CONSTRUCTION METHODOLOGY OF MANAGEMENT CONTROL RATIOS USING RATIONALES OF SYSTEMS DYNAMICS AND MULTICRITERIA DECISION AID

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ABSTRACT

A methodology to elaborate and specify strategic, tactic and operational management ratios is presented. It bases on a classical method to define management control panels, but incorporates rationale of systems dynamics in order to identify the control and regulation cycles where the ratios may be constructed in an organization. Additionnally, we propose a multi-level clustering process where, in a specific level, we may consider a ratio as a criterion. Thus, the consistent family of criteria properties may be used as a validation test of ratios in a cluster. We show an example of this methodology in the case of the ratios structure of a customer area in a sanitary and water resource management firm.

KEYWORDS

Management control ratios, system dynamics rationale, multicriteria decision aid, water resource management.

1. Introduction

In this paper, we propose a methodology to construct management ratios, based on system dynamics and multicriteria decision aid rationales. In order to do that, we fit together principles of system dynamics, strategic management and management control methods. Additionally, the principles of a coherent family of criteria, issued from multicriteria decision aid, permit us to establish a set of validation schemes for the constructed ratios in this methodology. This work is applied to business area of a sanitary firm. In fact, we agree with the classical approaches proposed for the management control system construction process [5,7,14] and the strategic, cultural, structural, formal and centralization/decentralization problems of control [1,3,12]. However, specifically, we articulate the basic feedback triplets (information, decision, action) proposed by Forrester [4] with the construction process of the management control system, in a way another methodology does not do. Furthermore, whilst we propose the validation tests on ratios families, other methods propose an internal ratio validation only.

2. The original problem

The considered firm[1] is a very important regional organization, by the number of workers it has and by the last five years critical changes developed in the management domain. Actually, in 1996, this company accomplished a strategic planification process which implied a great effort to integrate the functional and hierarchic areas. In the first part of this implementation, the marketing, administration and finance operative functions were supported with information technology. Recently, several external and internal obligations have pressed the firm to define a set of new technological and procedural requirements: government's quality control of water concessions (production, distribution, collection and disposal of waters); quality of services for customers; finance and activity control; and information technology opportunities. In this direction, several independent works have been undertaken, by managers, in order to construct useful function areas management ratios. Then, a logical need arise: a single methodology aiding to the ratios elaboration process.

[1] Names and data must rest confidential, then they are ficticious; the general results are real.

However, managers have faced two kinds of problems. First, the lack of standards for structuring and nominating the ratios. In fact, there is not a common vocabulary and/or procedure to define a ratio: it is not clear what is to be designated as a ratio, or how its structure must be specified. Secondly, managers do not necessarily appreciate the systemic and strategic facets of the ratios' elaboration process. Indeed, it is a common practice to see the ratios as local attributes representing certain aspects of a functional area. Thus, managers lose the perspective of their works and they construct ratios families which are not necessarily coherent from a strategic and systemic point of view. Our argument is that both problems are due to the absence of systemic and validation procedures in the core of their current elaboration methodologies. We propose to incorporate those features in the explicit practices of the managers by designing the respective methods.

3. Proposed methodology

The proposed methodology in this paper suggests that ratios must be constructed to support the cycles of regulation in the studied functional unit. Indeed, these explicit or implicit cycles [2] are implemented to perform the decision and action rules of the organization, in order to satisfy a set of explicit or implicit purposes. We have limited the extension of this methodology only to the functional unit in a firm; the business units are not considered in this approach.

