to the
markets of developed economies the greater is the
improvement in their food consumption per capita - peaking
at 7.7 gigajoules per head by 2020 for the four region
grouping compared with the long term *glut* level of
20 GJ per head in Australia and New Zealand and the level
of 10 GJ per head reached by Japan.

The rest of this paper deals with a comparison
of the importing levels in energy and minerals by Japan
and food by ESEA among these three groupings of regions
and some employment implications for each region
generated by the attendant liberalisation of trade.

7.   ENERGY AND MINERALS IMPORTING BY JAPAN

Energy imports by Japan from the other eleven
regions of the world, expressed as a percentage of their
total imports, corresponding to the reference scenario (or
standard run) and the various groupings of regions are
shown in Figures 5 through 8. The percentages shown on
the scales are cumulative. Hence of the 100 per cent of
Japan's total energy imports, the gap between the lines
gives the percentage from the region as labelled on the
line above the gap. Looking then at Figure 5, we can
see which regions gain or lose in their share of the
Japanese energy market. The largest supplier to this

market is West Asia and North Africa (WANA). Their share
in 1970 of around 60 per cent is reduced during the
seventies and eighties by cheaper energy supplies from
Australia. However, the WANA region recovers this loss
by 2000, at the expense of Australia and North America,
with 73 per cent of the Japanese market. Nevertheless,
since the most economic oil supplies are assumed to be
running low by the turn of the century this share falls
to about 46 per cent by 2020.

Figure 6 shows Australia's share peaking around
20 per cent in the year 1990 falling back to 10 per cent
by 2020. With ESEA in the four region grouping (Figure 8),
Australia's maximum share at year 2000 is 15 per cent of
the market. There is one other point to note. There
are two other regions that start to increase their share
of the Japanese markets towards the end of the simulation
period, namely North America and, in particular, China.
Consequently if China and North America liberalise trade
with Japan in the same way as considered here there will
be an even greater fall in Australia's imports to Japan
than indicated here.

For Japan's mineral imports the variations are
more striking. In Figure 9 we see that the reduction in
Australian imports are taken over, in part, by ESEA.
However, when ESEA is not in the community (Figure 10)
the Australian share increases to 53 per cent. The results
for the Australian, New Zealand and ESEA grouping shown
in Figure 11 closely resembles the outcome of the standard
run. In the four region grouping ESEA increases its
share to 54 per cent with the Australian share falling
back to about 30 per cent. Stronger competition between
the Australian and ESEA regions for the Japanese market
may occur in this case.

FIGURE 5

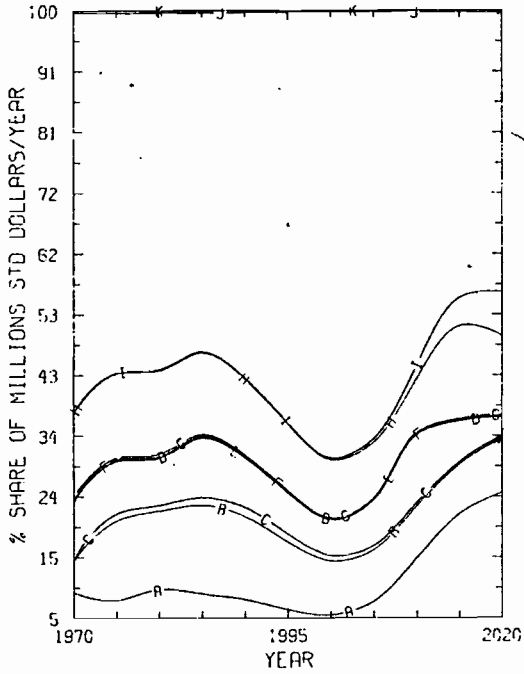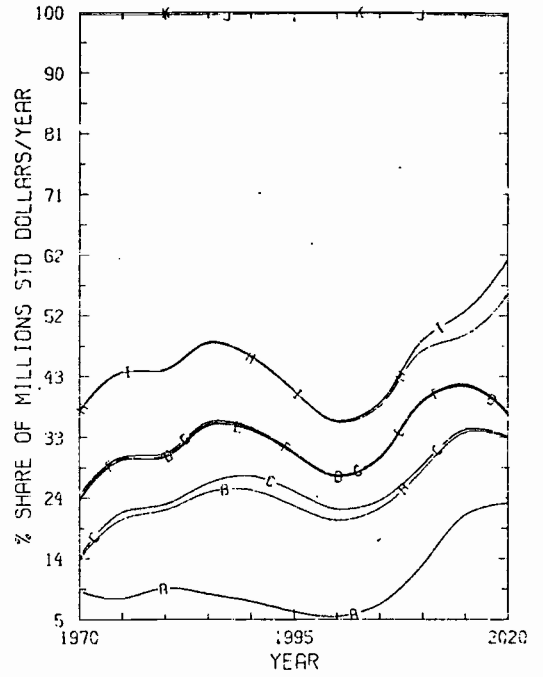SHARE OF IMPORTS OF ENERGY BY JAP,STD RUN

