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Optimizing Tourist Policy: A Linear Programming Approach

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VAN DER KNIJFF E. C. and OOSTERHAVEN J. (1990) Optimizing tourist policy: a linear programming approach, *Reg. Studies* **24**, 55–64. In this paper linear programming is presented as a means to support tourist policy formulation in the case of the West Frisian Islands. A model is constructed which calculates the maximum employment effect that can be reached at different levels of government financial support and shows the optimal combination of policy tools in order to achieve this maximum. Constraints imposed by environmental protection may reduce the effect of the instruments. We demonstrate the extent of this reduction in different simulations with an increasing number of constraints. Finally, we suggest possible improvements to our model and discuss the advantages and disadvantages of using this kind of model in support of tourist policy decision-making.

Linear programming Tourism Employment multipliers Environmental constraints Province of Friesland

VAN DER KNIJFF E. C. et OOSTERHAVEN J. (1990) Optimisation de la politique du tourisme par programmation linéaire, *Reg. Studies* **24**, 55–64 Cet article a pour but de présenter la programmation linéaire comme une aide à la formulation de la politique du tourisme en faveur des West Frisian Islands. On construit un modèle qui calcule l'effet-emploi maximum possible avec diverses enveloppes financières gouvernementales et démontre la combinaison optimale d'instruments politiques nécessaires à la réalisation de ce maximum. Il se peut que des contraintes imposées dans le but de sauvegarder l'environnement réduisent l'impact des instruments. On démontre l'ampleur de cette réduction en fonction de simulations différentes dont le nombre de contraintes augmentent. Pour conclure on propose des améliorations au modèle et discute des atouts et des invonvénients d'un tel modèle utilisé en faveur de la prise de décision dans la politique du tourisme.

Programmation linéaire Tourisme
Multiplicateurs de l'emploi
Contraintes écologiques Province de Friesland

VAN DER KNIJFF E. and OOSTERHAVEN J. (1990) Optimale Gestaltung der Tourismuspolitik: eine Stellungnahme unter Benutzung linearer Programmierung, *Reg. Studies* **24**, 55–64. In diesem Aufsatz wird lineare Programmierung als ein Mittel zur Unterstützung der Formulierung der Tourismuspolitik im Falle der westfriesischen Inseln dargestellt. Ein Modell wird konstruiert, das die Wirkung maximaler Erwerbstätigkeit berechnet, die bei verschiedenen Grössenordnungen finanzieller Unterstützung erreicht werden kann, und die optimale Kombination der Instrumente der Politik zur Erreichung dieses Höchststandes aufgezeigt. Beschränkungen, die der Umweltschutz verlangt, mögen die Wirksamkeit der Instrumente herabsetzen. Die Autoren stellen das Ausmass dieser Drosselung an verschiedenen Simulationen einer zunehmenden Anzahl an Beschränkungen dar. Schliesslich werden mögliche Verbesserungen des Modells vorgeschlagen, und die Vorteile und Nachteile der Benutzung dieser Art Modell als Hilfsmittel beim Beschlussfassen in der Tourismuspolitik diskutiert.

Lineare Programmierung Tourismus
Erwerbstätigkeitsmultiplikatoren
Umweltbeschränkungen Die Provinz Friesland

INTRODUCTION

In many cases policymaking is a matter of trade-off: aiming at one or more targets with limited means and subject to certain restrictions. Limited means can be used and combined in several ways. Which combination is the optimal one? This question can be solved in general with the aid of linear programming. In recreation and tourism research this technique may be used in several ways.

Land use planning is amongst the most frequently used fields of application. Typically, an area is divided into zones which each have a different potential with regard to their use (UFFMANN, 1979). Interesting complications arise if multi-purpose land uses are considered (HUNTER, 1978), whereas the technique also enables the analyst to estimate the implicit value of recreational co-use of, for example, forests (BISHOP, 1978). Our own approach disregards the spatial dimension which is present in most land use applications.

Non-spatial applications centre around two issues, both of which are present in our use of the technique. First, we see studies into the trade-off between recreational co-use of natural resources and environmental values. Typically, ecological goals are introduced as constraints to problems where either recreational use is maximized (GRAY, 1977) or value added in agriculture and forestry is maximized with recreational use as a constraint (BISHOP, 1978).

Secondly, one observes management applications where, for example, a national park's net revenue is maximized (WEAR and HOFFMAN, 1982) or equivalently where public investment in facilities and the like are planned in such a way that incomes from tourism are maximized (SWART *et al.*, 1975). The latter application is particularly interesting as it includes zero-one variables to model the sequential character of some of the investments.

Our approach comes closest to the last one. It also uses zero-one variables to model whether or not a discrete investment project is executed. We do not use such variables, however, to model the conditional character of such projects since that problem is solved in our case by the explicit introduction of demand constraints which are linked to the execution of such projects. We believe this to be a more efficient method as well as a more realistic representation of the underlying economic mechanisms.

