A DYNAMIC MODEL
FOR THE PLANNING OF HUMAN RESOURCES

Habib Sedehi
ENIDATA - TEMA S.p.A.
Viale Aldo Moro, 38
Fiera District
40127 Bologna
Italy

1. ABSTRACT

The methdology which this article deals with, is the fruit of the experience gathered thanks to the contributions of experts in the fields of programming, personnel and organisation.

The willingness of such people has given rise to the instruments now available in the field of Industrial Dynamics. It is thus possible to design a methodology and simulation models which, with the help of a computer, offer an instrument which can answer the needs of those involved in the planning of human resources in a company environment.

This model has so far been applied with satisfactory results in two technically different realities. At the present time, other applications are in progress which confirm the validity of this instrument. [1]

1. INTRODUCTION

When drafting company programs and strategies, particularly in the productive, economic and financial sectors, one can certainly not ignore human resources. Notwith-standing this, in the great majority of Italian companies, both private and public, management has so far given little attention to personnel planning and has very rarely shown the ability of treating the problem with a real quantitative methodology capable of including all the dynamics. [2]

It very often happens that there is an "unbalance" in the number of employees for several reasons: resignations, retirement, re-training, etc. Confronted with these situations, management often finds itself unprepared and in order to find an immediate remedy, risks taking hurried decisions which, over time, can lead to serious financial losses. With regard to the Italian situation, it must also be remembered that the programming of human resources has been obstructed by a series of rather unfavourable conditions, such as:

* the demand for a workforce which can easily adapt to the existing process-product type;

* a progressive legislative rigidity giving high job security which has obstructed programming processes;

* the homogeneity of the variables to be introduced into the planning process;

* the structure of personnel information systems(auditing or cost control).

2. A DYNAMIC MODEL

In this paper we describe an instrument which, by using the methodology of "Dynamic Models for corporate Strategies" (MDS, Modelli Dinamici per Strategia aziendale),[1] allows the forecasting of personnel trends based on the activities of particular sections. [3] [4]

This instrument, complete with an analytical methodology developed by a working group [2] is particularly suitable for medium/large companies, and may be applied independently of the sector in which they operate.

Starting from the assumption that the act of programming is much more a question of designing rather than simply foreseeing, a Dynamic Model has been developed which allows

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1) The MDS methodology has been developed by ENIDATA-TEMA, a company of the ENI group (Italian National Hydrocarbon Agency), by elaborating and integrating concepts of Industrial Dynamics. [5]

2) The working group was composed of: coordinators:Giovanni Parillo (ENI) and Vincenzo Gervasio (Tema); members: Giampiero Donnini and Piergiorgio Filippucci (ENI), Alberto Trebeschi, Claudio Nanni and Habib Sedehi (Tema), Felice Atanasio (Saipem), Ferruccio Costetti (Anic), Agostino Romoli and Aldo Rossi (Tic).

the verification of the validities of the different politics of intervention, by asking the following question: "Given a certain initial situation (either stationary or varying with time) and having made several hypotheses of intervention (or non-intervention), how will the workforce change over time?".

This mathematical model allows the determination of personnel costs (both for stable employees and those being trained) as a function of the different hypotheses chosen, and also an analysis of:

1) increases and/or reduction of the workforce in given areas of a company;

2) trends of internal and/or external mobilities;

3) attribution of priorities to different personnel categories;

4) the timing and the preferences which govern mobility from one category to another.

According to the classification made by Bowey "Corporate Manpower Planning", [6] which was also used by Buckley, Iantsh and others (although using a different terminology), in the real operative situation of a company there are three different possibilities:

A/ equilibrium (in which the organisation is stable over a considerable period of time);

B/ adaptive (in which the organisation varies due to internal stimuli);

C/ planned (in which the organisation changes according to choices made previously).

The experience gained in the use of this methodology allows one to show how all three approaches are characterised by results which can not be underestimated and is not, therefore, subject to limitations which often give to such a project a purely theoretical value. It was thus necessary to define a representation of company structure which allowed the testing of all three hypotheses, or better still, to verify the effects of all three and their different combinations.

