Urban Planning as Project Management

A limited rationality model

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Abstract: We consider program proposals as separate projects and use an incremental decision process (Incremental Functional Formulation) backed by methods of optimisation through incremental and interactive decision processes which have been developed in operations research. These methods fit the ill-structured problems in planning better than the conventional optimisation methods. We’ll conclude showing one of the possible concrete applications of our model to a real-life case, where one of the main results was a suggested expense of € 4 millions leading to the 90% of the result possible with the cost of € 10 millions (but with just a 40% expenditure).

1. INTRODUCTION

The speed of urban change is increasing, and asks for new tools to transform the existing functional, environmental, economical structures of the city.

The product of traditional planning - a static physical description of wished final state - is useless to the scope; the traditional way of making decision on plans and the related tools (zoning, standards) are insufficient.

The output of an “urban change oriented” planning must be an act as much complex as complex is the object to transform. To achieve the outlined aim, we must face the permanent need of new impulses, corrective actions, and interventions interacting with urban changes.

Despite the difficulties arising in abandoning the traditional planning, we need frameworks into which groups of coherent actions are fitted; in other words, we are more and more often going to implement “programs of actions”, finalised to wished change results. That means a form of planning
by projects”, “by agreements”, and a plan “evaluated”. This can be applied
at the time of plan design and after, during the management of existing plan.

This kind of “planning-programming by projects”, selecting actions and
putting them in a structured, evaluated framework, must achieve a double
result: (i) improve single projects, (ii) drive the urbane change.

Added to the technical difficulties in modelling urban phenomena
comprehensively, the excess of complexity in the actual decision process
address us towards a substitution of the “absolute rationality” approach with
a “limited rationality” approach. This will result from a merge of intuition
and negotiation actors’ behaviours, based on skill in creating knowledge on
problems and on understanding of constraints coming from institutional and
organisational context.

2. THEORETICAL APPROACH

2.1 Points of reference

The philosophy leading our work is: it is no useful to develop a “static”
model which does not include factors of irrationality (typical of political
decisions) or adaptability to future situations (typical of mid- and long-term
planning activities). That would end in a result which is either not accepted
or not flexible to the reality.

We develop an analytical model which is built on a step-by-step basis
upon bits of new data, leading to repeated runs of the model and thus to
“incremental decision”, as opposed to a synthetic approach which builds a
model based on experience all at once, and eventually adjust it with the
evolution of the system.

The “incremental decision” calls for the minimum amount of educated
guesses on model-building, delaying every open issue to the very latest
moment, when it should be possible to address it on concrete basis.

Furthermore we'll consider as key issue the legibility of both the results
and the process, because we wish the process itself, and not just the input
and output, to be transparent and understandable by the population and the
political player.

2.2 Method

One of the perspectives for the planning of activities on the territory is
that of project management which results in a structured set of interventions,
defined as “program”. Considering each proposal as a separate project
allows the use of analytical models to support the evaluation step of the
program, by selecting optimal set of projects through well-known operations research techniques.

This simplifying hypothesis allows us to focus on the main analytical results of our study, dealing with the “projects” level of the program structure. We highlight that different programs address different needs of the territory, therefore have different goals, so that the value of a single project depends by program structure.

2.2.1 The structure of the program

A program is made up of a global, holistic, synthetic part – the objectives – and of a local, punctual, analytical part – the tangible activities on the territory; therefore, it is logical to consider these two levels of analysis.

The objectives of the plan and their relative importance are decided in a political way. It would be extremely difficult, if not impossible, to include legislative, social, economic, electoral etc. factors into a viable model, therefore we’ll consider them as an input that the political decision-maker is free to manipulate.

On the other hand, it is possible to consider every single intervention on a territory as a separate project, given that the crucial issue of relationships between the various projects is properly addressed.

This preliminary consideration introduces the question about the urban program construction on the basis of the objectives assigned by the political player. Obviously, the stated objectives will not be precise and detailed enough to ensure that projects fit them. The first role for the analyst will be to translate these (sometimes partially or completely non-declared) objectives into “lines of action”.

Therefore, the complete structure of the program is built on three levels and it can be represented by a graph-tree in which elements and link between them are completely defined (in a deterministic way).

How to create a set of operative lines?

The lines have to fulfil some criteria:

– be generic enough in order to consider a numerous set of possible ways to pursue them
– be specific enough in order to define a metric, which measures the degree of adherence of a project to that line in numeric terms
– be numerous enough as to include all the stated (or implicit) objectives of the program; in general the set of lines should translate the political will into practice, therefore the political approval (for one) of the technically acceptable set(s) of lines is needed
be separate enough so that in case a project fulfils more than one line, it is really contributing to the goals of the program in more than one way and not simply taking advantage of a bad design of the system

be homogeneous in terms of importance, so that they all fall into the same order of magnitude of priority. This is an important guideline for building a sensible set of lines

A set of projects is either developed by the same office which is building the program, or elicited somehow by the “external world”. Once the set of lines is made public, the projects will tend to conform more strictly and explicitly to the initial intentions of the planner than it would happen with the simple declarations of objectives.

