Defining Demographic Change in Locational Planning Problems

Photis, Yorgos N. and Koutsopoulos, Kostis
University of Thessaly, Department of Planning & Regional Development, National Technical University

1996

Defining Demographic Change in Locational Planning Problems

Yorgos N. Photis
Department of Planning & Regional Develpoment
University of Thessaly, Greece

Kostis Koutsopoulos
Department of Rural & Surveying Engineering
National Technical University, Greece

Paper presented at the
***XXXVI** Regional Science Association*
European Congress

ZURICH 1996

Abstract

Since population, which actually represents demand in any organised or rearranged service system, is the final target and recipient of every planning strategy or policy action, the success of locational analysis and the locational planning process, is largely determined upon the decision makers' ability to estimate the study area's future population size and distribution. Such estimations can be demographically achieved through the analysis and extrapolation into the future of carefully measured birth, death and migration rates according to observed trends and tendencies of the relevant socio-economic factors that affect them.

As opposed to traditional generalisations and recent practices, which deal with population as a whole, the approach presented in this paper focuses on each individual's attitude towards the issue of intended births, which when aggregated formulate a fertility rate. More specifically, certain socio-economic characteristics, based on questionnaire data, are analysed using discrete choice models in order to estimate the prospective family-size desires. In this respect, a birth-rate choice model is derived through the assessment of the expected number of children to be born in a household during a specific time period and with regard to its socio-economic identity. Moreover, modifications of the above characteristics generate alternative family-size scenarios and thus differing population forecasts, which in turn can lead to unforeseen solution strategies and thus a more sophisticated and pragmatic decision-making process when dealing with facility-location problems both in the public and the private sector.

Key words: Locational Planning, Discrete Choice models, Population Projections

1. INTRODUCTION

In general, locational planning problems deal with the spatial organisation of services, which respectively require the location of centres and the allocation of the demand to them, according to specific constraints. In principle, we can differentiate the constraints into two major categories: The first one, which is termed **distance-oriented**, deals with the maximum time-distance that the population has to travel to get to its centre. The second, which is termed **demand-oriented**, refers to the minimum and maximum number of demand which justifies the existence of a certain service centre. In this paper, of interest is the second constraint category which leads to one of the most critical issues in any locational planning strategy or policy action, namely the assessment of centre utilisation.

More specifically, in most empirical locational planning applications it has yet to be satisfactorily answered the degree to which investments for the location of service centres will be finally justified by their future utilisation. Furthermore, location analysts are greatly interested in the avoidance of mistakes stemming from the absence or inadequate estimation of the critical planning parameters, such as the size and the composition of the population to be served, and the way they respond to changing conditions in the problem environment.

As a result, there is a need for an integrated planning approach that avoids costly and erroneous location of facilities as well as allocation of demand and thus generates viable solution strategies. This can be achieved via the definition of the future size and composition of demand or in other words, the study area's population. In such a framework, therefore, the derivation of accurate and realistic population projections, through the comprehension of the course and trends of relevant demographic indicators, such as fertility, mortality and migration rates of the study area's population, as well as the identification of the underlying socio-economic factors that affect them are of paramount importance.

In addition, in this framework and as opposed to traditional approaches and recent planning practices which deal with population as a whole, the approach presented in this paper focuses on the individual's behaviour during a specific time interval. That is, a disaggregate model of demographic behaviour is specified by estimating the total number of children to be born by every woman which is in at the reproductive age, on an age-specific basis and during a five-year time period. One of the main advantages of the approach is the fact that while we use recent questionnaire and census data, we actually define the future attitude of the entire population in the study area. Moreover, by manipulating *ex-post* to *ex-ante* data we practically, move from a static to a dynamic-like state of the problem environment.

Finally, it should be pointed out that every locational decision making process is surrounded by uncertainties. That is, given that public policy planning requires accommodation to future modifications of all planning characteristics, geographers and regional planners are faced with the problem of decision making under the condition of uncertainty. This ambiguity requires the search for such locational schemes whose efficiency and effectiveness should be viable for longer time periods. Consequently, the critical problem parameters which are not known during the decision making process should be dealt with as uncertain or random. As a result, in order to deal with this uncertainty there is a need for alternative methodological approaches, whereby the analysis of locational planning problems requires the definition and evaluation of a set of alternative strategies and the examination of their behaviour when critical problem parameters are altered.