The problem would also have to be approached both in terms of:

- optimisation (in the sense of minimising the costs over the interval required for reaching the desired situation);
- and simulation (in order to have a collection of results as a basis for decision making).

The complexity of the "process" and its peculiar characteristics governed the choice of a simulation instrument which has contributed, amongst other things, towards showing the necessity of close links between personnel planning and all the other company activities. In fact, personnel planning can not be considered as a "one-off" process, but as a dynamic activity, like all company activities, which require continual adjustment.

Thus, remembering that the interest of planners is normally centred upon forecasting supply, mobilities and demand, emphasis has been given to the company as a dynamic entity, with all of its ability to react to internal and external stress. [7]

The resulting instrument, complete with an appropriate methodology of analysis, is suitable for use in medium/large companies, independently of the sector in which they operate.

3. METHODOLOGY OF ANALYSIS

The methodology of analysis adopted in the definition of the structure and of the data of the model allows one to draw together the following aspects of the problem:

* structural analysis of the internal organisation;
* integral analysis of company budgets and strategies;
* analysis of personnel files;
* analysis of the social situation;
* analysis of internal mobilities.

Structural analysis of the internal organisation.
Used to subdivide the personnel in the operative unit under examination (society, factory, area, division, etc.) into homogeneous classes of functions having a set of requirements, or "describers", in common. Let us suppose that we wish to analyse the functions of a hypothetical company by means of three types of macro-describers:

a) qualification (a_1= diploma, a_2= arts or social science degree, a_3= science degree);

b) age group (b_1= 20-30, b_2= 30-40, b_3= 40-60 years old);

c) knowledge of foreign language(s) (c_1= English, c_2= French, c_3= German).

Let us also assume that in the above company the functions of welfare officer and public relations officer can be defined using a_2 and b_2. If we now construct a describer/function matrix, the intersection of the rows and columns represents the need for a describer for that function, and the functions which can be aggregated are those having the same describers (functions 2 and 4 in Figure 1).

It is, necessary to have a wide and detailed knowledge of the reality under examination in order to verify the validity of the results obtained so that errors and over-simplifications can be avoided.

Otherwise there is the risk of grouping together positions having the same describers but different functions or, vice versa, of not grouping together positions having different describers but similar functions. The sets of homogeneous positions resulting from this analysis are called "families".

Internal analysis of company budget and strategy. After having found the families, the duration of the simulation must be decided upon, by taking into account the aims and goals which the company intends to reach. Towards this end, the requirements of the company budget are integrated with the course of the strategic planning (investments, disinvestments, personnel retraining, technological innovation, etc.).

Macro-describers	Describers \ Functions	Secretary 1	Welfare officer 2	Porters 3	Public relations officer 4	Etc.
Qualification	a1 Diploma	X				
	a2 Arts/socials science degree		*		*	
	a3 Science degree					
Age group	b1 20-30	X				
	b2 30-40		*		*	
	b3 40-60			X		
Knowledge of foreign languages	c1 English	X				
	c2 French					
	c3 German					
ETC.						

Fig. 1

This analysis may lead to a possible revision of the previously classified families (for example, re-training may introduce new functions, and consequently, different groupings).

Analysis of personnel files. This has the following objectives:

- to find the number of employees belonging to each family identified (from the personnel information system);
- formulation of hypotheses on probable personnel losses (natural wastage) due to resignations, illness, etc. (from an analysis of the history of the structure);
- projection of known personnel losses, due to retirement and other causes (from the personnel information system).

Analysis of the social and trade union situation. In order to include external effects on the structure it is necessary to analyse the different variables (schooling, population, job market, etc.) and to identify those which exert the greatest influence on the reality in question, attempting also to correlate them.

To reach this aim one must construct a behavioural model which allows an evaluation of the quantity and quality of the personnel which the market offers. Regarding the trade union system, this analysis also serves to underscore constraints on mobility, working hours, different skills, etc.

Analysis of internal mobility. This step allows one to bring together the time, costs and limits involved in moving personnel from one family to another. For this, one can construct a mobility matrix with the rows representing the acceptor families and the columns the donors. (see Fig. 2).

