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Documentation of the Thammasat University International (TUI) Model

by

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The TUI Model is an abbreviation of the Thammasat University International Model. The model was orignally developed by Dr.Apichai Puntasen under the supervision of Dr. Peter Brain of the Institute of Applied Economic and Social Research, University of Melbourne, Australia. The model has its origin in 1978. The Australian version is known as the International Module which is part of the IMP Model (Institute Multipurpose Project). The IMP Model is basically an intermediate and long-term forecasting dynamic model of the Australian economy. It consists of seven modules:

1. Industrial Activity
2. Energy
3. State
4. Finance
5. Agriculture
6. Demography
7. International

The first six modules only deal with internal Australian scence. The last one deals with the development of world economies. Since this last module will be installed at Thammasat University and will be further developed to be more relevant to the Thai economy and the ones in the Asian-Pacific region, the new name of Thammasat University International Model (TUI MODEL) is given to the new version of the International Module.

Utilities of A World - Wide Model

In the process of constructing a nation-wide model, no mather whether it is a large or a small one, if the economy in question is an open economy (in most cases they are), modellers are confronted with a set of exogeneous variables resulting from changes in world economic enviroments. Small open economies will be affected more from such changes than the larger ones. Their economic performances are tied to world economic fluctuations. They vertually have no or only little influence on the performance of the world economies.

Under such circomstance, those who construct a nation-wide model must try to find the way to gain information for some of their exogeneous variables, among them are the growth rate of the GDP of developed countries, the change in exchange rates, the change in interest rates, the change in energy price especially oil and etc.

These variables will help determine the demand for exports, the values of imports, the amount of capital flows into and out of the economy in question. The combined influences of the above variables will set the limit to growth, investment, employment, and consumption in the country in question. Without such exogeneous constraints, the calculation of growth of a nation-wide model could have been increased without bound during the simulation process.

An appropriate question to be raised at this point is how to estimate these exogeneous variables as close to the values as they should be. Since the said exogeneous variables are actually endogenous variables in the world-wide system, therefore a logical answer to this

question is the construction of the world-wide model.

Another question remains to be raised is why each individual country needs a world-wide model for its own forecasting purpose? Whether, the a set of results produced by one model can be used by the others? The answer to the latter question is "yes". Nevertheless, there are several drawbacks for a nation-wide modeller for not having a world-wide model of his own. First of all, the benefits of having a thorough insight into how the model is operated and the understanding of its uderlined assumptions are lost. In this case, those who construct a nation-wide model must take the results from others world-wide model more or less on fate. Secondly, the available world-wide model may not be tailored to specific need of a specific nation-wide model. Some variables which are essential to a specific nation-wide model may not be available in the known world-wide model. Without direct accessibility, there is no way that the specific need of the nation-wide model will be satisfied. Thirdly, and most important of all, without having dirct access to the world-wide model, there is no way that different set of results from different scenarios will be produced on request.

Hence, it is a general practice that a research institute or organization that can afford to build quite detailed nation-wide model will also build their own world-wide model. Although, model building is a capital intensive excercise, once the model is built the updating cost and maintainance cost are relatively light given a good computer facilities. Also, a the world-wide model by itsely, is normally quite useful in helping reseachers to be able to gain insight into the interdepence of world economic activities. This will help them to think in a more systematic manner.

For Thammasat University, the installation of the TUI model will help stimulate the skills in model building for its students and faculty members. Those who are interested in the area can participate in the project to help enlarge the boundary of knowledge within the University in the area of large scale model buidling.

Structure of the TUI Model

The present version of the TUI model devides the world into four major regions, Organization of Economic Community Development (OECD) or Developed Market Economies, Oil Production Export Countries (OPEC), Non-OPEC Developing Economies (NODE) or Residual Developing Market Economies, and Centrally Planned Economies (CPE). The purpose of this regional classification is to ensure the adding up of the world economies. This procedure is a standard practice for assuring a closed system of a world-wide model.

Within the OECD countries there are detailed country models of the six leading OECD countries and two regions. They are Japan, France, Germany, Italy, the United Kingdom and the United States. Main aggregate equations are estimated for the two sub-regions within the OECD, namely, Residual Western Europe, and Residual OECD. The latter includes, Canada, Australia and New Zealand.

A Model of for Each of the Six OECD Countries

For each of the six OECD countries, there are set of equations for GDP determination by expenditure approach. Details of 5 sectoral value-added, namely, agriculture, manufacture, construction, services,

and residual are also classified. There are also a set of equations for GDP determination by income approach. The purpose of this exercise is to keep checking the GDP's for both approaches. Since, the production approach calculates the GDP in real term while that of the consumption approach is in current values The additional gain from doing so is that the GDP deflator can be calculated from the results of the two approaches. This GDP deflator is quite crucial because, it will, be fed back into the system in terms of the calculation of other deflators. The most important one among them is consumption deflator which is used to calculate inflation rates. This consumption deflator will in turn help determine most variables in the process of the calculation of current value of the GDP. Therefore the two GDP's must move in line with each other.

After the determination of the GDP, the model for each OECD country also provides five sectoral disaggregation in factor markets. Again, five equations are estimated for both the supplies, of and demand for labour. This classification is designed to conform with the five sectoral details of outputs which is partially constrainted by the GDP determination. The equilibrium solution in the labour market influenced by wages and inflation rate also determine employment and unemployment. Population is given exogeneously to the system.

Capital market is not yet fully integrated into the system. Nevertheless, capital utilization helps determine change in stocks and non-energy imports. Capital stocks and capital investment are determined by the desired level of GDP but there is no feed back effect from capital stock to the GDP.

There are quite detailed equations of energy flows for each major OECD country. Energy are classified into oil, gas, coal, nucear,

and hydro power. Each of them has an equation for production. Energy use are classified into three sectors, namely, industry, transportaion, and domestic uses. Electricity is treated as a secondary source of energy. Since electricitry is the main form of power for domestic uses, this item of energy is only classified into single use accordingly. The differences between demand and supply determined by prices of various forms of energy used also determine energy imports and exports.

There are only a set of seven equations for the GDP determination (main aggregats, expenditure approach) for the two OECD regions. Nevertheless, each of them has a set of equations for energy details as each of the major OECD country.

OPEC

There are no country detailed equations for OPEC. The main form of energy flown out of OPEC is liquid fuel. Therefore, for OPEC countries there is only a set of equations of demand for energy from OPEC and supply of energy of OPEC and the GDP equaions.

NODE

There are a set of two equations for a country model for some countries and region in the NODE. They are equations for the GDP and work forces. Countries and regions included are Singapore, Hong Kong, Taiwan, Korea, Thailand, Philippines, Malaysia, Indonesia, and the regional groups of Latin America, Africa and the residual of NODE.

The NODE aggregate contains a set of import and export equations and GDP determination. It also contains the set of disaggregate energy production, consumption and imports; also, a set of capital flows.

CPE

Also, the CPE does not has a country detail. It only has an equation for the GDP determination and the set of equations for energy sector.

World

Grouped under the 'world' contains only equations for GDP determination, world export price of agricultural products, world export price of non-fuel mineral products and world export price of energy.

Linkage Mechanism of Each Regional Group

The four main regional groups are linked together by commodity energy, capital, and service flows. Within the OECD, each individual country and region is linked together by bilateral trade flows. Each of them is linked to OPEC by the set of import equations from OPEC.

As for capital flows, the focus is only on bilateral flows between other regional groups and NODE only. The flows between OPEC and OECD and within the OECD themselves are not yet captured in the model.

Adding Up Property

Adding up property is quite crucial to this model in order to ensure that the system is properly closed. A closed system is a key to a successful operation of this model. Without this property one country or region may grow out of proportion during the process of iteration.

It has been shown earlier that regional adding up is done at all levels of aggregation in the model. However, there are other two crucial adding up properties to be explained below. These are the adding up of trade balances and current balances of payment. Theoretically, balances of payment should be most crucial in this model because it would influence exhcnage rate in each country. Unfortunately, capital flows in this model are not adequated treated. Therefore, balance of trade,is used as a factor to determine exchange rate. Also, theoretically, world balances of trade and of payment each should be added up to zero. Actual published figures from any sources do not have this property. Many errors involved in the process of data collection. Among them are different timing in statistical collection, the imprecision in the rates of conversion (exchange rates), definitional defferences and simple error in the process of data collection.

To solve this problem two measures are introduced. First, only import data are used for all countries to maintain consistency in the data set. In addition, it is assumed that imports of country A from B is equivalent to exports of country B to A. The flow can be represent unambiguously by arrow direction A<-B.

To ensure the adding up property of the balance of trade of each individual OECD country, balance of trade of Residual Europe is treated as a residual of the system and the summation of trade balances

of each OECD country and region must be equal to total OECD trade balance.

