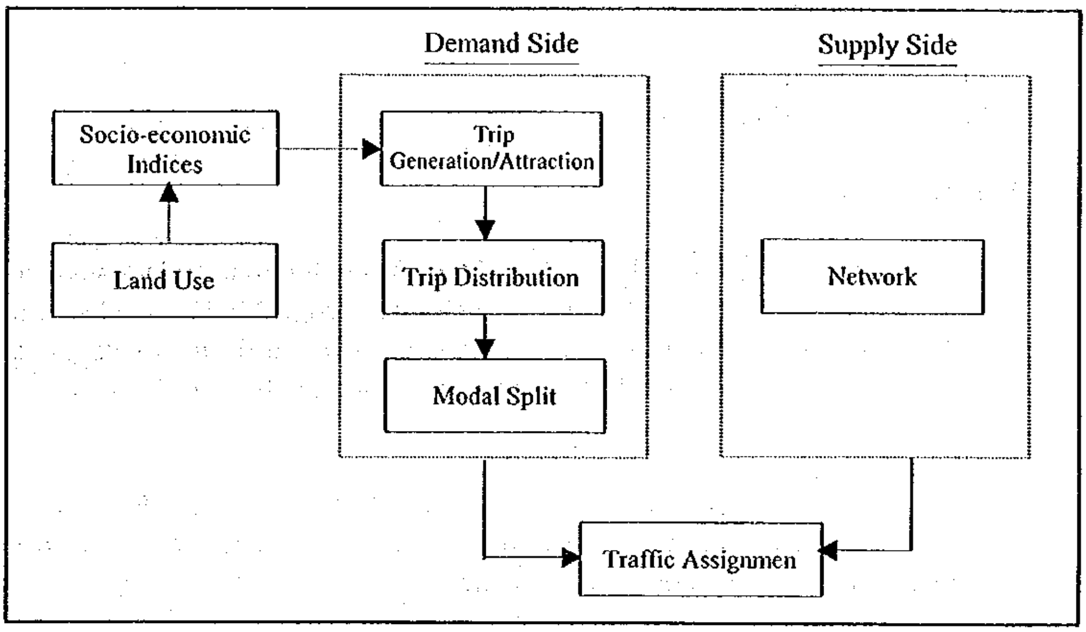
6 PASSENGER DEMAND FORECAST

6.1 Academic Background

In general terms the role of transport planning is to ensure the satisfaction of a certain demand for passengers and goods movements given a transport system (supply) with a certain operating capacity.

From the viewpoint of relation between demand and supply, a traditional and typical structure of demand forecast has been proposed and can be summarized as Table 6.1.

Figure 6.1
A Typical Structure of Demand Forecast



As illustrated in Figure 6.1, transport demand analysis requires two factors: supply side and demand side. As for supply side, it is represented by transport network being composed of links and their costs (see Chapter 4). Meanwhile, transport demand is analyzed through three steps: trip generation/attraction, trip distribution and modal split.

Trip Generation/Attraction

The trip generation/attraction stage of the transport model aims at predicting the total number of trips generated by (Oi) and attracted to (Dj) each zone of the study area, i.e., how many trips originate at each zone? (see Figure 6.2)

For generation/attraction model, several techniques have been proposed as follows.

i) Trip-factor Model

$Gi = \alpha X_i$

$Aj = \beta X_j$

Where, Gi : Generated trips at zone i

Aj : Attracted trips at zone j

α, β : Trip-factor

X_i, X_j : Zonal indices

ii) Growth-factor Model

$Gi = \lambda_g g_i$

$Aj = \lambda a\, gj$

Where, λg, λa: Growth-factor

gi, gj : Present trips generated and attracted respectively.

iii) Regression Model

$Gi = \alpha_0 + \Sigma \alpha_i X_i$

$Aj = \beta o + \Sigma \beta j Xj$

Where, α, β: Parameters

Trip Distribution

Generation and attraction provide an idea of the level of trip making in a study area but this is often not enough for modeling and decision-making. What is needed is a better idea of the pattern of trip making, i.e., from where to where do trips take place? (see Figure 6.2). For this trip distribution, many types of methods have been proposed as follows.

Growth-factor model, well known as "fratar method", is to forecast future trips using growth-factor being composed of "uniform growth factor", "singly constrained growth-factor" and "doubly constrained growth-factors".

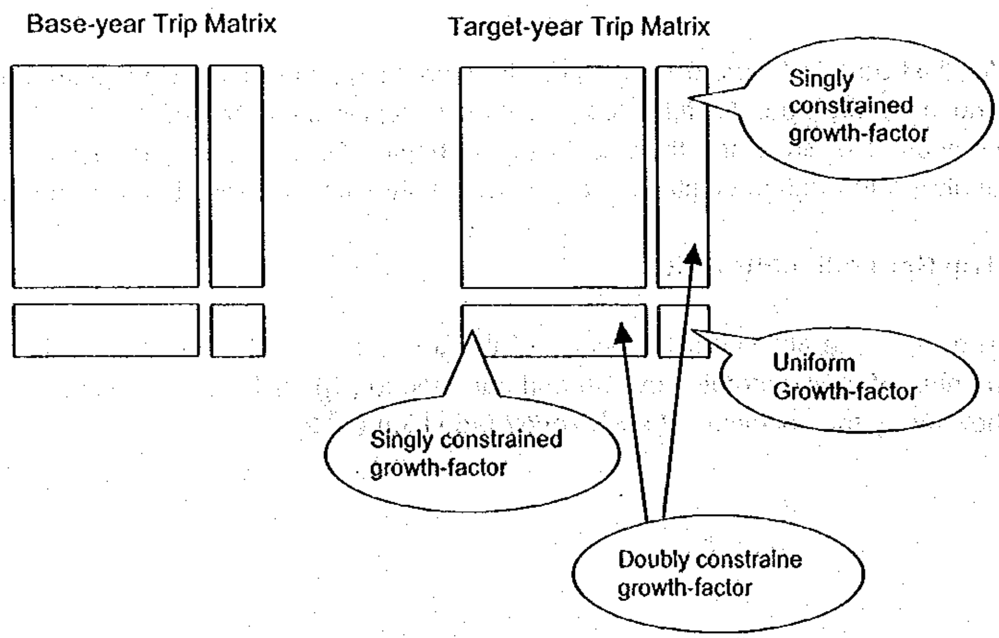
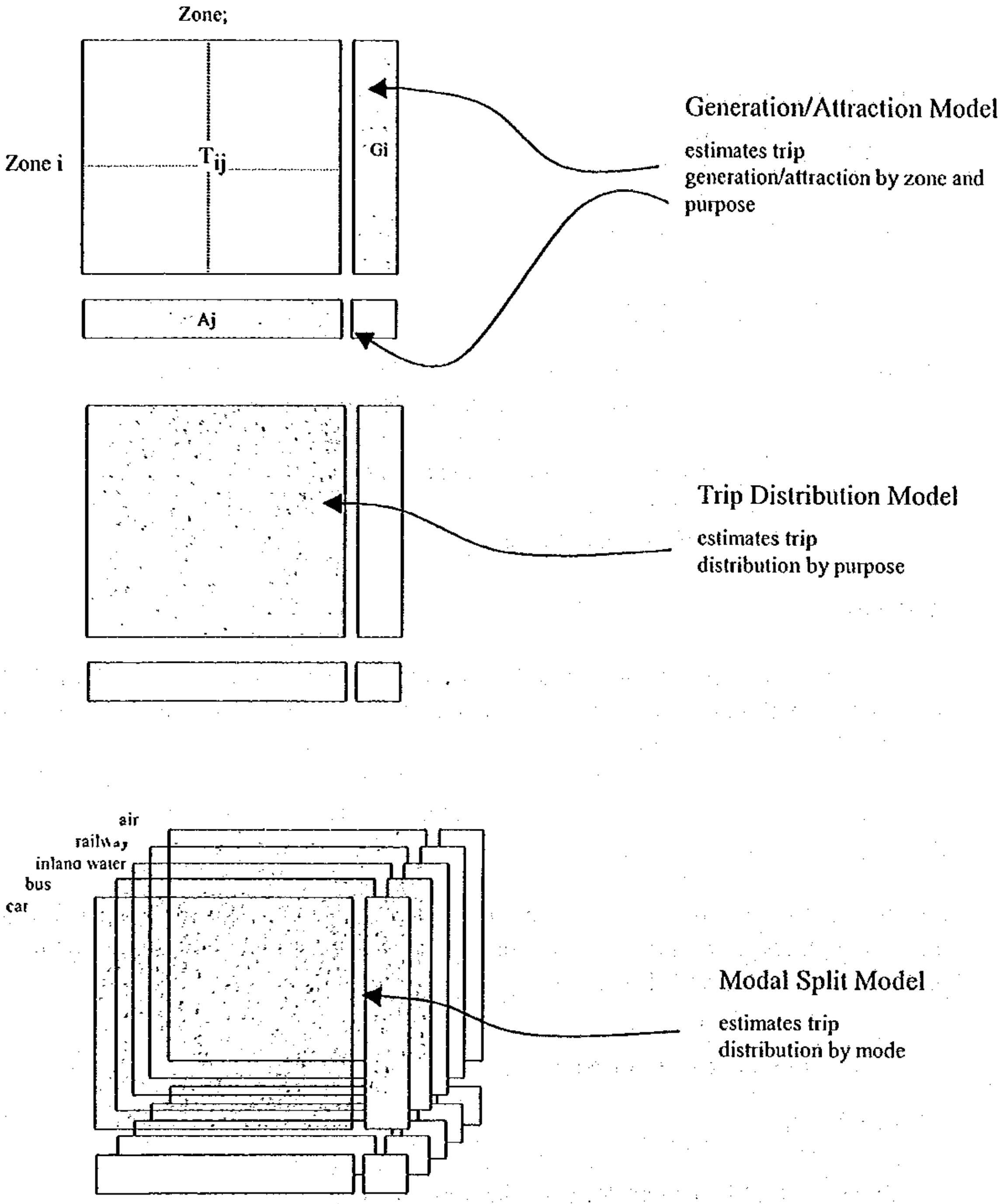


Figure 6.2
Demand Side Models with OD Matrix



Besides, many types of gravity model have been proposed.

i) Basic Gravity Model

$$T_{ij} = k.\frac{G_i^{\alpha} * A_j^{\beta}}{f(d_{ij})}$$

ii) Voorhees Type Gravity Model

$$T_{ij} = G_i.\frac{A_j * f(d_{ij})}{\sum A_j f(d_{ij})}$$

iii) BPR Type Gravity Model

$$T_{ij} = G_i.\frac{A_j * f(d_{ij}) * K_{ij}}{\sum A_j f(d_{ij}) * K_{ij}}$$

Where T_{ij} : the number of trips traveled from zone i to zone j
G_i : the number of trips generated from zone i
A_j : the number of trips attracted to zone j
d_{ij} : impedance from zone i and zone j
k, α, β: parameters
K_{ij} : adjustment factor

Modal Split

This step is to determine what kind of transport mode ones use (see Figure 6.2). At the aggregated level, there have been two representative methods for modal split: trip end modal split model and trip interchange modal split model. As the former assumed personal characteristics the most important determinants of mode choice, it failed in reflecting policy related variables such as improving public transport, restricting parking, charging for the use of roads, and so on.

For this reason, trip interchange model has been widely used for mode choice at the aggregated level. One of the most popular trip interchange models is binary logit model and it is represented as follows.

$$Pi = \frac{1}{1 + \exp(\alpha(Ci - Cj) + \beta)}$$

$$Pj = 1 - Pi$$

Where, Pi, Pj = Probability choosing mode i and j
Ci, Cj = Generalized cost of mode i and j
α, β = Parameters

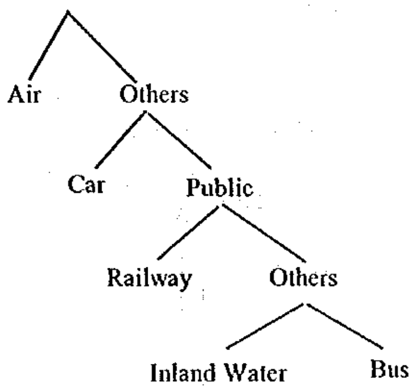
With contrast to the aggregate model, disaggregate model has been one of the most comprehensive methods which is based on theories of individual behavior. Its representative analysis method is discrete choice model, i.e., individuals have to select an option from a finite set of alternatives. In addition to binary logit model, some models have been proposed, for instance, multinomial logit model and hierarchical logit model.

But it is usually said that multinomial logit model is the simplest and most popular practical discrete choice model as follows.

$$Pi = \frac{\exp(\beta Vi)}{\sum_{j} \exp(\beta Vj)}$$

Where, Pi = Probability choosing mode i
Vi = Utility function of mode i
β = Parameter

An example of hierarchical logit mode is in practice shown below.



Example of Aggregate Binary Logit Model: Data about aggregate mode choice between five zone pairs, herein, is presented as follows. Deduce the parameters of the aggregate binary logit model.

Zone pair	P_{rail}(%)	P_{bus}(%)	C_{rail}	C_{bus}
1	51.0	49.0	21.0	18.0
2	57.0	43.0	15.8	13.1
3	80.0	20.0	15.9	14.7
4	71.0	29.0	18.2	16.4
5	63.0	37.0	11.0	8.5

Traffic Assignment

Depending on capacity restraint and stochastic effects, traffic assignment method is classified as follows.

Table 6.1
Classification scheme for traffic assignment

		Stochastic effects included? No	Yes
Is Capacity restraint included?	No	All-or-nothing	Pure stochastic Dial's, Burrell's
	Yes	Wordrop's Equilibrium	Stochastic user Equilibrium

Suppose that there are two routes between zone A and B, i.e., a route passing through town center and bypass route and each route has QC curves shown in the following figures. Now, a total of 2,000 drivers intends to move from A to B.

Figure 6.3
Town served by a bypass and a town centre route

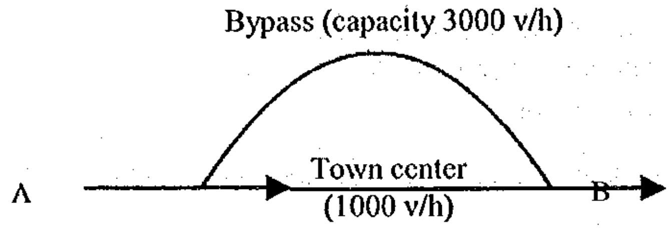
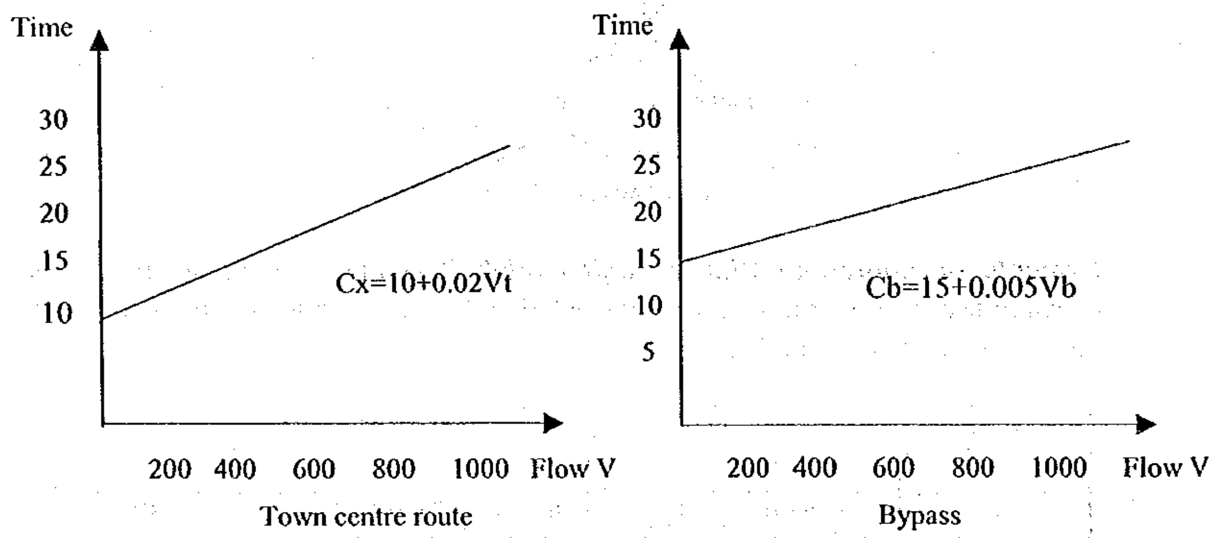


Figure 6.4
Time-flow Relationships



1) All-or-Nothing Assignment
   This method assumes that
   - There are no congestion effects (link costs are fixed);
   - All drivers consider the same attributes for route choice; and
   - All drivers perceive and weigh the attributes in the same way.

   As a result, all 2000 drivers choose town center route.

2) Stochastic Methods
   This method emphasizes the variability in drivers' perceptions of costs and composite measure they seek to minimize (distance, travel time, generalized costs). In usual, a logit-type formulation to split trips from A to B among alternative routes r is used as follows:

   $T_{ABr}=T_{AB} \exp(-\Omega C_{ABr})/\Sigma \exp(-\Omega C_{ABr})$
   Where, Ω is parameter

3) Congested Assignment

i) Wordrop's equilibrium

This method attempts to approximate to the equilibrium conditions as formally enunciated by Wordrop (1957).

Under equilibrium conditions traffic arranges itself in congested networks in such a way that no individual trip maker can reduce his path costs by switching routes.

If all trip makers perceive costs in the same way (no stochastic effects):

Under equilibrium conditions traffic arranges itself in congested networks in such a way that all used routes between an O-D pair have equal and minimum costs while all unused routes have greater or equal costs.

From the above example, the solution to Wordrop's equilibrium as a function fo the total flow Vb+Vt=V (2000) is:
Vb=0.8V-200: Vb=1400 and Vt=600

ii) Incremental Assignment

In this method the modeler divides the total trip matrix T into a number of fractional matrices by applying a set of proportional factors Pn such that ∑Pn=1. The fractional matrices are then loaded incrementally on the cost minimized route.

From the above example, suppose that the demand of 2,000 trips is assigned into four increments of 0.4, 0.3, 0.2, and 0.1, i.e., 800, 600, 400, 200 trips. Then the results are summarized as follows:

N	Increment	Flow town	Cost town	Flow bypass	Cost bypass
0	0	0	10	0	15
1	800	800	26	0	15
2	600	800	26	600	18
3	400	800	26	1000	20
4	20	800	26	1200	21

4) Stochastic Equilibrium Assignment

Generally, a probability to choose a specific route depends on not only variability in the perceived route costs but also capacity-restraint effects. Models which try to include both effects are called stochastic user equilibrium (SUE) models and they seek an equilibrium condition where:

Each user chooses the route with the minimum 'perceived' travel costs; in other words, under SUE no user has a route with lower 'perceived' costs and therefore all stay with their current routes.

5) Combined Mode Choice and Assignment

This approach is necessary mainly because congestion generated by a specific mode will affect the travel cost of other modes in certain routes and therefore affect mode choice because of the changed cost.

This method integrates as many sub-models as possible into one in particular if one can include assignment in the same prices.

Application to the VITRANSS Model

1) Passenger
- Demand Side: Regression model, Gravity model (Fratar Method), Aggregate binary logit model
- Traffic Assignment: All-or-Nothing method

2) Freight
 i) Trend pattern
  - Demand Side: Regression model, Fratar Method, Trend Pattern Modal Split
  - Traffic Assignment: All-or-nothing method

 ii) Economic Case
  - Demand Side: Regression model, Fratar Method
  - Traffic Assignment: Combined mode choice and incremental assignment
  - Modal share of each mode is determined in inverse proposition to the economic cost as follows:

$Rm = Cm^{-a} / \sum Ci^{-a}$

Where, Rm = Share of mode m
Cm = Transport cost of mode m
a = Parameter (Value of 1.0-1.2 is recommendable based on the present situation).

6.2 Demand Side Model

Trip Generation/Attraction

For trip generation/attraction, linear regression model was applied as follows:

$G_i = 3.2994 * UPOP_i * GDPC_j + 4629.5$

$A_j = 3.2993 * UPOP_j * GDPC_j + 4826.7$

Where, G_i : Trip Generation of zone i
A_j : Trip Attraction of zone j
$UPOP_i$: Urban Population of zone i (1,000 pers)
$GDPC_i$: GDP per Capita of zone i (VND million)

Although the multiple correlation coefficient is high at 0.96, this is strongly affected by some large cities, such as HCMC and Hanoi, and the error is not necessarily small particularly in zones with small demand. Thus, the following adjustment factor was introduced:

$$RG_i = \frac{G_i}{g_i} \qquad RA_j = \frac{A_j}{a_j}$$

Where, RG_i : Generation adjustment factor of zone i
RA_j : Attraction adjustment factor of zone j
G_i : Present actual generation of zone i
A_j : Present actual attraction of zone j
g_i : Present calculated generation of zone i
a_j : Present calculated attraction of zone j

This step requires data on population, GDP and adjustment factors (RG_i and RA_j). Population and GDP are obtained from macro economic sub-model with files of "*.csv", i.e., "population.csv" and "gdp.csv"(see Chapter 3). Adjustment factors involve values of differences between actual generations and attractions and estimated ones.