This paper aims to show, that through a scenario-based decision making approach to locational planning, improved problem analysis and hence more robust and sophisticated problem solving procedures can be obtained, since the uncertainty and thus the limited information inherent in a non-static problem environment can cause unpredictable mistakes along any choice procedure of sufficient complexity (de Palma and Papageorgiou 1991).

Consequently, given that in locational planning the locational choices made are generally judged by the 'quality' of the decision-making process which generated those choices (Densham and Rushton 1987), improved problem analysis will lead to better locational choices and thus better locational patterns.

Therefore, utilising this scenario-based approach, the purpose of the paper is two-fold: First, to investigate the effect of certain socio-economic characteristics on each woman's decision regarding the number of children to be born and second, to examine the way that the expected attitude of the entire population is affected through the modification of the overall distribution of these characteristics.

2. DEMOGRAPHIC AND LOCATIONAL MODELS

One of the major reasons that population projections are utilised during the process of locational planning is the formulation of estimations which are appropriate for the time, the area and the subset of the population of interest. The logical relationship of population projections to locational planning strategies are shown schematically in Figure 1.1. The selection of a particular population projection facilitates the transition from demographic to locational models as shown in the upper part of the diagram. Respectively, in the lower part of diagram there is the implication of the reverse effect. Namely, that specific locational parameters can affect the demographic indices of fertility, mortality and migration. Regarding fertility, (number of births) for example it is known that is directly affected by the existence of and access to corresponding facilities. In this respect, feedback from the locational model to the demographic model logically require that population projections be revised on the basis of the results of the locational model. This planning sequence implies that a number of iterations is carried out successfully, until it becomes possible to say, "If the locational pattern, then the population projection" which is a much stronger statement in terms of quality of the decision making process than the typical, sequence "If these assumptions about fertility, mortality and migration, then this population projection".

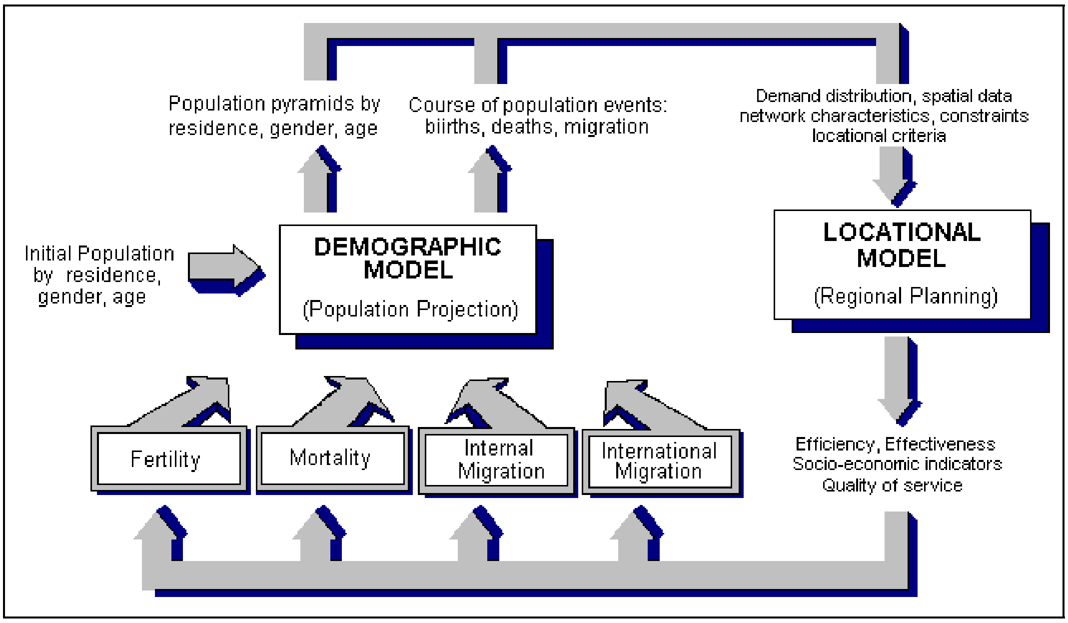

Figure 1. *Relationship between Demographic and Locational Models*

Until a much more extensive knowledge of the nature of interaction across the top and bottom of the diagram is attained, there are advantages to working with two separate models, whereby the output of top model will be the input to the bottom one and vice-versa. In this respect, the two approaches can be used in an interactive framework where on of each iteration an evaluation is performed and a decision is made whether or not to proceed to another pass. The aim is to put location analysts and demographers in a succession of situations in which they will be able to understand a significant range of relationships that are presently far from clear. In such a framework, the decisions and the choices at the individual level seem very crucial, especially when considering that their aggregation formulates the behaviour of the entire population.