If there is a number at the point where a row and a column intersect, this represents the time required for the transfer from one family to another, the absence of a number means that such a transfer is not allowed. For example, to transfer a person from family 1 to family 3, nine months' training are required.

Once the different steps in the analysis have been completed, we have all the structural elements and the necessary data at our disposal in order to construct the model (see Figure 3).

Donor family → / Acceptor family ↓	Family 1	Family 2	Family 3	Family 4	Etc.
Family 1		3 months		6 months	
Family 2			4 months		
Family 3	9 months				
Family 4		12 months			
Etc.					

Fig. 2

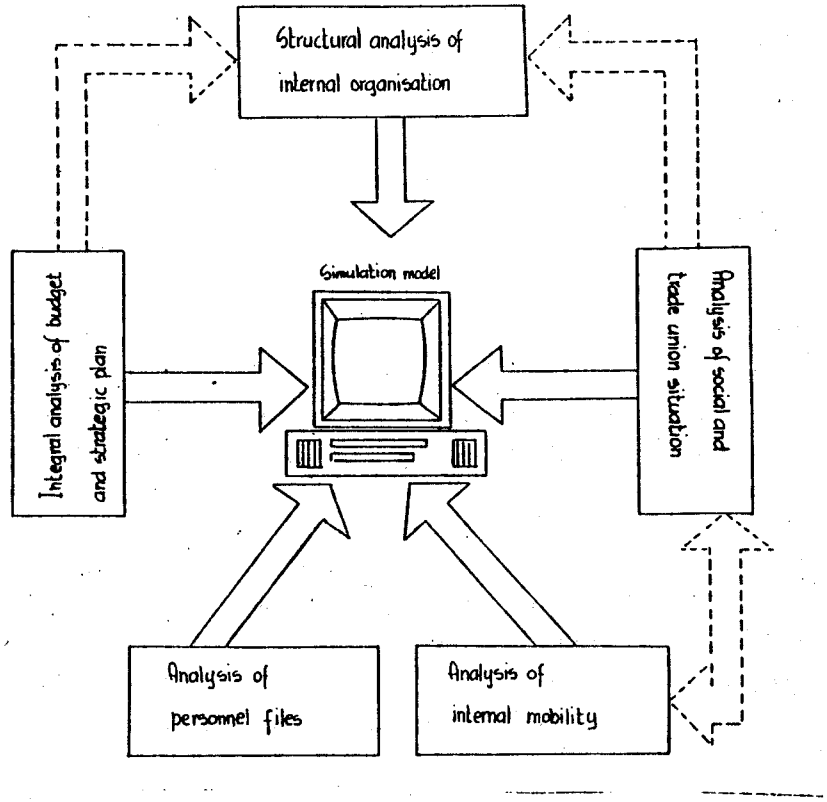

Fig. 3

4. MODEL STRUCTURE

The model consists of a set of differential equations which describe the process (deployment of personnel) thus allowing a dynamic simulation of the system within the given limits.

From the structural point of view (see Figure 4) the model is mainly composed of three logical elements:

- levels, the state variables of the system;
- flows, elements which modify the values of the levels over time
  - . endogenous calculated by the model
  - . exogenous inserted from exterior
- parameters, coefficients used to define the laws of the endogenous flows.

* Levels

The levels considered are:

- External market; represents the feedstock of the system.
- Personnel training; the so-called "waiting room" for employees which are about to change family.
- Operating personnel; the "operative force" of the personnel structure.
- Departures; represents the reservoir of personnel leaving the structure.