Trip Distribution

The following gravity model was obtained based on trip generation/attraction and interzonal impedance:

$$T_{ij} = \frac{0.0812 * G_i^{0.7075} * A_j^{0.70164}}{d_{ij}} * 6.4053^{\delta}$$

Where, C : Constant
T_{ij} : No. of trips between zone i and zone j
G_i : Trip Generation of zone i
A_j : Trip Attraction of zone j
d_{ij} : Distance between zone i and zone j (km)
δ : Dummy variable (-1 or 1 for selected zone pairs and 0 for the rest)

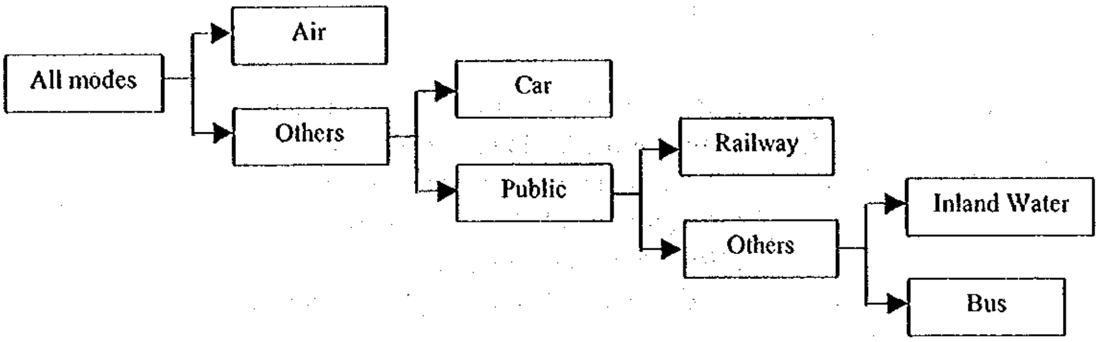
After applying the trip distribution model, the Fratar convergence calculation was conducted to adjust OD values to the trip generation/attraction.

This step requires data on present OD matrix and inter-zonal impedance in terms of travel distance. The present OD matrix of passenger demand comes from the result of formulating present OD matrix (see Chapter 5) and the inter-zonal impedance is the result of calculating inter-zonal impedance (see Chapter 6).

Modal Split

Aggregate binary logit model was applied as shown below.

Figure 6.5
Aggregate Binary Logit Model



Number of air passengers is estimated directly from zonal parameters by the following formula:

$$T_{ij}^{Air} = 0.6554 * (UPOP_i * GDPC_i)^{0.2951} * (UPOP_j * GDPC_j)^{0.1441} * 4.8423^{\delta}$$

Where, T_{ij}^{Air} : Air passengers between zone i and j
$UPOP_i$: Urban population of zone i (1,000)
$GDPC_i$: GDP per capita of zone i (VND million)
δ : Dummy variable (2 for HCMC-Hanoi, 1 for Danang-HCMC and Danang-Hanoi, and 0 for the rest)

Car passenger trips are also estimated from zonal parameters by the following formula:

$$T_{ij}^{Car} = \frac{0.6199 * UPOP_i^{0.3023} * GDPC_i^{0.4867} * UPOP_j^{0.2957} * GDPC_j^{0.5217}}{t_{ij}^{0.9449}}$$

Where, T_{ij}^{Car} : Car passengers between Zone i and j
$UPOP_i$: Urban Population of Zone i (1,000)
$GDPC_i$: GDP per Capita of Zone i (VND million)
t_{ij} : Car Travel Time between Zone i and j

Railway passenger trips are extracted by the following formula, if railway is available for the zone pair:

$$P_{ij}^{Rail} = \frac{1}{1 + e^{2.4281 - 0.0295 * (t_{ij}^{Bus} - t_{ij}^{Rail}) + 2.6279 * \delta}}$$

Where, P_{ij}^{Rail} : Share of railway between zone i and j
t_{ij}^{Bus} : Bus travel time between zone i and j
t_{ij}^{Rail} : Railway travel time between zone i and j
δ : Dummy variable (1 or –1 for selected zone pairs and 0 for the rest)

The following formula is applied to the remaining trips, if inland waterway is available for the zone pair:

$$P_{ij}^{Water} = \frac{1}{1+e^{-0.6676-0.0418*\left(t_{ij}^{Bus}-t_{ij}^{Water}\right)+3.9848*\delta}}$$

Where, P_{ij}^{Water} : Share of inland waterway between Zone i and j
t_{ij}^{Bus} : Bus travel time between Zone i and j
t_{ij}^{Water} : Inland Waterway travel time between Zone i andj
δ : Dummy variable (1 for selected zone pairs and 0 for the rest)

This step requires data on population, GDP, inter-zonal travel time and adjustment factors. As mentioned earlier, population and GDP are obtained from macro economic sub-model with files of "*.csv"(see Chapter 3). The inter-zonal travel time is results of inter-zonal impedance calculating component (see Chapter 4).

Adjustment factors involve values of not only differences between actual generations and attractions and estimated ones but also dummy variable.

OD Matrix Generating Operation

If one wants to produce OD passenger demand in future, one should execute "PaxODGen.exe". It allows one to generate OD passenger demand according to transport mode in future. With executing "PaxODGen.exe", one will see the following message on the screen.

One should select the case number of OD matrix which one wants to generate and press enter key. Then it will make the OD matrix which one selected.

```
List of OD Matrix

2010 OD Matrix at Low Assumption  : 1
2010 OD Matrix at High Assumption : 2
2020 OD Matrix at Low Assumption  : 3
2020 OD Matrix at High Assumption : 4

What kind of OD matrix do you want to make? Select No. =>
```

Note: In the VITRANSS, there are four scenarios assumed: low and high assumptions in 2010 and low and high assumptions in 2020. So, one can get four different OD passenger demand to one's purpose.

OD passenger demand is calculated through (see Figure 6.6 and 6.7):

i) Reading population, GDP, present OD matrix, adjustment factors, inter-zonal impedances such as travel time and distance.
ii) Calculating trip generations and attractions using population and GDP.
iii) Calculating trip distribution using trip generations and attractions calculated in previous step, inter-zonal distance and adjustment factors.
iv) Doing Fratar to satisfy $\sum_j T_{ij} = G_i and \sum_i T_{ij} = A_j$
v) Separating air passengers using population, GDP and adjustment factors.
vi) Separating car passengers using population, GDP, inter-zonal travel time and adjustment factors.
vii) Separating railway passengers using inter-zonal travel time and adjustment factors.
viii) Separating inland waterway passengers using inter-zonal travel time and adjustment factors

The following are input files:

Parameter file involves input filenames necessary for calculation as follows.

Parameter File ("PaxODGen.Par")

```
Present OD Matrix      = pass9_99.aod
Distance Matrix        = Car20.dij
Time Matrix (Car)      = Car20.tij
Time Matrix (Bus)      = Bus20.tij
Time Matrix (Inland)   = InlandWater20.tij
Time Matrix (Rail)     = Railway20.tij
Time Matrix (Air)      = Air20.tij
Adjustment (Car)       = Car.adj
Adjustment (Inland)    = Inlandwater.adj
Adjustment (Rail)      = Rail.adj
Adjustment (Air)       = Air.adj
Adjustment (GA)        = disadjst.adj
Population             = population .csv
GDP                    = gdp.csv
```

Used for Trip Distribution

Used for Modal Split

Used for Trip Generation and Attraction

Present OD matrix that is results of present OD matrix formulation involves OD passenger demand by transport mode as follows.

Figure 6.6
Flow Chart of Passenger OD Matrix Generating Operation

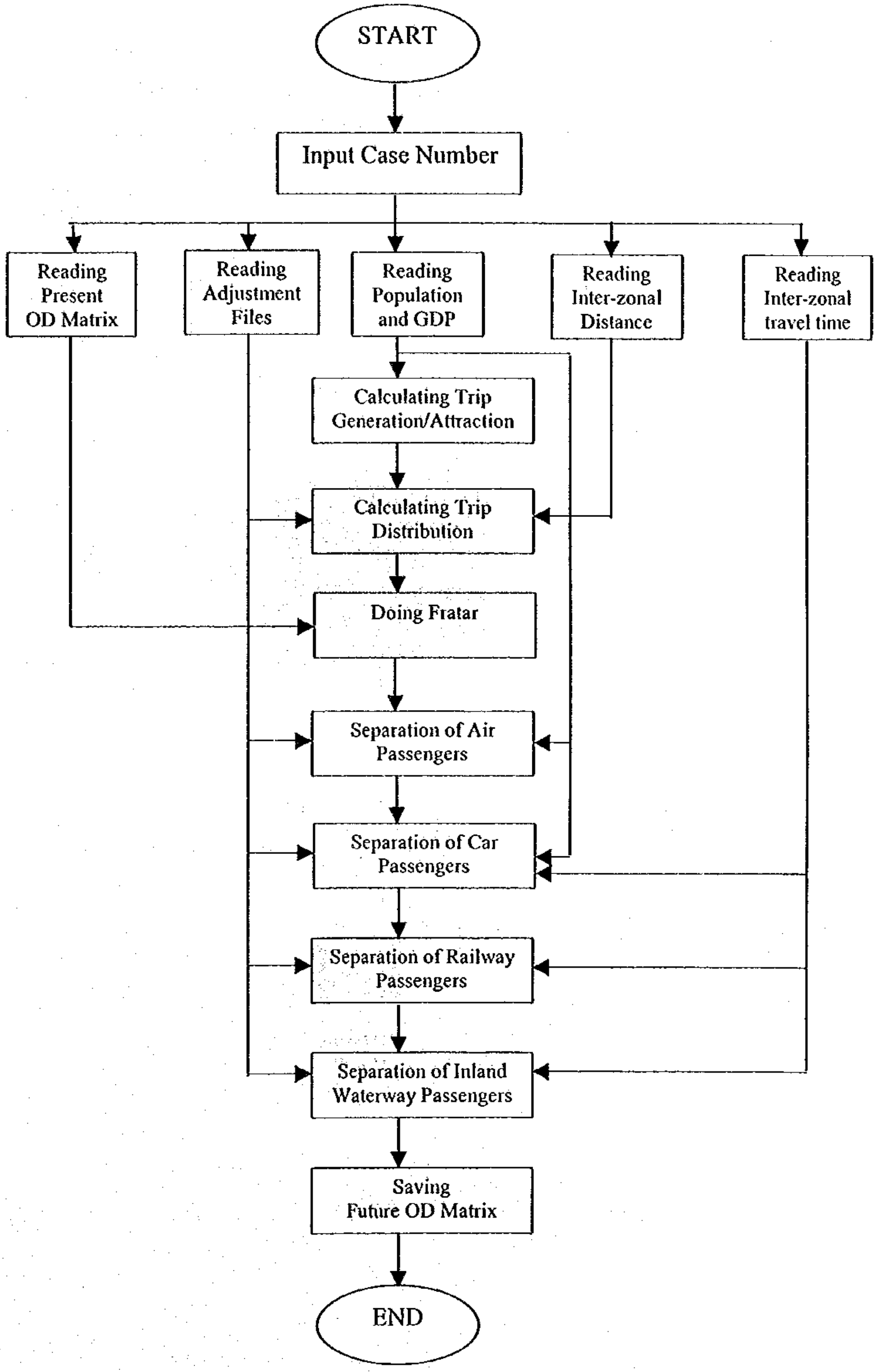
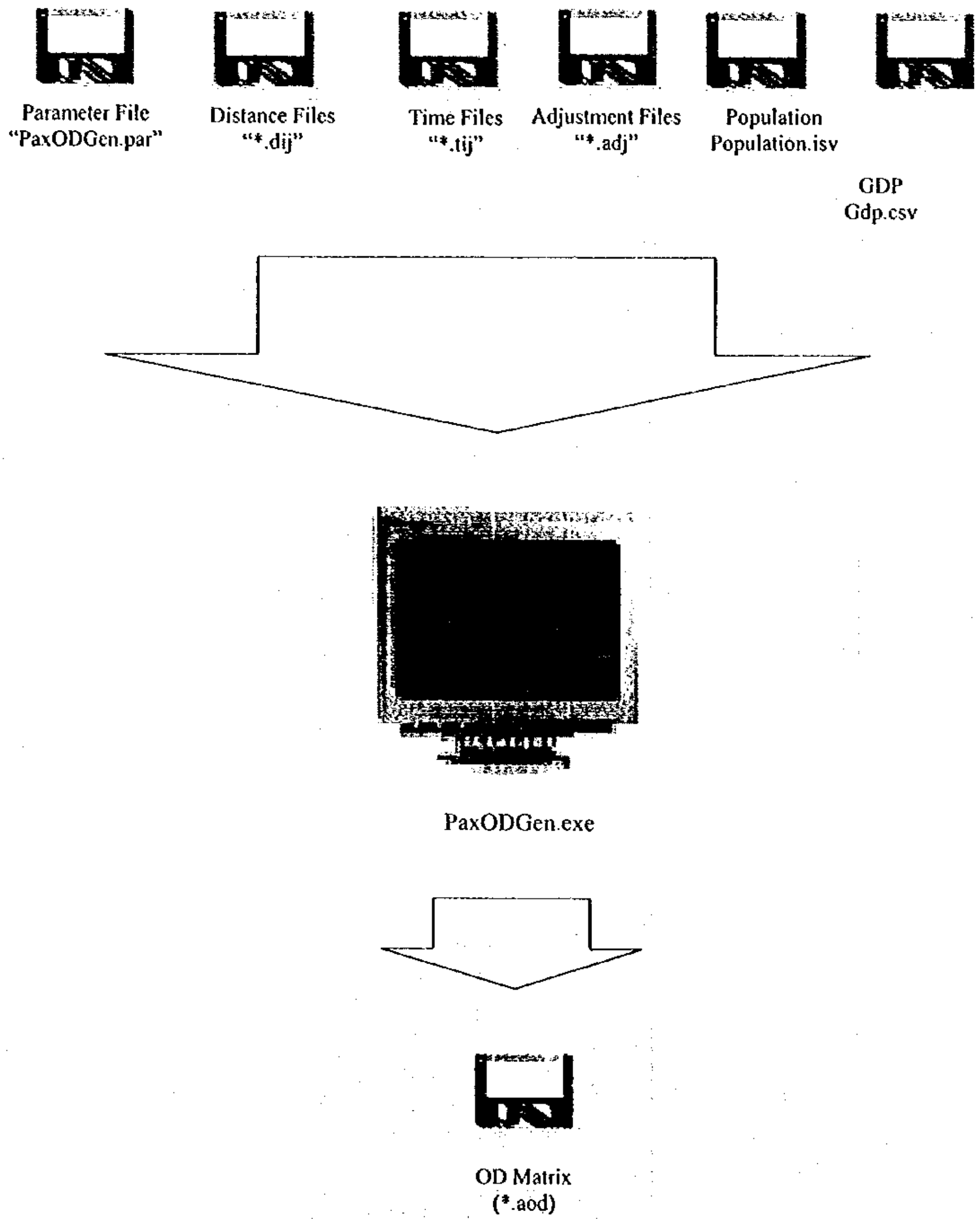
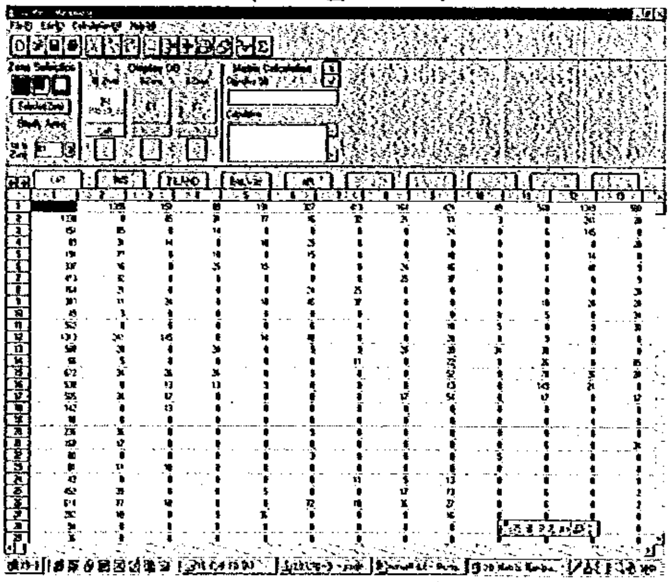


Figure 6.7
OD Matrix Generating Operation, Passenger Demand



Present OD Matrix ("Pass_99.aod")



Travel distance and time matrices that are results of inter-zonal impedance creating component involve travel distance (km) and time (hr) by searching the shortest paths as follows.

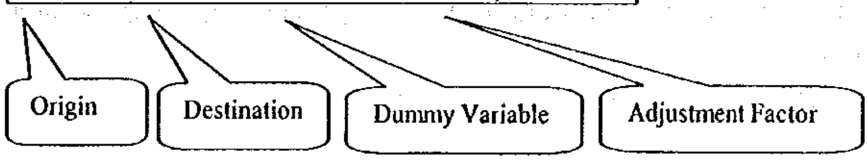
Distance or Time Matrices (*.dij or *.tij)

```
100  MakDat01  1.00 10/27/99↓
   81    1     0↓
(10F8.1)  ↓
      .0    98.4    67.6    63.9   107.4    84.3    89.5    55.5    13.2   243.3↓
   139.9   287.4    72.7   141.7    29.9    53.5   204.2    46.5   318.6   188.2↓
   137.6   275.6   249.0   383.6    40.9   148.1   286.8   332.2   472.2   561.7↓
   627.6   783.0   718.3   841.8   997.8  1089.4  1193.6   912.0   961.5  1125.4↓
  1602.3  1361.6  1288.8  1331.6  1446.8  1406.0  1579.1  1425.1  1576.3  1465.1↓
  1583.8  1619.4  1498.5  1844.5  1514.4  1691.9  1678.9  1789.1  1733.1  1786.4↓
  1848.4   302.4   213.9   270.4   291.7   454.2   410.7   186.6   232.7   432.8↓
   369.4   471.8   623.6   879.3  1030.8  1427.1  1468.2  1423.6  1569.5  1607.5↓
  1674.0↓
```

Adjustment files involve values of differences between actual trips and estimated trips as follows.

Adjustment Files (*.adj)

```
1→    2→    1→    0.56497↓
1→    3→    0→    1.27813↓
1→    4→    0→    0.59918↓
1→    5→    0→    1.42444↓
1→    6→    0→    2.29703↓
1→    7→    0→    2.45402↓
```



6.3 Traffic Assignment

Passenger traffic assignment is based on all-or-nothing approach. It is done through (see Figure 6.8 and 6.9):

i) Reading network data and OD matrix.
ii) Reading the number of mode, origin and destination.
iii) Initializing m, i and j.
iv) Searching the shortest path of mode m between origin i and destination j in terms of travel time.
v) Assigning OD passengers of mode m between i and j, T_{ij}^{m} ,on the shortest path.
vi) Iterating to satisfy m = M, i = I and j = J.
vii) Saving traffic volume assigned on links.

This process requires three files: parameter file, network file and OD matrix file.

Parameter file involves information necessary for passenger traffic assignment. Most of all, one should designate input and output filenames ("*.int", "*.aod" and "*.ire") all of which follow JICA STRADA format. At the same time, it is required to set up information on number of mode and zone. User flag is made use of when one searches the shortest path by transport mode. Value of time is used to convert fare charged into travel time. Average passenger occupancy and PCU are used to convert passengers into PCU or vehicle unit. But, if one wants results of passenger unit, they should be set one as default values. If one wants incremental traffic assignment, one should control number of incremental traffic assignment, e.g. 5 or 10. At the same time proportional percent of incremental traffic assignment should be handled.

Parameter File ("assign01.par")

```
Network : n99p.int↓
OD Matrix : pass9_99.aod↓
Output : n99p.ire↓
No. of Zone : 81↓
No. of Mode : 5↓
Car           3   R F Z        1.0    1.0  1.0   1  100↓
Bus           3   R F Z        1.0    1.0  1.0   1  100↓
Inlandwater   3   I W Z        1.0    1.0  1.0   1  100↓
Railway       3   L Y Z        1.0    1.0  1.0   1  100↓
Air           3   A P Z        1.0    1.0  1.0   1  100↓
```

No. of incremental traffic assignment

Proportional percent of incremental traffic assignment

Transpor Mode

No. of User Flag Used

User Flag Used

Value of Time

Average passenger occupancy

PCU

With respect to network file ("*.int") and OD matrix ("*.aod"), they will follow the JICA STRADA format.