This happens because the general objectives, shift and shared into operative line-goals, are now more detailed. This kind of transparency is useful for getting results actually closer to the expectations, so in the interest of the decision-maker himself.

Understanding this point is very important to overcome the natural political resistance to put a decision-process into at least partially analytical terms. A decision-support model will be considered useful when the public hand gets highest desired return for money invested and the population the highest benefit from the realization of the plan.

2.2.2 Dimensions of analysis

a) Well-defined projects

Each project should specify clearly the localization, time of beginning, duration of the realization, expected life and cost. If the same project may have more than one possible localization or time/cost combination, we put them all in the program but only one will be selected. It can be useful to include proposed projects (at early stage of the project cycle) in the analysis, in order to outline a exhaustive scenario for the whole duration of the program.

b) Territorial criteria

Each project while working for the whole territorial system, also carries a “local” benefit. So, the “local” decision-maker will try to attract projects to its own community. Therefore, an equitable distributive criteria is needed.

c) Budget levels

A budget availability, both at present time and in the future, has to be assumed, so as specific budget constraints depending by the nature of the project and/or localization. Of course the easiest situation is a budget without constraints at all, but it rarely happens.

d) Time frame
The program has a given time horizon, which is divided into discrete slots. We want to make a decision for the first time slot, and just outline the program realization for the rest of its duration. The analysis will be performed in the future, when monitoring of the program shows “new” decision.

2.3 The IFF model

As a strategic goal, we wish to accomplish the highest return on the set of activities that will eventually be realized.

a) Objective function

We define “return” as the politically weighted sum of a multiple-aim weighted sum of social utilities which are necessarily a qualitative and quantitative satisfaction of both objective and subjective needs of the population.

b) Interactions

Furthermore the interactions among clusters of two or more projects which affect the effectiveness of our plan have to be included in the analysis. Also, in the constraints, will be considered the interactions in efficiency. In this case we only show how to consider interactions between two projects, but more may be handled in a similar fashion.

c) Constraints

Having set up an objective and a strategy it only remains to define the constraints and the implementation. It is not worth to highlight that:

– the set of constraints we propose is just suggested by the specific case we studied, and may be adjusted to a broad range of different needs

– the constraints are mathematically formulated but will be understandable in their motivation and effects also to the non-educated reader of the decision process.

As a group of bounds we considered that we want: the benefits of the various projects to be well distributed over the territory; the public budget constraints to be satisfied; then to have a well-balanced fulfilment of the set of the operative aims; finally we have time constraints and cost opportunities and threats (due to interactions between different projects).

2.3.1 Formulation

This leads to the following Linear Programming (LP) formulation:

$$\max \sum_{h,k=1}^{n} z_{hk} \sum_{i=1}^{m} q_{i} x_{ihk}$$
where $q_i$ represents the politically assigned weight for the line $i$. 

subject to:

$$\sum_{i=1}^{m} x_{ih} = V_h / V_{\text{max}} \quad \forall h = 1 \ldots n$$ (1)

where $x_{ih}$ is the contribution of the interaction between projects $h, k$ on the line $i$, and $V_h / V_{\text{max}}$ is the normalized value of the project $h$ and $x_{ih}$ the contribution of the project $h$ to the line $i$.

$$\begin{cases} 
  z_{ij} \leq \frac{y_i + y_j}{2} \quad \forall i \neq j \in 1 \ldots m \\
  z_{ij} \geq y_i + y_j - 1
\end{cases}$$ (2)

where $z_{ij}$ represents the existence of the interaction between projects $i$ and $j$. This constraint obliges $z_{ij}=1$ if $z_{ii}=1$ and $z_{jj}=1$.

$$\sum_{h,k=1}^{n} z_{hk} x_{ihk} \geq Q_i / V_{\text{max}} \quad \forall i = 1 \ldots m \sum Q_i \neq B$$ (3)

minimal realization for each line where $B$ is the total budget

$$k_k - c_k - \sum_{h=1}^{n} w_{hk} z_{hk} = 0$$ (4)

$k_k$, efficiency earnings or losses due the interaction (positive or negative) between projects

$$\sum_{h=1}^{n} z_{hh} k_h a_{hh} \leq B_h, \forall h \neq k = 1 \ldots n \forall b = 1 \ldots v$$ (5)

budget constraint of public intervention

$$\sum_{h,k=1}^{n} z_{hk} x_{ihk} - A_{ij} \sum_{h=1}^{n} z_{hh} x_{jhh} \leq 0 \quad \forall i, j = 1 \ldots m$$ (6)