In order to investigate this relationship the discrete choice theory can be utilised and more specifically the multinomial logit model. The major consideration confronted by discrete choice analysis is the formulation of models describing the procedure through which a decision maker makes a choice *i* from a set of mutually exclusive and collectively exhaustive alternatives C_n ($i, j \in C_n$) usually utilising the well known principle of utility maximisation (Ben Akiva and Lerman, 1987). Respectively, the probabilistic models provided by discrete choice theory are termed discrete choice models and in the general case connect the probability of a decision maker finally selecting an alternative with the characteristics of both the decision maker and the alternatives in the choice set. These models are called binary when the choice set C_n consists of only two alternatives *(n=2)* and multinomial when the decision maker faces a choice set of more than two alternatives *(n≥2)*. One of the most popular discrete choice models is the logit whose formulation is appropriate in achieving the objectives of this study.

The multinomial logit model (MNL) is expressed as

$$P_n(i)= \frac{e^{V_{in}}}{\sum_{j \in C_n} e^{V_{in}}} \qquad (1)$$

where

$$0 \leq P_n(i) \leq 1 \text{ for all } i \in C_n \qquad (2)$$

and

$$\sum_{i \in C_n} P_n(i)=1 \qquad (3)$$

As a result, **we suggest** the following planning process: During the problem solving procedure the decision maker defines a set of future scenarios through the implementation of certain hypotheses regarding the size and the distribution of demand and the physical characteristics of the given network. Beginning with some initial data he derives possible scenarios for the future, trying to visualise all feasible states of the system in order to improve the quality of his choice. He then examines the performance of every scenario's optimal solution on the basis that if one is adopted, another might be achieved. Finally, he proceeds with his choice with the help of two solution-performance criteria. The expected loss and the minimax loss criterion.

3. SCENARIO-BASED LOCATIONAL PLANNING

When demand is covered by a set of facilities, the **location** of those centres is the compromise between the need for **effectiveness** and **equity** (Koutsopoulos 1989). The modification of the criteria values after a time period, calls for adjustments by the decision makers, which tend to raise the system's decreasing attractiveness. In terms of retaining a competitive position, planners and decision makers must deal with the uncertainties inherent in the problem environment. This requires first, the generation of a set of S ($\sigma \in S$) alternative possible future scenarios, and second, the design of strategies that are viable in the long run, considering both the system's current status and future trends which can be accomplished by identifying the critical elements giving rise to uncertainty. After the definition of the set of possible scenarios, the next step is the evaluation of the impact of each scenario to the strategic decisions taken and applied. More specifically, critical questions that seek an answer are:

- Which is the optimal strategy for each scenario?
- How does each strategy respond to modifications of the problem environment?
- Are there any strategies that behave “well” under a subset of scenarios?

By comparing the efficiency and effectiveness of the various optimal solutions for each scenario, the decision makers is able to estimate the possible consequences in their robustness. Consequently, the new question that needs to be answered is how should the best overall strategy be defined when dealing with a set of future scenarios.

3.1. Solution evaluation criteria

Let us denote $\mathbf{L_\sigma}$ the optimal solution for the configuration of scenario σ, and $\mathbf{z(b, \sigma)}$ the value of the objective function if solution $\mathbf{L_b}$ is imposed and scenario σ is realised ($b,\sigma \in S$). When **S** contains more than one scenario, the planner can solve his problem for the **s** alternative network configurations and then examine the performance first, of each optimal solution $\mathbf{L}^{t+\Delta t}$ and second, the performance of each configuration if the optimal solution of scenario **b** is imposed but scenario σ is achieved ($b,\sigma \in S$).