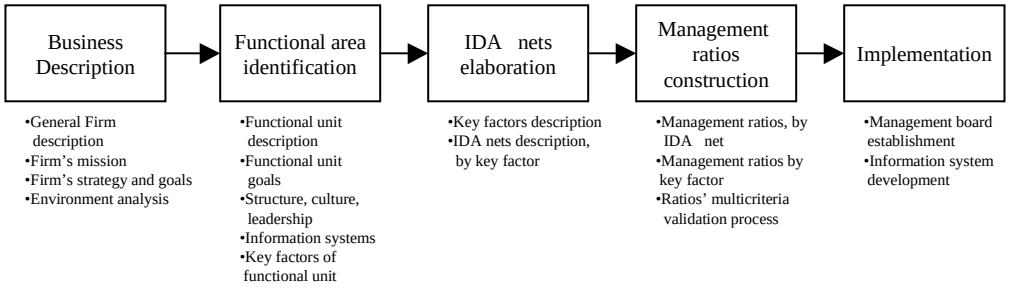

Fig 1. The proposed management ratios elaboration methodology

There are five fundamental stages in this methodology. The first one, the *business description* searches the strategic vision and goals of the studied firm. In fact, it is supposed that management ratios must finally respond to the strategic needs broadcasted by the firm's executives to the functional units. In the stage of the *functional area identification*, managers (and analysts) must clearly describe the considered functional unit, identifying: the strategic and functional goals; the structure of tasks, decisions, procedures and norms; the leadership structure; the culture; and the information systems. A principal purpose from this stage is to identify the *key factors* of the functional unit.

The stage of the *IDA nets elaboration* is a particular step where the key factors and functional description are organized in order to carry out a relation between these factors and the triplets (information, decision, action). Actually, we propose that the triplets may represent the cycles of regulation [4], implicitly or explicitly used by managers to align the unit activities and the key factors. Therefore, the management ratios construction phase explores the hierarchy of ratios' families related to the previously identified IDA triplets. Multicriteria analysis rationales are applied here in order to achieve a well-defined set of ratios' families. Finally, in the *implementation* phase, a typical management board is suggested and the respective information system developed.

In the following sections, we introduce an application of this methodology, from the first to the fourth phases. Thus, in Section 4, the business, functional and IDA analysis are presented. Afterwards, in Section 5, the management ratios elaboration is advanced.

4. The business, functional and IDA phases

4.1 Business description

The considered firm has a classical structure of organization: a strategic area with a management board, a general manager and three units of staff: information management, audit and judiciary; a tactic area, composed by management units of marketing, finance, human resources and engineering; three divisional operative units, distinguished by their respective geographical domains, each developing the concessions, i.e., production, distribution, collection and disposal of water. A number of the government institutions regulate the firm's investments, operations, results and service's prices. The water customers reach the number of 145.000, approximately, and they represent 34.1000M m3 (1998) of water a year.

The price regulation of government encourages the firm's strategy focused on the costs reduction in order to maximize utility. The firm has defined the organizational vision as "the leadership on efficiency, quality and modern style of the sanitary services". Thus, the strategic goals are established to get: 1) the optimal-quality services, in a timely, effective and efficient way; 2) a qualified, capacitated and autonomous human resource; 3) a maximal utility, reducing costs, in order to increase profit, to ameliorate the competitive position and to increase the investments; 4) the protection and preservation of the environment quality; 5) the reliability in the water provision.

A summarized environmental analysis reveals that this firm has no dangerous competitors in a near future because the exploited concessions are accorded, by the central government, for a long period and a great territorial extension. There is no considerable interest to develop the territory's concessions due to the implied large costs. Recently, environmental constraints, established by the government institutions, came out: a set of quality standards for the drinking water and disposed water was imposed.

4.2 The functional area description

We have centered our attention in the marketing function of the studied firm. It is compound by two principal areas: marketing development and marketing management. The first one, is dedicated to the economic aspects of marketing, corporative image, customer, publicity, invoicing, water supply continuity, water collection, water pressure and customer applications. The second area, is devoted to the customer debt management, correct invoicing, marketing planning, marketing management control, management ratios elaboration and evaluation processes, and the marketing's information systems. Indeed, there are several information systems in this area, but the most relevant one is the marketing's information management system which implements the following subsystems: marketing processes, register operations, cash flow, customer services, marketing management reports and forecast. Additionally, the leadership operates in an involvement base where the performances are evaluated in accordance to this aspect. Each working group has a responsable manager who must search the necessary means to achieve the objectives.