Figure 6.8
Flow Chart of Passenger Traffic Assignment

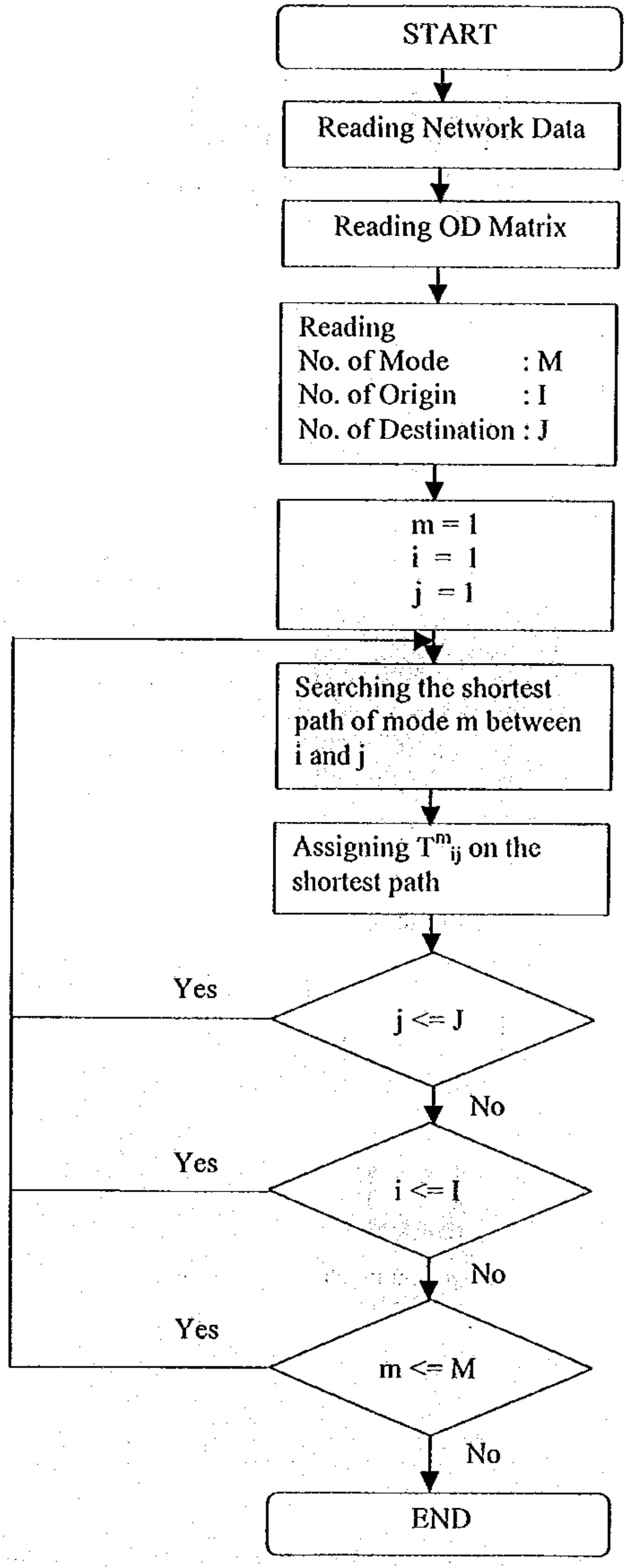
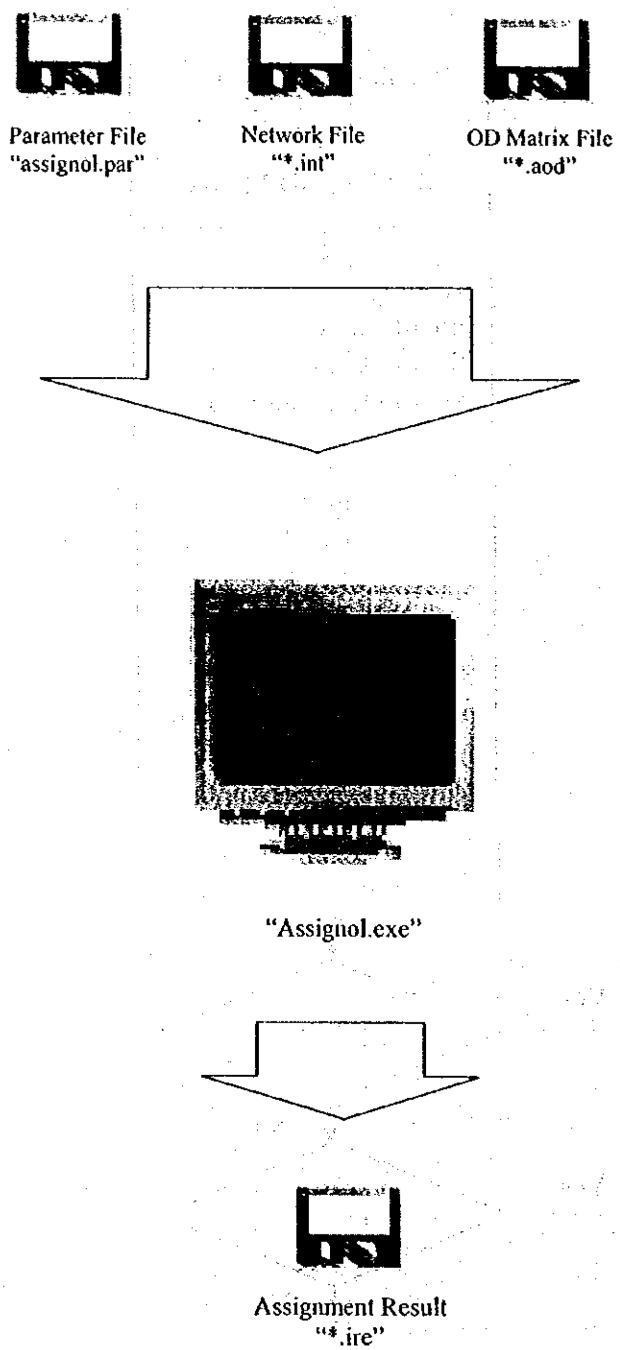


Figure 6.9
Passenger Traffic Assignment Operation

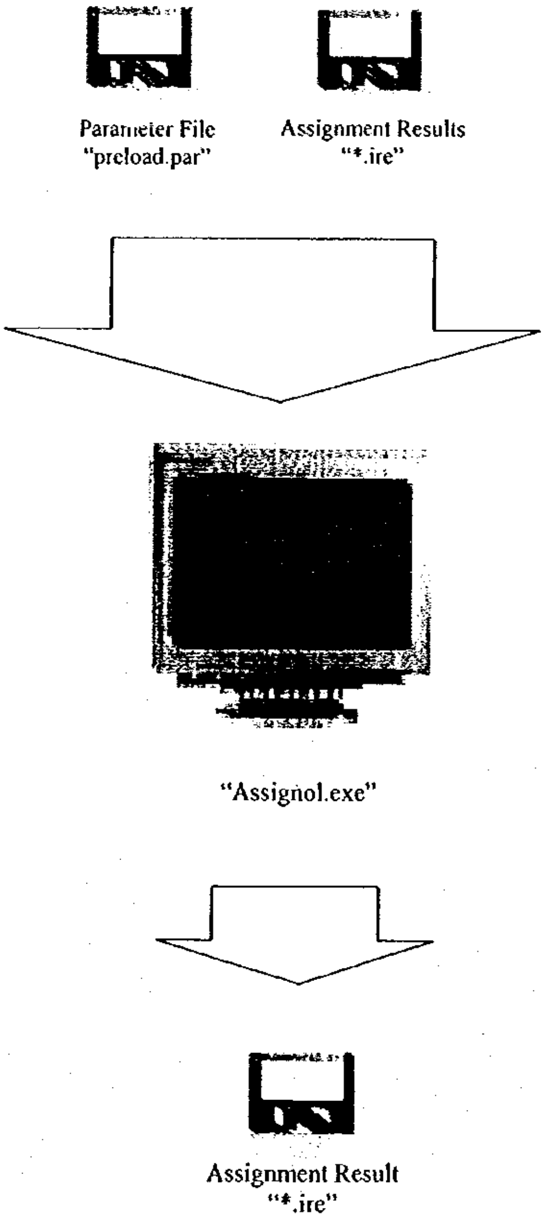


Passenger assignment results are used as an input file afterward so that they should be converted into ton unit. Executive file of "preload.exe" enables the passenger assignment results to convert into ton unit by taking into account PCU unit and average occupancy. Its execution requires two files: parameter file and assignment results of passenger demand.

Parameter File ("preload.par")

```
Input file  = n99p.ire
Output file = n99p_pre.ire
```

Figure 6.10
Preload File Making Operation



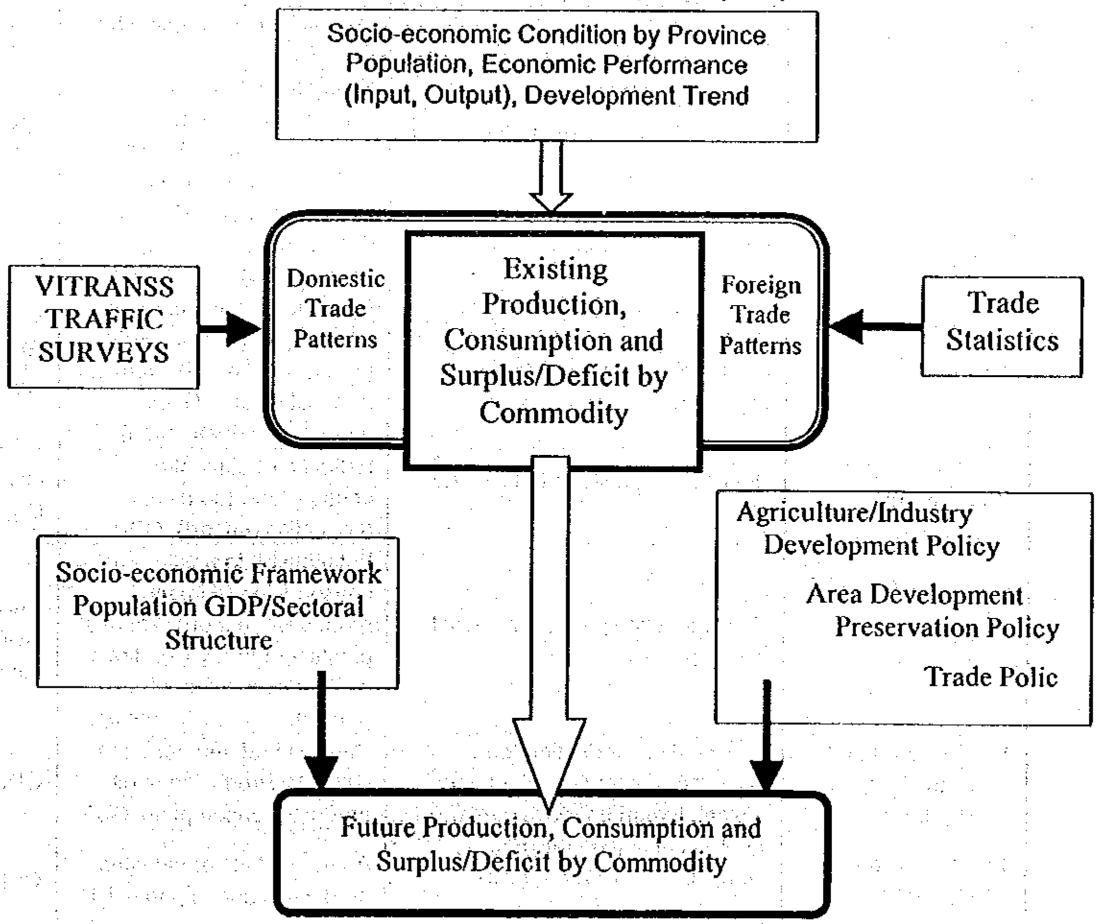
7 PRODUCTION AND CONSUMPTION FORECAST

7.1 General

Cargo transport must be analyzed according to commodity since each commodity has a particular package (i.e. bagged, tank, bulk, etc.) and consignment size. Some commodities even are seasonal. Given these variances it is not proper to make generalizations on cargo flow. Specific commodity analysis is required including production sites, consumption sites and suitable haulage methods.

The VITRANSS conducted a series of traffic surveys and analyzed the present traffic flow consisting of 13 major commodities. To understand the socio-economic conditions of the present cargo traffic, commodity production and consumption were analyzed at provincial level, using provincial statistics, trade statistics, government documents, and the results of various VITRANSS surveys. As a next step, future production and consumption by commodity are forecast to specify possible cargo traffic demand. Figure 7.1 illustrates general flow to forecast production and consumption by commodity items.

Figure 7.1
Forecast of Production and Consumption by Major Commodities



7.2 Methodology

Commodities are composed of 13 items in the VITRANSS and their methods and variables used to forecast production and consumption are depicted in Table 7.1.

Table 7.1
Methods used to forecast Production and Consumption of Main Commodities

Commodity	Production	Consumption	Indicators
1. Rice and Other Food Crops	Change in sown area. Yield increase. Conversion rate from paddy equivalent to rice equivalent	Per capita consumption rate. Explored volume and its target.	Population, Export
2. Sugarcane, Sugar	Change in sown area. Yield increase. Designed capacity of sugar by sugar mill	Designed processing volume of sugarcane by sugar mill. Per capita sugar consumption	Population
3. Wood	The government's wood-cutting control policy. Cut to meet the demand	GDP (industry & construction). Limited consumption by the Government's policy	GDP (industry & construction)
4. Industrial Crops	Commodity market analysis export policy	Estimate of domestic consumption. GDP	GDP. Export
5. Fishery Products	Trend in fishery products. Potential analysis of catching fishery and breeding fishery. Export policy	Per capita consumption by region	Population by region. Export
6. Animal Meat	Trend in animal meat output	Per capita consumption by region	Population by region
7. Steel	Designed capacity of steel by plant	Estimate of domestic consumption (domestic production+import). GDP (industry & construction)	GDP (industry & construction). Import
8. Construction Materials	Exploitation of stone and sand	Demand forecast (MOC). GDP (industry & construction)	GDP (industry & construction)
9. Cement	Designed capacity of cement by plant. Neighboring countries experience	Estimate of domestic consumption (domestic production+import). Demand forecast (MOC). GDP (industry & construction)	GDP (industry & construction)
10. Fertilizer	Designed capacity of fertilizer by plant	Estimate of domestic consumption (domestic production+import). GDP	GDP (primary sector). Import
11. Coal	Coal extraction predictions. Coal export policy	Estimate of domestic consumption (domestic production+export). Thermal plants for energy use. Major coal-industrial use, rural population for residents use	Rural population. GDP (industry & construction). Export
12. Crude Oil and Petroleum Products	Expected oil production form discovered reserves, oil refinery project. Export policy	Supply to refinery form the oil fields. Prediction of oil products consumption. GDP	GDP. Export. Import
13. Manufacturing Goods	Analysis of major industrial production and export. GDP (industry & construction)	Analysis of major industrial production and import. GDP	GDP. Export. Import

Rice and Other Food Crops

With respect to rice production, it will be strongly affected by not only cultivated area but also paddy productivity. It was estimated taking into account change in cultivated area and paddy productivity in future.

Meanwhile, population and rice consumption per capita will have impact on rice consumption in the future. The rice consumption was assumed to become the following in the future:

Year	Rice Consumption per Capita (kg/year)
1997	228
2010	250
2020	233

Note that rice consumption per capita will decrease in 2020 due mainly to more dependence on other food crop.

Production	Cultivated Area x Paddy Productivity
Consumption	Population x Rice Consumption per Capita

Sugarcane and Sugar

In Vietnam, substantial increase in the gross output of sugarcane has been shown because of the corresponding increase in the cultivated area of sugarcane. Likewise, sugarcane production will be affected by not only cultivated area by sugarcane productivity. Note that only about 50% of cultivated sugarcane is transported to sugar mills and processed there because the rest is used for drink such as juice.

Sugar production depends on sugar mills located, production capacity of sugar mills and their production plan and policy. These factors were a clue to estimate sugar production in the future.

Like rice, as population and sugar consumption per capita increase, total sugar consumption will increase at the same time. The past experiences in other countries tell that sugar consumption per capita increases as an economy grows. These trends needed the following assumption of increase in sugar consumption per capita to GDP per capita.

Sugar Consumption according to Change in GDP

Sugar Consumption per capita (kg/year)	10	11	12	13	14	15	16	17	18	19	20
GDP per capita (US$)	300	390	440	510	580	650	920	990	860	930	1000

As a result, it was assumed at 15kg/year of high case and 14kg/year of low case in 2010, and 20kg/year of high case and 18kg/year of low case in 2020, respectively.

Production	Production Plan and Capacity of sugar mills
Consumption	Population x Sugar Consumption per Capita

Wood

Due to substantial reduction of forest lands, the government has taken actions to intervene and control in amount of cutting wood. For this reason, wood production followed the government's reforestation policy. Simultaneously, total wood production lumbered was broken down to province considering GDP of industry and construction sector when estimating wood consumption.

Production	Following the government's policy
Consumption	Break down to province by GDP of secondary sector

Industrial Crops

Based on the past trend, industrial crop production was assumed to increase at a growth rate of 5% during 1999-2010 and 5.2% during 2011-2020. Its total amount was broken down to province taking into account total GDP when estimating industrial crop consumption. Note that most of industrial crops will be exported to other countries.

Production	Taking into account the past growth trend
Consumption	Break down to province by total GDP

Fishery Products

Like industrial crops, fishery products production is based on the past trend. It was assumed to increase at a growth rate of 5% during 1999-2010, and 3% of high case and 1.8% of low case during 2011-2020.

Fishery products consumption, meanwhile, was estimated by considering population and its consumption per capita in the future. It should be noted, however, that its consumption will increase as an economy grows as follows.

Fishery products Consumption per Capita

Kg/year	20	22	24	26	28	30
GDP per Capita (US$)	300	450	600	750	900	1050

Little change was seen in regional balance between at present and in future.

Regional balance of Fishery Products Consumption

Region	1997	2010	2020
1. Red River Delta	52	52	53
2. North East	28	28	29
3. North West	28	28	29
4. North Central Coast	69	69	71
5. South Central Coast	146	146	138
6. Central Highlands	52	52	53
7. North East South	138	138	132
8. Mekong River Delta	189	184	173
National Average	100	100	100

Production	Taking into account the past growth trend
Consumption	Population x Fishery Products Consumption per Capita

Animal Meat

This production is based on the past growth trend and the government's plan and policy. It was assumed to increase at a growth rate of 7.5% during 1999-2010, and 5.5% of high case and 4.5% of low case during 2010-2020.
Population and its consumption per capita are among major factors that will have impact on animal meat consumption. Note that its consumption per capita is also affected by an economic increase as follows.

Animal Meat Consumption per Capita

Kg/year	10	14	18	22	26
GDP per Capita (US$)	300	500	700	900	1100

Like fishery products, little change was seen regional balance between at present and in future.

Regional Balance of Animal Meat Consumption

Region	1997	2010	2020
1. Red River Delta	109	106	108
2. North East	93	94	92
3. North West	93	69	73
4. North Central Coast	73	78	73
5. South Central Coast	78	81	78
6. Central Highlands	73	78	73
7. North East South	127	121	121
8. Mekong River Delta	109	106	108
National Average	100	100	100

Steel

Steel production is determined by production capacity of steel plants located throughout the country. On the other hand, its consumption was calculated in proportional to the growth of secondary GDP and it was broken to the province level.

Production	Taking into account production capacity of steel plans
Consumption	Taking into account growth rate of secondary GDP

Construction Materials

This production comes from exploitation plan of sand and stone and its consumption is based on the amount form the Ministry of Construction (MOC). Total consumption was broken down to the province level by considering the secondary GDP.

Production	Based on exploitation plan
Consumption	Based on the amount from the MOC

Cement

Cement production is determined by production capacity of cement plants located throughout the country. Like construction materials, cement consumption comes form the amount proposed by the MOC.

Production	Taking into account production capacity of cement plans
Consumption	Based on the amount from the MOC

Fertilizer

Fertilizer production is determined by production capacity of fertilizer plants located throughout the country. Its consumption was assumed to increase in proportional to the growth rate of primary GDP.

Production	Taking into account production capacity of fertilizer plans
Consumption	Taking into account the growth rate of primary GDP

Coal

Coal production is based on the report on energy sector published by the World Bank (WB). Coal consumption was assumed to increase in proportional to the growth rate of secondary GDP.

Production	Coming from WB report
Consumption	Taking into account the growth rate of secondary GDP

Crude Oil and Refined Oil

This production followed oil refinery project and its consumption came from the World Bank Report.

Production	Following oil refinery project
Consumption	Coming from WB Report

Manufacturing Goods

Manufacturing goods production was assumed to increase at the same growth rate of secondary GDP whereas their consumption assumed to increase at the same growth rate of total GDP.

Production	Taking into account the growth rate of secondary GDP
Consumption	Taking into account the growth rate of total GDP

8 FREIGHT DEMAND FORECAST

8.1 Academic Background

Even though freight movement has been one of major concerns especially in the developing countries, much less research has been undertaken on its modeling mainly because of:

- There are many aspects of freight demand that make it more difficult to model than passenger movements.
- The movements of freight involved more actors than the movement of passengers.
- For some time urban congestion has been highest in the political agenda of most industrialized countries.

Also, compared to the movement of passenger, considerable factors are related to the movement of freight, e.g., location factors, physical factors, operational factors, geographical factors, dynamic factors, pricing factors and so on. With a lot of difficulties and limitations, several methods of modeling of freight movement has been so far tried and applied.

Aggregate Model

The key components of this model is the same as those of passenger demand model involving:

- Estimation of freight generations and attractions by zone
- Distribution of generated volumes to satisfy generation and attraction constrains. The usual methods for this task are linear programming or use of a gravity model
- Assignment of OD matrix to modes and routes

Firstly, usual techniques to estimate freight generations and attractions include:

- Direct survey of demand and supply may be undertaken for major flows for some homogeneous products: sugar, petroleum products, iron ore, coal, cement, fertilizers etc.
- The use of macroeconomic models may be applicable based on regional data
- Growth-factor method may be applicable in forecasting future trips
- Zonal multiple linear regression is often used to obtain freight generations and attractions
- Demand may be associated with warehouse capacity or with total shopping area at each zone rather than with industrial development

Secondly, freight distribution models may include:

- Growth-factor methods:
- Gravity model: and
- Linear programming approach

In particular, the gravity model and linear programming approach has been in the mainstream to estimate goods movement matrices. With regard to linear programming (LP), it usually takes the form to minimize total haulage costs (usually generalized cost), subject to supply and demand constraints as follows.

Minimize $Z = \sum_{ij} T_{ij} C_{ij}$

Subject to: $\sum_{i} T_{ij} = D_j \quad \sum_{j} T_{ij} = O_i$

Thirdly, modal choice strongly depends on shipper's decision in the movement of freight. For this reason, a multinomial logit model has been popular to determine the share of mode.

Disaggregate Model

Since discrete choice models were developed and applied to model passenger demand, the idea of extending them to cover freight movements was also applied. In the case of freight, the demand for freight is seen as a number of individual consignments, each with its own characteristics, for which the individual shipper has to take a number of transport-related decisions. Every decision is seen as a choice made from a discrete set of alternatives.

8.2 Demand Side Model

Trip Generation and Attraction

Zonal multiple linear regression model was applied to estimate freight generation and attraction given the following assumption:

a) If a province has much surplus (production-consumption), it will have more freight generation or if a province has much deficit (consumption-production), it will have more freight attraction.
b) More freight is generated and attracted in a province with well-equipped logistics or delivery system. Usually, leading cities, such as Hanoi and HCMC, have good logistics and a lot of freight is delivered to the final destination via such cities. For this reason, socio-economic indicators were also used as exogenous variables.
c) Export is regarded as consumption and import as production. Therefore, provinces with international ports will have more generation and attraction.