Given that figure in the bracket 01,02,.....08, represents a country and a region of Japan, France, Germany, Italy, United Kingdom, The United States, Residual Western Europe, Residual OECD respectively and that 50 is for OECD, and $BT stands for current value in U.S. doller of balance of trade.

[01]$BT+[02]$BT+[03]$BT+[04]$BT+[05]$BT+[06]$BT+[07]$BT+[08]$BT = [50]$BT

or [07]$BT = [50]$BT-[01]$BT-[02]$BT-[03]$BT-[04]$BT-[05]$BT-[06]$BT-[08]$BT.

For the global balance of trade, the balance of trade of the CPE is treated as a residual.

[53]$BT = 0.0- [50]$BT-[51]$BT-[52]$BT

where: [51] = OPEC

[52] = NODE

[53] = CPE

The adding up property of the balance of payment is calculated from the fact that balance of payment is equal to the summation of the balance of trade, net service and private transferred payment and government transferred payment. Since the summation of $BT is zero, if the summation of net service and private transferred payment and government transferred payment are all equal to zero. The summation of the world balance of payment is also zero. In actual calcultion of the world balance of payment, it is assumed in addition that for the CPE balance of trade is equal to balance of payment and the two items of transferred payment are equal to zero.

If $BP is the current value in U.S. dollar of balance of payment.

[50]$BP+[51]$BP+[52]$BP = 0

For each OECD country or region, the balances of payment of each country and the Residual OECD are estimated. Again, the balance of payment of Residual Europe is treated as the residual of the system.

[07]$BP = [50]$BP-[01]$BP-[02]$BP-[03]$BP-[04]$BP-[05]$BP-[06]$BP-[08]$BP

Determination of the System Solution

The model is basically a medium and long-term dynamic of a Keynesian type. Namely, aggregate demand is a growth stimulating factor. The model contains the property of a general equilibrium within each country and the global equilibrium through balance of trade and balance of payment constraints.

There are vertually no supply constraints within the system. Actually, there are two factor inputs that can generate growth and are exogeneous to the system. The first factor is population growth. This factor will help determine labour input which could, in theory, influence growth. However, in this model, labour input does not enter into production directly. It merely helpe determine the supply of labour. On the other hand, the demand for labour is estimated from the production function. The difference between the supply of and the demand for labour will in turn determine employment and unemployment.

The second factor is oil supply. Again, oil supply is not totally independent to the oil demand. In this model, it can be done as a matter of an excercise to simulate different amount of oil supply independently from the demand for oil. One will soon find out that such scenario will not conform to actual economic situation in the real world. For example during the period of the world recession the demand for oil would be reduced. It is not practical for the OPEC to increase its supply of oil during that time because it will contribute more to a down-ward pressure in oil price. However, if the OPEC tries to squeeze their oil supply during such period, the world will plunge into deeper recession and the OPEC will find themselves in great difficulty as well. On the other hand, if the OPEC decide to decrease its oil supply during the up-turn of the industrialized economies. They can do so but the world growth will be sluggish and the OPEC may not neccessary maximize their long-term net gain from the given amount of their oil supply. During the slugglish period, the price of oil may fall again or can increase only slowly. Although OPEC can control their oil supply in theory, they cannot do much except regulate their supply of oil in line with the world demand. A change in oil supply can actually influence world output growth, but a case for independently increase or decrease in the supply of oil from that of the world demand is quite limited. Therefore the growth generation in this model must be initiated from the demand side. This is why the model is of a Keynesian type. Therefore, the two exogeneous variables namely, oil supply and population growth play less significant role in growth stimulation.

Minimum Amount of Exogeneous Variables.

Since the model is designed for a medium and a long-term purpose, it is logical to cut down number of exogeneous variables to the minimum. Expecially, with the world model where the simulation results of this model will be fed into exogeneous variable of a nation-wide one, a situation of a so called "hand off' run or the "free run" of the model should be encouraged. It has always been a problem for medium-term or long term model builders to supply future values for their exogeneous variables. Hence the approach in constructing the TUI model is to design as many variables to be determined within the system as much as possible. In order to achieve such objective price mechanism is used in most cases as a driving force for each market to reach each local equilibrium solution. Fortunately, all price equations in this model provide very good fit, and price variables in most equations are significant. Also, all policy variable must be designed as built-in mechanism and must be consistent with growth objectives. These two properties add a neo-classic flavour to the model.

Because of the nature of the demand led growth and the built in policy and price mechanism, without any proper constraints, the model can grow without limit during the process of simulation. The logical constraints in this case are balances of trade and balances of payment. However, as already mentioned earlier, because of the incomplete structure of the capital flow, balance of trade are both, necessary and sufficient constraints.

The main driving force for growth on the demand side of any country is export. However, in order to achieve long term global balance a country cannot afford to have chronic deficit balance of trade for a long period of time especially those of the OECD. Balances of trade in these countries carry significant weight in their balances of

payment. Chronic deficits in balances of trade would mean chronic deficits in balance of payment for most of them. A built-in mechanism in this respect, is the change in exchange rates. Those who have surplus balances of trade after a certain limit must appreciate their currencies. Those who have deficit balances of trade after a certain limit must depreciate their currencies. The change in exchange rates will cause the change in export deflators of the related countries, and the relative export prices in the model. This will cause a change in the direction of trade and the balances of trade will be readjusted in the sub-sequent periods. This mechanism will prevent any individual country to grow without limit.

Actual Control Mechanism

In order to control the simulation results to be within a reasonable bound, the technique known as quadratic optimization by Tinbergen and Theil is adopted (See B. Friedman Economic Stabilization Policy : Method in Optimization). The logic behind the whole operation is that the objective target should be specified within a reasonable bound. Then, significant variables should be used as instruments which will change their values for each simulaion according to a specified shock parameters. In the process of chasing after the set of targets, values of all variables effected by intrumental variables will also change accordingly. In most cases, the final solutions are reached at the point where computed target values are still different from the set target values. The results are mainly due different values of shock parameters supplied. It is not likely that one could supply a shock parameter that finally bring computed target value to converge

to the set value. In most cases, the shock parameter could be either too high or too low. In the case that the value of shock parameter is too high, the computed value may fluctuate around the set target and will never converge. On the other hand, if the shock value is too low, the system may require too many iterations before, the final solution can be reached. In such case, the program will stop in the middle of the calculation process because it runs out of time. Therefore the shock parameter must be carefully selected mostly by a process of trials and errors.

A set of target variables and instrumental variables can be changed from one run to the others. However, the intrumental variable that are crucial to the proper performance of this model are exchange rates and oil price. The former set of variables are the main driving forces determining the direction of trade flows. The last variable reflects the oil demand and supply situation and the whole range of energy prices. These prices will influence import prices of the OECD countries and will in turn influence the inflation rates, unemployment within those countries and finally their exports prices. The change in oil price will have important impact on the economic performance of the global economy.

Target variable must be set in a reasonable manner. Presently, target variables are competitive parity prices.

[I]TARG = [I]%X$L1*[06]%X$/[06]%X$L1

where: %X$ = export deflator in U.S. dollar.

%X$L1 = one year lag of export deflator in U.S. dollar.

[I] = 01,02,03.....,05

The target variable of a country in question is equal to the lagged value of export price of that country multiplied by the rate of change of export price of the United States. This relationship means that, in order maintain export parity, export price of other country should change in proportion to the change in export price of the United States. The instrumental variables for achieving the above set of targets are exchange rates.

The target variable for the oil price instrument is logical enough to be a market clearing condition.

OID-OIS = 0

Oil demand minus oil supply must be zero.

The adding up property which implies the balance of trade and balance of payment constraints together with the above controlling technique will keep control the perfomance of the model to be within a reasonable bound while it requires only a minimum set of exogeneous variables. This sums up how the TUI model is designed to operate. within a minimum set of exogeneous variables.

MODEL STRUCTURE

Before listing the whole model structure, variables must be specified. Since the model contains 1,084 variables (not including distributed lags) if each variable is listed one after the other, the list will be cumbersome and long. The technique adopted here is to list only distinctive variables. Appropriate prefix, subfix, to identify a variable country or region, by current value in domestic currency or in U.S. dollar, or by real value in domestic currency or in U.S. dollar, will be supplied by the set of rules after the variable list.