1 In general (apart from the point 2) the pedices $i,j$ represent lines, and $h,k$ projects
homogeneity constraint for the ‘line’ values

\[ V_k - bk_k \leq 0 \forall k = 1...n \]  

(7)

willingness to pay (adjusted costs) for each unit of benefit realized.

\[
\begin{align*}
\sum_{h \in \text{ListZone}} z_{hh} - q \sum_{h \in \text{ListZone}} z_{hh} & \leq 0 \\
\sum_{h \in \text{ListZone}} z_{hh} - d \sum_{h \in \text{ListZone}} z_{hh} & \geq 0
\end{align*}
\]

\( \forall t, r \in \text{ListaZone} \)  

\( \sum_{t} \sum_{r} 0 \),  

(8)

territorial homogeneity constraint

\( t_o^h - z_{kk}^k \geq 0 \)  

(9)

time constraints between projects

\[ z_{hh} \in [0,1]^\text{max} ; q_i \in \mathbb{R}^+ ; x_{ihk} \in [-1,1]^\text{max} ; c_h, k_h \in \mathbb{R}^+ ; B_i \in \mathbb{R}^+ ; A_{ij} \in [0,1]^\text{max} ; V_h \in [0,1]^n ; w_{hk} \in \mathbb{R}^+ ; a_{hh} \in \{0,1\}^n ; b_d, q \in \mathbb{R}^+ \]

The definition of the \( x_{ihk} \) is a critical step with regard to the needed legibility of the decision process. It is indeed at this stage that the projects are evaluated line by line (maybe by different independent observers for each line, maybe using structured interaction techniques). We called earlier for the need of a metric to be defined on the lines.

In general we consider the \( x_{ihk} \) as an indication of the degree of “satisfaction” induced by a project (respectively, by the marginal contribution of an interaction between two projects on one or more lines), which carries different meanings for the different lines and metrics.

To achieve an overall comparability between lines, we decided to weight the \( x_{ihk} \) on the intensity of the “satisfaction” induced but also on the quantity of people interested directly or indirectly, positively or negatively, by the realization of the project limitedly to the line \( i \) under analysis.

2.3.2 Notes on the formulation

To successfully implement this model it’s necessary to understand direct and indirect characteristics of this peculiar point of view.
On the direct side, this approach is thoroughly multiple-decision maker by means of having multiple agents evaluating different lines and different clusters of projects according to different criteria and metrics.

It is bottom-up in that it attaches utility proportionally to the quantity and quality of response to population demands. It allows for margins of political adjustment in setting up the aims, but also in defining the overall weights, in balancing the parameters of the territorial constraints, in breaking the ties which unavoidably may result at the very last stage of the decision process. We also included a specific line called “institutions” in our implementation, so that for each project it would be possible to introduce an adjustment “degree of fulfilment of institutional goals”. Finally we also included “priority” values politically decided in order to further promote recognition by the political agent of its own vision.

But on the reverse it requires for an attentive and transparent analysis which implies specific sacrifice of resources. So, it requires a political culture mature enough to consider scientific decision support system input in the decision making process.

Last, but not least, its “incremental nature” implies only minimal and available information be sought at each time slot; and on the other side, notably it is flexible with time evolution, allowing for recursive runs of the model which include newer pieces of information in order to control the evolution of the system and adjust it where needed.

3. **A CASE STUDY: “SABINA”**

We implemented the IFF model for building up the “Socio-Economic Plan for the Mountain Community of Sabina” (a mountain district near Rome, Italy).

a) Description

The “Sabina” Community counts about 13200 inhabitants and periodically (every 5 years) needs a new socio-economic program to invest the money that the Italian State reserves for disadvantaged areas (scarcely populated and with mainly mountain territory).

We proceeded to inquire the budget availabilities and built a scenario-based simulation over the about 60 possible interventions (projects) at the moment of the compilation of the program. The budget availabilities over the program life were are not well known, as normally happens. There were given 9 lines: Agriculture, Forestry, Waste Disposal, Society and Culture, Sports, Settlements, Technologies, Institutions, Production and Tourism.
Each of these lines was properly formulated and contained sub-lines which explained its scope and aims.

b) Actors in the analysis

The political actor contributed to the program in such ways: proposing part of the interventions, proposing the lines and the relative weights, assigning priority values to the projects and also adjusting each project's evaluation through the direct assignment of values to the “Institutions” line.

The population contributed to the program in such ways; for every project, it was statistically calculate the number of inhabitants affected by the realization of the intervention; furthermore, it was inquired the population to define the perceived value (positively or negatively) of the project.