FIGURE 6

SHARE OF IMPORTS OF ENERGY BY JAP.,PEC

A North America
B Australia
C New Zealand
D European & Asian COMECON

E Other Europe & Asia
   Minor
F Latin America &
   Caribbean
G South Asia
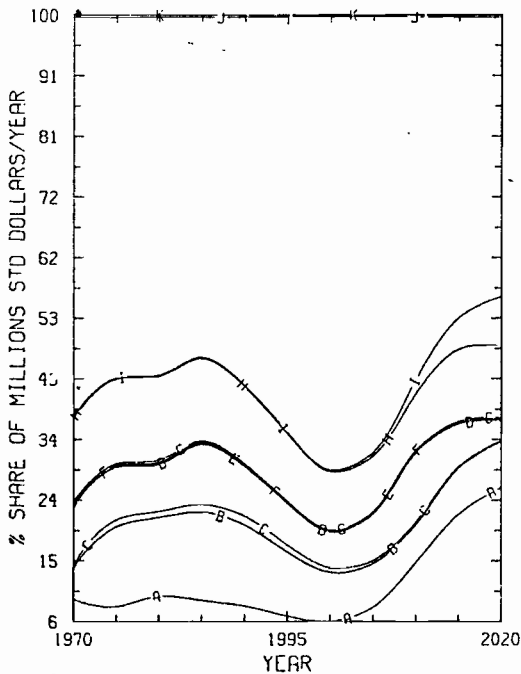H East & SE Asia