Variable List

AHW	Average working hour per week
AM	Amortization
AW	Average wage
BP	Balance of payment
BT	Balance of trade
CB	Cash benefit
CO	Coal
COE	Conpensation of employees
CON	Private consumption expenditure
DCO	Domestic coal
DCOP	Domestic coal production
DEN	Domestic energy

DGA	Domestic gas
DGAP	Domestic gas production
DIN	Disposible income
DOI	Domestic oil
DOICON	Domestic oil consumption
DOIP	Domestic oil production
DNP	Domestic nuclear production
DSER	Debt services
DSK	Stock of debts
DT	Direct tax
DTL	Disputed time lost
DTR	Direct tax rate
EL	Electricity
ELFD	Final Demand of electricity
ELID	Electricity input into domestic sector
ELII	Electricity input into industry
EM	Employment
EN	Energy
ENFD	Final demand for energy
ENCONT	Total energy consumption

ENID	Energy input into domestic sector
ENII	Energy input into industry
ENIT	Energy input into tranportation
ENPT	Total energy production
ENFU	Energy to final users
ENRM	Energy requirement
EXR	Exchange rate
FAHW	Five years moving average of average hour per week
GA	Gas
GACON	Gas consumption
GAP	Gas production
GCE	Goverment consumption expenditures
GDP	Gross domestic product
GDPT	Trend of gross domestic product
GIN	Government income
GINV	Goverment investment
GKD	Goverment capital depreciation
GRB	Gross borrowing
GRFINV	Gross fixed investment
GROS	Gross operating surplus

GT	Gasoling tax
HASER	Housing and accommodative service
HID	Household dispossible income
HIN	Household income
HP	Hydro production
HNENP	Hydro/Nuclear Energy production
IEN	Industrial energy
IIR	International interest rate
IITR	Indirect income tax revernue
INV	Investment
INVSK	Investment stock
KSK	Capital stock
KU	Capital utization
LF	Liquid fuel
LFCON	Liquid fuel consumption
LFP	Liquid fuel production
M	Import
MCOT	Total imports of coal
MEN	Import of energy
MG	Import of goods

MGAT	Total import of gas
MGSER	Imports of goods and services
MOI	Imports of oil
MONE	Money supply (M1)
MNEN	Imports of non-energy
MT	Total import
NB	Net borrowing
NEN	Non energy
NGA	Net goverment accummulation
NIR	Norminal interest rate
NOIENS	Non-oil energy supply
NPL	Net public lending
NWHI	Non-wage household income
OGE	Other goverment expenditure
OGIN	Other goverment income
OI	Oil
OID	Oil demand
OIP	Oil product
OIRM	Oil requirement
OIS	Oil supply

ONTR	Other non-tax revernue
OSER	Other services
POP	Population
POPFO	Population of age 15 and over
@RE	Change in reserve
RESINV	Residential investment
RESK	Reserve stock
SEAEN	Supply elasticities of alternative energy
SDR	Special drawing right allocation
SF	Solid fuel
SFCON	Solid fuel consumption
SFP	Solid fuel production
@SK	Change in stocks
SR	Saving ratio
T	Time
TF	Transport fuel
UL	Unemployment level
UR	Unemployment rate
WF	Workforces
WHPW	Work-hour per week
WPH	Wage per hour
WS	Wages and salaries
X	Exports
XT	Total exports

WHPW	Work-hour per week
WPH	Wage per hour
WS	Wages and salaries
X	Exports
XT	Total exports

Prefix and Subfix Rules

1. Variables in Monetary Units

Variables expressed in monetary values are either in domestic currency or in the U.S. dollar. Both are expressed in real price and current price. The base year of the real price is 1970. For those expressed in the U.S. dollar, 1970 price and 1970 exchange rate is used for the conversion.

The following notations are adopted for such variable expressed in monetary units. Those in real domestic price is represented by the variable names listed above, and those in current value start with the prefix "C". Those in real U.S. dollar start with the prefix "R" and those in current value start with the prefix "$".

All deflators computed from domestic value start with the prefix "%" and those from the U.S. dollar start with "%" and end with "$". For the price that is expressed in "real price" (the price deflated by some deflators), the prefix "RP" will be used. If it is calculated from the value in U.S. dollar then the prefix "RP" with the subfix "$" will be used. For the current price expressed in domestic currency the prefix "CP" will be used. Again the prefix of "CP" with the subfix "$" will be used for the current value expressed in the U.S. dollar.

Example 1

CON stands for private consumption expenditures.

CON = Real private consumption expenditures in domestic currency.

CCON = Current value of private consumption expenditures in domestic currency.

RCON = Real private consumption expenditure in the U.S. dollar (at 1970 price and 1970 exchange rate)

$CON = Current value of private consumption expenditures in the U.S. dollar.

%CON = Consumption deflator computed from domestic currency.

%CON$ = Consumption deflator computed from the U.S. dollar.

2. Sectoral Disaggregation

Some variables are classified into five sectoral diaggregations. The following number of subfix will be used to distinguish one from the other:

1. Agriculture
2. Manufacturing
3. Construction
4. Community and personal services
5. Residual sector
6. Residential sector
7. Government sector (not specified explicitly elsewhere)

8. Military services

Example 2

GDP stands for gross domestic product.

GDP = Real gross domestic product in domestic currency.

GDP1 = Real output or real value added of an agricultural sector in domestic currency.

GDP2 = Real output or real value added of a manufacturing sector in domestic currency.

GDP3 = Real output or real value added of a construction sector in domestic currency.

GDP4 = Real output or real value added of a community and personal service sector in domestic currency.

GDP5 = Real output or real value added of a residual sector in domestic currency.

3. Country and Regional Distinction

In order to dintinguish one country or a group of countries from the others. The following two digit number are used in a square bracket as a prefix of the relevant variable.

OECD's Country and Region

[01] Japan

[02] France

[03] Germany

[04] Italy

[05] United Kingdom

[06] The United States

[07] Residual Western Europe

[08] Residual OECD

Non-opec Developing Economies

[30] Hong Kong

[31] Singapore

[32] Korea

[33] Taiwan

[34] Indonesia

[35] Malaysia

[36] Philippines

[37] Thailand

[38] Latin America

[39] Residual Africa

[40] Residual Non-Opec Developing Economics

Group of Countries

[20] Europe OECD

[50] OECD

[51] OPEC

[52] Non-opec Developing Economics

[53] Centrally Planned Economies

[60] World

Example 3

GDP stands for gross domestic product.

[01]RGDP = Real GDP of Japan in the U.S. dollar.

[60]RGDP = Real world GDP in the U.S. dollar.

[03]GDP2 = Real value added in a manufacturing sector of Germany in domestic currency.

[06]GDP3 = Real value added in a construction section of the united States in domestic currency.

4. Variable Transformed into Natural Log

A variable transformed into natural log value will be expressed in a parenthesis with the prefix LN before the open parenthesis (i.e.LN(....))

Example 4

LN([01]CON2/[01]POP) = Natural log of the real value in domestic currency of consumption of manufactured goods of Japan devided by its population.

LN([03]%RESINV/[03]%CON) = Natural log of residential investment deflator calculated from domestic currency of Germany devided by its consumption deflator also calculated from domestic currency.

5. Distributed Lags

A lagged variable is identifed by the subfix (L1, L2, L3, L4, L5) at the very end of the variable. Numerical values 1, 2, 3, 4, 5, stand for 1, 2 ....., 5 lagged periods accordingly.

Example 5

[02]%X$L1 = Export deflator of Frence calculated from U.S. dollar with one period lag.

[03]%CONL5 = Consumption deflator of Germany calculated from domestic value with five period lag.

LN([01]GDP1L2) = Natural log of value added in agriculture of Japan expressed in real domestic currency with two period lag.

Other Notations

ZI.J Variables

A variable expressed as a combination of several variables such that many lines are occupied by one complex variable, ZI.J will be used for such variable.

Example 6

```
Z6.2 = (GDPL1-@SKL1)*(0.5*(GDPL1-@SKL1)/(GDPL2-@SKL2)+0.5*(GDPL2-
       @SKL2)/(GDPL3-@SKL3))-(GDP-@SK)
```

Z112.2 = (AHW2+CWPH2+EM2*48.0)/1,000,000.0/GDP2

Predefined Coefficients

Predefined coefficients are represents by lower case letters prespecified in each equation.

Example 7

al = industry weight (coal)

am = industry weight (oil)

an = industry weight (gas)

[I] al = 0.20, 0.16, 0.20, 0.10, 0.17, 0.20, 0.18, 0.12,

[I] am = 0.59, 0.50, 0.50, 0.40, 0.44, 0.27, 0.46, 0.27,

[I] an = 0.02, 0.16, 0.30, 0.22, 0.25, 0.35, 0.20, 0.37,

[I] = 01,02,.....,08

Directions of Flows

Since the model is basically designed to handle bilateral flows of energy and nonenergy and well as capital, directions of flows must be adquately represented. The symbol of "->" will be used to represent export flows from one country to the other, and "<-" for the import flows. Either of the two symbols will be used in the prefix square bracket that represent country distinction.