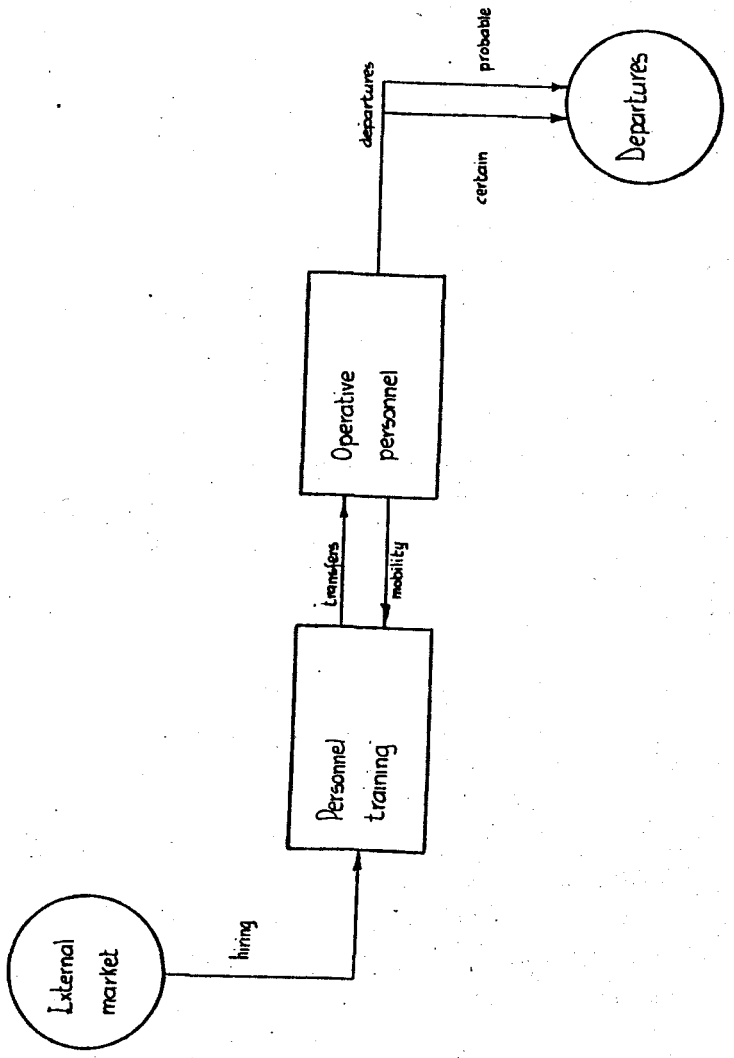

Fig. 4

* Flows

The flows identified are:

- hiring of personnel from the external market;
- mobility of personnel from the donor family to the formation of the acceptor family;
- personnel transfer from training to the operative personnel of the family;
- personnel resignations (probable departures);
- retirements (certain departures).

* Parameters

The principle parameters adopted are:

- training period required to pass from one family to another;
- preference for mobility from the donor family to the acceptor family;
- desired workforce of the families;
- minimum and maximum percentages of family employees with respect to the desired workforce;
- percentage distribution of qualifications across the families;
- operative and formation costs of the families;
- percentages of resignations from the families with respect to the total.

All the parameters over the entire duration of the simulation may be subject to programmed variations.

The elements of the model structure (levels, flows and parameters) may have dimensions (space); for example, the "operative" level of the personnel is composed of n sub-levels which corresponds to the number of families identified in the analysis steps.

Exploding the model (Figure 5) and focussing upon a family (Fam. a) one can note the possible interactions existing between such families and the outside world.

The circled numbers on the arrows represent the number of months' training necessary for a person to pass from the donor family (or the external market) to the acceptor family (training time parameter), whereas the uncircled numbers define the order of preference with which, when necessary, the acceptor family draws from the donor family.