One element that is common in all applications is the need for sensitivity analysis as well as the usefulness of policy simulations. Our present application only reports two kinds of simulations. First, we discuss the basis model and indicate the importance of the basis optimization which in our view needs to be able to reproduce the actual state of most of the (decision) variables, i.e. the simulation property of the model. Secondly, we discuss several policy runs which all serve to illustrate the trade-off between regional employment effects, public investment cost and environmental considerations, i.e. the optimization character of the model.

The subject of the present study is the regional government's policy concerning the development of tourism on the West Frisian Islands, the 'Wadden Islands'. These four islands form a traditional destination for Dutch and especially West German holidaymakers. People living on the islands largely depend on tourism: over 70% of the employment is directly or indirectly related to this activity. For the Province as a whole this amounts to about 7%, whereas the national number of jobs dependent on tourism does not even reach 2% of national employment (OD 205, 1986).

Since the 1970s, the provincial government has strongly restricted the growth of accommodation since unlimited growth of tourism threatened to cause too much damage to the natural environment. This policy resulted in a stagnation of quantitative as well as qualitative developments in tourist accommodation. Recent developments on the demand side of the tourist market tend to favour more upper-class facilities and luxury accommodation. The present supply cannot meet this demand. This situation could possibly lead to a stagnation in the number of overnight stays and a reduction of the market share of the islands.

This is one reason for aiming at an improvement in quality. Another reason is that the upgraded accommodation has a higher regional employment effect per overnight stay. Therefore, with the same external effect on the environment, more jobs can be generated. After all, the need for job creation in tourism grows since other sectors show a severe decline in employment in this peripheral and mainly rural area.

Investment in tourist accommodation is a matter of private enterprise. Government policy can influence the level of this investment in two ways. In the first place, the attractiveness of the islands as a whole can be improved by expanding and improving public facilities. Second, subsidizing private investment in new accommodation and subsidizing the upgrading of existing accommodation will stimulate the expansion of private enterprise.

In this context, the object of Frisian tourist policy is to maximize the regional economic impact of tourism on employment and income. A further objective is the conservation of a certain part of the low-budget accommodation for the inhabitants of the province of Friesland. The main constraints are the conservation of landscape and the natural environment, which are major factors of attraction, and the limited availability of financial means.

More formally, in this paper we aim to solve the following problem: how could a mix of government expenditures be generated which maximizes the region's employment in spite of some restrictions? We will emphasize the contribution of input–output analysis in this optimization process. Hence, in the following section we present the formal structure of the model that we developed for the West Frisian Islands. In the third section, the empirical operationalization is discussed along with the type of data used and in section four the results of a series of policy simulations are shown. The paper ends with a discussion of the present shortcomings of the model and the way in which these can be solved. The strength and weakness of the linear programming approach towards optimizing tourist policy are briefly evaluated in the conclusion.

MODEL FORMULATION

The general nature of a linear programming model is quite simple (GASS, 1985). There is a linear objective, goal or target function that is maximized subject to a set of linear constraints or restrictions, namely:[1]

$$\max \sum_j c_j x_j \quad (1)$$

$$\text{s.t.} \ \sum_j a_{ij} x_j = b_i \ \text{for different } i \quad (2)$$

and:

$$x_j \geq 0 \ \text{for all } j \quad (3)$$

where the x_j are adjustable variables and the a_{ij}, b_i and c_j are fixed coefficients. In addition to the objective function, our model has four types of restrictions.

First, we define the *goal function* which maximizes total employment in the province of Friesland that is directly or indirectly due to tourism on the West Frisian Islands. Employment is taken to be a function of two types of adjustable variables: the number of overnight stays; and the number of beds. The number of overnight stays per bed is, of course, restricted by a physical maximum of 365 per year, whereas an economic minimum needs to be formulated.

This choice of adjustable variables implies that our employment function per bed has the following form:

$$e = c_0 + c_1 x \quad (4)$$

where: c_0 = employment effect per bed
c_1 = employment effect per overnight stay
x = number of overnight stays.

From equation (4) it is clear that we, in fact, make a distinction between the average employment coefficient $[c_0/x + c_1]$ and the marginal employment coefficient per overnight stay $[c_1]$, as was advocated earlier (Oosterhaven and van der Knijff, 1987). The number of beds itself is given at the start of the period of analysis. This means that the part of the total employment that is related to this number of beds, is fixed at the beginning of the period of analysis.

Four categories of accommodation will be distinguished: expensive hotel beds (abbreviated as HE); cheap hotel beds (abbreviated as HC); expensive bungalow beds (abbreviated as BE); and cheap bungalow beds (abbreviated as BC). With regard to the number of overnight stays in the above types of accommodation, two periods will be distinguished: season (60 days), abbreviated as S; and off-season (305 days), abbreviated as O. There will be two ways to change the number of beds per sector: creation of new bed capacity (abbreviated as NB); and upgrading of existing cheap beds into expensive ones (abbreviated as UP).