GROUPING OF EQUATIONS

GDP DETERMINATION OF OECD COUNTRIES AND REGIONS (Expenditure Approach)

Total Consumption of 8 major OECD

- Total Consumption of 6 Major OECD
- Total Consumption of 2 OECD Regions

Other Disaggregation of Consumption of 6 Major OECD

- Total Consumption of Manufacturing Products of 6 Major OECD
- Consumption of Housing and Accommodation of 6 Major OECD
- Consumption of Other Services of 6 Major OECD

Government Expenditure of 6 Major OECD

Change in Stocks of 8 Major OECD

Gross Fixed Capital Formation of 6 Major OECD

Disaggration of Gross Fixed Capatal Formation of 6 Major OECD

- Investment in Agriculture of 6 Major OECD
- Investment in Manufacture of 6 Major OECD
- Investment in Construction of 6 Major OECD
- Investment in Services of 6 Major OECD
- Investment in Residual Sector of 6 Major OECD
- Investment in Residential Sector of 6 Major OECD
- Government Investment of 6 Major OECD

Exports of 8 Major OECD

Total Imports of 8 Major OECD

- Imports of Non-Energy of 8 Major OECD
- Imports of Non-Energy of 6 major OECD

Gross Domestic Product Of 8 Major OECD

- Gross Domestic Product of 6 Major OECD
- Gross Domestic Product of 2 Residual OECD

Disaggregation of GDP of 6 Major OECD

- Value Added in Agriculture of 6 Major OECD
- Value Added in Manufacture of 6 Major OECD
- Value Added in Construction of 6 Major OECD
- Value Added in Services of 6 Major OECD
- Value Added in Residual Sector of 6 Major OECD

GDP DETERMINATION OF OECD COUNTRIES AND REGIONS (Income Approach)

Total Wage and Salaries of 6 Major OECD

Non-wage Household Income of 6 Major OECD

Cash-Benefit of 6 Major OECD

Household Income of 6 Major OECD

Household Disposable Income of 6 Major OECD

Indirect Tax Revenue of 6 Major OECD

Rate of Direct Tax of 6 Major OECD

Direct Tax of 6 Major OECD

Current Price Private Consumption of 6 Major OECD

Real Household Saving of 6 Major OECD

Saving Ratio of 6 Major OECD

Current Price GDP of 6 Major OECD

FACTOR MARKETS OF OECD COUNTRIES AND REGIONS

MANPOWER

Labour Supply

Disaggregation of Labour Supply of 6 Major OECD

- Employment in Agriculture of 6 Major OECD
- Employment in Manufacture of 6 Major OECD
- Employment in Construction of 6 Major OECD
- Employment in Service of 6 Major OECD
- Employment in Residual Sector of 6 Major OECD
- Total Civilian Employment of 6 Major OECD

Employment in Military Services of 6 Major OECD

Unemployment Rate

Unemployment Level

Total Work Forces of 6 Major OECD

Population of 6 Major OECD

Population of Age 15 and Over of 6 Major OECD

Disaggregation of Average Hours of Work per Week of 6 Major OECD

- Average Hours per Week in Agriculture of 6 Major OECD
- Average Hours per Week in Manufacture of 6 Major OECD
- Average Hours per Week in Construction of 6 Major OECD
- Average Hours per Week in Service Sector of 6 Major OECD
- Average Hours per Week in Residual Sector of 6 Major OECD

Disaggregation of Five Year Moving Average of Work-hours per Week of 6 Major OECD

- Five Year Moving Average of Work-hours per Week in Agriculture of 6 Major OECD
- Five Year Moving Average of Work-hours per Week in Manufacture of 6 Major OECD
- Five Year Moving Average of Work-hours per Week in Construction of 6 Major OECD
- Five Year Moving Average of Work-hours per Week in Service of 6 Major OECD
- Five Year Moving Average of Work-hours per Week in Residual Sector of 6 Major OECD

Demand for Labour

Disaggregation of Demand for Labour of 6 Major OECD

- Total Work-hours per Week in Agriculture of 6 Major OECD
- Total Work-hours per Week in Manufacture of 6 Major OECD
- Total Work-hours per Week in Constraction of 6 Major OECD
- Total Work-hours per Week in Service of 6 Major OECD
- Total Work-hours per Week in Residual sector of 6 Major OECD

Wages

Current Price Conpensation of Employee of 6 Major OECD

Total Wage and Salaries of 6 Major OECD

Disaggregation of Wage by Sector of 6 Major OECD

- Current Wage per Hour in Agriculture of 6 Major OECD
- Current Wage per Hour in Manufacture of 6 Major OECD
- Current Wage per Hour in Construction of 6 Major OECD
- Current Wage per Hour in Service of 6 Major OECD
- Current Wage per Hour in Residual Sector of 6 Major OECD

CAPITAL

Real Capital Stocks of 6 Major OECD

Real Capital Investment of 6 Major OECD

Capital Utilization of 6 Major OECD

Return to Capital

Norminal Interest Rate of 6 Major OECD

PROPRIETORS

Gross Operating Surplus of 6 Major OECD

ENERGY

Energy Production

Domestic Oil Production of 8 Major OECD

Domestic Coal Production of 8 Major OECD

Domestic Gas Production of 8 Major OECD

Domestic Nueclear Productions of 8 Major OECD

Domestic Hydro Production of 8 Major OECD

Non-Oil Import Energy Supply of 8 Major OECD

Energy Consumption

Energy Requirement of 8 Major OECD

Oil Requirement of 8 Major OECD

Energy Exports

Oil Exports of 8 Major OECD

Energy Imports

Oil Imports of 8 Major OECD

Imports of Coal of 8 Major OECD

Internal Flows of Energy

Final Demand for Energy of 8 Major OECD

Energy Input Into Industry of 8 Major OECD

Energy Input Into Transportation of 8 Major OECD

Total Energy Input Into Domestic Uses of 8 Major OECD.

Electricity Energy Demand

Total Electricity Into Industry of 8 Major OECD

Total Ectricity Into Transport of 8 Major

Total Electricity Into Domestic Uses of 8 Major OECD

Internal Energy Prices

Price of Energy for Industry of 8 Major OECD

Price of Energy for Transportation of 8 Major OECD

Price of Energy for Domestic Uses of 8 Major OECD

Price of Electricity of 8 major OECD

Policy Variables of Energy

Gasoline Tax of 8 Major OECD

Energy Indirect Taxes of 8 Major OECD

PUBLIC SECTOR AND POLICY VARIABLES OF OECD COUNTRIES AND REGIONS

Other Government Income of 6 Major OECD

Other Non-tax Revenue of 6 Major OECD

Other Government Expenditure of 6 Major OECD

Net Public Lending of 6 Major OECD

Money Supply of 8 Major OECD

PRICE VARIABLES OF OECD COUNTRIES AN REGIONS

Personal Consumption Deflator of 8 Major OECD

Government Expenditure Deflator of 6 Major OECD

Gross Fixed Investment Deflator of 6 Major OECD

Residential Investment Deflator of 6 Major OECD

Export Deflator of 8 Major OECD

Import Deflators of 8 Major OECD

GDP Deflator of 6 Major OECD

GDP Deflator of 2 Residual OECD

Manufacturing Deflator of 6 Major OECD

CONVERSION OF VARIABLES INTO U.S. DOLLARS OF OECD COUNTRIES AND REGIONS

Real Exports (in U.S. Dollar) of 8 Major OECD

Real Total Imports (in U.S. Dollar) of 8 Major OECD

Real GDP (in U.S. Dollar) of 8 major OECD

Export Deflator (in U.S. Dollar) of 8 Major OECD

Import Deflator (in U.S. Dollar) of 8 Major OECD

REGIONAL GROUPS IN THE WORLD ECONOMY

EUROPE OECD

Real Exports of Europe OECD

Real Imports of Europe OECD

Export Deflator of Europe OECD

Import Deflator of Europe OECD

OECD

GDP Determination

Real Exports of OECD

Current Value of Exports of OECD

Real Imports of OECD

Current Value of Emports of OECD

Real GDP of OECD

Export Deflator of OECD

Import Deflator of OECD

Consumption Deflator of OECD

Energy

Net Oil Imports of OECD

Net Oil Sumply of OECD

OPEC

Oil Supply from OPEC to OECD

Oil Demand of OPEC to OECD

OPEC Export to Non-OPEC Developing Economies

OPEC Export to CPE

OPEC Oil Exports.