The primary goal of this area is to ameliorate the billing process quality and optimize the services' sales revenues. Thus, a set of specific objectives is defined: 1) the construction of a marketing management control model implementing the functions to satisfy the user levels; 2) the amelioration of the customer debt collection; 3) the optimizing of the invoicing process; 4) the control of the allowances of invoicing and the firm and municipality relationship; 5) the implementing of the operative decentralization of the invoicing process; 6) the optimizing of the marketing management system; 7) the control of the correct marketing operations in the influence zone of the firm.

After an extensive analysis of the firm's marketing function, managers and analysts have concluded on four key factors for this area: collection, customer debt date, invoicing and customer service. According to our methodology, we have proposed to identify the cycles of regulation currently implemented in the marketing processes associated to these factors.

4.3 IDA nets elaboration

An IDA net constitutes a number of decision and action rules of the organization, implemented (in a explicit or implicit way) by the firm's actors. Thus, the managers must indicate what are the arranged processes which regulate the satisfaction on the identified key factors. In our application, the five month's conclusion has revealed a number of nets in the studied area. In Table 1, we identify the set of IDA nets related to each key factor.

In Table 2, the triplets (information, decision, action) are shown in order to appreciate the kind of information we can get from this analysis. Only a few IDA nets are presented here.

Key Factor	IDA nets
A. Collection	A.1. Constitution of collection. A.2. Efficiency of collection process.
B. Customer due date	B.1. Debt constitution. B.2. Agreements. B.3. Unpaid. B.4. Notification, cuts and replacements.
C. Invoicing	C.1. Measurement. C.2. Invoicing quality. C.3. Invoicing distribution. C.4. Subsidies.
D. Customer service	D.1. Problem solutions. D.2. Technical quality.

Table 1. Identified IDA nets, by key factor.

INFORMATION	DECISION	ACTION
▪ Achieving of invoicing. ▪ Collection in a period. ▪ Collection of invoicing process in a period.	To determine the collection constitution.	To ameliorate collection, depending on constitution.
▪ Number of payment centers. ▪ Number of customers served by the payment centers. ▪ Gathered total amount on each payment center. ▪ Attention time on payment centers.	To diagnose the collection efficiency.	To undertake corrective actions in case of low efficiency of payment centers.

(a) Collection.

INFORMATION	DECISION	ACTION
▪ Number of indebted customers, arranged by notebook. ▪ Percentage of unpaid customer debt which has been redempted. ▪ Kinds of customers. ▪ Accumulated time of the unpaid customer debt. ▪ Social layer of the indebted customer, by notebook. ▪ Unpaid debt total value.	To establish the constitution of unpaid customer debt.	To ameliorate the unpaid customer debt redemption.
▪ Total amount of the agreements. ▪ Agreements term. ▪ Number of agreements. ▪ Time of the agreed unpaid customer debt. ▪ Number of customers accomplishing the agreements. ▪ Percentage of unpaid debt which corresponds to agreements. ▪ Agreements payment term.	To examine agreements.	To undertake corrective actions for the agreements.

(b) Customer debt dates: a subset of IDA nets.

Table 2. Some examples of IDA nets description.

5. Management ratios construction

5.1 Management ratios definition

The IDA nets are used as process models in order to identify and then define the management ratios. In Table 3, the management ratios for a subset of IDA nets and key factors are presented. These ratios have been analyzed and defined with the participation of the marketing managers, over a period of four months.

Key factor: Collection		
IDA net	Name of ratio	Description
constitution of collection	Relative collection.	Proportion of collection over the total invoicing in a period.
	Effective collection in a period.	Percentage of collection which corresponds to issued invoicing's collection in a period.
	Collection of issued invoices.	Proportion of collection which corresponds to issued invoices' collection in a period on the total invoicing in that period.
efficiency on collection	Position of payment centers, in customers capture.	Competitive position of payment centers, according to the number of gathered customers.
	Position of payment centers, in money gathering.	Competitive position of payment centers, according to the gathered amounts.
	Average time of customer attention on a payment center.	Competitive position of payment centers, according to the average period of customer attention.

(a) Collection.