Hence, our goal function maximizes the employment effect of the above type of activities, namely

$$\max \left[c_0 + \sum_i c_i OS_i + \sum_j c_j NB_j + \sum_k c_k UP_k \right] \quad (5)$$

where: c_0 = fixed employment related to the number of beds available at the start of the period of analysis
c_i = employment effect per overnight stay
OS_i = number of overnight stays
i = eight categories of overnight stays, viz, HES, HEO, HCS, HCO, BES, BEO, BCS and BCO
c_j = employment effect per bed
NB_j = number of new beds
j = four categories of accommodation, viz. HE, HC, BE and BC
c_k = employment effect of upgrading a bed
UP_k = number of upgraded beds
k = 2, respectively hotel beds and bungalow beds, viz. H and B.

Next, we will formulate the *budget constraint* for public expenditures on tourist policy. Two types of public expenditures will be distinguished: investment premiums for expansion and upgrading of accommodation; and expenditures made to execute public projects. The latter category constitutes our final group of adjustable variables. These do not appear in the goal functions as their employment effects are included in the extra overnight stays induced by the execution of these projects. This category of public projects consists of two subgroups: integer variables for discrete projects, i.e. a golfcourse (G), a swimming pool (S) and a racket centre (R); and continuous variables for five types of promotional campaigns.

The three integer variables give the model a *mixed integer* character. The budget constraint has the following form:

$$\sum_j a_{1j} NB_j + \sum_k a_{1k} UP_k + \sum_l a_{1l} PP_l + \sum_m PP_m \leq b_1 \quad (6)$$

where: a_{1j} = investment subsidy per new bed of type j
a_{1k} = investment subsidy per upgraded bed of type k
PP_l = (integer) number of executed public projects of type l
a_{1l} = cost of public project l
PP_m = (continuous) expenditures on public projects of type m
b_1 = public budget available for tourist policy.

Secondly, the *capacity constraints* for overnight stays are defined per type of accommodation per season. The equations for hotels and bungalows will have the same form, but otherwise four different mathematical forms are needed, as upgrading has a different impact on cheap and expensive accommodation and because both seasons have a different duration. Hence, we have for:

1. Expensive accommodation in the high season:

$$(1/60) OS_i \leq b_{2i} + NB_i + UP_i \quad (7a)$$

where $i = HE(S)$ and $BE(S)$, and where the season indication (S) is, of course, deleted at the right hand side of the inequality, as the number of beds is not affected by seasonal influences.

2. Cheap accommodation during the high season ($i=HC(S)$ and $BC(S)$):

$$(1/60)OS_i \leq b_{2i} + NB_i - UP_i \qquad (7b)$$

3. Expensive accommodation in the off-season ($i=HE(O)$ and $BE(O)$):

$$(1/305)OS_i \leq b_{2i} + NB_i + UP_i \qquad (7c)$$

4. Cheap accommodation in the off-season ($i=HE(O)$ and $BE(O)$):

$$(1/305)OS_i \leq b_{2i} + NB_i - UP_i \qquad (7d)$$

In (7a)–(7d), b_{2i} indicates the number of beds in accommodation category i at the start of the period of analysis. Hence the basis employment in equation (5), i.e. c_0, is directly derived from these start values (b_{2i}), viz. $c_0 = \sum_i b_{2i}$.

The third kind of restriction specifies the *demand constraints* on overnight stays per type of accommodation and per season. Here, only one type of formula suffices mathematically to describe all eight constraints, viz:

$$OS_i \leq b_{3i} + \sum_j a_{3ij} PP_j \qquad (8)$$

where: $i=$ HES, HEO, HCS, HCO, BES, BEO, BES and BCO
b_{3i} = the demand for overnight stays of category i at the start of the period of analysis
a_{3ij} = extra demand for overnight stays in category i created by the implementation of public project j.

Equation (8) implies zero cross-price elasticities. In view of the relatively small size of the islands' number of overnight stays, substitution will primarily occur in relation with comparable mainland accommodation and not among different accommodation on the islands themselves.

The fourth kind of restriction specifies the *minimum occupation rate constraints* which have to be satisfied before investments in accommodation may be considered economically viable. For the sake of convenience they are specified as the necessary minimum number of overnight stays per type of accommodation, see equations (7a)–(7d). There are two types of equations, respectively, for expensive accommodation and for cheap accommodation:

$$OS_{HES} + OS_{HEO} \geq a_{4HE}(b_{2HE} + NB_{HE} + UP_H) \quad (9a)$$

and analogously for expensive bungalows:

$$OS_{HCS} + OS_{HCO} \geq a_{4HC}(b_{2HC} + NB_{HC} - UP_H) \quad (9b)$$

and analogously for cheap bungalows:

where: a_{4i} = minimum occupation rate for accommodation of type i.