OPEC Gas Export (TOE)

Current Value of OPEC Exports

Current Value of OPEC Imports

GDP of OPEC

NODE

Exports and Imports

Real Exports of NODE Among Themselves

Real Exports of NODE Among Themselves

Real Exports of NODE to OECD

Real Exports of NODE to OPEC

Real Exports of NODE to CPE

Real Total Exports of NODE

Current Value of Total Exports of NODE

Non-Oil Import NODE

Oil Imports NODE

Total Imports of NODE

GDP

Real GDP of NODE

Energy

Energy Production

Solid Fuel Production of NODE

Liquil Fuel Production of NODE

Gas Production of NODE

Hydro/Nuclear Production of NODE

Total Energy Production of NODE

Energy Consumption

Soild Fuel Consumption of NODE

Liquid Fuel Consumption of NODE

Gas Consumption of NODE

Total Energy Consumption of NODE

Imports

Solid Fuel Imports of NODE

Liquid Fuel Imports of NODE

Gas Imports of NODE

Capital Flows

Amortization Position of NODE

Gross Borrowing of NODE

Debt Services of NODE

Net Borrowing of NODE

Change in Annual Reserve of NODE

Reserve Stocks of NODE

GDP DETERMINATION OF SINGAPORE HONG KONG TAIWAN SOUTH KOREA INDONESIA MALAYSIA PHILIPPINES THAILAND LATIN AMERICA AFRICA AND RESIDUAL NODE

Work-Forces of Developing Countries

GDP of Sub-Groups of NODE

CPE

GDP

- GDP of CPE
- NODE and CPE Export Deflator

Energy

Energy Production

Solid Fuel Production of CPE

Liquid Fuel Production of CPE

Gas Production of CPE

Hydro Production of CPE

Total Energy Production of CPE

Energy Consumption

Total Energy Consumption of CPE

Energy Exports and Imports

Solid Fuel Imports CPE

Liquid Fuel Imports of CPE

GAS imports of CPE

WORLD

World GDP

World Export Price of Agriculture Product

World Export Price of Non-Fuel Product

Norminal OIL Price

Price of Coal

Import Parity Price

Time

COMMODITY FLOWS (TRADE MATRIX) OF INDIVIDUAL OECD COUNTRY OR RIGION
REGIONAL FLOWS

Import Share of All Countries from Japan

Import Share of All Countries from France

Import Share of All Countries from Germany

Import Share of All Countries from Italy

Import Share of All Countries from United Kingdom

Import Share of All Countries from United States

Import Share of All Countries from Residual Europe

Import Share of All Countries from Residual OECD

Real Non-Energy Exports from Japan to the Rest of the World.

Real Non-Energy Exports from France to the Rest of the World.

Real Non-Energy Exports from Germany to the Rest of the World.

Real Non-Energy Exports from Italy to the Rest of the World.

Real Non-Energy Exports from United Kingdom to the Rest of the World.

Real Non-Energy Exports from the United States to the Rest of the World.

Real Non-Energy Exports from the Residual Europe to the Rest of the World.

Real Non-Energy Exports from Residual OECD to the Rest of the World.

Imports from OPEC of 8 Major OECD

WORLD REGIONAL FLOWS

OECD Exports to CPE

Real OECD Exports to Non-OECD

OECD Exports to Non-OECD (IN U.S. Dollar)

OECD Imports from OPEC

OECD Imports from CPE

Export Deflator of OECD to Non-OECD

OPEC Exports to OECD

OPEC Exports to NODE

OPEC Exports to CPE

OPEC Imports from OECD

OPEC Imports from CPE

NODE Exports to OECD

NODE Exports to OPEC

NODE Exports to CPE

NODE Imports from CPE

CAPITAL FLOWS OF OECD, OPEC TO AND FROM NODE

Government Transferred Payment of OECD

Government Transferred Payment of OPEC

Government Transferred Payment of NODE

SDR Allocation for NODE

Investment into NODE from OECD

Stocks of Investment into NODE from OECD

Investment Repayment from NODE to OECD

Investment Flows from NODE to OPEC

Investment Stocks from NODE to OPEC

Investment Repayment from OPEC to NODE

Net Services and Private Transferred Payment of 6 Major OECD

Net Service and Private Transferred Payment of Residual OECD

Net Services and Private Transferred Payment of Residual Europe

Net Services and Private Transferred Payment of OECD

Net Service and Private Transferred Payment of OPEC

Net Services and Private Transferred Payment of NODE

OECD TRADE BALANCE

Current Value of Trade Balance of 8 Major OECD

OECD BALANCE OF PAYMENT

Current Value of Balance of Payment of 6 Major OECD

Current Value of Balance of Paymment of Residual OECD

Current Value of Balance of Payment of Residual Europe

WORLD REGINAL TRADE BALANCE

Current Value of Net Exports of OECD

Current Value of Net Imports of OECD

Current Value of Trade Balance of OECD

Current Value of Net Exports of OPEC

Current Value of Net Imports of OPEC

Current Value of Trade Balance of OPEC

Current Value of Net Exports NODE

Current Value of Net Imports of NODE

Current Value of Trade Balance of NODE

Current Value of Net Exports CPE

Current Value of Net Imports CPE

Current Value of Trade Balance of CPE

Target and Instrumental Variables.

Target Variables

[I]TARG = [J]%X$L1*[06]%X$/[06]%X$L1

I = 1, 2,.....5

J = 01, 02,.....05

[6]TARG = [51]OID-[51]OIS = 0

Where : OID = Oil Demand
OIS = Oil Supply

Instrumental Variables

[I]EXR

[I] = 1, 2, 3, 4, 5

[6]RPOI$ = [60]%OI$-[50]%X$

Where : RPOI = Real Price of oil

Main Control Mechanism

The flow chart below demonstrates how quadratic optimization technique introduced by Tinbergen and Theil operating in actual simulation. The whole mechanism can be explained by the process, A,B and C in Figure 1. Process A starts by specifying all neccessary inputs and instrumental

Main Control Mechanism

The flow chart below demonstrates how quadratic optimization technique introduced by Tinbergen and Theil operating in actual simulation. The whole mechanism can be explained by the process, A,B and C in Figure 1. Process A starts by specifying all neccessary inputs and instrumental variables. Six shock parameters were specified. The first five instruments are specified as exchange rates of Japan, France, Germany, Italy and United Kingdom, respectively. The last is real price of oil which is the difference between oil deflator and export deflator of OECD. The upper limit of these instruments are defined as their lagged values plus the specified marginal changes. The lower limits are the lagged instruments minus maginal changes.

Process B only tests all the values of instruments whether they are within tolerant limits. If they are within the limits, the values of instruments will be set accordingly. If they are higher than the upper limits, they are set to the upper limits. If the values are lower than the lower limits, they are set to the lower limits.

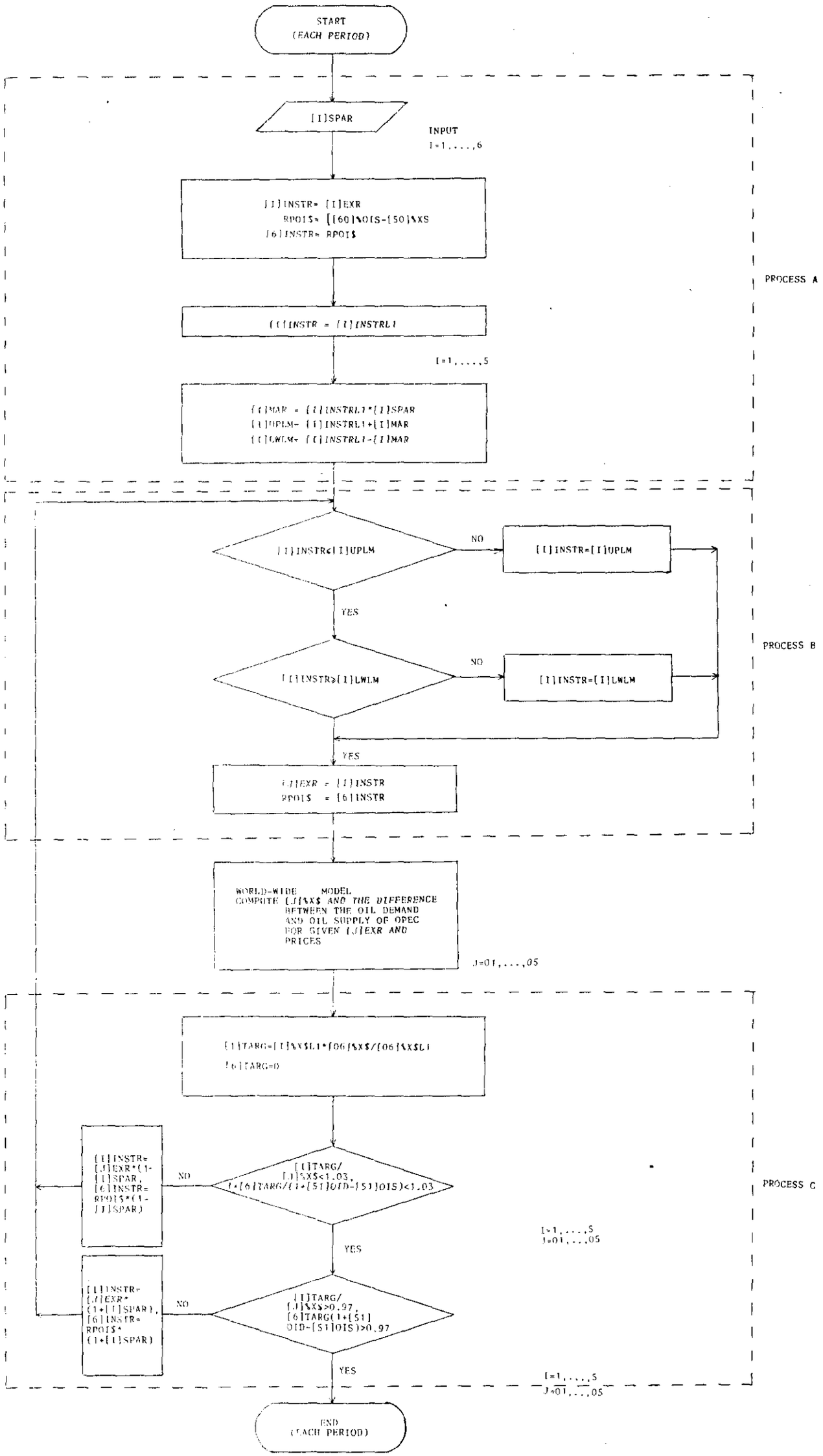
Process B will finally supply the values of relevant exchange rates and real price of oil. Given these values, the whole model will be simulated and the corresponding values of export deflators of Japan, France, Germany, Italy and the United Kingdom and the difference between the demand for and supply of oil from OPEC will be calculated together with the values of all variables in the model.