Taking surplus, deficit and socio-economic indicators as external variables based on above assumption, multiple linear regression model is expressed as:

$$G_i = a_1 S_i + a_2 X_i + b$$
$$A_j = c_1 D_j + c_2 X_j + d$$

Where, G_i : Generation from Zone i
A_j : Attraction to Zone j
S_i : Surplus in Zone i
D_j : Deficit in Zone j
a_1, a_2, c_1, and c_2 : Parameter
b and d : Constant

The exogenous variables used to forecast freight generation and attraction and calibration results are summarized in Table 8.1 and 8.2 respectively.

Table 8.1
Exogenous Variables used to Forecast Freight Generation and Attraction

Commodity	Generation	Attraction
1. Paddy and Other Crops	Surplus, Tertiary GRDP	Deficit, GRDP
2-1 Sugarcane 2-2 Sugar	Surplus Dummy Variable3/ Surplus, GRDP	Deficit, GRDP Urban Population
3. Wood and Forest Products	Surplus1/, Secondary GRDP1/	Deficit1/, GRDP1/
4. Steel	Surplus, Tertiary GRDP	Deficit, GRDP
5. Construction Materials	Surplus Dummy Variable2/ Tertiary GRDP	Deficit Dummy Variable2/ Secondary GRDP
6. Cement	Surplus, Tertiary GRDP	Deficit, Secondary+Tertiary, GRDP
7. Fertilizer	Surplus, Tertiary GRDP	Tertiary GRDP1/
8. Coal	Surplus, Secondary GRDP	Deficit
9. Petroleum Products	Surplus, Tertiary GRDP	Deficit, Secondary+Tertiary GRDP
10. Industrial Crops	Surplus, Tertiary GRDP	Deficit, Urban Population
11. Manufacturing Goods	Surplus, Tertiary GRDP	Deficit, Secondary GRDP
12. Fishery Products	Surplus, Tertiary GRDP	Deficit, Urban Population
13. Animal Meat and Others	Surplus, Tertiary GRDP	Deficit, Urban Population

1/ Regional data were used as an exogenous variable
2/ If a province has more than 1.000 tons of generation or attraction, generation or attraction are divided by 1000 and dummy variable has its integer. Otherwise, dummy variable is 1.
3/ If a province has more than 100 tons of generation or attraction, dummy variable is 1. Otherwise, dummy variable is 0.
4/ Units of GRDP and population used in forecast model are billion VND and 1.000 population, respectively.

Table 8.2
Freight Generation and Attraction Model

Commodity	Generation	R^2	Attraction	R^2
Paddy and Other Crops	1.5X1+0.25X2-39.7 (4.4) (11.2)	0.71	1.13X1+0.10X2-10.3 (5.5) (6.1)	0.93
Sugarcane	0.05X1+148.8X2+10.3 (3.0) (10.3)	0.78	0.70X1+0.001X2+8.3 (19.8) (1.9)	0.88
Sugar	1.60X1+0.03X2-53.9 (2.6) (15.5)	0.81	0.25X2-2.93 (10.1)	0.71
Wood/ Forest Products	0.55X1+0.07X2+90.9 (0.3) (2.9)	0.76	2.51X1+0.01X2+13.4 (4.4) (11.2)	0.98
Steel	1.73X1+0.06X2-19.8 (12.4) (13.6)	0.86	1.80X1+0.02X2-9.6 (3.4) (6.6)	0.58
Construction Materials	0.78X1+0.11X2-54.7 (19.4) (7.4)	0.88	0.27X1+0.04X2+436.8 (3.2) (1.0)	0.41
Cement	1.72X1+0.06X2+6.9 (21.1) (6.9)	0.92	1.37X1+0.04X2+23.0 (4.8) (6.3)	0.62
Fertilizer	2.36X1+0.13X2-41.7 (5.8) (11.9)	0.87	0.15X2+218.2 (5.6)	0.96
Coal	4.32X1+0.01X2+110.4 (59.2) (1.2)	0.98	7.14X1-234.1 (9.4)	0.60
Petroleum Products	1.12X1+0.24X2-195.1 (6.4) (13.5)	0.94	2.55X1+0.01X2-34.4 (7.9) (3.2)	0.62
Industrial Crops	1.79X1+0.03X2-22.4 (5.5) (6.3)	0.53	0.40X1+0.35X2-44.4 (1.4) (6.9)	0.90
Manufacturing Goods	1.43X1+0.20X2+62.5 (8.0) (15.1)	0.92	1.33X1+0.16X2+188.5 (3.0) (5.2)	0.80
Fishery Products	0.004X1+0.026X2-9.9 (7.1) (7.2)	0.63	0.0008X1+0.29X2-16.5 (1.2) (11.0)	0.85
Animal Meat and Others	0.007X1+0.02X2+4.3 (3.5) (10.5)	0.66	0.01X1+0.13X2-11.2 (4.1) (5.2)	0.93

Trip Distribution

Gravity model produced very poor model fitness so that growth factor approach, usually called as Fratar method, was adopted to forecast origin-destination freight. If generation and attraction take place in certain province in future where there are no generation and attraction at present, future generation and attraction will be taken into account.

Modal Split

There are two approaches for modal split and traffic assignment, namely trend pattern method (TPM) and cost minimization assignment (CMA). TPM extrapolates the past trend or demand to the future, using the growth rate or mathematical models, while CMA seeks the most desirable demand structure by maximizing or minimizing some target functions. With regard to modal split, it is expressed as follows, respectively:

TPM
$$T_{ij}^{m} = T_{ij}\frac{PT_{ij}^{m}}{\sum_{m} PT_{ij}^{m}}$$

CMA
$$T_{ij}^{m} = T_{ij}\frac{\left(C_{ij}^{m}\right)^{-a}}{\sum_{m}\left(C_{ij}^{m}\right)^{-a}}$$

Where, T_{ij}^{m} : trips by mode m between i and j in future
PT_{ij}^{m} : trips by mode m between i and j at present
C_{ij}^{m} : transport cost by mode m between i and j
T_{ij} : trips by all modes between i and j

Note that, with respect to CMA, modal split is determined while doing traffic assignment, i.e., combination of modal choice and traffic assignment.

OD Matrix Generating Operation

If one wants to generate OD freight demand in future, one should execute "Fire ODGen.exe". It allows one to produce OD freight demand according to commodity item in future. Note that this component doesn't involve modal split calculation. With executing "FireODGen.exe", one will see the following message on the screen.

List of OD Matrix

2010 OD Matrix at Low Assumption: 1
2010 OD Matrix at High Assumption: 2
2010 OD Matrix at Low Assumption: 3
2010 OD Matrix at Low Assumption: 4

What kind of OD Matrix do you want to make? Select No. ⇒

Note: In the VITRANSS, there are four scenarios assumed: low and high assumptions in 2010 and low and high assumptions in 2020. So, one can get four different OD passenger demand to one's purpose through this operation.

One should select the case number of OD matrix which one wants to generate and press enter key. Then it will make the OD matrix which one selected.

OD freight demand is calculated through (see Figure 8.1 and 8.2):

i) Reading case number input by user
ii) Reading population, GDP, production and consumption present OD matrix and inter-zonal travel distance
iii) Calculating trip generations and attractions using population, GDP and production and consumption
iv) Adjusting trip generations and attractions taking into account differences between actual generations and attractions and estimated ones.
v) Using Fratar method to estimate freight volume of commodity C between zone i and j T_{ij}^{c}
vi) Saving future OD matrix calculated

The following are input files:

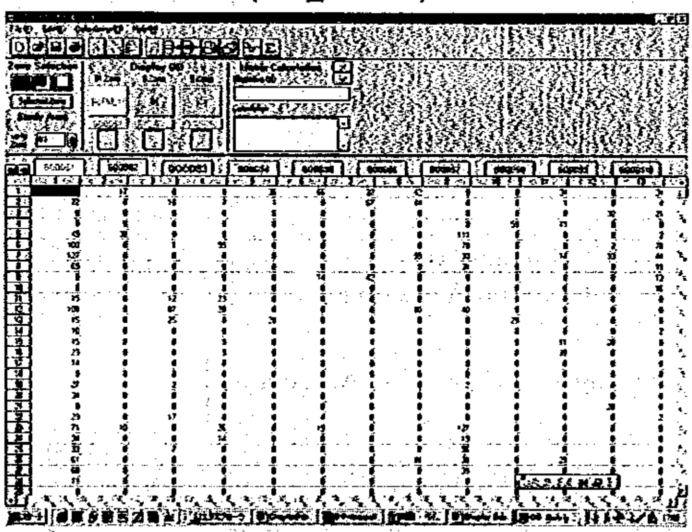
Parameter file involves input filenames necessary for calculation as follows.

Parameter File ("FireODGen.Par")

Population	: population.csv
GDP	: gdp.csv
Pro/Con (1999)	: ProCon99.csv
Pro/Con (2010 Low)	: ProCon10L.csv
Pro/Con (2010 High)	: ProCon10H.csv
Pro/Con (2020 Low)	: ProCon20L.csv
Pro/Con (2020 High)	: ProCon20H.csv
Output	:F10L.aod

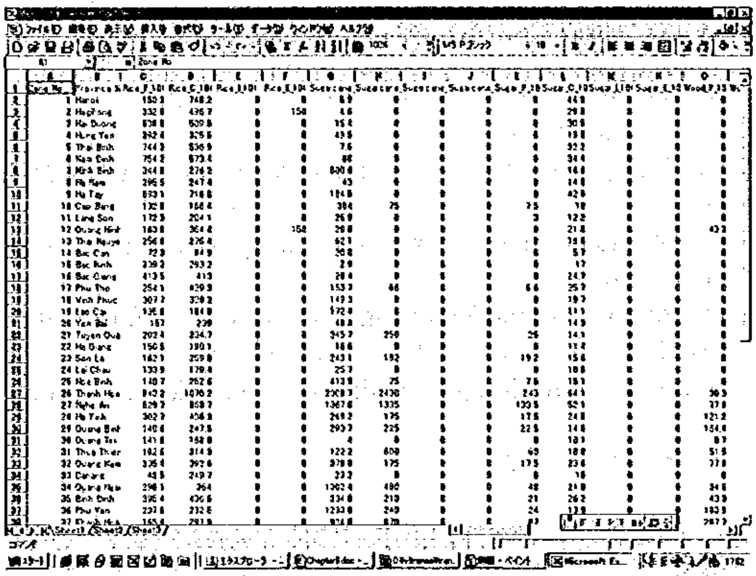
Present OD matrix that is results of present OD matrix formulation involves OD freight demand by transport mode as follows.

Present OD Matrix ("f99_19.aod")



Production and Consumption that are results of production and consumption sub-model involve production and consumption of each commodity in 61 provinces as follows.

Production and Consumption File ("*.csv")



Population and GDP that are results of macro economic sub-model involve population and GDP by province.
Travel time matrix that is results of inter-zonal impedance creating component involves travel distance (km) calculated by searching the shortest path as follows.

Figure 8.1 Flow chart of Freight OD Matrix Generating Operation

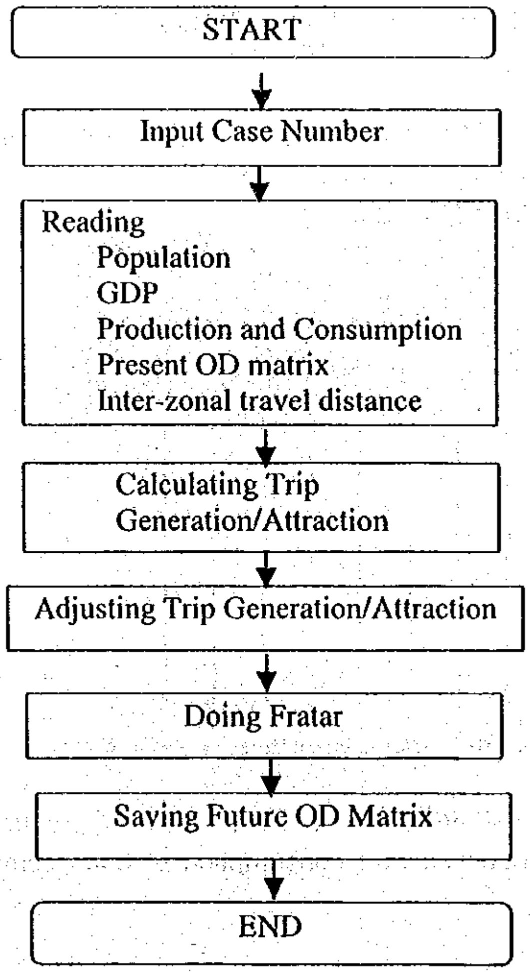
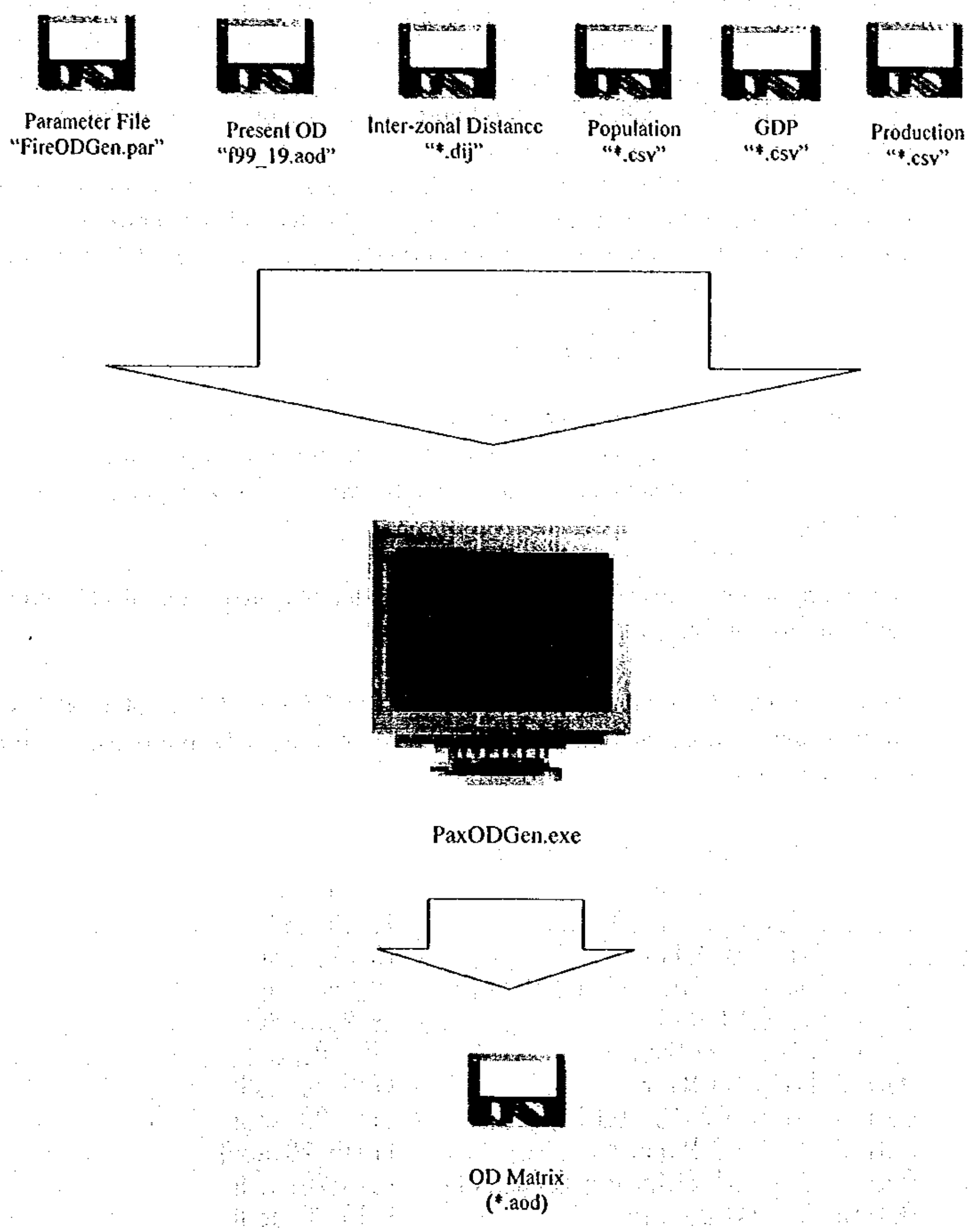


Figure 8.2
Freight OD Matrix Generating Operation, Freight Demand



Modal Split of Trend Pattern Approach

This component is to determine the modal share of trend pattern approach. If one wants to produce OD matrices by mode, one should execute "F_Trend_OD.exe". This allows one to get OD matrices according to mode calculated by reflecting present OD matrices pattern into the future. This component is calculated through the following steps (see Figure 8.3 and 8.4):

vii) Reading present OD matrices of road, inland water, rail, coastal shipping and air.
viii) Reading future OD matrix calculated by freight OD matrix generating component.
ix) Calculating trip of mode m between zone i and j based on the following formula:

$$T_{ij}^{m} = T_{ij}\frac{PT_{ij}^{m}}{\sum_{m} PT_{ij}^{m}}$$

where, T_{ij}^{m} = Trips of mode m between zone i and j in future.
PT_{ij}^{m} = Trips of mode m between zone i and j at present.
T_{ij} = Trips including all modes between zone i and j in future.

x) Saving . T_{ij}^{m}

This component requires seven files: parameter file, five present OD matrices by mode, future OD matrix including all modes.

Parameter file designates filename necessary for calculation of modal share of present pattern approach as follows. Don't forget each OD matrix file comprises 13 commodity items.

Parameter File ("F_Trend_OD.par")

```
Input Road OD Matrix                  = r9_99.aodl
Input Inland Water OD Matrix          = i9_99.aodl
Input Rail OD Matrix                  = r9_99.aodl
Input Coastal Shipping OD Matrix      = c9_99.aodl
Input Air OD Matrix                   = a9_99.aodl
Input Future OD Matrix                = f15_20.aodl
Output Road OD Matrix                 = tr15_20.aodl
Output Inland Water OD Matrix         = ti15_20.aodl
Output Rail OD Matrix                 = tra15_20.aodl
Output Coastal Shipping OD Matrix     = tc15_20.aodl
Output Air OD Matrix                  = ta15_20.aodl
```

Figure 8.3
Flow Chart of Modal Split of Present Pattern Approach

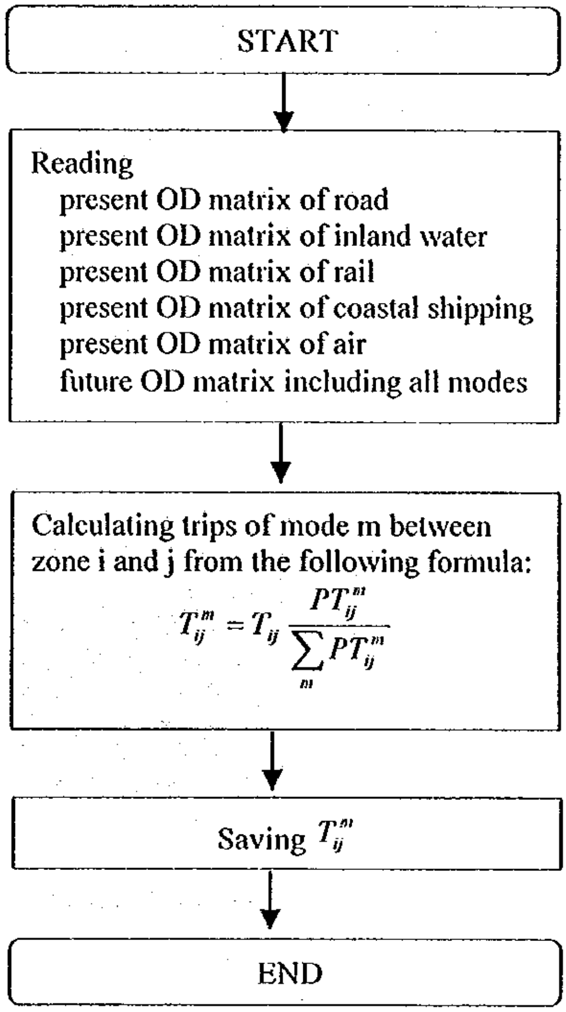
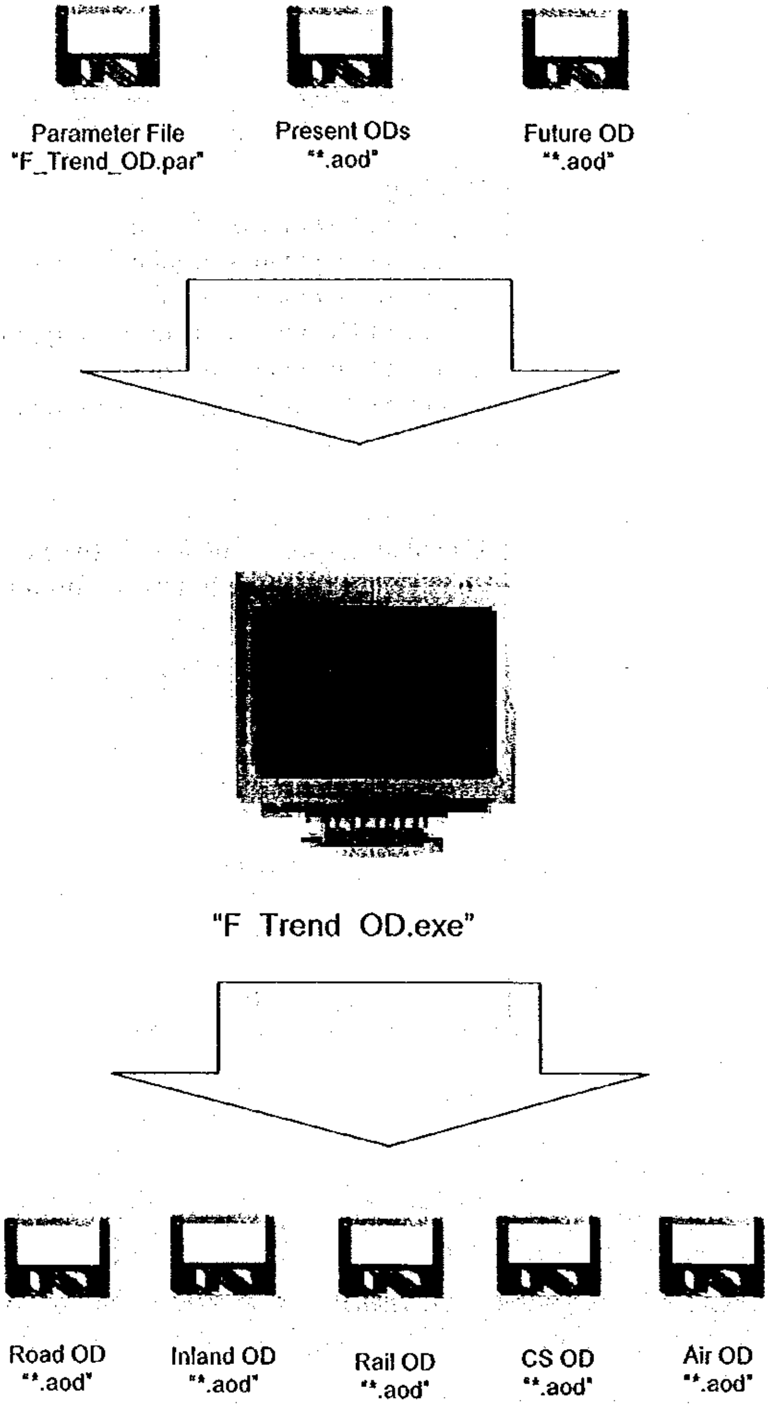


Figure 8.4
Modal Split of Present Pattern Approach



8.3 Traffic Assignment

As mentioned earlier, there are two approaches for freight traffic assignment: present pattern approach and cost minimization approach. The former does traffic assignment after determining modal share by reflecting present modal share into the future. Meanwhile, the letter does traffic assignment while calculating modal share based on transport cost by mode between OD pairs at the same time.