I China
J West Asia & North
   Africa
K Other Africa

FIGURE 7

SHARE OF IMPORTS OF ENERGY BY JAP.,PEC1B

FIGURE 8

SHARE OF IMPORTS OF ENERGY BY JAP.,PEC

17
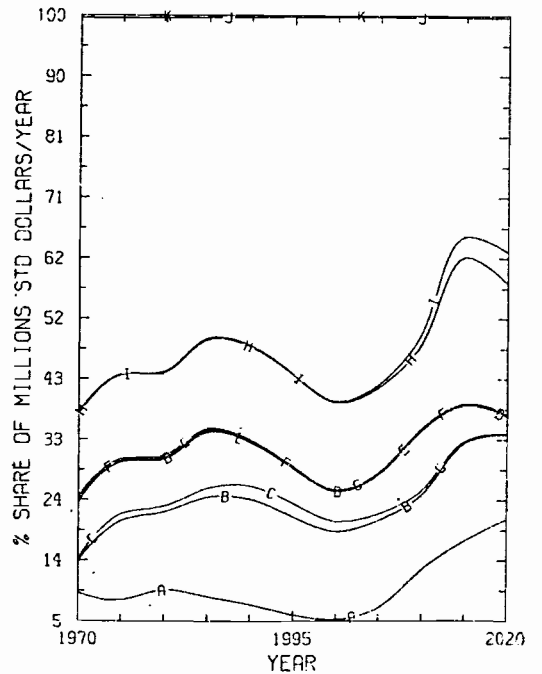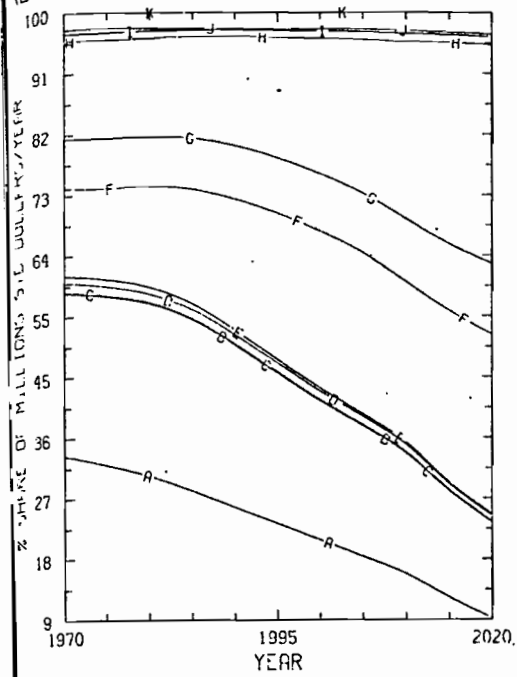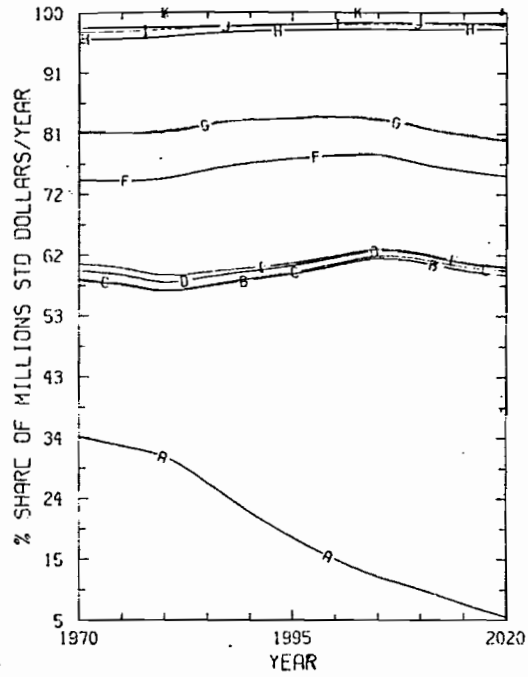
FIGURE 9
% OF IMPORTS OF MINERALS BY JAP..STD

FIGURE 10
SHARE OF IMPORT OF MINERALS BY JAP.PEC1A

A North America
B Australia
C New Zealand
D European & Asian COMECON

E Other Europe and Asia
  Minor
F Latin America &
  Caribbean
G South Asia
H East & SE Asia

I China
J West Asia & North
  Africa
K Other Africa

FIGURE 11
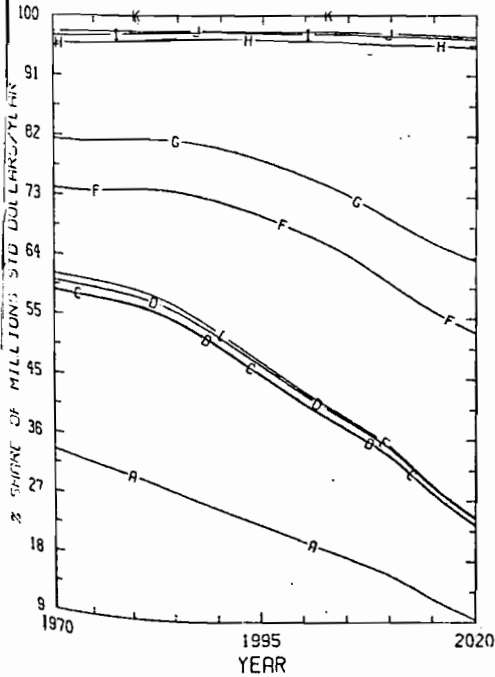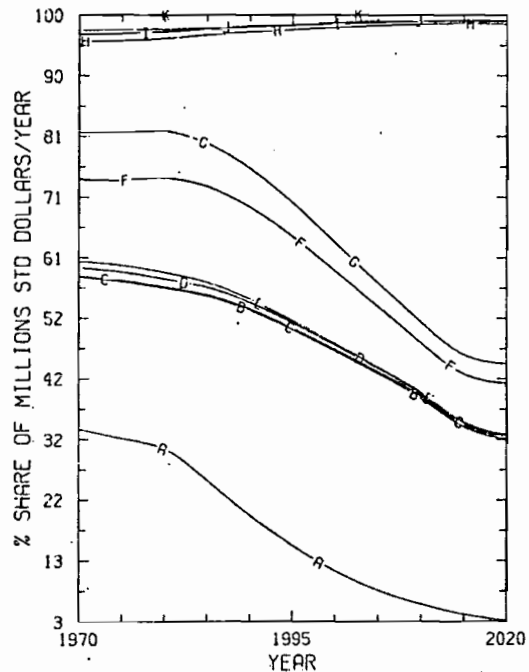% OF IMPORT OF MINERALS BY JAP,PEC1B