Process C will test the target values against the computed targets. In this particular case 0.03 is specified as the tolerable limit. If the ratio of the targets and the calculated variable is within

the tolerant limits (0.97-1.03), the the calculated instrumental variables will represent the value of relevant exchange rates and real price of oil and the values of all other variables in the model will be determined. The calculation process will be terminated. If not the instruments will be recalculated and the Process B will be repeated (See Figure 1).

FIGURE 1

DETERMINATION OF EXCHANGE RATES AND OIL PRICE



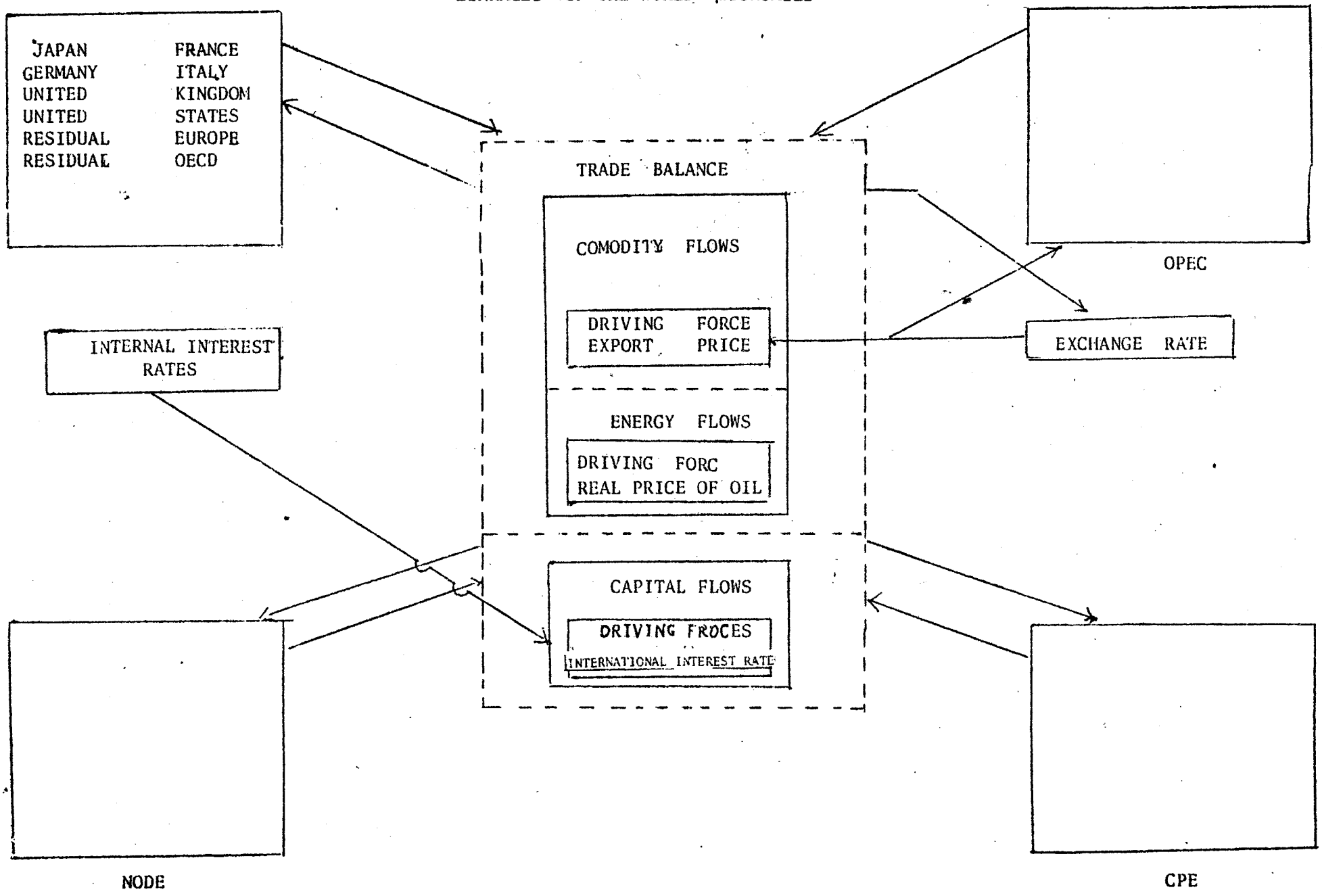

LINKAGES OF THE WORLD ECONOMIES
JAPAN
GERMANY
UNITED KINGDOM
UNITED STATES
RESIDUAL EUROPE
RESIDUAL OECD
FRANCE
ITALY
TRADE BALANCE
COMODITY FLOWS
DRIVING FORCE
EXPORT PRICE
ENERGY FLOWS
DRIVING FORC
REAL PRICE OF OIL
CAPITAL FLOWS
DRIVING FROCES
INTERNATIONAL INTEREST RATE
OPEC
EXCHANGE RATE
INTERNAL INTEREST RATES
NODE
CPE