Present Pattern Approach

This component is to do traffic assignment using freight OD matrices by mode which estimated in freight trend pattern OD generating component. It is basically based on all-or-nothing approach and done through the following steps (see Figure 8.5 and 8.6):

xi) Reading network data and OD matrix.
xii) Reading the number of mode, commodity item, origin and destination.
xiii) Initializing m, c, i and j.
xiv) Searching the shortest path of mode m between origin i and destination j in terms of transport cost of commodity item c.
xv) Assigning OD passengers of mode m and commodity item c between i and T_{ij}^{cm} j, , on the shortest path.
xvi) Iterating iv) and v) to satisfy j = J, m = M, c = C and i = I.
xvii) Saving traffic volume assigned on the links.

If one wants to do the traffic assignment, one should execute "assign04.exe". To do this, it is required to prepare seven files: parameter file, network file and five present OD matrices.

The parameter file involves information necessary for freight traffic assignment. Most of all, one should designate input and output files ("*.int", "*.aod" and "*.ire") all of which follow JICA STRADA format. In addition, it is needed to give information on number of mode, commodity item and zone. User flag is made use of when one searches the shortest path by transport mode. Operating cost and cargo time cost are for calculating transport cost (see Appendix I for details).

The network file can be prepared through executing network building operation. Also, the five present OD matrices can be provided through calculating the modal share of present pattern approach.

Parameter File ("Assign04.par")

```
Network = n99f.int;↓
Output = t99f.ire;↓
Zone = 81;↓
Mode = 5;↓
r9_99.aod        RFZ     0.546↓
i9_99.aod        IWZ     0.181↓
ra9_99.aod       LYZ     0.263↓
c9_99.aod        CSZ     0.084↓
a9_99.aod        APZ     0.000↓
Goods = 13;↓
 0.041↓
 0.097↓
 0.008↓
 0.077↓
 0.003↓
 0.010↓
 0.041↓
 0.005↓
 0.062↓
 0.048↓
 0.384↓
 0.274↓
 0.274↓
```

User Flag

Operating Cost

Cargo time cost

Figure 8.5
Flow Chart of Traffic Assignment of Trend Pattern Approach

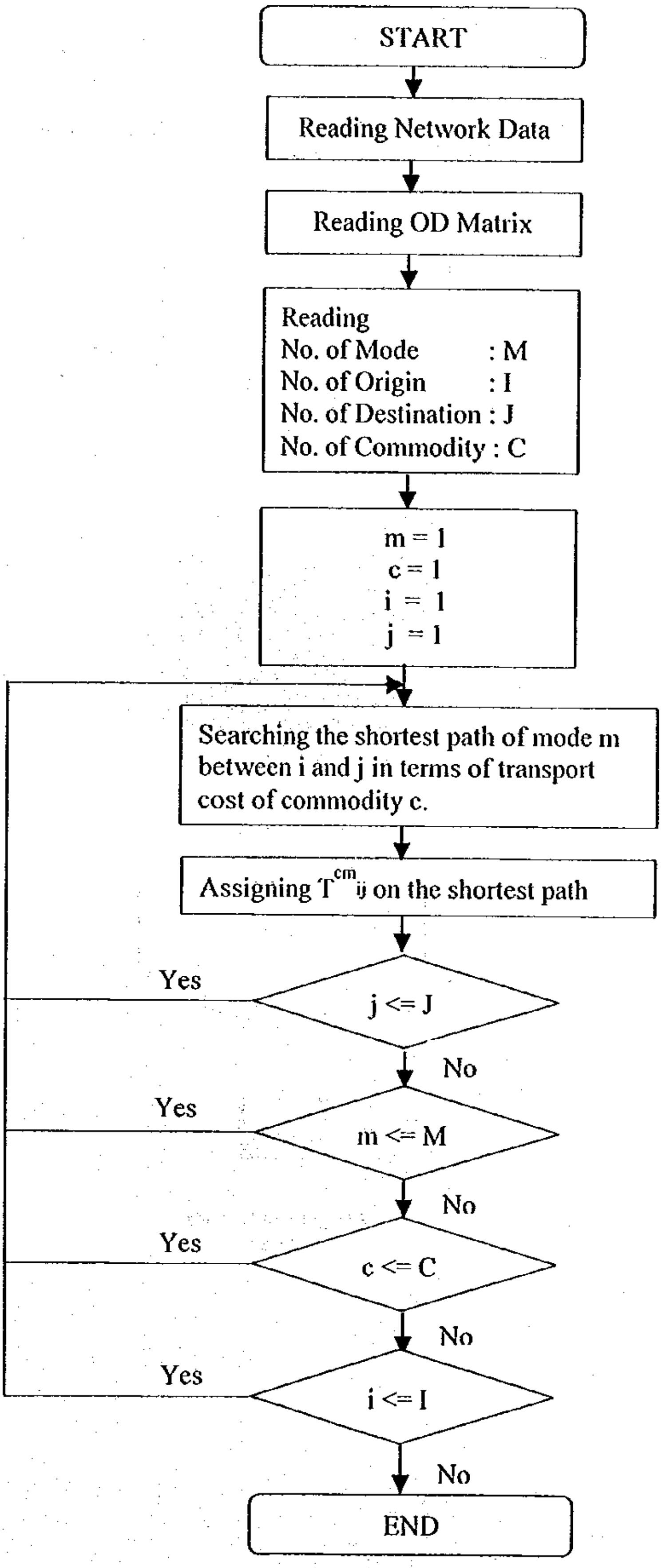
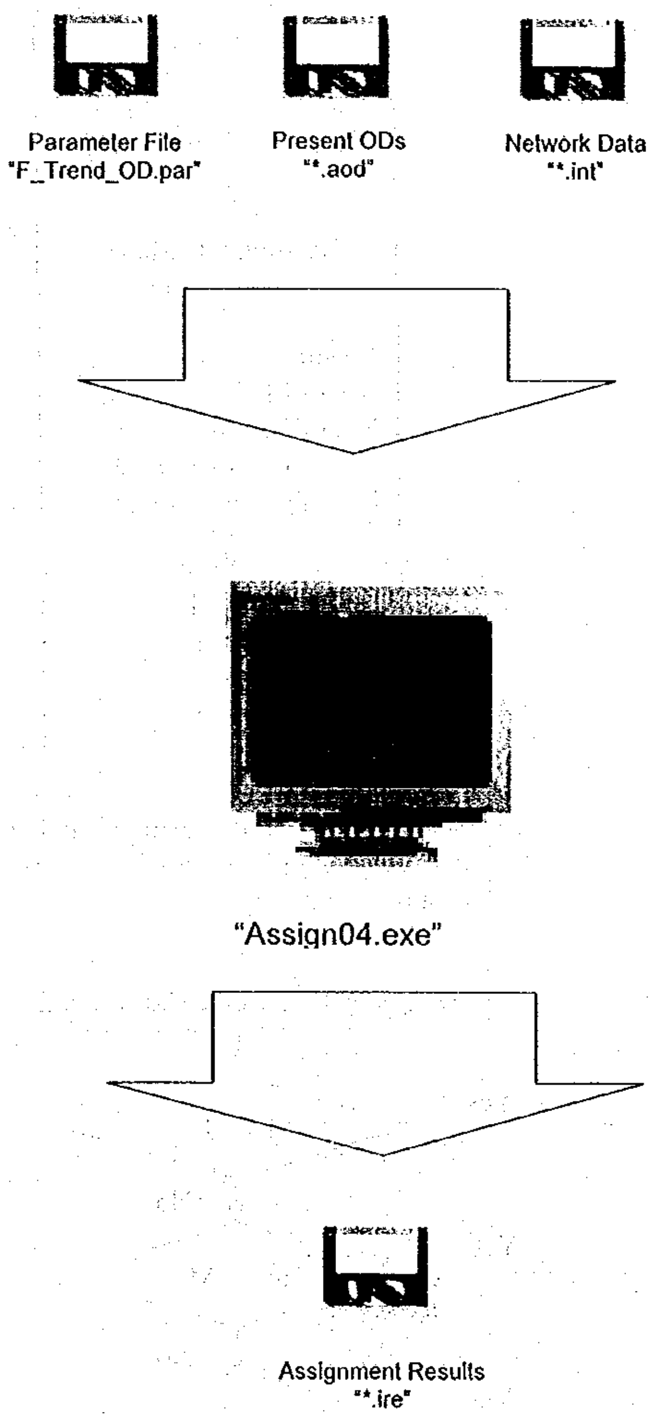


Figure 8.6
Traffic Assignment of Trend Pattern Approach



Cost Minimization Approach

This is to do modal split and traffic assignment at the same time, i.e., the combination of modal split and traffic assignment and done through the following steps (see Figure 8.7 and 8.8):

i) Reading network data, OD matrix, QC curve and inter-zonal travel distance.
ii) Reading the traffic assignment times (T) and the number of mode (M), commodity item (C), origin (I) and destination (J).
iii) Preloading traffic assignment results of passenger demand.
iv) Updating travel time of all links based on traffic volume preloaded.
v) Initializing t, m, c, i and j.
vi) Searching the shortest path of mode m between origin i and destination j in terms of transport cost of commodity item c.
vii) Iterating vi) to satisfy m = M.
viii) Determining modal share based on transport cost by mode calculated in vi) and vii).
ix) Assigning OD matrices of mode m and commodity item c between i and j, T_{ij}^{cm}, on the shortest path.
x) Iterating vi), vii), viii) and ix) to satisfy j = J, c = C, i = I and t = T.
xi) Saving traffic volume assigned on the links.

If one wants to do the traffic assignment, one should execute "assign08.exe". To do this, it is required to prepare five files: parameter file, network file, OD matrix, QC curve file, inter-zonal travel distance matrix file.

The parameter file involves information necessary for freight traffic assignment. Most of all, one should designate input and output files ("*.int", "*.aod" and "*.ire") all of which follow JICA STRADA format. Besides, one should designate QC curve file ("*.tqc") and inter-zonal travel distance file ("*.dij"). In addition, it is needed to give information on number of mode, commodity item and zone. User flag is made use of when one searches the shortest path by transport mode. Traffic assignment times are used for incremental traffic assignment, i.e., traffic assignment calculation will be repeated as times as input here. Cargo time cost is one of factors to calculate transport cost.

The network file can be prepared through executing network building operation. Also, the OD matrices can be provided through freight OD matrix generating operation. The traffic assignment results file preloaded can come from preload file making operation (see Chapter 6).

Parameter File ("Assign06.par")

```
Network = n99f.int;↓
OD Matrix = f9_99.aod;↓
QC Curve = n99f.tqc;↓
Preload = n99p_pre.ire;↓
Output = n99.ire;↓
Mode OD = f9_99m.aod;↓
Dist OD = car.dij;↓
Zone = 81;↓
Mode = 5;↓
Truck               RFZ↓
Inland Waterway     IWZ↓
Railway             LYZ↓
Coastal Shipping    CSZ↓
Air                 APZ↓
Times = 10;↓
  10  10  10  10  10  10  10  10  10  10↓
Goods = 13;↓
    1.0     1.0     1.0     1.05     1.0↓
    0.041   1.0↓
    0.097   1.0↓
    0.008   1.0↓
    0.077   1.0↓
    0.003   1.0↓
    0.010   1.0↓
    0.041   1.0↓
    0.005   1.0↓
    0.062   1.0↓
```

User Flag

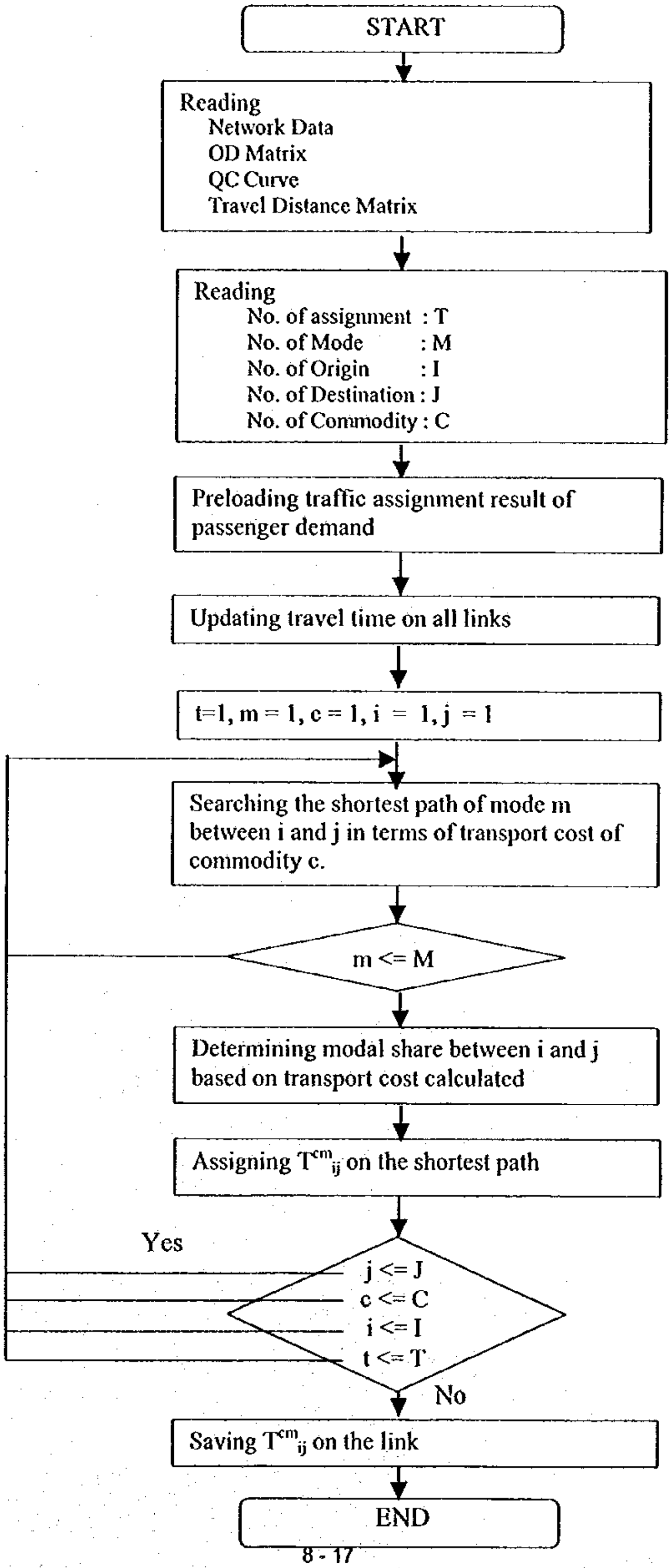
Traffic Assignment Times

Proportional Factors for Incremental Traffic Assignment

Parameter used to determine modal share

Cargo Time Cost

Figure 8.7
Flow Chart of Traffic Assignment of Cost Minimization Approach



APPENDICES

APPENDIX I CAPACITY, TRAVEL SPEED AND TRAVEL COST

1 Capacity

1.1 Road

In usual, road capacity is calculated by the following formula:
$C=C_O x FC_W x FC_{sp} x FC_{mc} x FC_{sf} x FC_{sc} x FC_{it}$

Where: C=Capacity (PCU/hr),
C0=Basic capacity in ideal conditions (PCU/hr),
FCw=Adjustment factor for carriageway width,
FCsp=Adjustment factor for directional split,
FCmc=Adjustment factor for motorcycle traffic,
FCsf=Adjustment factor for side friction
FCsc=Adjustment factor for surface condition
FCit=Adjustment factor for inter-provincial traffic

Basic Capacity

Basic capacity (C0) for 2-lane undivided road was assumed as follows:

Terrain type	Base Capacity (PCU/hr)	Definition
Flat	3,100	Generally less than 5 % gradient
Hilly	2,900	Normally within 4 % to 8 % gradient
Mountainous	2,500	Frequent steep sections often reaching 10 % gradient

Adjustment for Carriageway Width

Adjustment factor (FCw) for carriageway width (FCw) for two-lane undivided road is shown in the following table. In the actual application, "effective width" was understood to be equal to pavement width for paved roads in the absence of accurate road inventory. For unpaved roads, "effective width" was assumed to be less than 5 m.

Effective Width	FCw
<5m	0.69
5m	0.81
6m	0.91
7m	1.00
8m	1.08
9m	1.15
12m	1.27

Source: IHCM

Adjustment for Directional Split

The adjustment factor for directional split (FCsp) depends on the directional split of the traffic as shown in the following table. In fact, however, most of the road links fall in the category of "60-40", judging from the results of VITRANSS traffic counts.

Directional split (%)	FCsp
50-50	1.00
55-45	0.97
60-40	0.94
65-35	0.91
70-30	0.88

Source:IHCM

Adjustment for Motorcycle Traffic

According to the IHCM, the adjustment factor for motorcycle traffic (FCmc) is based on the motorcycle ratio as follows:

FCmc=1-Qmc/Qc

Where, QCmc=Motorcycle flow (PCU/hr)=0.25xMotorcycle flow (MC/hr)
Qc=Sum of flow for all motor vehicle types expressed in PCU/hr

When this formula is applied to the results of VITRANSS traffic counts (39 stations), FCmc was calculated at 0.662 to 0.935 with an average of 0.820. The stations near HCMC tend to show lower values. In this study, the average was used to the entire network because traffic data is not available for all road links and the traffic mix changes quickly depending on the situation of road development and traffic demand.

The PCU values used in this study are shown in the next page.

Vehicle Type	PCU	Vehicle Type	PCU
Bicycle	0.50	Light truck	1.00
Motorcycle	0.25	Medium truck	2.00
Car	1.00	Heavy truck	2.50
Minibus	1.50	Articulated truck	3.00
Large bus	2.00	Others	1.00

Source: IHCM

Adjustment for Side Friction

Adjustment factor for side friction (FCsf) is based on roadside activities and shoulder width. For two-lane undivided roads, this factor is as shown in the following table.

Typical conditions	Side friction Class	Shoulder Width			
		<0.5m	1.0m	1.5m	>2m
Rural, agriculture or undeveloped, no activities	Very low	0.96	0.98	1.00	1.03
Rural, some roadside building & activities	Low	0.90	0.92	0.95	0.99
Village, residential activities	Medium	0.83	0.86	0.90	0.96
Village, some market activities	High	0.76	0.80	0.85	0.93
Almost urban market/business activities	Very High	0.70	0.74	0.80	0.90

Source: IHCM

However, judging from the fact that side friction is usually large on Vietnamese roads (e.g. non-motorized vehicles, farmer's activities), it was assumed that road shoulder is always less than 0.5 m regardless of the actual width. As a result, the hourly capacity of a 2-lane undivided road is summarized as follows.