Ignoring exogenous factors, we consider the system at time **t** which might move to another state at time **t+Δt**. Unable to predict the behaviour of the system with perfect certainty, we treat the alteration of the system's characteristics as a random phenomenon and use probabilities to describe the alteration propensities. Let P_σ denote the scenario probability, which is the probability that the system moves towards scenario σ by the end of the interval **[t, t+Δt]**.

At the end of the problem solving procedure for every $b,\sigma \in S$, we can construct a "decision matrix" $[\mathbf{DZ}_{b\sigma}]$ whose elements will be $\mathbf{dz}_{b\sigma}$, representing the loss in the solution performance of scenario σ if the optimal solution of scenario **b** is adopted. Consequently, if the realisation probabilities of each alternative scenario are known in advance, then the planner may proceed with his choice through two different approaches. In the first one, he calculates the expected loss of each scenario $\mathbf{E_b}$ which is the summation of the losses $\mathbf{dz}_{b\sigma}$ in the objective function if the solution of scenario **b** is implemented but scenario σ is realised, times $\mathbf{P}_\sigma$ which is the adoption probability of **σ**, for every $b,\sigma \in S$:

$$E_b = \sum P_\sigma dz_{b\sigma} \quad \forall\ b,\sigma \in S \tag{4}$$

and

$$E_e = min\ \{E_b\}. \quad \forall\ b \in S \tag{5}$$

In the second approach, the planner searches for the solution $\mathbf{L_b}$ which minimises the maximum loss in the objective function of every other alternative scenario σ, when **b** is imposed but σ is finally achieved. In this regard

$$E_m = min\ (max\ dz_{b\sigma}) \tag{6}$$

4. APPLICATION

4.1 Data

The questionnaire data on which the specific study is based were obtained from personal interviews, during a household survey that was conducted between 1992-93 by the National Technical University of Athens on behalf of the National Welfare Organisation. The questionnaires contained information regarding the socio-economic characteristics of both the household and its members. Thus, data were available related to the family size, income category and social problems faced by the household, as well as for every household's member his/her gender, date of birth, working status, family status, education level, religion and main communication language.

After the initial data analysis it was decided that the independent variables of the model should be, the number of children in the household (KIDSFIVE), the monthly income (INCOME), the wife's educational level (WEDUC), her religion (WRELIG) and her employment status (WSTATUS).

The proposed model considers as dependent variable the choice about the number of children that a married woman will give birth to, during a five-year time interval. (BORN). All the variables are shown in Table 1.

Variable	Explanation	Values	Interpretation
BORN	*Number of children born in five years*	0	• *No children*
		1	• *One child*
		2+	• *Two or more children*
KIDSFIVE	*Number of children in household, five years ago*	0	• *No children*
		1	• *One child*
		2+	• *Two or more children*
INCOME	*Household income*	1	• *Low income*
		2	• *Medium income*
		3	• *High income*
WEDUC	*Wife's educational level*	1	• *High level*
		2	• *Middle level*

		3	• *Low level*
WRELIG	*Wife's religion*	1	• *Christian*
		2	• *Other*
WSTATUS	*Wife's working status*	1	• *Working*
		2	• *Not working, student, retired*

Table 1. Categories of the model variables

From selected correlation analyses and two-way tables it was observed that the wife's age was very significant with regard to the dependent variable. Thus, it was decided that the sample should be segmented into eight categories according to the wife's age in every household (<14, 15-19, 20-24, 25-29, 30-34, 35-39, 40-44 and >45 years old). Moreover, the data used during the model calibration refer to 12.234 married women from the 13.500 household sample which represents the 1% of the total number of households in the survey regions of Sterea, Thessalia, Ipeiros, Makedonia and Thraki in Greece. The observed frequencies of the dependent variable in the sample are shown Table 2.

	Frequency	**Percentage**
No children	10222	81,9%
One child	1714	14,0%
Two or more children	498	4,1%

Table 2. Observed sample frequencies

Finally it should be noted that data for the time period five year prior to the interview were assumed to be the same as those of the questionnaire. Although certain variables do not change (i.e. religion) and fully justify the approach, others (i.e. working status) caused some scepticism. On the overall, however, the approach remains theoretically consistent. Furthermore, it leaves ground for further refinements and extensions, wherever those should be identified.

4.2. Analysis

The usual economic model of fertility postulates a rational decision-maker weighing the expected benefits of an additional child against the costs expected to be imposed by that child. To formulate the decision-making process in this way is not to suggest that everyone considers all such factors in monetary terms.