FIGURE 3

COMMODITY FLOWS

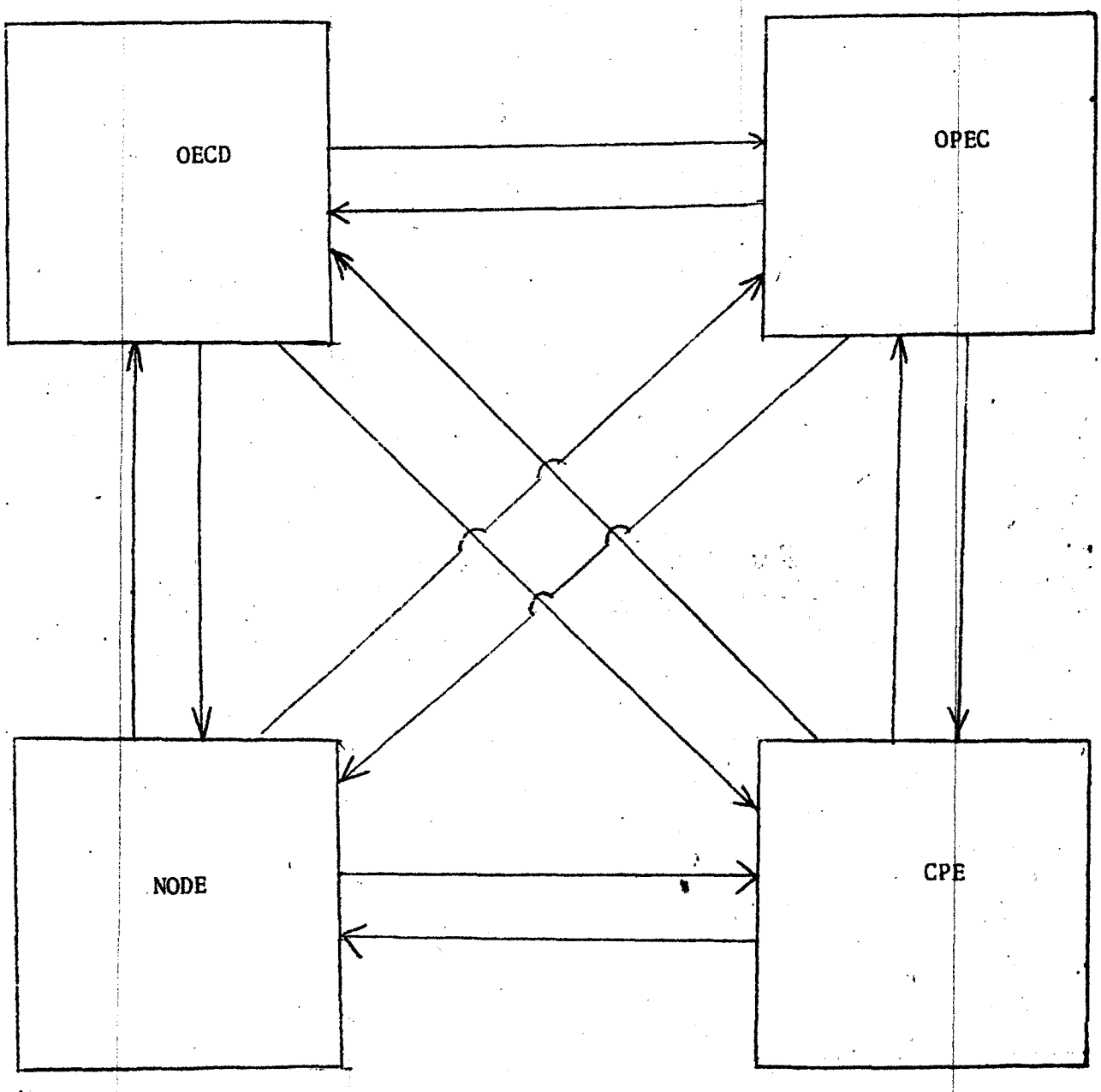


FIGURE 4

NET ENERGY FLOWS

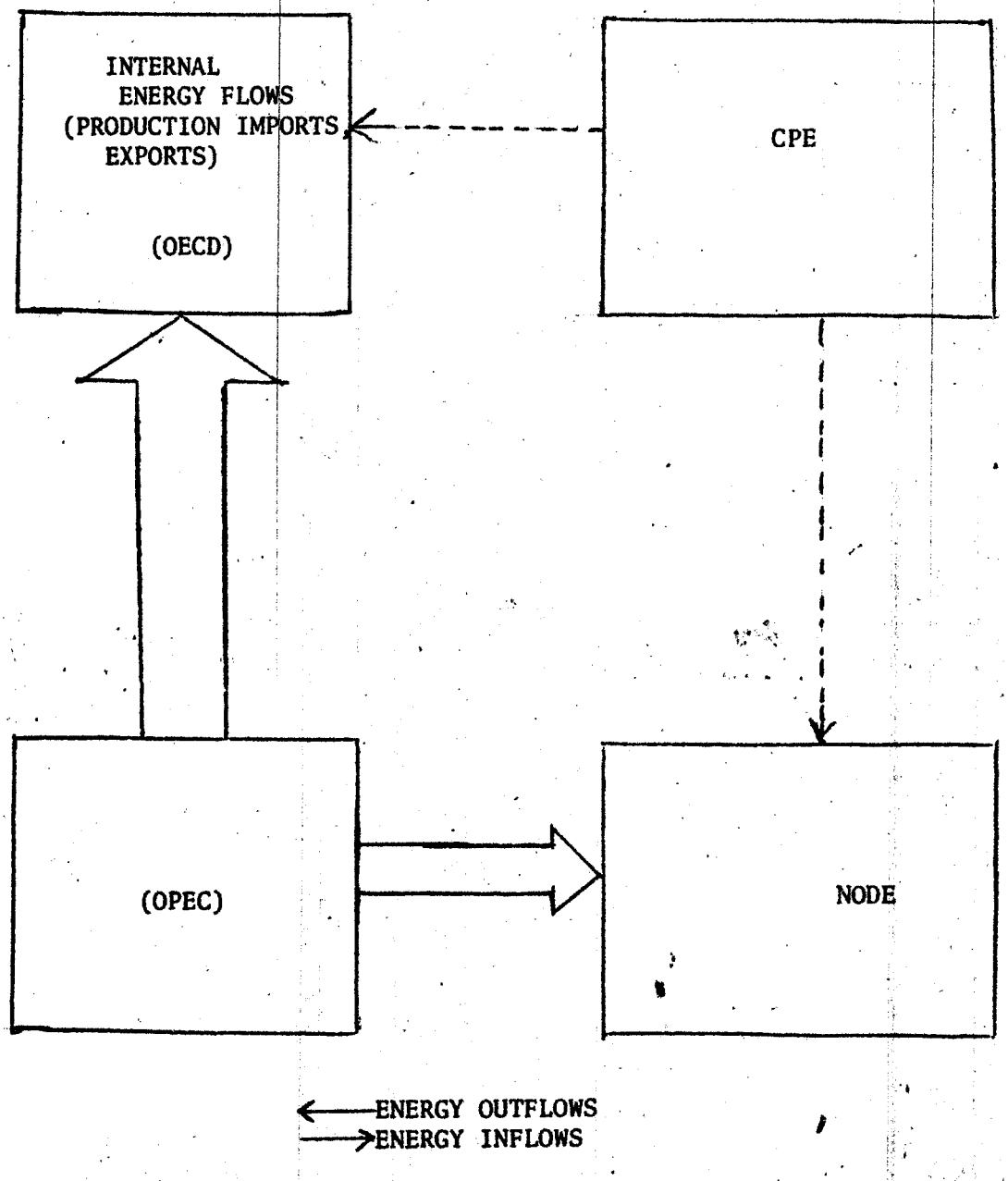


FIGURE 5

CAPITAL FLOWS

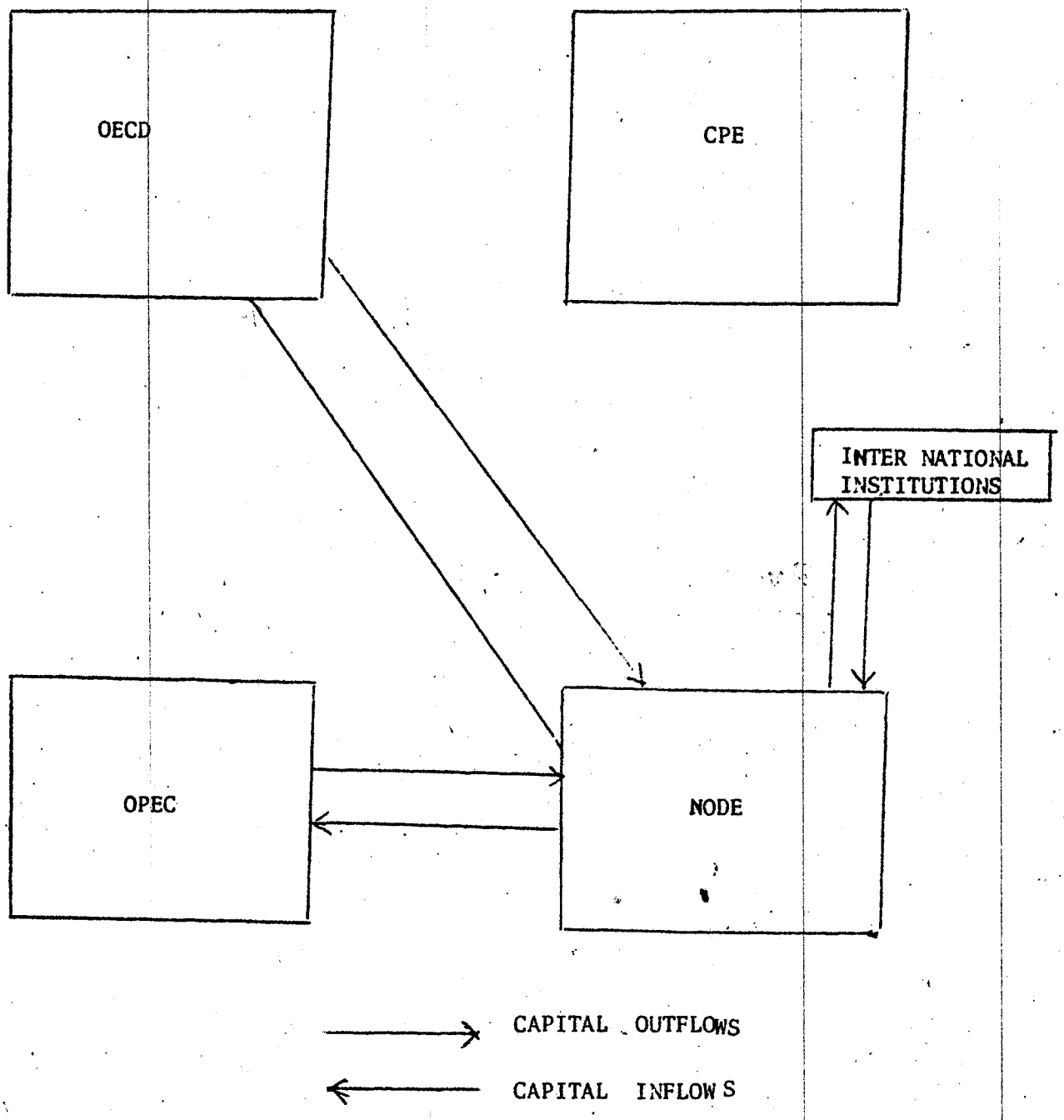


FIGURE 6