Table 1.1
Hourly Capacity of 2-lane Undivided Road

(PC/hr)

	Side Friction	Pavement Width						
		<5m	5m	6m	7m	8m	9m	12m
Flat	Rural, no activity	1,583	1,858	2,087	2,294	2,477	2,638	2,913
	Rural, some activity	1,484	1,742	1,957	2,151	2,323	2,473	2,731
	Village, residential	1,368	1,606	1,805	1,983	2,142	2,281	2,519
	Village, some commercial	1,253	1,471	1,653	1,816	1,961	2,088	2,306
	Urban	1,154	1,355	1,522	1,673	1,806	1,924	2,124
Hilly	Rural, no activity	1,481	1,738	1,953	2,146	2,318	2,468	2,725
	Rural, some activity	1,388	1,630	1,831	2,012	2,173	2,314	2,555
	Village, residential	1,280	1,503	1,688	1,855	2,004	2,134	2,356
	Village, some commercial	1,172	1,376	1,546	1,699	1,835	1,954	2,158
	Urban	1,080	1,267	1,424	1,565	1,690	1,799	1,987
Mountainous	Rural, no activity	1,276	1,498	1,683	1,850	1,998	2,217	2,349
	Rural, some activity	1,197	1,405	1,578	1,734	1,873	1,994	2,203
	Village, residential	1,104	1,296	1,455	1,599	1,727	1,839	2,031
	Village, some commercial	1,011	1,186	1,333	1,465	1,582	1,684	1,860
	Urban	931	1,093	1,227	1,349	1,457	1,551	1,713

Capacity per Day

Based on the VITRANSS traffic counts (39 stations), the peak hour ratio (against 24-hour traffic for both directions in terms of PCUs, excluding motorcycle and non-motorized transport) varies depending on the survey station from 5.0% to 11.9% with typical values between 8 and 9%. Assuming a peak hour ratio at 8.5%, which is the same as the French study, the hourly capacity can be converted into daily capacity as shown in the following table.

Table 1.2
Daily Capacity of 2-lane Undivided Road

(PCU/day)

	Side Friction	Pavement Width						
		<5m	5m	6m	7m	8m	9m	12m
Flat	Rural, no activity	18,624	21,859	24,553	26,998	29,141	31,035	34,271
	Rural, some activity	17,459	20,494	23,024	25,306	27,329	29,094	32,129
	Village, residential	16,094	18,894	21,235	23,329	25,200	26,835	29,635
	Village, some commercial	14,741	17,306	19,447	21,365	23,071	24,565	27,129
	Urban	13,576	15,941	17,906	19,682	21,247	22,635	24,988
Hilly	Rural, no activity	17,424	20,447	22.976	25,247	27,271	29,035	32,059
	Rural, some activity	16,329	19,176	21,541	23,671	25,565	27,224	30,059
	Village, residential	15,059	17,682	19,859	21,824	23,576	25,106	27,718
	Village, some commercial	13,788	16,188	18,188	19,988	21,588	22,988	25,388
	Urban	12,706	14,906	16,753	18,412	19,882	21,165	23,376
Mountainous	Rural, no activity	15,012	17,624	19,800	21,765	23,506	25,024	27,635
	Rural, some activity	14,082	16,529	18,565	20,400	22,035	23,459	25,918
	Village, residential	12,988	15,247	17,118	18,812	20,318	21,635	23,894
	Village, some commercial	11,894	13,953	15,682	17,235	18,612	19,812	21,882
	Urban	10,953	12,859	14,435	15,871	17,141	18,247	20,153

When a 2-lane road is widened to a 4-lane road, it is assumed that the capacity increases by its base capacity without multiplying any adjustment factors.

Adjustment Factor for Road Surface Condition

Beside above factors, capacity strongly depends on a road surface condition[1]. So, it was adjusted by the following factors.

(%)

Good	Fair	Poor	Very Poor
100	80	50	30

FCsc=Adjustment factor for surface condition
FCit=Adjustment factor for inter-provincial traffic

Adjustment Factor for Inter-provincial Traffic Volume

[1] According to the IRI (International Roughness Index), road surface condition is defined as follows. It is applied to VITRANSS.

Road surface	Road condition	Range of IRI (m/km)	Average IRI (m/km)
Paved	Good	0-4	3
	Fair	4-8	6
	Poor	8-10	9
	Very Poor	>10	12
Unpaved	Good	5-9	7
	Fair	9-11	10
	Poor	11-15	14
	Very Poor	>15	17

As the VITRANSS study focused on the inter-provincial traffic, intra-provincial traffic on the link should be discarded. One of ways to do it is to use adjustment factor for inter-provincial traffic volume and it was assumed as follows reflecting the impact of land use.

Side Friction	Adjustment Factor
Rural, agriculture or undeveloped, no activities	0.7
Rural, some roadside building & activities	0.6
Village, residential activities	0.5
Village, some market activities	0.4
Almost urban market/business activities	0.3

1.2 Railway

There are two ways to expand railway capacity, i.e., enlarging a train's capability and increasing frequency of train.

Enlarging the capability of a train

This is achieved by the traction power up of a locomotive or making the train longer. The traction power-up is relatively easy by introducing more powerful locomotives. As for train length, it is determined by the effective length of passing, departing or arriving tracks of stations.

Increasing of Train Frequency

As for the infrastructure, there are two ways to expand capacity:

a. Shortening the distance between stations is the first thing to do for the train frequency up. If a distance between stations is made to a half, nearly twice as many as trains will be put to the section because a train's time in the section is cut to a half. Then, shortening the distance between stations shall be executed in order to put more trains.

b. After the shortening the station distance, comes the double tracking. If the section is double-tracked, up-trains and down-trains can run the section on the separate track. Then every up-train (or down-train) can run successively on the same track (up-track or down-track) in the minimum interval after the preceding train. The double tracking will be done from the most congested sections, in most cases, the longer distance sections are more congested than the other sections, as the first case.

The past experiences give an idea of relationship between train frequency and track quantity as follows:

Table 1.3
Train frequency and the track quantity

Train frequency/day	Note
Under 60	Single track is adequate
60-80	Limit of single track
More than 60-80	Double tracked sections must be introduced in congested sections
More than 100	All sections must be double-tracked
More than 250	The line shall be two double-tracked if various trains {long distance trains, short distance (commuter) trains, freight trains, etc.} are on the same track. And tracks shall be separated by the character, if the two double tracks are in use (e.g., long distance line, commuter line, freight line, etc.)

Note: The section length between stations was assumed nearly 4-5 km.

It was assumed that one train could transport 700 passengers and 100 tones respectively when calculating the railway capacity.

1.3 Inland Waterway and Coastal Shipping

As for inland waterway and coastal shipping the capacity of port has strong impact on their movement. Therefore, it is required to investigate and determine the capacity at the port where the freight volume carried is affordable.

1.4 Air

Freight volume carried by aircraft is so marginal that the impact of capacity on the movement of freight was disregarded.

2 Speed

2.1 Road

Based on factors such as no. of lanes, terrain type and surface condition, travel speed is assumed as follows.

Table 2.1
Travel Speed

Category	Lanes	Designed Speed (kph)			Surface Condition			
		Flat	Hilly	Mountainous	Good	Fair	Poor	Very poor
1	4x3.75(m)	120	105	90	100	80	50	30
2	2x3.75	100	90	80	100	80	50	30
3	2x3.5	80	70	60	100	80	50	30
4	2x3.0	60	50	40	100	80	50	30
5	1x3.5	40	35	25	100	80	50	30
6	1x3.0	25	20	15	100	80	50	30

2.2 Railway

As for railway, the speed is strongly affected by curve and the following relation appears between the two factors.

$V=3.5\sqrt{R}$

Where, V=Speed

R=Curve

Based on the above formula, the speed is induced according to the various curves.

Table 2.2
Train Speed and Radius of Curvature

Train speed (km/h)	Radius of curvature (m)
78	500
70	400
60	300
49	200
35	100

Average travel speed was calculated from actual operation situation according to operation section in terms of passengers and freight train respectively.

Table 2.4
Required Time and Average Speed of Freight Train

Line	Required time (Hours & minute)	Average speed (Km/h)
Ha Noi-Sai Gon	30h27m	57
Ha Noi-Lao Cai	17h50m	17
Ha Noi-Dong Dang	9h00m	18
Ha Noi-Hai Phong	6h15m	16
Ha Noi-Quan Trieu		
Ha Noi (Y.Vien)-Ha Long (M.Khe)	5h15m	22

Taking into account the above factors, the travel speed was determined according to the operation section.

2.3 Other Modes

Travel speed was assumed at 20 km/h for inland waterway and 37 km/h for coastal shipping respectively. Regarding air, its speed was determined considering aircraft type operated on its route.

3 Travel Cost

Economic Operating Cost

The economic cost of passenger and freight transport was assumed as follows.

Table 3.1
Economic Operating Cost

Mode	Passenger transport (VND/passenger-km)	Cargo Transport (VND/ton-km)	Loading/unloading and other mobilization charge (VND/ton)
Car	264	-	-
Bus	94	-	-
Truck	-	546	55,000
Inland Waterway	48-66	138-223	104,000
Railway	209	263	91,000
Coastal Shipping	-	84	199,000

For road traffic, running speed varies depending on the volume/capacity ratio, and the running speed influences the operating cost considerably. In this study, the following adjustment factors were assumed.

Vehicle Type	Speed (km/hr)						
	15	20	30	40	50	60	70
Passenger Car	2.61	1.80	1.45	1.24	1.10	1.00	1.02
Bus	1.92	1.49	1.29	1.16	1.07	1.00	1.00
Truck	2.01	1.53	1.31	1.17	1.07	1.00	1.00

Source: Transport Master Plan for the Central Region for Vietnam (1998), French ODA

Economic Infrastructure and Maintenance Cost

Economic infrastructure and maintenance cost was assumed as follows.

Table 3.2
Road Infrastructure and Maintenance Cost
(VND million/km/year)

Terrain	Construction Cost1)	Maintenance Cost	Total
Flat	801(283)	86	887
Hilly	947(283)	86	1,033
Mountainous	1,092(283)	86	1,178
Highly mountainous	1,125(217)	86	1,211
Bridge	34,693	86	34,779

Note: 1/ Annualized at 12% for 30 years.
2/ Figures in parenthesis show pavement cost.

Table 3.3
Railway Infrastructure and Maintenance Cost

Investment	Economic Cost (VND billion/km)	Annualized Economic Cost (VND million/km) 1/
New single Tracking Double Tracking	22.40 11.20	2,483 1,241
Station	0.43	48
Electrification	11.20	1,241
Communication Facilities Improvement	0.64	71
Maintenance	-	258

Note: 1/ at 12% for 30 years

Table 3.3
Port Infrastructure and Maintenance Cost

	Construction Cost	Equipment Cost	Maintenance Cost	Operation Cost
Annualized Economic Cost (VND 000/ton)	39.9	7.9	3.6	3.6

Note: At 12% for 30 years.

Passenger and Cargo Time Cost

As for passenger time cost, passenger time cost was determined by an income approach as shown in the following table.

Table 3.4
Passenger Time Cost[1]

(VND/hr)

	1999	Low Case		High Case	
		2010	2020	2010	2020
Average Income	3,180[2]	5,097	7,691	5,757	9,558
Growth rate of Per Capita (%/¥)	4.0	4.0	4.2	5.0	5.2
Passenger Time Cost					
-For bus, railway and inland water	3,180	5,097	7,691	45,757	9,558
-For car and air	6,360	10,194	15,382	11,514	19,116
Economic Passenger Time Cost					
-For bus, railway and inland water	960	1,539	2,323	1,739	2,887
-For car and air	1,921	3,079	4,645	3,477	5,773

Note: 1/ Passenger time cost by income approach.
2/ Average of state sector employee under local government (assuming 160 working hours/month)

Cargo time cost can be quantified as an interest cost during transport. In this study, it was assumed as follows:

Cargo	Assumed Value (VND million/ton)	Cargo Time Cost (VND/hour/ton)
1.paddy and food crop	3.0	41
2.sugar/sugarcane	7.1	97
3.wood/forestry	0.6	8
4.steel	5.6	77
5.construction materials	0.2	3
6.cement	0.7	10
7.fertilizer	3.0	41
8.coal	0.4	5
9.petroleum products	4.5	62
10.industrial crop	3.5	48
11.manufacturing goods	28.0	384
12.fishery Products	20.0	274
13.animal meat	20.0	274

Note: 1/ assumes an interest rate of 12%/year.

Annualized cost was calculated from the following formula:
$R=r(1+r)^{n}/((1+r)^{n}-1)/365=0.126/365$

Where, R: Factor for conversion of infrastructure cost into daily cost
n: Project life (30 years)
r: Discount rate (12%)

APPENDIX II OD MATRIX ESTIMATION FROM TRAFFIC COUNT

The most important thing for the estimation of a transport demand model from traffic counts is to identify the paths followed by trips from each origin to each destination. The variables p_{ij}^{a} is used to define the proportion of trips from zone i to zone j traveling through link a. Thus, the flow (Va) in a particular link a is the summation of the contribution of all trips between zones to that link. Mathematically, it can be expressed as follows:

$$Va = \sum_{ij} T_{ij} p_{ij}^{a}, \qquad 0 \le p_{ij}^{a} \le 1$$

The variable p_{ij}^{a} can be obtained using trip assignment techniques ranging from a simple all-or-nothing to a more complicated equilibrium assignment.

1 A case of All-or-Nothing Assignment

In the case of all-or-nothing assignment, P_{ij}^{a} is defined as:

$$p_{ij}^{a} \begin{cases} 1 & \text{If trips from origins i to destination j use link a} \\ 0 & \text{Otherwise} \end{cases}$$

Assuming that trip matrix can be expressed as a simple gravity model, it could be:

$$Tij = \frac{\alpha PiPj}{d_{ij}^{2}} \qquad (1.1)$$

Where, Pi, Pj : Population
d_{ij} : Distance between zone i and zone j
α : Parameter

If a matrix of this kind is assigned on the network, one gets:

$$V_{a} = \sum_{ij} \frac{p_{ij}^{a} P_{i} P_{j}}{\left(d_{ij}\right)^{2}} = \alpha \sum_{ij} \frac{p_{ij}^{a} P_{i} P_{j}}{\left(d_{ij}\right)^{2}} \qquad (1.2)$$

Note that on the right-hand side of this equation the only unknown is α and the other variables are provided by external data or a good route choice model. If one denotes the gravity part of this model by:

$$G_{ij} = \frac{P_{i} P_{j}}{\left(d_{ij}\right)^{2}} \qquad (1.3)$$

Where, $P_{i} P_{j}$: trip generation/attraction factors such as population, employment, industrial production, GRDP and so on.

One can write:

Va = $\alpha \sum_{ij} P_{ij}^{a} G_{ij}$ (1.4)

Then, parameter α is simply estimated through least squares techniques. Further, if one postulates that Va = Va + εa, where εa is an error term, it permits writing:

$$V_a' = \alpha_0 + \alpha_1 \sum_{ij} p_{ij}^{a} G_{ij}$$

Where, α_0 : intercept
α_1 : parameter

If one uses more conventional model of :

$$T_{ij} = \alpha X_i G_i Y_j A_j f_{ij}$$

Where, α : parameter
X_i, Y_j : Balancing factors
f_{ij} : Deterrence (impedance) function, e.g. exp (- $\beta_{(ij)}$)

A greater effort should be given to calculate parameter of α, β, X_i and Y_j using non-linear regression.

2 A Case of Assignment considering Traffic Congestion

A representative traffic assignment with capacity constraint is done as follows.

i) With no traffic, one searches the shortest routes.
ii) A OD matrix is assigned on the shortest routes. With the assigned OD traffic, one searches the shortest routes.
iii) A OD matrix is assigned on the newly calculated shortest routes. Traffic on links is adjusted based on:

$$x_a^{(n)} = \left(1 - \frac{1}{n}\right) x_a^{(n-1)} + \frac{1}{n} x_a \quad (2.1)$$

Where, $x_a^{(n)}$ = Adjusted traffic on link after n_{th} reiteration.
x_a = Assigned traffic on link a at n_{th} calculation.

iv) Assignment calculation is repeated until $\left| x_a^{n} - x_a^{n-1} \right| < \varepsilon$
Using gravity model, traffic on link a is expressed as:

$$x_a = \sum_{ij} T_{ij} p_{ij}^{a} = \alpha \sum_{ij} p_{ij}^{a} G_i A_j C_{ij}' = \alpha X_a \quad (2.2)$$

Where, $T_{ij} = \alpha G_i A_j c_{ij}'$
$x_a = \sum p_{ij}^{a} G_i A_j c_{ij}'$
From equation (2.1) and (2.2), one obtains:

$$X_a = \left(1 - \frac{1}{n}\right) X_a^{(n-1)} + \frac{1}{n} X_a \quad (2.3)$$

$$x_a^{(n)} = \alpha X_a^{(n)} \quad (2.4)$$

Given the assumption that observed traffic x_a is independent each other, mean, $x_a^{(n)}$, follows normal distribution depending on variance of $x_a^{(n)}$, parameters α and r can be estimated through maximum likelihood method.

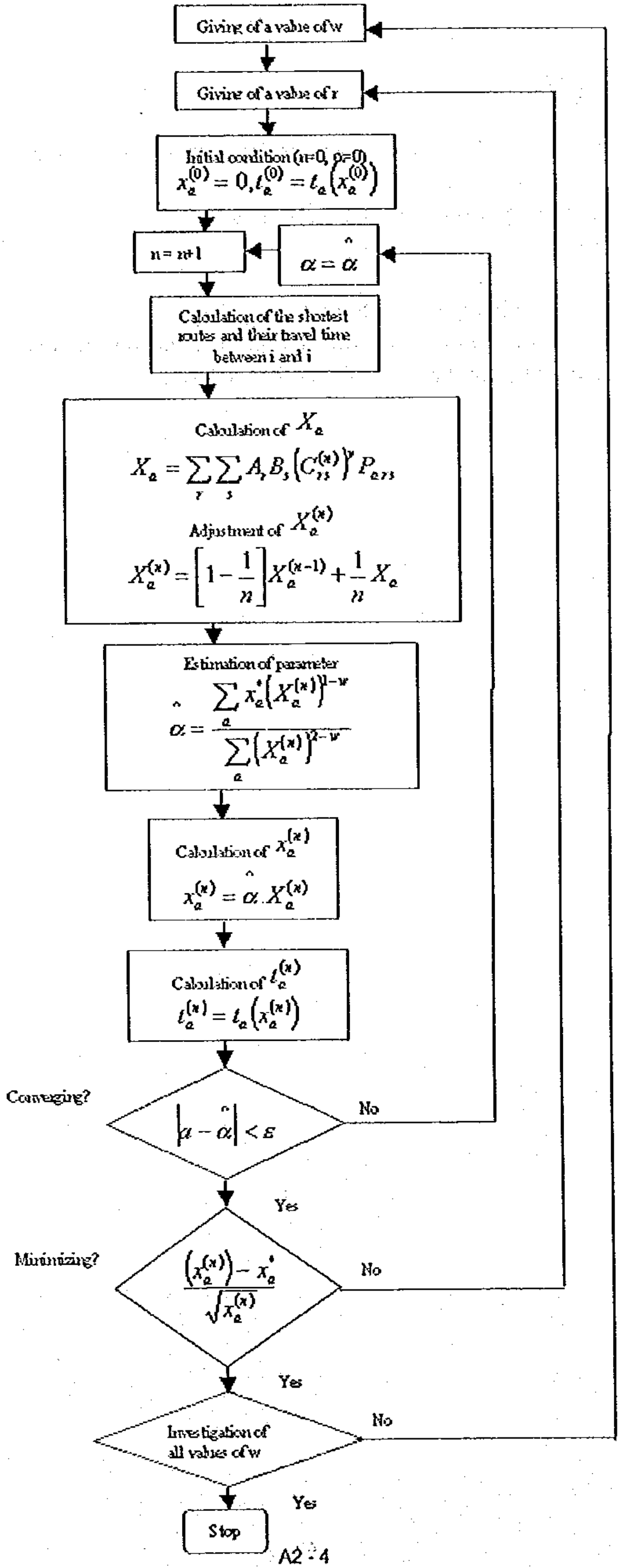
$x_a^{*} = x_a^{(n)} + \varepsilon_a$

where, ε : error term

w: weighting to error term ε .

Note that error term ε follows normal distribution $N(0, \left(x_a^{(n)}\right)^{w} \sigma^2)$. In detail, parameters of α, r and w are estimated as follows.