The technical staff contributed to the program by proposing the different metrics for each line and by interpreting the values obtained through the statistical research and by analysing preventively the efficiency and effectiveness interactions between projects. Furthermore, they gathered project “proposals” and checked them (also in term of information needs) for the admission in the program.

c) Results

The first findings were quite surprising; the set of lines was actually preventing a proper distribution of the budget resources as shown in Fig 1. Also, it was possible to assign the whole budget only relaxing some constraints. The average ratio of expenditure in the different budget
scenarios, was of 0.7 (only 70% of the available budget could be allocated respecting all the constraints).

Therefore, a “new” set of lines was implemented, trying to keep it as similar to the given one in order not to waste the data already gathered. So in this case, we define the “new” lines from the previous set decreasing their number and making the resulting lines more homogeneous between themselves.

Figure 2. Growth of the lines for different budget scenarios

Figure 3. "Return" Function
The result, in terms of growth of the lines (Fig. 2), is very regular and internally homogeneous: the differences always fall in the same order of magnitude as requested. As regards the use of available budget, it grew dramatically, being possible to invest between 0.97 (97%) and 1.00 (100%) for each scenario without compromising the level of coherence and constraints given.

The resulting “return” function (Fig. 3) shows how it is not possible to determine an optimal value, but just an optimal interval of expense.

With the information available at present time, the average value in this interval would ensure as much as 90% of the result with just 40% of the budget needed for the realization of all the 60 projects. This means saving about € 6 millions and sacrificing just 10% of the result for the population.

For every possible scenario, the benefits (based on the number of projects) are quite homogeneously distributed over the territory (Tab. 1), which is exactly the critical factor we were seeking since the beginning – non-discrimination.

| Table 1. Territorial distribution of projects for budget scenarios (€ milion) |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Budget Levels     | 0.5 | 1   | 1.8 | 2   | 2.2 | 2.5 | 3   | 4   | 5   | 7   | 9   | 10  |
| Casperia          | 12  | 19  | 23  | 24  | 26  | 26  | 28  | 29  | 30  | 32  | 32  | 33  |
| Configni          | 10  | 15  | 18  | 19  | 21  | 21  | 22  | 24  | 25  | 26  | 27  | 27  |
| Cottanello        | 13  | 19  | 24  | 25  | 27  | 27  | 29  | 31  | 32  | 32  | 33  | 33  |
| Mompeo            | 13  | 18  | 23  | 24  | 26  | 26  | 29  | 30  | 31  | 33  | 34  | 34  |
| Montasola         | 9   | 13  | 18  | 19  | 21  | 21  | 23  | 27  | 29  | 31  | 31  | 33  |
| Montebuono        | 11  | 17  | 18  | 19  | 19  | 22  | 23  | 25  | 26  | 27  | 28  |
| Poggio Catino     | 14  | 19  | 23  | 24  | 27  | 27  | 29  | 31  | 32  | 33  | 34  | 35  |
| Poggio Mirteto    | 10  | 14  | 19  | 19  | 21  | 21  | 24  | 24  | 26  | 27  | 28  | 28  |
| Roccentica        | 11  | 17  | 23  | 24  | 26  | 26  | 29  | 31  | 33  | 35  | 35  | 36  |
| Salisano          | 12  | 19  | 23  | 24  | 27  | 26  | 28  | 29  | 30  | 31  | 32  | 33  |
| Torri in Sabina   | 13  | 19  | 22  | 23  | 24  | 24  | 27  | 31  | 32  | 34  | 36  | 36  |
| Vacone            | 9   | 15  | 19  | 20  | 21  | 21  | 23  | 26  | 28  | 30  | 30  | 31  |

4. CONCLUSIONS

This paper has shown as an operational research technique can be used in “planning-programming by projects”. It was defined an analytical model, Incremental Functional Model, useful in the evaluation step of the decision-making process. The IFF model has been tested on a given program of interventions for the “Sabina” Community; this results in a structured set of projects which:
is coherent for every scenario of budget availability and responds to the needs of the population
- encompasses a more rational/effective (e.g. ability to spend budget) set of lines than the one proposed
- allows a homogeneous distribution of the interventions over the territorial system, to fulfil the equitable distributive criteria

Furthermore, the proposed method makes transparent the assignment of resources, in order to make the planning process legible by the population. It, also, draws attention to the line construction step in building program process as a critical point to achieve the defined objectives.

In particular, it is important to notice how in this case the technique was at service of the decision, informing it and fostering its development, without reducing the freedom for the decision maker to choose his own parameters and to set the context. Just too often indeed the decision support models rely on assumptions which deny a natural evolution of the decision process

However, the IFF model presents some weak points. It is based on the existence of cause-effect relationship between the projects and objectives referred to the urban system (“deterministic” approach); this is not completely true in the real world, where this kind of link is not well-known. Furthermore, the model is suitable only with balanced lines of action; it doesn’t work well if decision-makers assign very different line values (this case is not rare).

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