In the specific study the multinomial logit utilised was:

$$P(0/V_0,V_1,V_{2+}) = \frac{e^{V_0}}{e^{V_0}+e^{V_1}+e^{V_{2+}}} = \frac{e^{(V_0-V_1-V_2)}}{1-e^{(V_0-V_1-V_{2+})}} \qquad (7)$$

where

0, 1, 2+	are the alternatives “no”, “one”, “two or more” children respectively,
V_0, V_1, V_{2+}	are the systematic utilities and
$P(0/V_0,V_1,V_{2+})$	is the conditional probability that a woman will give birth to no children.

The last probability is conditioned on the systematic utilities V_0, V_1 and V_{2+}, which are linear functions of the independent variables:

$$V_0 = \beta_0 X_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k \qquad (8)$$

where

β_0, β_1, β_2,…, β_k are the parameters to be estimated and

X_0, X_1, X_2, …, X_k are independent variables characterizing each alternative.

Given that the values of the parameters β_0, β_1, β_2,…, β_k convey information regarding the relative importance of the independent, the objective of the study, is to identify the values of the parameters that conform to observed behaviour. That is they best fit the set of observations, each of which relates to one household. This was accomplished using the maximum likelihood estimation method.

In essence, the accurate specification of the model as shown in equation (8) relies on the very significant observation that the choice probability $P(0/V_0,V_1,V_{2+})$ is dependent on the difference in utilities, rather than the absolute level of utility for each alternative.

The first variable X_0 is referred to as the alternative specific constant and for each observation is defined as $X_{00} = 1$, $X_{01} = 0$, $X_{02+} = 0$. The corresponding parameter β_0 is a measure of the effect on choice probability of the difference in utility when all else are equal. In our case, with three alternatives, there are two alternative specific constants defined. All other independent variables used are of the type termed alternative -specific socioeconomic variables, which in general are similar to the alternative specific constant, except that instead of taking always the value 0 or 1, it varies from one observation to another.

4.3 Model parameter estimation

The specification of the systematic utilities is given in tabular form in table 3. The three rows correspond to the utilities of the three alternatives, “no children”, “one child”, “two or more children”. The columns correspond both to the two alternative specific constants, β_1 and β_2, and the alternative specific socioeconomic variables which refer to the wife of the household. The alternative “two or more children” serves as the reference alternative.

	KIDSFIVE				INCOME				WEDUC				WRELIG		WSTATUS	
	X_{k1}		X_{k2}		X_{ih}		X_{im}		X_{em}		X_r		X_{el}		X_w	
	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}	β_{16}	β_{17}	β_{18}
0 children	**1** *one child* **0** *other*	**0**	**1** *two children* **0** *other*	**0**	**1** *high income* **0** *other*	**0**	**1** *middle income* **0** *other*		**1** *middle* **0** *other*	**0**	**1** *low* **0** *Other*	**0**	**1** *Christian* **0** *other*	**0**	**1** *working* **0** *other*	
1 child	**0**	**1** *one child* **0** *other*	**0**	**1** *two children* **0** *other*	**0**	**1** *high income* **0** *other*		**1** *middle income* **0** *other*	**0**	**1** *middle* **0** *other*	**0**	**1** *low* **0** *other*	**0**	**1** *Christian* **0** *other*		**1** *working* **0** *other*
2+ children	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Table 3. Systematic utilities

As for the alternative specific socioeconomic variables, according to Wrigley (1985), each variable which contains K categories can be represented in the model by K-1 variables, which will correspond to K-1 alternative values. Thus for example, the variable KIDSFIVE which embodies the categories (0, 1, 2+) can be divided into the variables X_{k1} which takes the value 1, if there is already one child in the family and 0 in any other case and in X_{k2} which takes the value 1, if there are two or more children in the family and 0 in any other case. In a similar manner are defined all the other variables INCOME : X_{im} (middle income) and X_{ih} (high income), WEDUC : X_{em} (middle education level) and X_{el} (low education level), WRELIG : X_r (Christian) and WSTATUS : X_w (working). Consequently, the model, can be formulated as follows:

$$\ln\frac{P_0}{P_{2+}} = \beta_1+\beta_3X_{k1}+\beta_5X_{k2}+\beta_7X_{im}+\beta_9X_{ih}+\beta_{11}X_{em}+\beta_{13}X_{el}+\beta_{15}X_{rc}+\beta_{17}X_w \quad (9)$$

$$\ln\frac{P_1}{P_{2+}} = \beta_1+\beta_3X_{k1}+\beta_5X_{k2}+\beta_7X_{im}+\beta_9X_{ih}+\beta_{11}X_{em}+\beta_{13}X_{el}+\beta_{15}X_{rc}+\beta_{17}X_w \quad (10)$$