FIGURE 12
SHARE OF IMPORT OF MINERALS BY JAP,PEC1C

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8.   FOOD IMPORTING BY EAST AND SOUTH EAST ASIA

Trade in food may lead to a highly competitive situation between Australia and New Zealand. Figures 13 through 16 show the share of ESEA's food imports from all regions. In the standard run (Figure 13) there is an increase in the share of imports being supplied by China with some increases from Australia and New Zealand. These gains are made at the expense of Japan mainly, whose share falls from about 41 per cent in 1970 to 21 per cent in 2020.

Japan in the grouping with ANZ shows some gains (Figure 14) over the standard run. There is little change in the share of this market going to Australia and New Zealand. China losses about 2 per cent of this market by 2020.

When Japan is not in the community as shown in Figure 15, the gain for Australia is very marked, reaching some 70 per cent of all ESEA's imports. New Zealand increases her share from about 1 per cent to 13 per cent by 2020. At the same time the North American share falls from 30 per cent to 9 per cent. A similar fall is shown for China.

Finally, in Figure 16, when we have all four regions in the community, Australia's share of the ESEA market is still an appreciable one of around 55 per cent, with New Zealand retaining its share of 13 per cent in 2020. Japan returns to a share of around 16 per cent in the year 2020 with North America and China remaining the same as in the PEC-1B previous case.

FIGURE 13
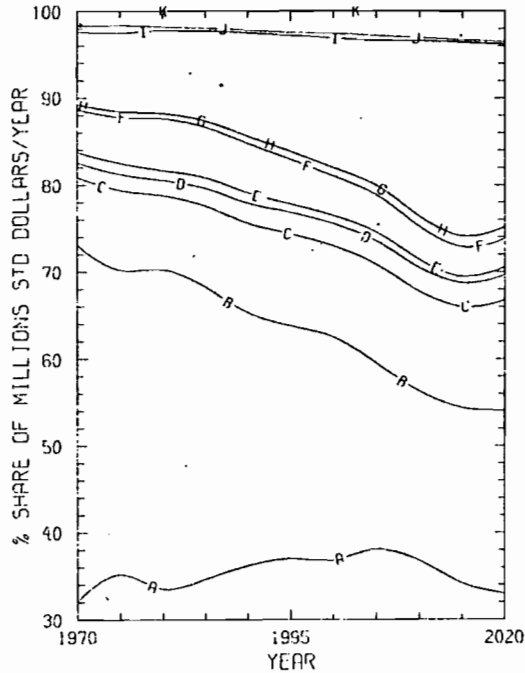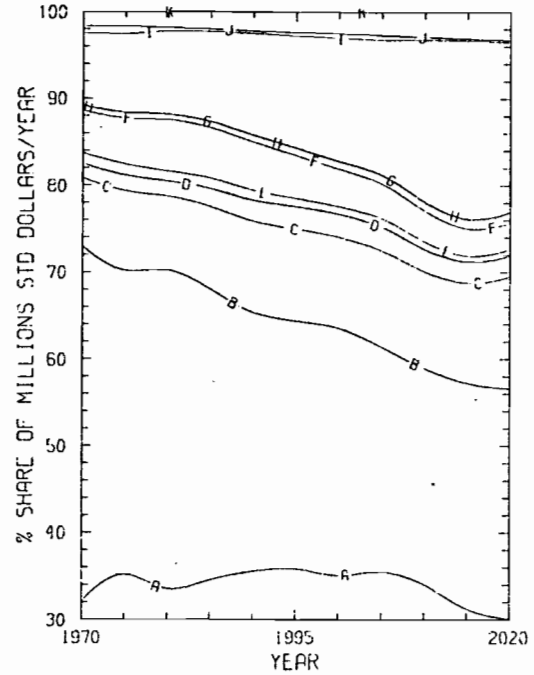### SHARE OF IMPORTS OF FOOD BY ESEA.STD RUN