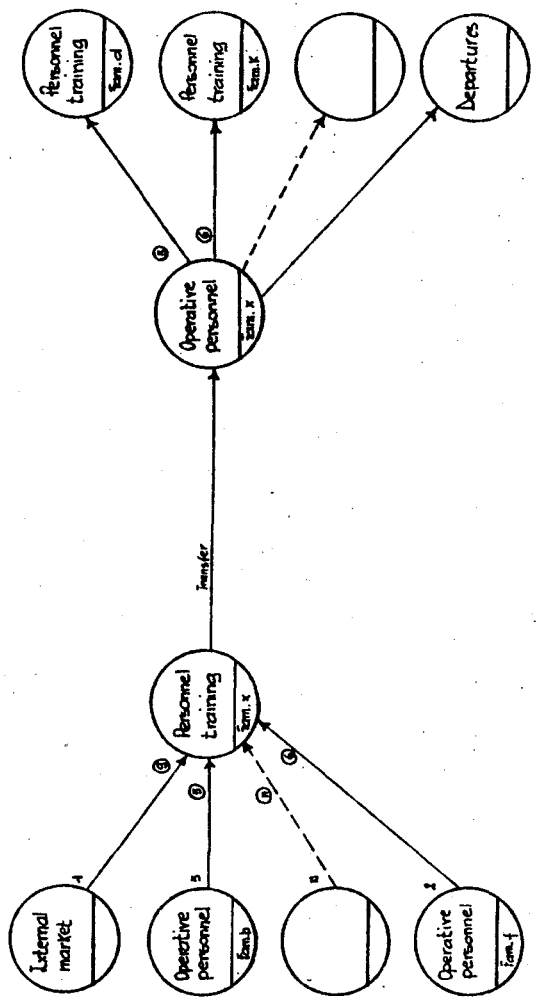

Fig. 5

5. PROCESSING LOGIC

The principal aim of the model is as follows: given the initial state of the workforce subdivided into "families" (initial values of the Levels) and given a desired state of the workforce accompanied by a series of constraints (values of the Parameters and their variation with time), what will be the evolution of the state of the "families" for a given duration of the simulations?

The model provides two types of simulation for reaching the objective:

a) Automatic Simulation (quantitative aspect).

b) Guided Simulation.

These two simulations are always preceded by a third(ageing aspect), which may be carried out independently and represents the relaxation of the system. In fact, this simulation, by freezing hiring and internal mobility clearly shows the "emptying" of the reservoir of the family operatives due to retirements, resignations, or other departures, and identifies which families would become inoperative due to the lack of personnel. This simulation also provides further indications on the critically important professional figures.

a) Automatic Simulation(qualitative aspect)

Starting from the initial conditions, fixed on the basis of the results of the ageing simulation, this simulation determines the families which will become quantitatively

more critical thus automatically creating a resolution priority vector. This vector consequently modifies the number of allowed transfers since the model, resolving the families one at a time on the basis of their assigned priority can not upset the order of an already settled group. Having done this, it simulates, on the basis of the automatic priority vector and other parameters of the model, the evolution of the described levels.

b) Guided Simulation

Given the initial conditions, by choosing this type of simulation, it is the user who defines the resolution priority vector and who also has the possibility of inserting possible exogenous plans for mobility or for hiring, and therefore the model simulates the behaviour of the levels described "guided" by indications from the user.

In these two principle simulations, within the priority vector, the transfer of personnel from one level to another takes place by bearing in mind three elements (in the following order of priority):

- training period;
- removal of the operatives from the workforce of the donor family;
- transfer preferences.

6. PRESENTATION OF RESULTS

The system provides different types of output, both of a graphic and of a numerical nature, such as:

The mobility plan. This may be considered as the most complete output for each family, because, after each simulation, it furnishes all the movements of the employees belonging to the family under examination, both to and from other families. In particular, it specifies both internal movements (internal mobility) and external ones (hirings, retirements, resignations, etc.).

The training program. This output gives the trends in personnel being trained underlining the relative periods, both individually and globally.

The employment plan. If new appointments are foreseen, then this prospectus indicates which ones are to be made by specifying the qualifications required for each case (the percentages of different qualifications desired for each family are input data).

Cost report. For each family and/or globally this output gives the training and running costs in graph or numerical form.

All the prospectuses and graphics of the system can be requested with any desired frequency which can also be changed at will by the user, within the limits of the duration of each simulation.

7. CONCLUSIONS

This model has so far been applied with satisfactory results in two technically different situations. The first was a chemical plant having about 4000 employees and a problem of global planning of the workforce. In this case the main difficulties arose from the structural analysis of the internal organisation, and in particular from the identification of the families, whereas the model responded well to the requirements of the problem.

The second case involved the planning of only the intermediate levels (about 1000 employees) of a large company. This application showed fewer difficulties in the analysis stage, but required several modifications in order to correspond more closely to the reality being simulated.

Both cases, however, confirmed the validity of this decisional aid for the manager who has to design a personnel structure in a "turbulent" environment such as the present-day one, and who wishes to test his ability to judge si - tuations by widening the number of solutions to be taken into consideration.

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