It should be noted that the terms between brackets in (9) are equal to the right hand sides of (7) as they define the number of beds per category after optimization has taken place. Furthermore, it should be noted that when equation (9) is reformulated into the mathematical straightjacket of equation (2), we get the following constant at the right hand side: $b_{4i} = a_{4i} \cdot b_{2i}$, where $i=$ HE, HC, BE and BC.

REQUIRED MODEL INPUT

In this section we will describe how we have estimated the a, b and c coefficients used in equations (5)–(9).

Putting the target function into operation

In order to estimate the c coefficients in equation (5) we need information about the relation between the number of beds, the number of overnight stays and the number of jobs. Regional input–output analysis plays an important role in this process. The way in which tourist expenditures have their impact on the region is closely related to input–output relations. Therefore we need to know how much tourists spend per overnight stay, what kind of consumer goods they buy, and where these consumer goods come from, both in terms of region of origin and in terms of industries. After these expenditures have been corrected for different levels of VAT, the information obtained enables us to construct an interregional final demand column per type of overnight stay. In terms of input–output analysis these columns can be used in an interregional input–output model to obtain endogenous production, income and employment per region (OOSTERHAVEN and VAN DER KNIJFF, 1987).

Almost all data are, in fact, available. The input–output table for the Province of Friesland as well as the level and the composition of the consumption expenditures of visiting tourists are known from extensive field studies (ETIF, 1979; VAN DER KNIJFF, 1984; PIEK and STELDER, 1986). The respective difference in expenditures of customers in cheap or expensive accommodation, however, is only based on the differences in the prices per overnight stay per type of accommodation.

In Table 1 the results of these input–output calculations are presented. The extensive hotel sector is defined as those accommodations that obtain four stars or more in the classification system. The expensive bungalow sector is defined as those accommodations that yield over Hfl.600 a week during the summer season. In this sector an appropriate classification system is lacking.

Seasonal differences appear in the yield of the accommodation itself. During off-season periods, bungalows are 30% cheaper than in the summer season. Hotel beds yield about 15% less in the off-season period. Expenses outside of accommoda-

Table 1. Regional employment effects, 1987

	Per 1,000 overnight stays	Per 1,000 beds
Hotels/expensive/season	0·3839	126
Hotels/expensive/off-season	0·3839	126
Hotels/cheap/season	0·2203	75
Hotels/cheap/off-season	0·2203	75
Bungalows/expensive/season	0·6515	12
Bungalows/expensive/off-season	0·6515	12
Bungalows/cheap/season	0·3936	10
Bungalows/cheap/off-season	0·3936	10

tion, however, are assumed to be the same in the two periods. This means that employment effects per 1,000 overnight stays as well as per 1,000 beds are in practice the same in the two periods.

The employment effect of upgrading accommodation, which is one of the options of the model, equals the difference between the employment multipliers of expensive and cheap accomodation. Hence, the c_k coefficients in equation (5) are derived as follows (see Table 1):

$$c_H = c_{HE} - c_{HC} = 126 - 75 = 51$$

and:

$$c_B = c_{BE} - c_{BC} = 12 - 10 = 2.$$

The total employment effect in case of an average occupation rate per bed is relatively high within the hotel sector, especially within the area of expensive hotels. The variable effect per overnight stay is high within the bungalow sector. Overnight stays in this sector mean relatively more expenditures outside the accommodation. The fixed employment effect in this sector seems extremely low, being only about 10% of the fixed effect in the hotel sector.

Adjustable variables and government tools

Adjustable variables that are directly related to the objective function are the number of overnight stays per category. There is, of course, a direct relation between the number of beds and the number of overnight stays. The maximum number of overnight stays per bed amounts to 60 in the summer season and to 305 in the off-season period—see equations (7a)–(7b). A minimum occupation rate per bed is also introduced as a constraint—see (9a)–(9b). Expensive accommodation requires a higher occupation rate than cheap accommodation, as appears from Table 2.

The effect of these constraints is that private investment will only take place when the occupation rate is sufficiently above the minimum *and* if the government judges it profitable to award it a subsidy, after having considered other possibilities to spend the budget for enlarging employment. Table 3 presents the cost of expanding accommodation and the cost of upgrading existing low-budget accommodation, both per bed. In Table 3 the government subsidy on investment is also presented. The percentages differ per category of investment, which aims at inducing investments with a relatively high yield in terms of employment.

Table 2. Occupation rate constraints, 1987

	Minimum %	Maximum %
Expensive hotel	54	100
Cheap hotel	33	100
Expensive bungalows	49	100
Cheap bungalows	27	100

Table 3. Cost of expanding and upgrading accommodation per bed, 1987

	Hfl 1,000 per bed	Subsidy on investment
New beds		
Expensive hotel	50·0	25%
Cheap hotel	25·0	15%
Expensive bungalow	52·0	25%
Cheap bungalow	17·5	15%
Upgrading beds		
Hotels	30·0	10%
Bungalows	40·0	10%

Source: CIMK, 1988.