FIGURE 14
SHARE OF IMPORTS OF FOOD BY ESEA.PECIA

A North America E European & Asian COMECON I China
B Japan   F Other Europe & Asia Minor   J West Asia & North Africa
C Australia   G Latin America & Caribbean   K Other Africa
D New Zealand   H South Asia

FIGURE 15
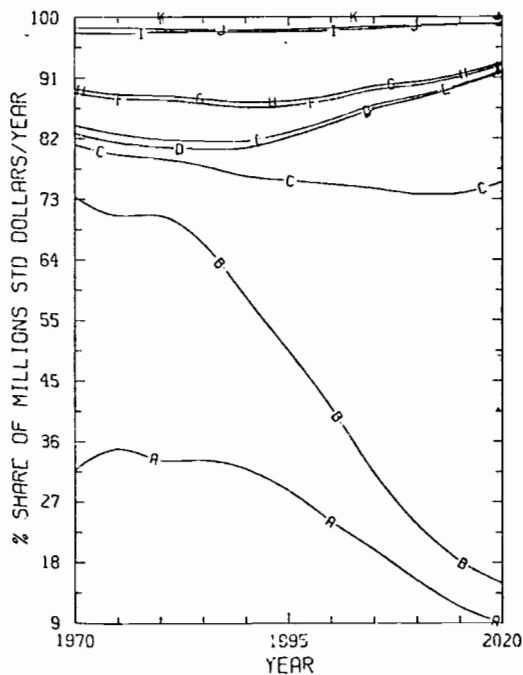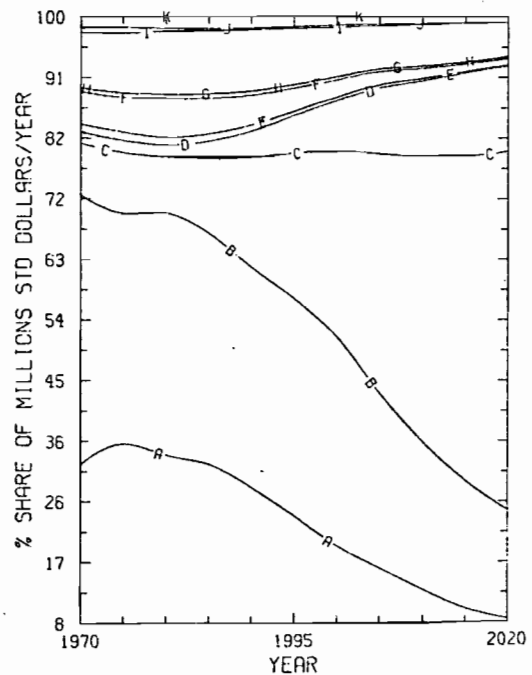### SHARE OF IMPORTS OF FOOD BY ESEA.PECIB

FIGURE 16
SHARE OF IMPORTS OF FOOD BY ESEA,PECIC

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9.   SOME EMPLOYMENT IMPLICATIONS

A comparison of the economic benefits of trade liberalisation in GDP terms hides many other economic considerations. For example, the employment implications of development programmes, such as those for trade liberalisation considered here, would be a major economic concern. In this regard we see from Table 2 that the effect on the Australian manufacturing sector is to almost halve the numbers employed in this sector for any of the trade liberalisation cases considered here.

TABLE 2
EMPLOYMENT IN MANUFACTURING SECTOR BY 2020
(Expressed in millions of man years per year)

Region (Population)	Reference (1970 levels)	PEC-1A ANZ+Japan	PEC-1B ANZ+ESEA	PEC-1C ANZ+Japan+ESEA
Aust (20.6M)	0.91(1.01)	0.53	0.68	0.48
NZ (4.1M)	0.15 (0.12)	0.11	0.12	0.10
Japan (151M)	8.43 (7.14)	8.45	8.44	8.44
ESEA (853M)	34.75 (11.30)	36.75	37.68	35.78