The categorical variables divide the population into 108 groups (3·3·3·2·2). When all variables take the value of 0, a group is defined which is characterized by no children, low income, high education level of the wife, not a Christian and not working and represents the base or anchor group in our model.

Using the data and utilizing the maximum likelihood estimation procedure which yields consistent parameter estimates for the different age-specific groups, the calibration process resulted in Table 4. According to the theory described earlier in this paper we used and. The overall fit of the model as it is expressed by the different values of ρ^2, appears quite satisfactory, since according to McFadden (1979) a value of ρ^2 above 0.2 represents a good fit. The *t*-ratios shown in parenthesis, under each parameter estimate, were calculated by dividing the parameter estimate by its standard error and they are interpreted as the usual *t-statistics*, for which a value outside the (-2, +2) interval is considered significant at the 0.05 level.

	Age	β_1 constant	β_2 constant	β_5 X_{k2}	β_{11} X_{em}	β_{12} X_{em}	β_{15} X_r	β_{16} X_r	β_{17} X_w	ρ^2
1	**<=14**		2,004 *(3,409)*		3,316 *(5,395)*		1,613 *(2,479)*			**0,741**
2	**15-19**	-1,017 *(-3,218)*	0,896 *(7,630)*		-0,287 *(-1,722)*		3,166 *(8,894)*			**0,230**
3	**20-24**	-2,689 *(-9,735)*	-2,392 *(-10,342)*			0,866 *5,968*	12,394 *(3,785)*	11,370 *(3,474)*		**0,411**
4	**25-29**	-2,192 *(-9,065)*	-2,420 *(-8,035)*	2,291 *(16,252)*	0,194 *(1,126)*		10,690 *(3,523)*	11,749 *(3,867)*	0,545 *(3,927)*	**0,518**
5	**30-34**	0,419 *(1,944)*	1,748 *(11,068)*	1,786 *(12,598)*			1,862 *(7,277)*			**0,514**
6	**35-39**		1,303 *(6,283)*		1,353 *(6,283)*		3,233 *(14,268)*			**0,746**
7	**40-44**		0,650 *(2,544)*				4,424 *(18,676)*			**0,826**
8	**>=45**	7,127 *(5,893)*	3,367 *(3,336)*				1,318 *(1,781)*			**0,963**

Table 4. Model parameters per age group.

Since this is a real-world decision, the main interest is on the entire population's fertility (numbers of births) behaviour which determines the future demand. As a result, an aggregation of individual behaviour is necessary using the following equation:

$$W(i) \cong \sum_{g=1}^{G} \frac{N_g}{N_T} P\left(i \middle| \tilde{\tilde{x}}_g\right) \quad (11)$$

where :

G are the mutually exclusive and exhaustive groups,

X_g represents the values of the various variables for the individuals belonging in that group,

N_g, N_T represent the number of decision makers in each group and the total number of decision makers respectively choosing the alternative i and

W(i) is the fraction of population choosing alternative i.

Finally to calculate the future population, according to the different scenario assumptions (number of people belonging in each group), the cohort survival model is applied, which estimates the percentage of a cohort that will survive and thus enter the following age group (Masser, 1972). Its mathematical definition is

$$\prod\nolimits_{n+1}^{t+1} = S \prod\nolimits_{n}^{t} \quad (12)$$

For every age group n the population percentage $W_n(i)$ choosing alternative i, can be calculated by summing W(i) for all socio-economic groups, which in turn can be transformed into B_n births (fertility of cohort n) by multiplying it with the value of i.

$$B_n = \sum_{i=1}^{J} W_n(i) i \quad (13)$$

In a similar manner the total number of births in the specific time interval are calculated, through the utilisation of the cohort fertilities (eq. 13):

$$^{(t)}b_n^{(t+1)} = f \prod\nolimits_{n}^{t} \quad (14)$$

where *f* is the probability that a woman of age n has to give birth to a child during the time interval [t,t+1].