The second way in which the government may have an influence is through investment in public projects. Such investment may be made in public provisions such as swimming pools, parks, sport facilities or in promotional activities. The model assumes that these public investments are needed to attract more tourists to the islands or for penetrating new segments of the market—see equation (8).

New accommodation or upgraded accommodation will only be profitable if new tourists are attracted to the islands. The effect of government investment is different for the season than for the off-season. The aim is mainly to improve the occupation rate of the beds during the off-season period.

The coefficients for the effects of public investments in swimming pools, golf courses and other attractions (see Table 4) are based on figures that appear in regular feasibility studies of project developers. Such figures are based on the number of visitors needed to reach a minimum return on investment and market research (CIMK, 1988). The coefficients for the effects of promotional activities are rough estimates. Probably these effects will not be linear, but in this version of the model we assume that they are.

Table 4. Cost of public investment in relation to effects on number of overnight stays, 1987

Project	Costs in million Hfl	Yield in thousands of overnight stays			
		HE	HC	BE	BC
Golf course[1]	3	22·4	—	9·6	—
Racketcentre[1]	1·5	1·0	2·0	5·0	2·0
Swimming pool[1]	4	—	68·0	0·0	100·0
General promotion	1	0·2	7·9	1·4	10·6
Specific promotion	—	—	—	—	—
HE	1	15·0	—	—	—
HC	1	—	18·0		—
BE	1	—	—	24·0	—
BC	1	—	—	—	30.0

Notes: HE = expensive hotels; HC = cheap hotels; BE = expensive bungalows; and BC = cheap bungalows.
Source: 1. CIMK, 1988.

Table 5. Main features of the model: basic version

	HE	HC	BE	BC
Goal function				
Overnight stays[1]	20,000	792,500	144,000	1,064,400
Employment effect (variable part)[2]	8	174	84	419
Restrictions				
Number of beds[3]	100	6,400	800	10,600
Occupation rate[1]	54·7	33·9	49·3	27·5
Minimal occ. rate	54·0	33·0	49·0	27·0

Note: Abbreviations as in Table 4.
Sources: 1. CIMK, 1988
2. ETIF, 1979 (adapted)
3. Provincie Friesland, 1987

RESULTS

Simulation of the present situation

In order to obtain a basis version of the model we used the figures that corresponded to the present situation on the West Frisian Islands. The figures were obtained from various sources which will be discussed in the next section. It took some adaptations of the coefficients to come to a feasible solution. The greatest problem was to fit in the minimum occupation rate: the real level was considerably lower than we assumed at first. The most important figures are summarized in Table 5. They are the results of the base optimization of model (5)–(9) with the public budget (6) put equal to zero.

In the next four paragraphs we will simulate four versions of the model with an increasing number of limitations. In all four cases we will investigate the way in which the public budget is spent optimally in order to obtain the maximum possible employment effect.

The unlimited tourists markets

The first series of simulations starts with the basis model simulation of the present situation from the last section and gradually increases the public budget. According to the model (5)–(9), the budget will be used to subsidize private investment in accommodation and to increase the number of overnight stays. In view of the linearity of the demand restrictions, the number of overnight stays may in principle be enlarged infinitely. In general, we expect the model to increase employment by using mainly a single instrument—the one that yields the highest employment per guilder. In Table 6 the results of this exercise are presented.

The first one million guilders will be spent on new cheap hotel accommodation and on promoting the cheap bungalow sector. When the budget increases to six million guilders, it is profitable to build a swimming pool instead of directly promoting cheap bungalows. A public budget of 100 million guilders will also be spent on the promotion of cheap hotels as well as on expensive bungalows. A further increase in the budget leads to the growth of cheap hotel accommodation: expansion of the number of beds in combination with the promotion of specific types of overnight stays.

Table 6. Simulation with unlimited markets

Public budget in million Hfl	Employment	Expansion with new beds				Upgrading		Public investments in million Hfl.							
		HE	HC	BE	BC	H	B	G	R	S	PG	PHE	PBE	PHC	PBC
1	1313	0	181	0	0	1	—	—	—	—	—	—	—	—	0·32
5	1360	0	181	0	0	1	—	—	—	—	—	—	—	—	4·32
6	1390	0	533	0	0	—	—	—	—	1	—	—	—	—	—
10	1444	0	746	0	0	—	—	—	—	1	—	—	—	—	3·2
50	1916	0	746	0	0	1	—	—	—	1	—	—	—	—	43·0
100	2499	0	3,866	0	0	1	—	—	—	1	—	—	7·2	15·0	58·0
200	3655	0	15,270	0	0	1	—	—	—	—	—	—	7·2	73·0	58·0
500	7122	0	49,482	0	0	1	—	—	—	—	—	—	7·2	244·0	58·0

Notes: H = hotels; B = bungalows; G = golf course; R = racket centre; and S = swimming pool.