In considering trade liberalisation between Australia, New Zealand, Japan and ESEA it is a relatively simple matter to identify the factors that cause the results generated in the foregoing. Australia is in a position to supply the community with mineral and energy resources as well as land resources for the production of food. New Zealand is an economic producer of high quality foodstuffs, most of which do not clash with the cereal food products of Australia. Japan has the secondary industry infrastructure

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to produce machinery and manufactured goods in either a semi-finished or finished condition. East and South East Asia has a large human resource which at an estimated 850 million by 2020 would be 83 per cent of the population of the Pacific economic community of four regions considered here. In other sectors we see that Australia would double its workforce in the service sector to a level of seven million people and double the numbers employed in the energy and minerals sectors by 2020. While ESEA also has marked gains in employment levels in all its sectors, it nevertheless would experience a decrease in the percentage of the population employed from about 37 per cent in 1970 to about 25 per cent by the end of the simulation period, 2020. This is due to a more rapid growth in population than in the economy.

10. CONCLUSIONS

A case has been made for using dynamic simulation models as a tool of prospective analysis in general and of global futures research in particular. The research results used to develop this case have been produced by a project being conducted within government which has the aim of assessing the utility of a World-Australia model for prospective analysis and evaluating policy options.

The process of assessing the developing utility of these models needs to go beyond the validation of model structures and the verification of model results to an evaluation by other *futures studies* analysts and modellers. This symposium offers an opportunity to stimulate such evaluation. Without critical evaluation these models are not likely to proceed to the stage of direct use within the policymaking framework of government.

FOOTNOTES

1. . For a more detailed treatment of modelling concepts refer to
   J.M. Mula, Modelling Concepts and Models Reviewed. Presented
   to a seminar *Essential Concepts Underlying Financial Management
   Information Systems Development,* Qld Department of Main Roads,
   Brisbane, June 1978.

2. M.K. Starr, *Management : A Modern Approach,* Harcourt Bruce
   Jovanovich, 1971, p.31.

3. J.W. Forrester, *Industrial Dynamics,* M.I.T. Press and John Wiley
   & Sons, Cambridge, Mass., 1961.

4. J.M. Mula, A Survey of World and Australia Models, *Environmental
   Studies Paper, AREA-6,* Department of Science and the Environment,
   Canberra, March 1979. This paper contains a description of 10
   world models and 6 Australia models plus discussion on other
   global and national modelling work. The 'T' model of Y. Kaya
   and other co-workers in Japan where a static model is linked to
   a dynamic model is further explained in Report on Project
   FUGI : Future of Global Interdependence, presented at *5th
   IIASA Global Modelling Conference,* September 1977. This linking
   mechanism between global and national models will be the focus
   of future research that has been designed for the 1980 Global
   Models Project of the East-West Center, Hawaii.

5. K.T. Parker, Modelling Inter-regional Activity by Means of
   Trade Biases, in *Proceedings of 2nd IFAC/IFORS/IIASA International
   Conference on the Modelling and Control of National Economics,*
   North Holland, Vienna, 1977.

6. OECD, *INTERFUTURES : Facing, the Future : Mastering the
   Probable and Managing the unpredictable,* OECD, Paris, 1979.

7. *Ibid,* Part V.

8. More details can be found on these scenarios in J.M. Mula and
   D. MacRae, Assessing the Impact of a Pacific Economic Community
   (PEC) on Australia and New Zealand Using AREAM, *Environmental
   Studies Paper, AREA-12,* Department of Science and the Environment.
   Presented to *7th IIASA Global Modelling Conference,* International
   Institute for Applied Systems Analysis, Laxenburg, Austria,
   October 1979 and to be published in proceedings.

9. A more detailed analysis of the Australia-New Zealand union
   scenario will be found in J.M. Mula and D. MacRae, Global
   Economic Modelling : Some Australian and New Zealand Perspectives,
   Environmental Studies Paper, AREA-14, Department of Science
   and the Environment. To be presented at the *ANZ 4th Regional
   Science Association Conference,* Albury-Wodonga, December, 1979.

10. The term *glut* is a limit placed on the amount a person can physically consume. Although the expenditure on food continues to increase for the rich countries, we assume they are buying more expensive food and also paying more for services such as retailing, preparation and catering. The glut limit is set to 20 gigajoules per person per year and is the cereal equivalent of Australian food consumption in 1970.