COMMODITY FLOWS WITHIN OECD

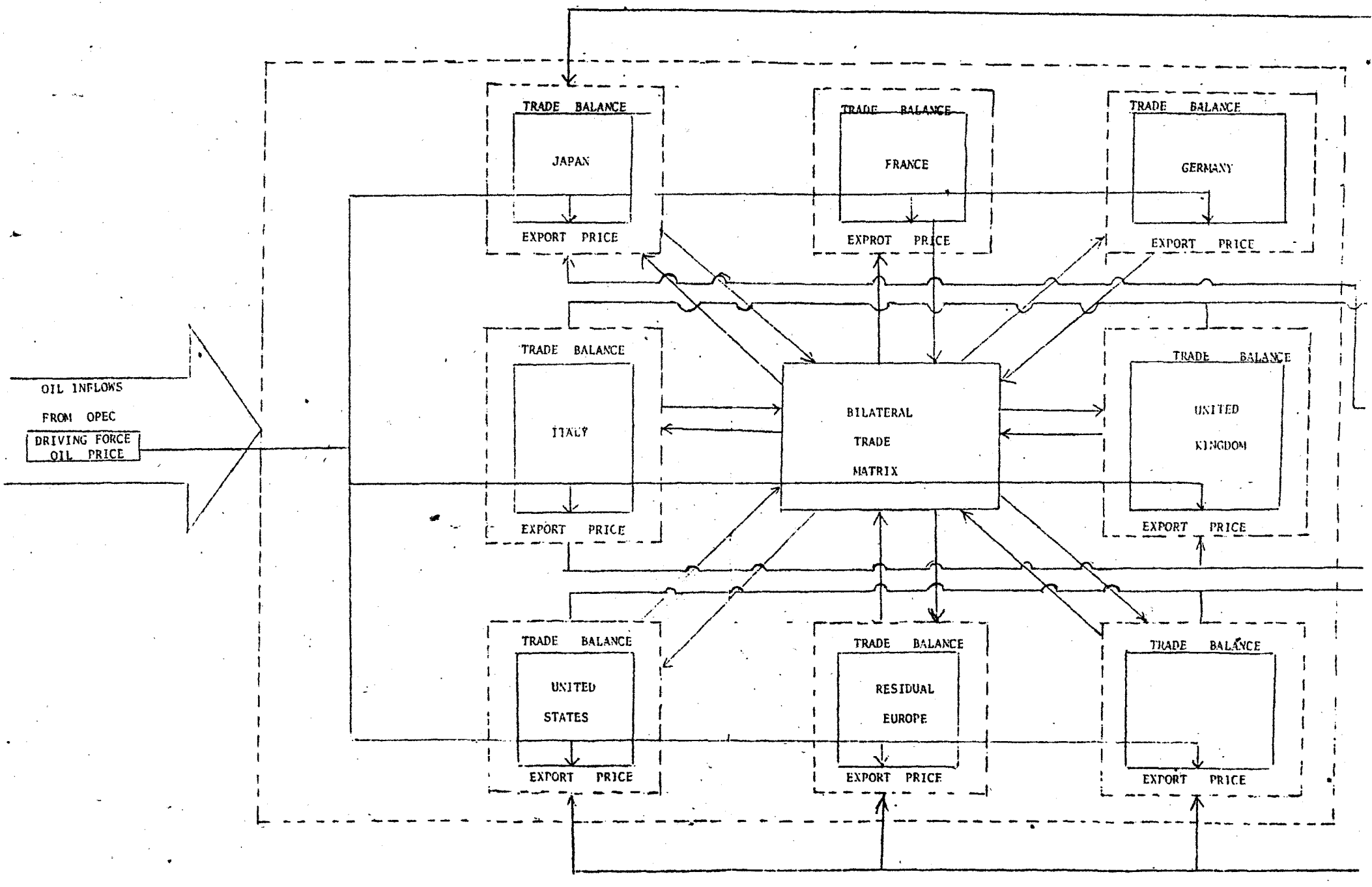
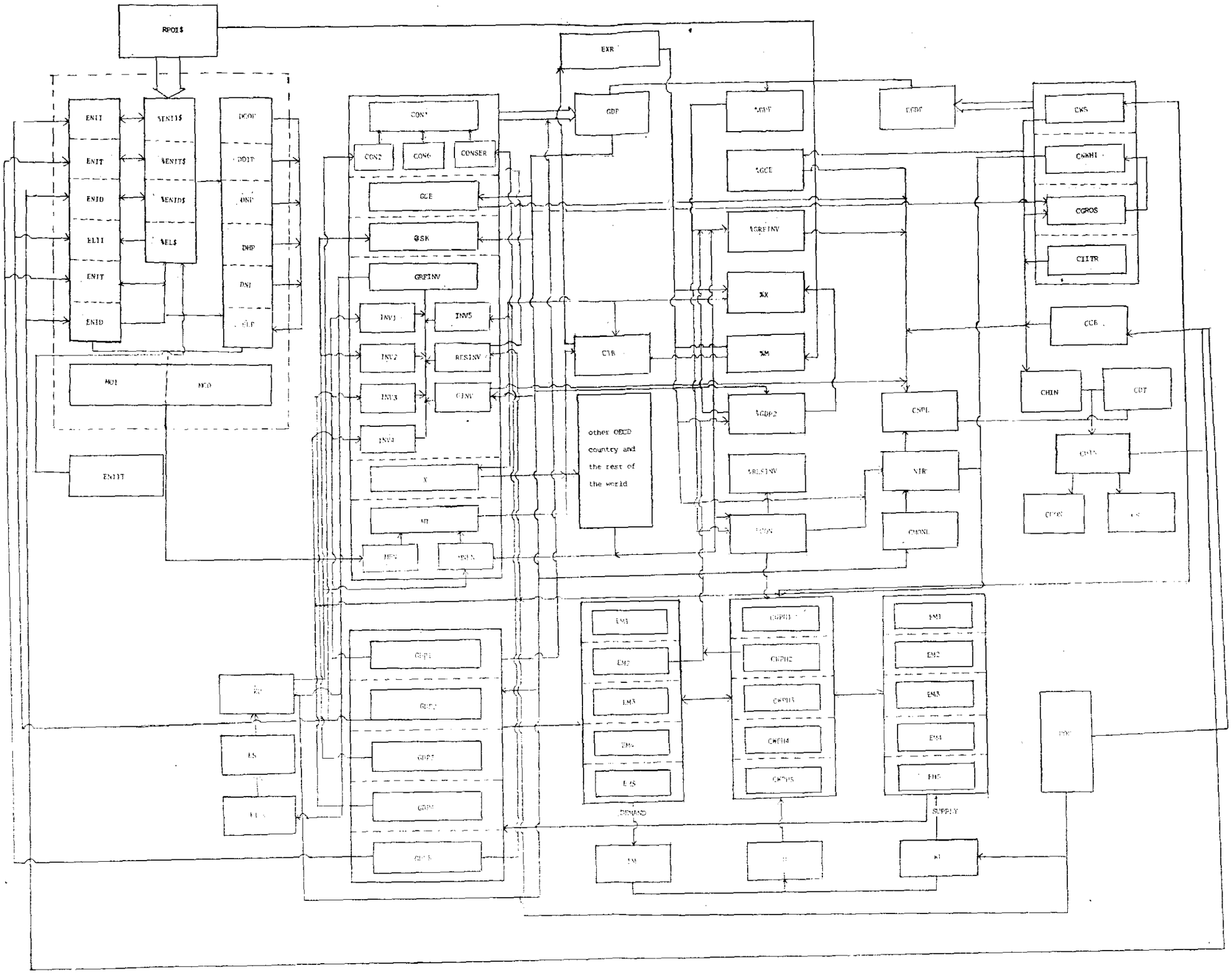


FIGURE 7

GDP DETERMINATION OF AN OECD COUNTRY



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