The detailed results behind Table 6 show that the *socially* optimal occupation rates differ considerably. For both types of hotel, the actual rate always equals the minimum. For bungalows, the occupation rate approaches 100% as its multipliers per overnight stay relative to the cost of stimulating such stays are far larger than the multipliers per new bed relative to the subsidy cost per new bed (see Tables 1 and 3).

Adding market restrictions

The linear character of the demand constraints, equation (8), is not entirely plausible as it assumes that demand can be increased indefinitely through public spending. To increase the plausibility of the model we assume that an absolute maximum market size exists per sector per season, i.e. we add to equations (5)–(9):

$$OS_i \leq b_{5i} \qquad (10)$$

where: i = HES, HEO, HCS, HCO, BES, BEO, BCS and BCO.

This additional constraint may also be interpreted as a limit imposed by government—a limit that might be reasonably enforced through the permit system for the ferries to the islands. The market limits used are presented in Table 7.

Table 7. Market limits.

Sector	Basic situation[1]	Maximum overnight stays (×1000)[2]	Maximum growth
Expensive hotel:			
season	4·5	45·0	40·5
off-season	15·5	155·0	139·5
Cheap hotel:			
season	242·5	267·0	24·5
off-season	550·0	1100·0	550·0
Expensive bungalows:			
season	26·4	132·0	105·6
off-season	117·6	588.0	470·4
Cheap bungalows:			
season	292·8	322·0	29·2
off-season	771·6	1543.0	771·4

Sources: 1. CIMK, 1988.
2. NBT, 1988 (adapted)

Until the first limit is reached the path of optimal budget spending will be the same as in the first exercise. As is shown in Table 8, a different path is reached when public spending exceeds five million guilders. Above this level the marginal effect of an extra one million guilders diminishes faster than in our earlier series of simulations. The market constraint forces the model to select investment in accommodation that is less successful in terms of employment creation. The appearance of a swimming-pool at the level of six million guilders and its subsequent disappearance between 50 and 100 million guilders is rather strange.

The absolute market constraint also creates a maximum level of public spending above which it is not profitable to spend anything at all. That level is in this case 198 million guilders, with a maximum level of employment related to tourism of 2,780 jobs.

Restricted number of beds

The present policy on the West Frisian Islands, in fact, leads to a limitation in the number of beds to almost its present level. The following constraint is added to express this physical planning goal:

$$\sum_j NB_j = 0 \qquad (11)$$

With this simulation, we examine the consequences of the addition of this constraint and its public cost in relation to the benefits in terms of employment. The results of this exercise are shown in Table 9.

The marginal employment effect diminishes directly when the first one million guilders is spent in comparison with the first two series of simulations. The decision to upgrade a number of beds appears in the range of 20 to 50 million guilders. Before this decision is made, the budget is spent on the improvement of occupation rates by promoting the use of existing accommodation. The budget at which the employment level reaches its maximum is 152 million

Table 8. Simulation with limitations of tourist markets

Public budget in million Hfl	Employment	Expansion in new beds				Upgrading		Public investments in million Hfl.							
		HE	HC	BE	BC	H	B	G	R	S	PG	PHE	PBE	PHC	PBC
1	1313	—	181	—	—	1	—	—	—	—	—	—	—	—	0·3
5	1360	—	181	—	—	1	—	—	—	—	—	—	—	—	4·3
6	1380	—	533	—	—	—	—	—	—	1	—	—	—	—	—
10	1431	—	667	—	—	1	—	—	—	1	—	—	3·5	—	—
20	1540	—	1,311	—	—	1	—	—	—	1	—	—	7·2	3·9	—
30	1644	—	1,972	—	—	1	—	—	—	—	—	—	7·2	9·6	5·8
100	2353	—	5,800	—	—	851	—	—	—	—	—	11·2	7·2	27·5	29·8
200	2780	—	5,864	3,226	8,324	915	—	—	—	—	—	16·2	35·2	27·5	30·9
500	2780	—	5,864	3,226	8,324	915	—	—	—	—	—	16·2	35·2	27·5	30·9

Note: For abbreviations see Tables 4 and 6.

Table 9. Simulation with restrictions on the number of beds

Public budget in million Hfl	Employment	Expansion in new beds				Upgrading		Public investments in million Hfl.							
		HE	HC	BE	BC	H	B	G	R	S	PG	PHE	PBE	PHC	PBC
1	1,308	—	—	—	—	1	—	—	—	—	—	—	—	—	1·0
5	1,355	—	—	—	—	1	—	—	—	—	—	—	—	—	5·0
6	1,667	—	—	—	—	1	—	—	—	—	—	—	0·2	—	5·8
10	1,414	—	—	—	—	1	—	—	—	—	—	—	4·2	—	5·8
20	1,518	—	—	—	—	1	—	—	—	—	—	—	7·1	—	12·7
50	1,812	—	—	—	—	1	497	—	—	—	—	—	17·1	—	30·9
100	2,177	—	—	—	—	851	1,208	—	—	—	—	11·2	31·4	19·2	30·9
200	2,223	—	—	—	—	915	3,226	—	1	—	39·8	14·2	25·7	—	—
500	2,223	—	—	—	—	915	3,226	—	1	—	39·8	14·2	25·7	—	—

guilders. At this level a racket centre is introduced and an important part of the budget is spent on general promotion. Specific promotion on behalf of the cheaper accommodation disappears.