Figure 2.1
OD Estimation from Traffic Count and Traffic Assignment with Capacity Constraint



Appendix III Training on JICA STRADA

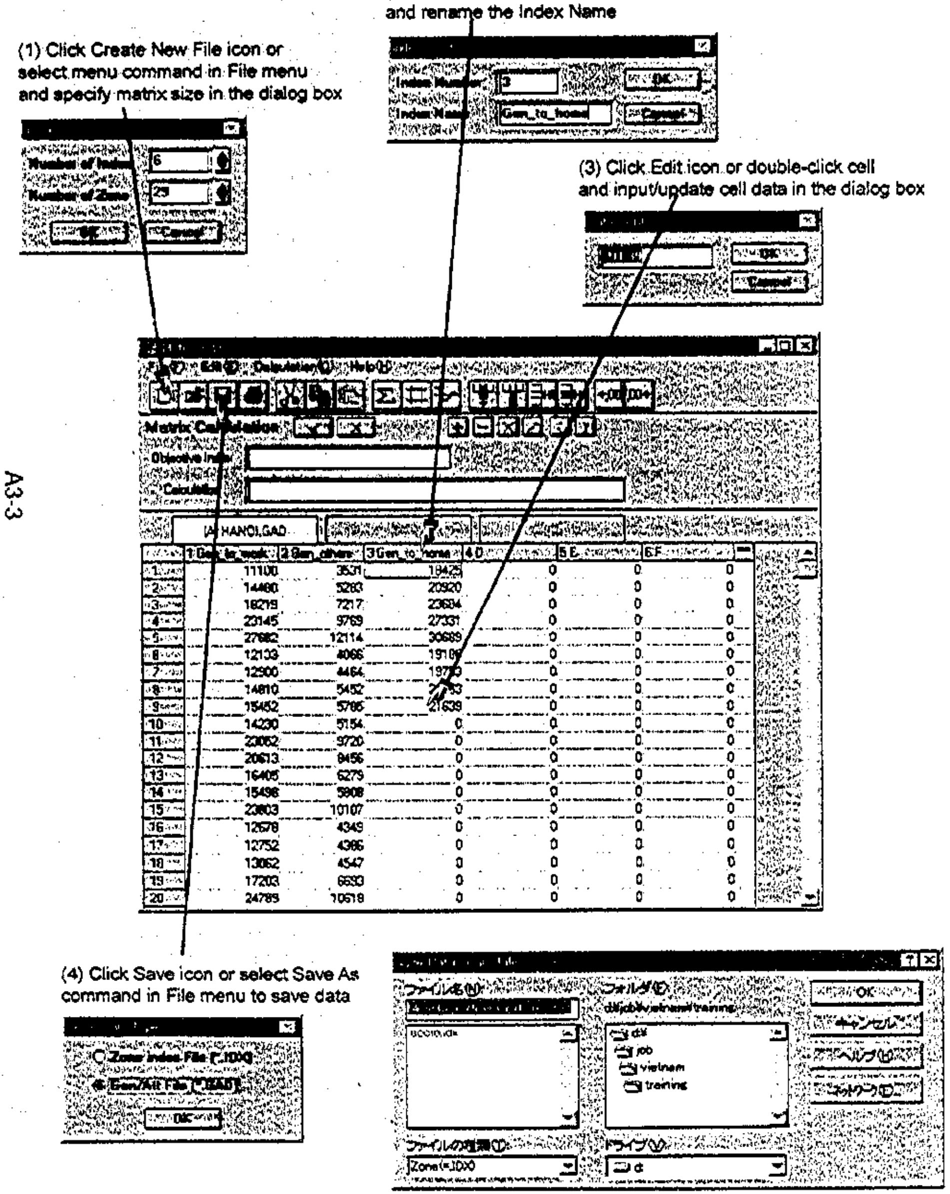
1. Transport Planning and JICA STRADA
2. Matrix Editor
3. GA Model Builder
4. GA Generation
5. OD Model Builder
6. OD Generator
7. MS Model Builder
8. MS Generator
9. Network Editor

1. Transport Planning and JICA STRADA

Planning Process	Task and Analysis	STRADA component	Other Software
Present Situation Analysis	- Socio-economic Analysis - Road Inventory and Existing Network Database - Traffic Condition Analysis - Transport Surveys - Person Trip Analysis etc.	- Point Reader - Zoning Editor - Matrix Editor - Zone Graph - Network Editor - Desired Line Viewer	- Spread Sheet - Database - GIS
Model Building	- Production Rate Analysis - Analyze relationship between Generation and Attraction and Zonal Attribute - Trip Length Distribution by Mode - Modal Share by Trip Length - Modal Share by Travel Time - Traffic Assignment of Existing OD Matrix on Existing Network	- OD Matrix Manipulator - GA Model Builder - OD Model Builder - MS Model Builder	- Spread Sheet - Database - GIS Etc
Demand Forecast	- Estimate Trip Production - Estimate Trip Generation/Attraction and Traffic Zone - Estimate Trip Distribution (OD Matrix)	- GA Generator - OD Generator - MS Generator - OD Matrix Manipulator - Desired Line Viewer	- Spread Sheet Etc.
Project Formulation	- Estimate Modal Share on Existing Network (OD Matrix by Mode) - Traffic Assignment on Spider Network - Traffic Assignment on Existing Network - Volume/Capacity Analysis - Link Flow Analysis - Formulate Future Network etc.	- Network Editor - Parameter Editor - Spider Net Generator - Incremental Assignment - Equilibrium Assignment - Highway Reporter	- Spread Sheet - GIS Etc.
Demand Analysis and Project Evaluation	- Estimate Modal Share on Future Network (OD Matrix by Mode) - Volume/Capacity Analysis - Corridor Analysis - Calculate Travel Cost - Calculate Travel Time Cost - Calculate Project Benefit Cost/Benefit Analysis Etc.	- Network Editor - Parameter Editor - Spider Net Generator - Incremental Assignment - Equilibrium Assignment - Highway Reporter	- Spread Sheet - GIS Etc.

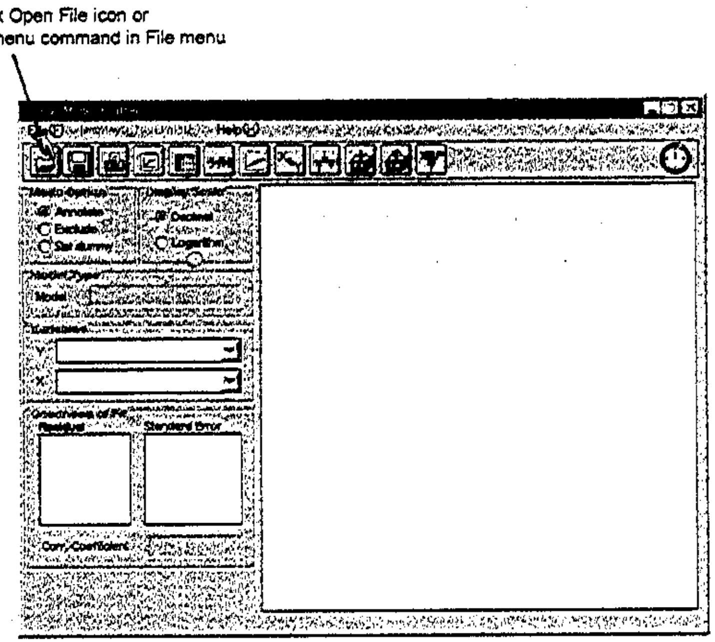
2.Matrix Editor

[Matrix Editor]
Creating zonal attribute file (*.IDX) and
Generated/attracted trip file (*.GAD)

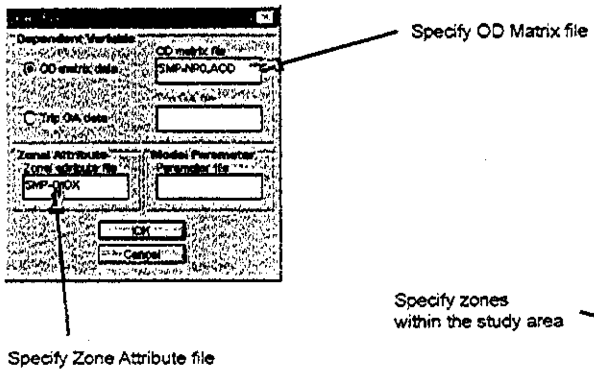


3.GA Model Builder

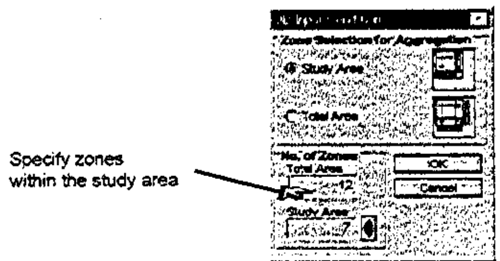
[GA Model Builder]
1. Opening Data Files



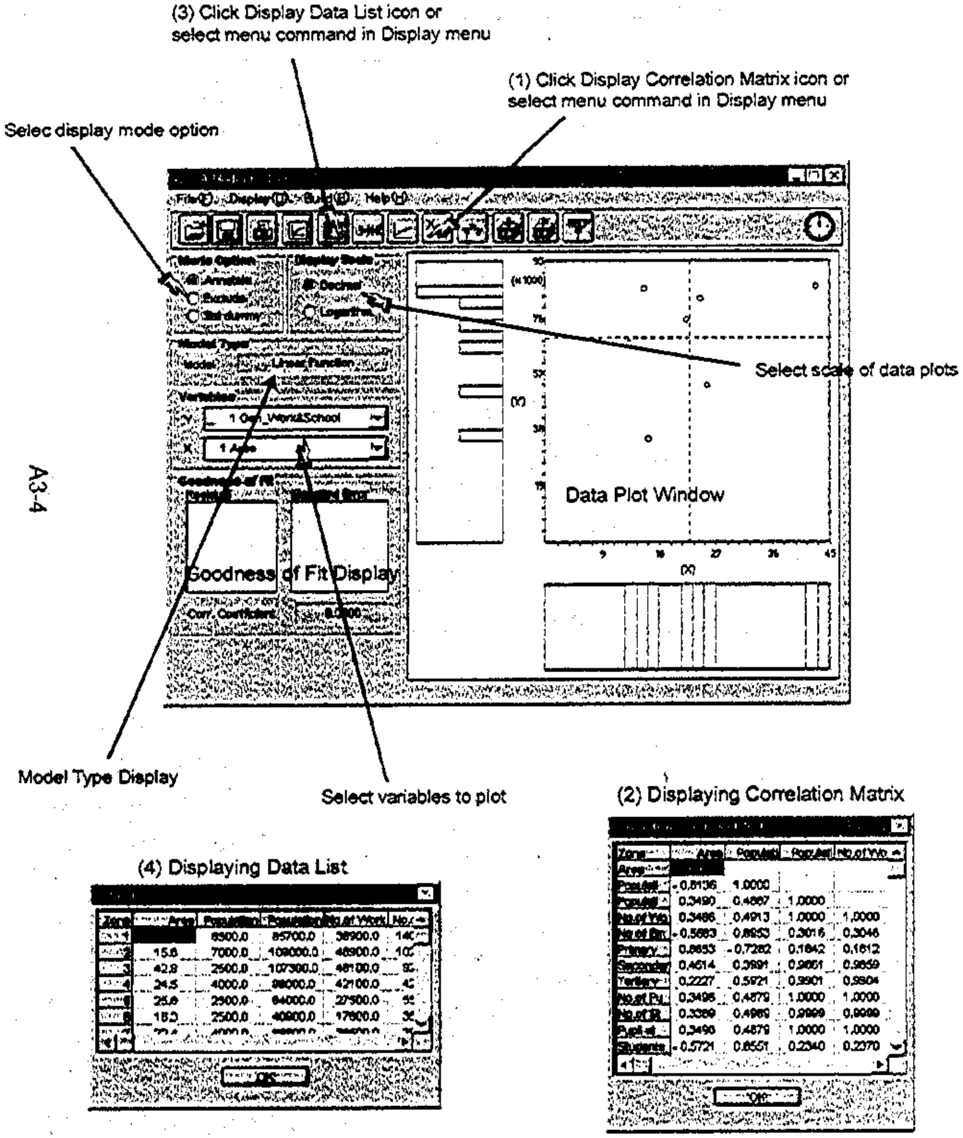
(2) Specifying Data Files



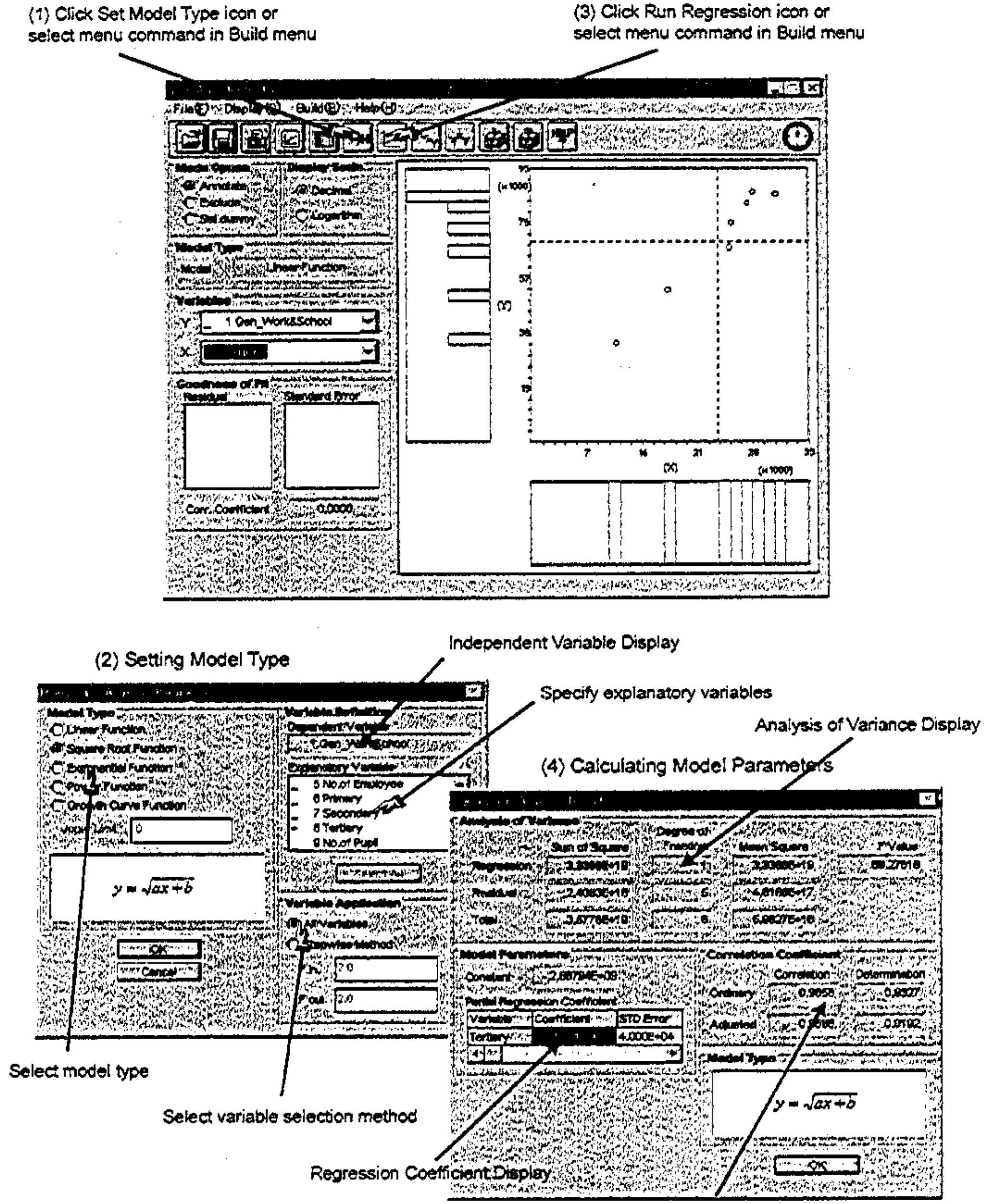
(3) Specifying Zone Size



[GA Model Builder]
2. Working on the Main Screen

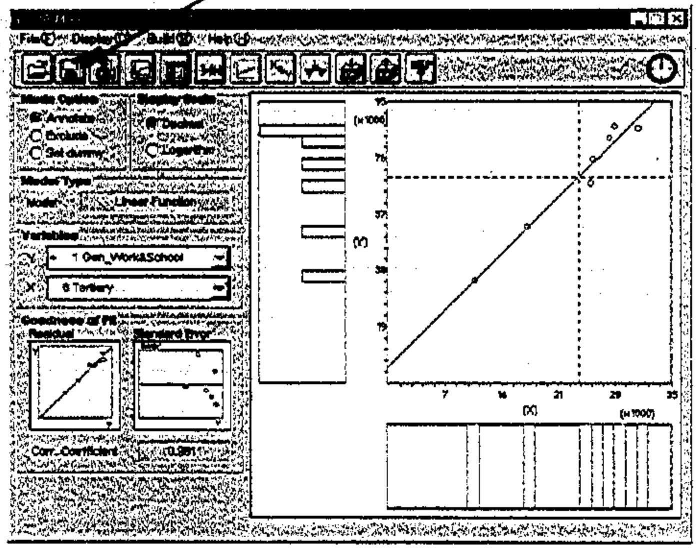


[GA Model Builder]
3. Calculating Model Parameters

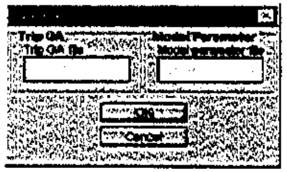


4.GA Generator

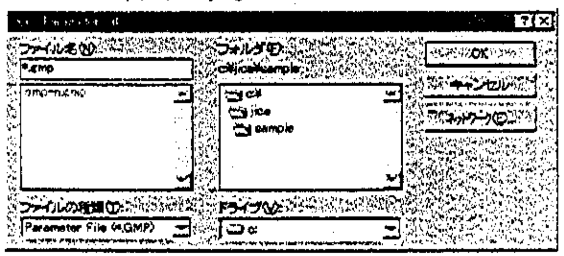
[GA Model Builder]
4. Saving Model Parameters



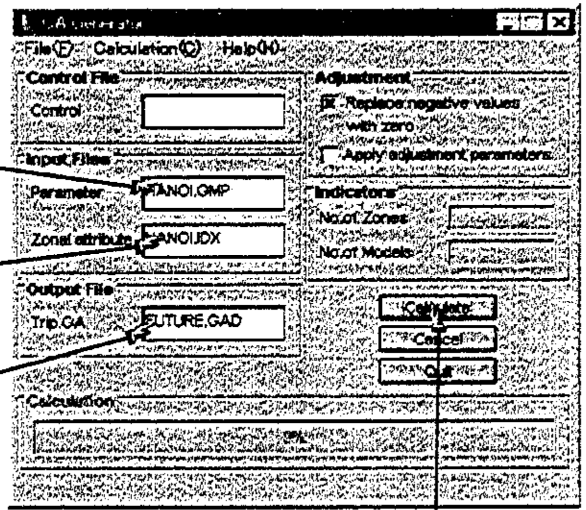
(2) Specifying Data Files



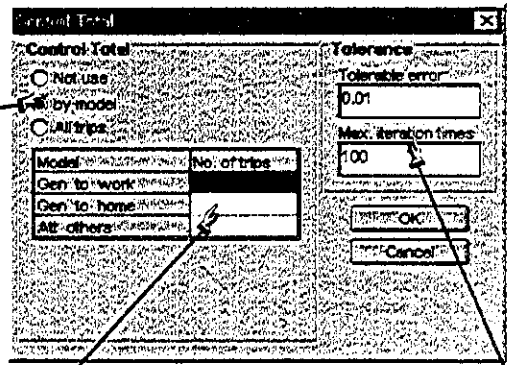
(3) Specifying File Name



[GA Generator]
Forecasting generated/attracted trips



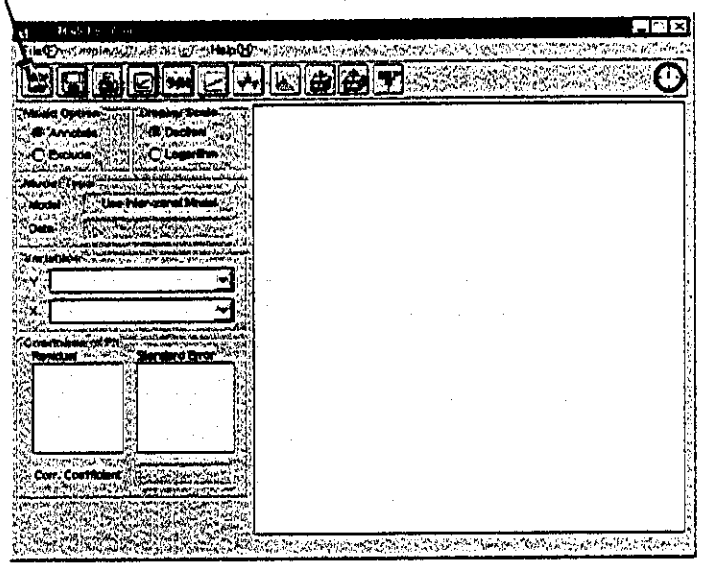
(5) Specify control totals



5.OD Model Builder

[OD Model Builder]
1. Opening Data Files

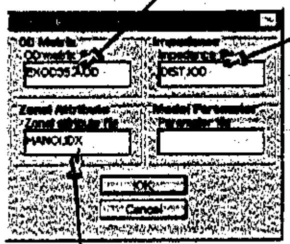
(1) Click Open File icon or
select menu command in File menu