4.4 Empirical Application

The derived model was applied in Northern Greece to locate new health centres. The two sets, each one containing three scenarios (columns one, two and three in Table 4) regarding the size of four socio-economic groups (rows Group1, Group2, Group3, Group4) represent the basic premises of the application. The results are shown in Table 5 indicating the demand population distribution in the 26 communities of the application area according to the various scenarios. The first three columns of Table 5 are related to the scenarios of the first set, the next three to the second set, while the last three columns represent the final demand of each community according to the adopted by the decision maker. Given therefore these demands we can resolve the initial problem of location of health centres and allocation of demand of these centre, by applying the classical p-median location-allocation model.

Scenario Summary Report			Set #1			Set #2			Final
	ONE	TWO	THREE	ONE	TWO	THREE	ONE	TWO	THREE
Group1	*219*	*219*	*518*	*119*	*19*	*0*			
Group2	*60*	*0*	*0*	*260*	*260*	*406*			
Group3	*22*	*22*	*22*	*22*	*0*	*0*			
Group4	*421*	*110*	*110*	*842*	*842*	*421*			

Table 4. Problem Scenario Sets

THASOS	127	144	151	116	95	111	116	95	111
SKALA RACHONIOU	0	0	0	0	0	0	0	0	0
AGIOS GEORGIOS	6	7	7	5	5	5	6	7	7
RACHONI	31	55	37	29	27	27	31	55	37
NOU	0	0	0	0	0	0	0	0	0
PRINOS	50	56	59	26	44	43	26	44	43
SKALA SOTIRA	6	7	7	5	5	5	6	7	7
SOTIRAS	5	5	5	4	4	4	5	5	5
SKALA KLALLIRACHI	3	4	4	3	3	3	3	4	4
KALLIRACHI	39	44	67	36	35	34	39	44	67
SKALA MARION	9	10	11	8	8	8	9	10	11
MARIES	24	27	29	22	21	21	24	27	29
KALIVIA	0	0	0	0	0	0	0	0	0
LIMENARIA	110	124	130	100	97	96	100	97	96
PEFKARI	0	0	0	0	0	0	0	0	0
POTOS	14	16	16	13	12	12	14	16	16
THEOLOGOS	58	43	65	35	34	33	58	43	65
ASTRIS	0	0	0	0	0	0	0	0	0
ALIKI	0	0	0	0	0	0	0	0	0
KOINIRA	0	0	0	0	0	0	0	0	0
CHRISI AKTI	0	0	0	0	0	0	0	0	0
LEFKI	0	0	0	0	0	0	0	0	0
POTAMIA	58	55	58	44	43	42	58	55	58
PANAGIA	36	41	43	33	32	31	36	41	43
CHRISI AMMOUDIA	0	0	0	0	0	0	0	0	0
MAKRIAMMOS	0	0	0	0	0	0	0	0	0

Table 5. Node demand according to selected scenarios

5. CONCLUSIONS

Uncertainty is inherent in most locational planning situations, due to the dynamic nature of the problem environment and the inability of the planners to predict with accuracy the exact future system configuration and network specification. Nevertheless, it is the exception rather than the rule that such considerations are studied in locational decision problems. In this paper we presented a scenario-based locational planning framework. We have deal it with a set of alternative scenarios for the future, concerning vital spatial parameters, namely, the geographical distribution of certain socio-economic characteristics and thus the future size of demand.

Furthermore, the paper assists the decision making process through the utilisation of two solution performance criteria. In this respect, it is argued that through the implementation of our approach, a more reasonable decision making process can be determined undoubtedly, there are many possible types of change in the problem environment and consequently a plethora of ways of translating them to decision criteria and incorporating them in the problem framework.

However, the overall objective of this paper is to provide insights into integrated methodologies which can greatly contribute to the solution of practical locational decision problems, where we believe that there is a strong need for further refinements of the decision making process. At this stage, and according to current trends, there is an increasing interest in the ability to operationalize the handling of more theoretical fields under the umbrella of an integrated planning support system. In this integrated planning tool, location - allocation, discrete choice, demographic and other models will be ready to support the decision making process, and allow for true and productive interaction among the analysts and the decision makers. This, we believe, will lead to 'better' strategic decisions, which certainly are more vital than a stand-alone 'realistic' unidisciplinary model.