Restricted number of overnight stays

The conservation of existing nature and landscape can be truly achieved only by restricting the number of visitors and the number of overnight stays. The latter can be reached directly by adding the following constraint:

$$\sum_i OS_i \leq \sum_i b_{3i} \qquad (12)$$

At the same time, we again delete equation (11). In this way, substitution between different types of overnight stays, especially from cheap to expensive ones, is still possible but its total number is restricted to its present level.

This simulation demonstrates the effect of public spending under these environmental restrictions. Table 10 which shows the results is a short one. The maximum employment effect appears at a government spending level of just below 9 million guilders. With small budgets it is profitable to spend public money on cheap hotels and upgrading of hotels and also on specific promotion for expensive hotels. In the maximal situation there is only an upgrading of hotel beds supported by a promotion of expensive hotels.

Some preliminary conclusions

In general, the above simulations show that small government budgets should not be directed towards the expansion of capacity. Promotional activities to raise the occupation rate of the existing beds are more profitable in terms of employment. In some cases provisions like a luxurious swimming pool or a racket centre are socially profitable. Stimulating private investment is profitable when occupation rates reach a higher level.

Figs. 1 and 2 clearly show the effect of adding extra constraints. In Fig. 1, the first part of the optimal path of spending the public budget is examined. We see that some lines cross. In this interval, restricting the number of beds or restricting the number of overnight stays do not give significantly different employment effects. In general, restricting the number of overnight stays has the most radical effect on employment growth. The increase in the marginal effect in the interval of five or six million guilders is somewhat remarkable. The explanation of this strange feature in the process of optimizing is the use of integer variables, in this case building a swimming pool. The creation of this facility is apparently very useful, but only in combination with spending money on promotion.

In Fig. 2, the optimal path of public spending is shown at larger budgets up to 500 million guilders. A restriction on the number of overnight stays means

Table 10. Simulation with restrictions on the number of overnight stays

Public budget in million Hfl	Employment	Expansion in new beds				Upgrading		Public investments in million Hfl.							
		HE	HC	BE	BC	H	B	G	R	S	PG	PHE	PBE	PHC	PBC
1	1,311	—	197	—	—	17	—	—	—	—	—	0·2	—	—	—
5	1,318	—	247	—	—	68	—	—	—	—	—	0·9	—	—	—
3	1,323	—	272	—	—	123	5	—	—	—	—	1·6	—	—	—
4	1,325	—	226	—	—	195	5	—	—	—	—	2·5	—	—	—
10	1,338	—	—	—	—	556	—	—	—	—	—	7·3	—	—	—

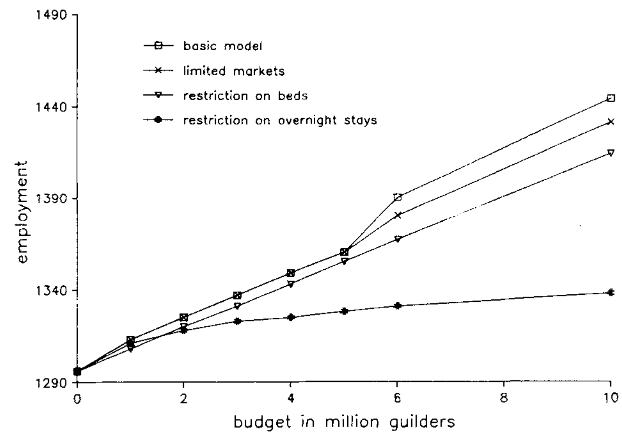

Fig. 1. Employment effect of small public budgets

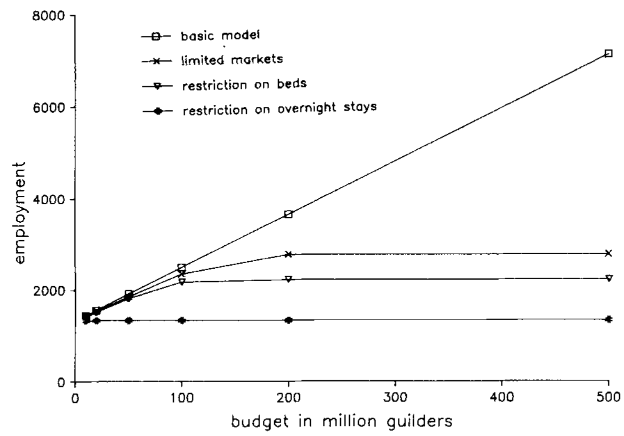

Fig. 2. Employment effect of large public budgets

that public budgets above 10 million guilders have a zero marginal effect. A budget above 100 million guilders has a diminishing effect when the number of beds is restricted. At a budget of 200 million guilders, the marginal effect is reduced to zero. At this point, market limitations restrict further development of tourism in the West Frisian Islands.