(2) Specifying Data Files

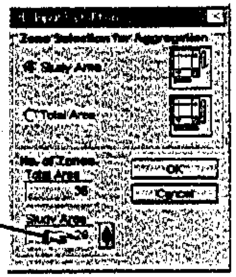
Specify OD Matrix file

Specify Impedance Matrix file



Specify Zone Attribute file

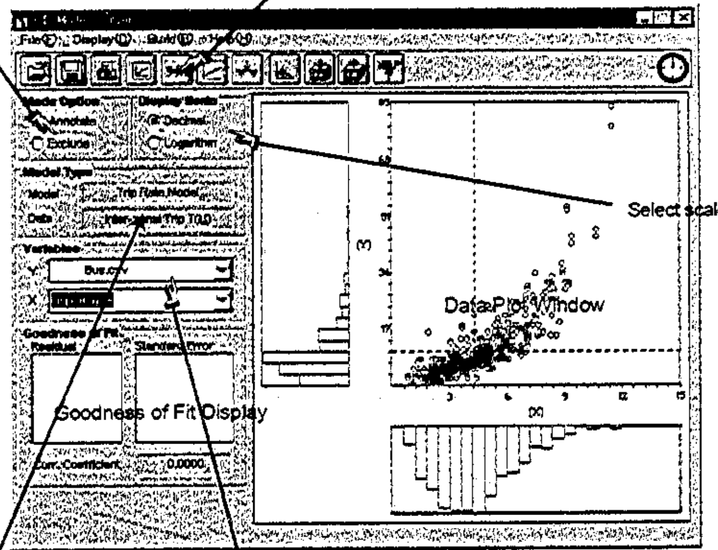
Specify zones
within the study area



[OD Model Builder]
2. Working on the Main Screen

(1) Click Set Model Type icon or
select menu command in Build menu

Selec display mode option



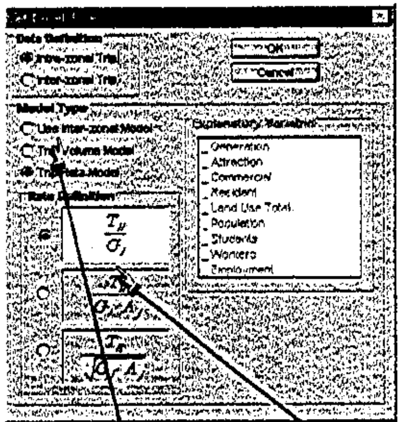
Select scale of data plots

Model Type Display

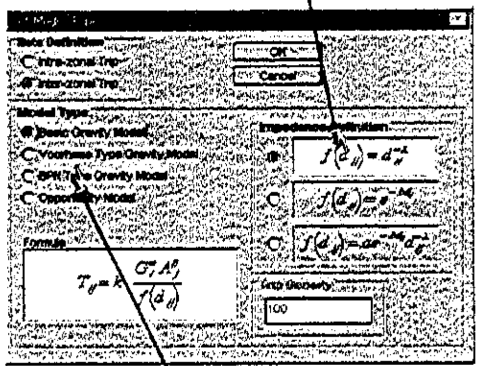
Select variables to plot

Select impedance definition

(2) Setting Model Type for Intra-zone



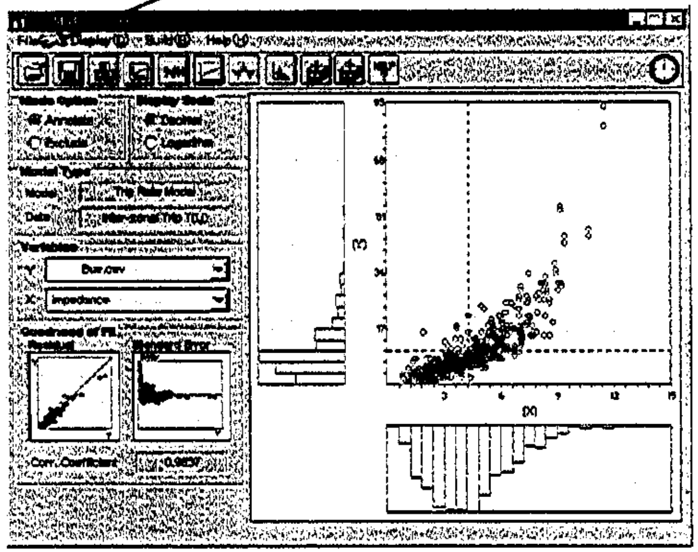
(3) Setting Model Type for Iner-zone



Select model tvoe

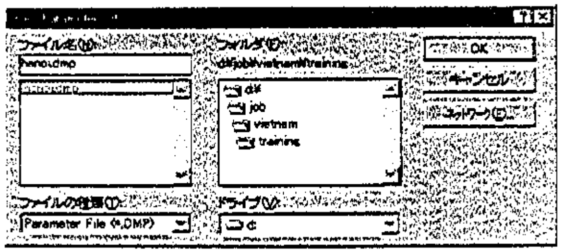
[OD Model Builder]
3. Saving Model Parameters

(1) Click Save command in File menu



(2) Specifying Data File

(3) Specifying File Name



6.OD Generator

[OD Generator]
Forecasting Distribution Trips

(6) Specify future OD matrix file

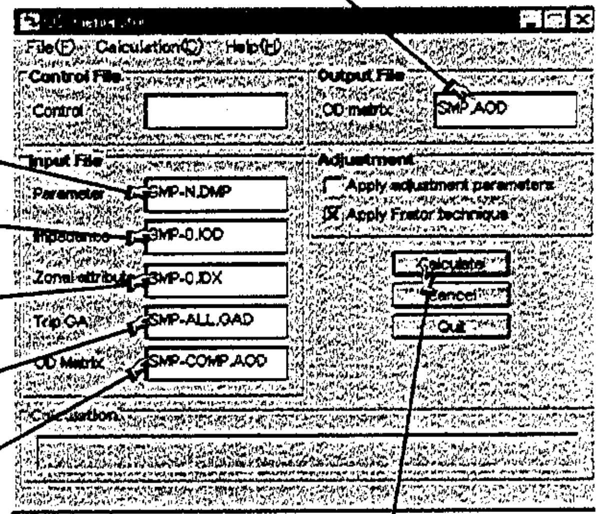
(1) Specify parameter file

(2) Specify future impedance matrix file

(3) Specify future zonal attribute file

(4) Specify future generation/ attraction trip file

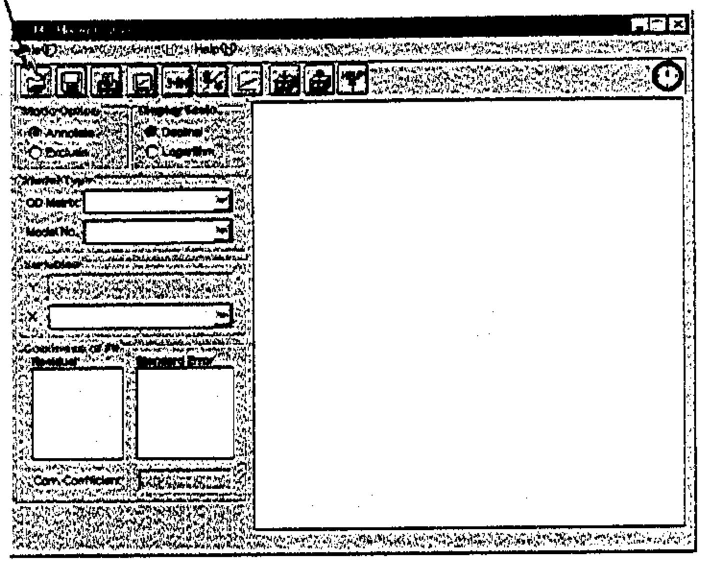
(5) Specify existing OD matrix file



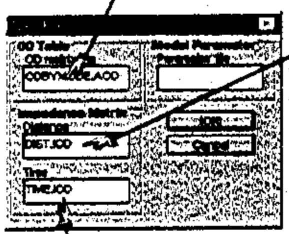
(6) Specify Calculate button or
select Calculate command in Calculation mer

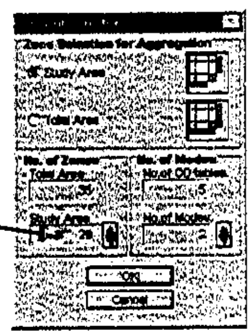
7.MS Model Builder

[MS Model Builder]
1. Opening Data Files

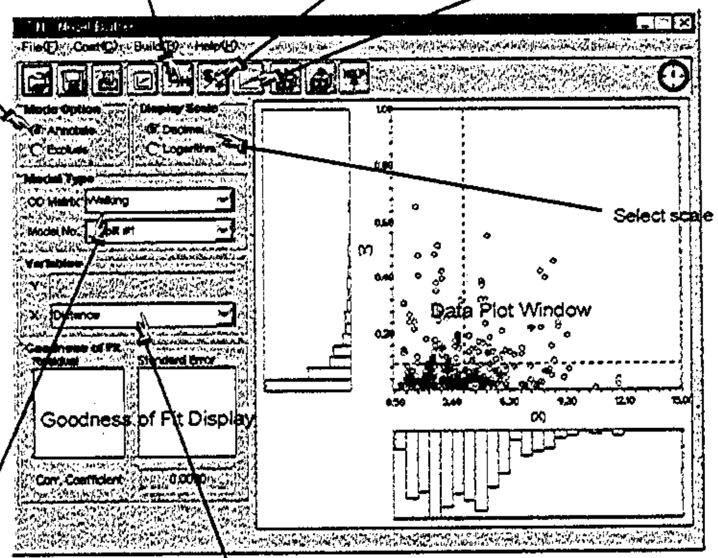


(2) Specifying Data Files

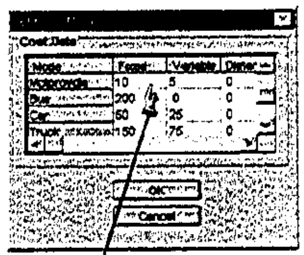




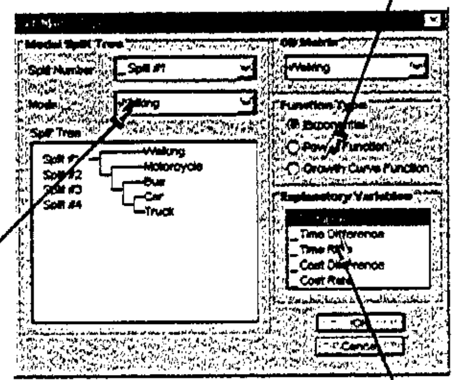
[MS Model Builder]
2. Working on the Main Screen



(2) Setting Cost Matrix

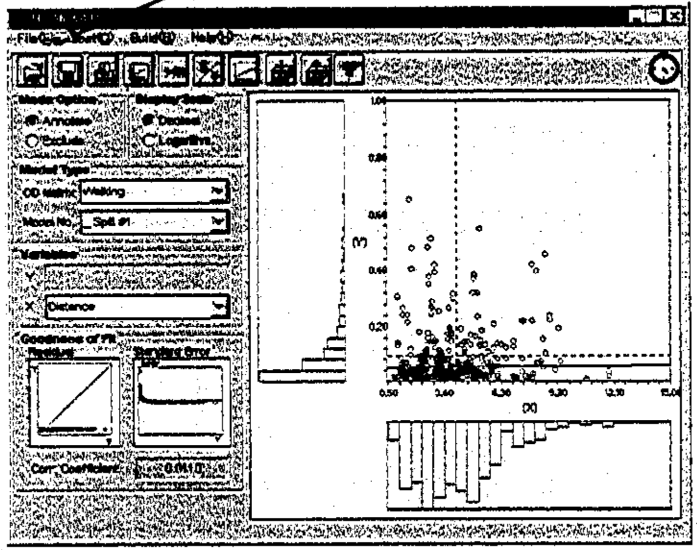


(4) Setting Model Type



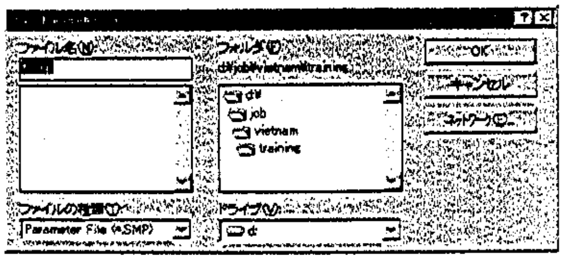
[MS Model Builder]
3. Saving Model Parameters

(1) Click Save command in File menu



(2) Specifying Data File

(3) Specifying File Name



8.MS Generator

[MS Generator]
Forecasting Modal OD Trips

(6) Specify future OD matrix file

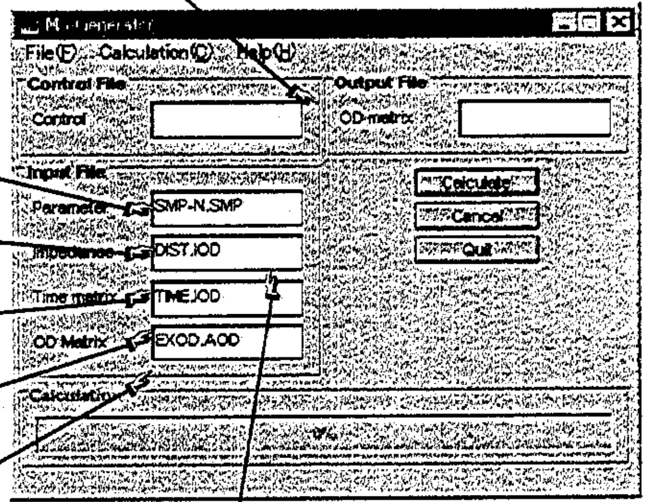
(1) Specify parameter file

(2) Specify future distance impedance matrix file

(3) Specify future time impedance matrix file

(4) Specify future generation/ attraction trip file

(5) Specify existing OD matrix file

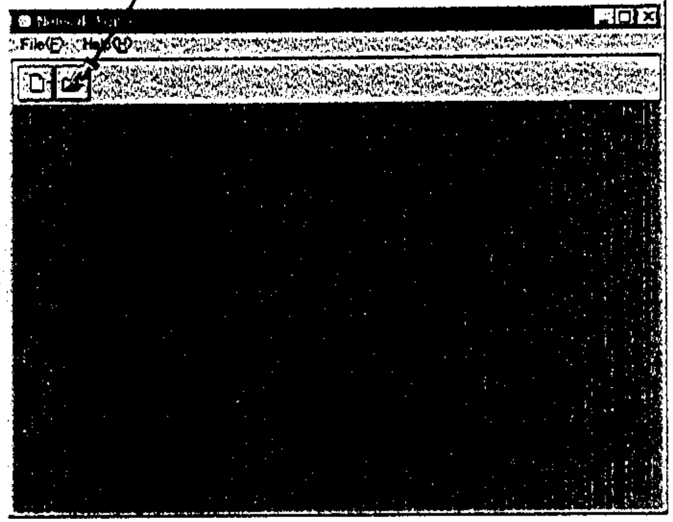


(6) Specify Calculate button or select Calculate command in Calculation menu

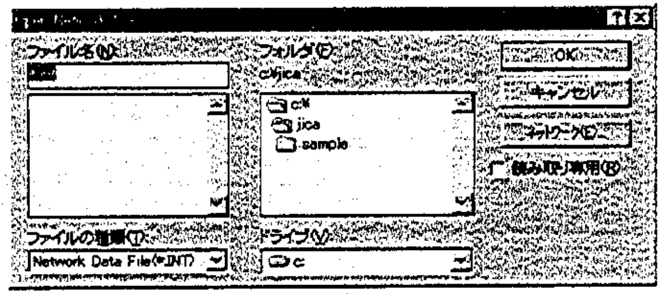
9.Network Editor

[Network Editor]
1. Reading Network Data File

(1) Click Open File icon or
select menu command in File menu



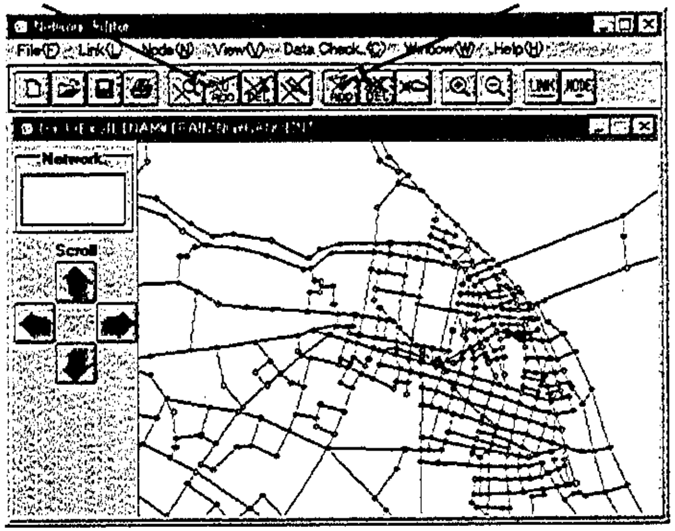
(2) Select name of network file



[Netowork Editor]
2. Additing Node and Link

(3) Click Add New Link icon

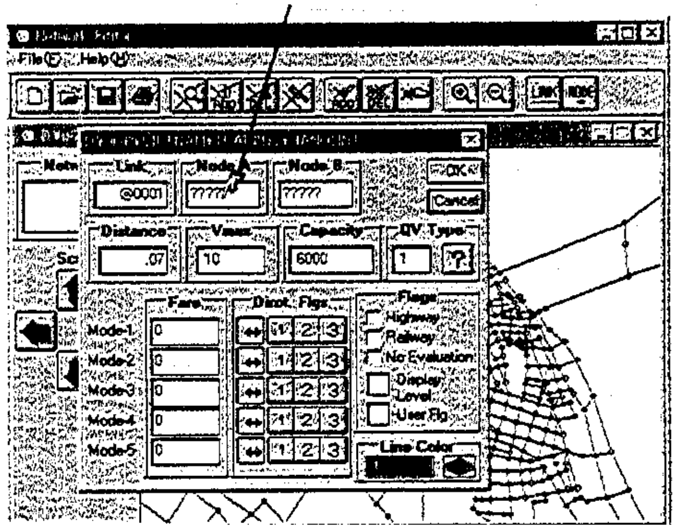
(1) Click Add New Node icon



(4) Enter name of new link

(2) Enter name of new node
and click pointer

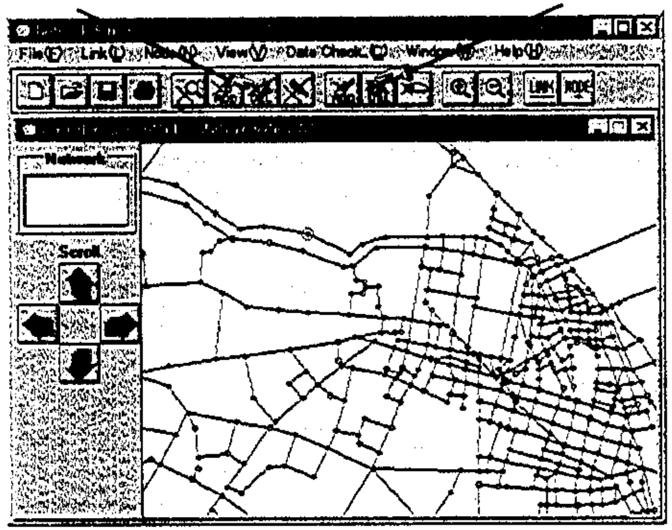
(5) Specify link attributes for new link
and click pointer to specify two end nodes



[Network Editor]
3. Deleting Node and Link

(3) Click Delete Link icon and click link to delete

(1) Click Delete Node icon and click node to delete



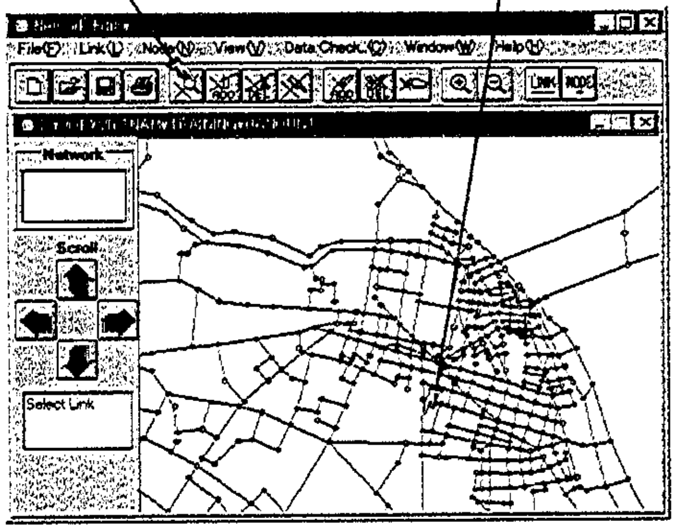
(4) Comfirmation message prompt

(2) Confirmation message prompt

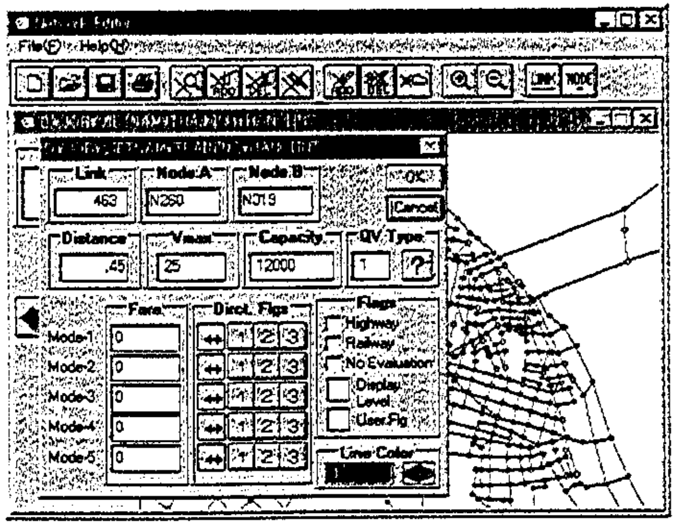
[Network Editor]
4. Modifying Link Descriptions

(1) Clik Modify Link icon

(2) Specify modify link by clicking

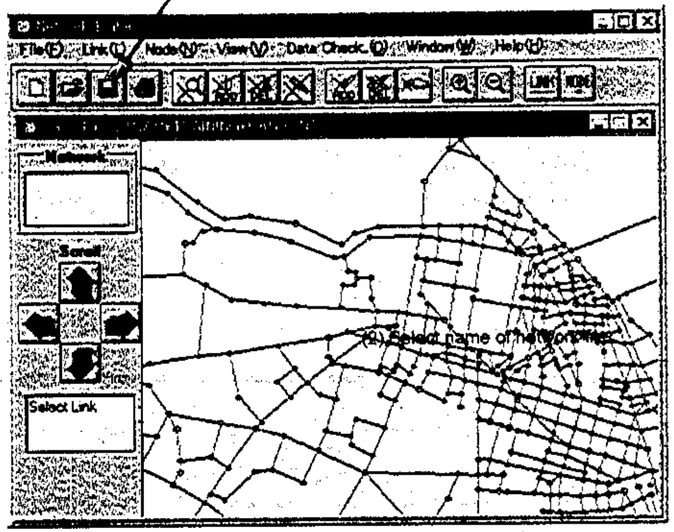


(3) Modify link descriptions in dialog box

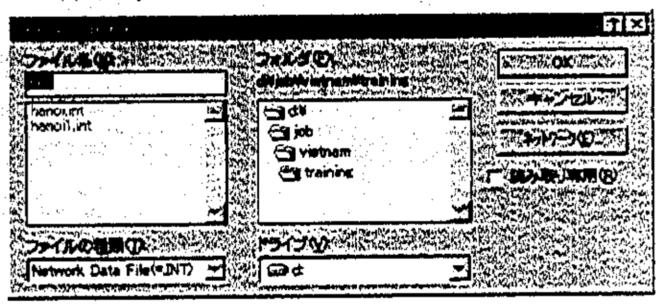


[Network Editor]
5. Saving Network Data File

(1) Click Open File icon or select menu command in File menu



(2) Specify name of network file



JICA