Although we have deal with a rather simplified case, our approach can be considered as an attempt to provide answers to a limited number of 'what if' questions and furthermore, yields insights into two basic aspects. On the one hand, scenario-based locational planning is emphasising on the definition of possible future states of the system, through the visualisation and the definition of alternative hypothetical scenarios. On the other, is focusing on the urgent need for the development of an integrated locational planning support system. Undoubtedly locational, discrete choice and demographic models are well developed in planning. However, we believe that by transferring input and output data between those models and using the graphic and representational capabilities of GIS, planners and decision makers will be assisted both in the analysis of spatially distributed service systems and the evaluation of the consequences of the proposed alternative solution strategies.

Since location decisions require long-term future investments that can be changed only at considerable costs, and given the importance and possible impact of the systematic evaluation of future uncertainties, we believe that considerable effort should be placed on the development of respective methodologies which through the assessment of the expected performance of alternative system configurations will finally lead to more sophisticated analyses of locational planning problems and thus more efficient locational patterns.

REFERENCES - LITERATURE CITED

Batey P W J, Madden M, 1982. "Demographic-Economic Forecasting within the activity-Commodity Framework: Some theoretical Considerations and Empirical Results", **Environment and Planning A**, 13, 1067-1083.

Ben-Akiva M, Lerman S R, 1985. **Discrete Choice Analysis: Applications to Travel Demand**, The MIT Press, Cambridge, CA.

Boots B N, Kanaroglou P S, 1988. "Incorporating the effects of spatial structure in discrete choice models of migration", **Journal of Regional Science**, 28, 495-509.

Cambell A A, 1983. **Manual of Fertility Analysis**, London: Livingstone, Longman.

De Palma A, Papageorgiou Y Y, 1991. "A model of rational choice behaviour under imperfect ability to choose". Forthcoming.

Ghosh A, Rushton G, 1987. **Spatial Analysis and Location - Allocation Models.** (New York: Van Norstrand Reinhold Company).

Harris, B. and M. Batty. 1992. **Locational Models, Geographic Information and Planning support systems.** Technical Paper 12-1, NCGIA.

Kanaroglou P S, 1994. "Sampling and Discrete Choice Analysis", **The Professional Geographer**, 46(3), 359-368.

Koutsopoulos K, 1990. **Geography: Methodologies and Spatial Analysis Methods** (in Greek)**,** Symmetria, Athens.

Koutsopoulos K, Makris G, Tziafetas G, 1985. "Simultaneous Location-Allocation of Facilities and Servers", **Methods of Operation Research**, 55: 33-25.

Masser I, 1972. **Analytical Models for Urban and Regional Planning,** David & Charles: Newton Abbot.

McFadden D, 1974. "Conditional Logit Analysis of Qualitative Choice Behaviour" in Zarembkar (ed.), **Frontiers in Economics**, New York: Academic Press.

McFadden D, 1979. "Quantitative methods for analyzing travel behaviour of individuals: Some recent developments". In **Behavioral Travel Modeling**, Hensher D A, Stopher P R, 279-318. London: Groom Helm.

Newell, C. 1988. **Methods and Models in Demography** (New York: The Guilford Press)

Photis Y, Koutsopoulos K, 1994. "Supporting Locational Decision Making: Regionali-zation of Service Delivery Systems", **Studies in Regional and Urban Planning**, 1:19-35.

Rogers A, 1975. **Introduction to Multiregional Mathematical Demography,** New York, Wiley.

Rushton G, 1979. **Optimal location of facilities.** (Wenworth: COMPress, N.H.)

Schilling D A, 1980. "Dynamic location modeling for public sector facilities: A multi-criteria approach", **Decision Science** 714-723.

Schilling D A, 1982. "Strategic Facility Planning: The Analysis of Options", **Decision Sciences**, 13(1), 1-14.

Woods R, 1979. **Population Analysis in Geography**, London: Longman.

Wrigley N, 1985. **Categorical Data Analysis for Geographers and Environmental Scientists.** New York: Longman Inc.