POSSIBLE MODIFICATIONS TO THE MODEL

To make the model more realistic, some modifications of the structure of the model as well as of the data input could be introduced.

One important modification would be a more detailed description of entrepreneurial behaviour. Presently it is assumed that investments can be made as soon as the minimum occupation rate is exceeded. It is, however, more realistic to assume that a range exists between the minimum rate to continue in business and the rate at which it is actually profitable to invest in new accommodation. In subsequent versions of the model we will be able to use the forthcoming results of a survey among Frisian tourist firms.

Second, more attention should be paid to overnight stays during the off-season period. They might be more valuable than overnight stays during the summer season, as they will lead to a better spread of activities in time, which in its turn will lead to positive internal and external economic benefits.

A third important way of improving the model would be the introduction of non-linearity in the effect of the instruments, especially in the case of promotional activities. The marginal effect will certainly not be constant. Moreover, the reliability of our estimates of the effects of promotional campaigns is still relatively weak. These effects differ in each situation, which requires additional field research when fully specified campaign data becomes available.

The simulations presented do not describe a growth path with an internally fixed structure of public spending; with every rise of the budget a new situation arises with its own unique solution. A new solution may not be appropriate for the earlier situation. If a growth model is desired, the model should consider a new basis situation with every step.

In relation to this, it should be noted that the trade-off between premiums on investments and promotional activities might deserve a more detailed description in the model. The time path of the employment effect of the respective instruments obviously differs. In this version, it is implicitly assumed that government promotion is a unique injection which leads to a temporarily higher yield for the tourist enterprises. They use this extra yield to meet a part of the cost of their investment. A more elegant way to overcome problems of time dimensions is to use different periods of depreciation for the effects of the various instruments.

In the introduction, a second goal was postulated—the conservation of low-budget accommodation for Frisian holiday-makers. In all of our simulations we arrived at solutions that are compatible with this second goal. The Frisians' share in the overnight stays is, at least in the sectors examined, too low to lead to any problems even when the number of beds or overnight stays are restricted.

Finally, it should be noted that the model does not describe the whole tourist sector in the West Frisian Islands. The camping sector and the youth hostel sector have not been included. Hence, the conclusions are only valid for the hotel and bungalow sectors. This also means that a model that includes all sectors may lead to other solutions especially concerning the effect of general instruments.

CONCLUSIONS

The simulations described in this study lead to several conclusions about the usefulness of the linear programming technique in solving policy problems. A great advantage of linear programming is the consistent way in which problems are solved. In particular, when a problem has many constraints, the model gives solutions that simply could not otherwise be obtained. Present ideas about tourism policy, such as the need to stimulate the upgrading of accommodation, which are mainly based on the same information as was used in the model, lead to another way of spending the public budget than our model suggests.

Another advantage of the technique is that it offers information about the shadow prices of restrictions imposed by a policy, such as the cost of nature conservation in terms of employment. In a public context such information might lead to a more optimal policy decision.

It should be stressed that each model is by definition a simplified version of reality. This fact always restricts the usefulness of modelling techniques in general, notwithstanding their ability to handle large amounts of information consistently. The greatest disadvantage of the linear programming, technique is the supposed linearity of the relations. Within the scope of linear programming this problem can partly be solved by introducing intervals with different slopes. Of course a more advanced technique, such as nonlinear programming, may be preferred.

The second general problem is the availability and reliability of the data. In this particular case, the information about the market and the effects of promotion is very important. However, when we realize that policy decisions are always taken on the basis of limited information, the technique of linear programming can use the available information in a more optimal way.

Improvement of the quality of policy decisions can be supported by this technique in two ways: it will lead to a consistent use of information and it offers a structure that can help to select the direction of further data-based research.

NOTES

1. This standard way of formulating a linear programme is more general than it seems. First, an objective function that has to be minimized could easily be changed into one that has to be maximized by changing the signs of the c_j coefficients. Second, the constraints do not have to be equalities. In practice they are, in fact, mostly inequalities, such as:

$$\sum_j a_{ij}x_j \geq b_i \text{ or } \sum_j a_{kj}x_j \leq b_k$$

These can easily be changed into equalities by adding a so-called slack variable, viz:

$$\sum_j a_{ij}x_j + x_n = b_i \text{ or } \sum_j a_{kj}x_j - x_m = b_k$$

where $x_n \geq 0$ and $x_m \geq 0$. Third, negative decision or adjustable variables can also be used by simply replacing $x \leq 0$ with $y \geq 0$, *where* $y = -x$. When both formulations are combined, it is possible to create an x that may assume all values, i.e. by replacing it with $y_1 - y_2 = x$, where $y_1 \geq 0$ and $y_2 \geq 0$.

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