Key factor: Customer due date		
IDA net	Name of ratio	Description
Unpaid customer debt constitution	Indebted customers on level d.	Percentage of indebted customers which has d periods as indebted.
	Indebted customers on kind j.	Percentage of indebted customers on the j kind.
	Indebted customers on kind f.	Percentage of indebted customers in the social layer named f.
	Collection of unpaid customer debt.	Percentage of invoices which corresponds to unpaid customer debts.
	Collection of unpaid customer debt in a period.	Percentage of unpaid customer debt which has been collected in a period.
	Level of unpaid customer debt in the invoicing's period.	Percentage of invoicing which corresponds to the unpaid customer debt.
Agreements	Days on agreement.	Average number of days on agreements.
	Agreements by layer.	Percentage of agreements on layer f.
	Time of unpaid customer debt on agreement.	Percentage of the unpaid customer debt on agreement, with the similar number of indebted periods.
	Indebted amount on agreement.	Percentage of agreed amount which are indebted.
	Debt on agreements.	Percentage of the total unpaid customer debt which corresponds to indebted amount on agreement.
	Indebted on agreement	Percentage of agreements which are indebted.

(b) Customer due dates: a subset of IDA nets.

Table 3. Some examples of ratios, by IDA net and key factor.

5.2 Validation process of ratios

In order to know if the set of ratios defined on an IDA net is coherent, a multicriteria analysis approach has been applied. Indeed, we propose that the IDA nets represent the organizational rules and we associate them to the key factors. Thus, the set of ratios on a net represent the available variables to managers in order to make decisions. Moreover, the ratio definition and structure of a ratio are extremely similar to the criterion definition used in the multicriteria decision aid domain [13]. Therefore, we propose that the ratios identified in an IDA net constitutes a family of criteria, in the more classical sense [10].

Consequently, we have applied the test of the coherent family of criteria, proposed by Roy [11], to the set of ratios, by each IDA net on each key factor. In fact, the ratios shown in Table 3 have been determined after a long deliberation process where three properties were tested: 1) the exhaustion test, which demonstrates that, on a net (or key factor), the set of ratios is enough to guide the management process; 2) the test of the coherent ratio, which searches the internal exhaustion of one ratio; 3) the test of no redundancy, where two ratios are not sending to the same kind of information.

5.3 Management ratios aggregation

We have proposed to managers a multicriteria aggregation procedure for the ratios set comprehension. In fact, let us define n_i the number of IDA nets established on the key factor $i\,(i=1,...,4)$; n_{ij} the number of ratios established on the IDA net j and on the key factor i; and, g_{ijk} the management ratio k, on the IDA net j and on the key factor i. Then, we have selected the synthesis criterion approach [11] to aggregate the ratios. In particular, a multiplicative function has been used. Indeed, Pomerol and Barba-Romero [8] and Lootsma [6] have shown the well structured properties of this kind of aggregation. Therefore, the IDA nets and key factors ratios are defined as follows:

$g_{ij} = \prod_{k=1}^{n_{ij}} g_{ijk}^{\,w_{ijk}}$: the management ratio of the IDA net j, on the key factor i, where $0 \le w_{ijk} \le 1$ represents the relative weight of the ratio g_{ijk}, subject to $\sum_{k=1}^{n_{ij}} w_{ijk} = 1$.

$g_i = \prod_{j=1}^{n_i} g_{ij}^{\,w_{ij}}$: the management ratio of the the key factor i, where $0 \le w_{ij} \le 1$ represents the relative weight of the ratio g_{ij}, subject to $\sum_{j=1}^{n_i} w_{ij} = 1$.

Weights of the ratios must be defined by the firm's managers because they represent their decisional latitude. Actually, the culture and leadership in this firm suggest the respect of such a latitude. Normally, any decision which has a recognizable impact in the firm must be well argued. Thus, the conclusions achieved in a decisional process are the result of the robustness analysis [9], in particular, from the weights changes in order to explore different scenarios.

5.4 Management ratios calculation

In practice, the necessary conditions to calculate the management ratios are: the information and information procedures availability. In the case of our firm, there exists the marketing's information management system that considers a main part of the elementary information which determines the ratios values. Indeed, 62 ratios have been defined, but only 10% may be directly calculated; 71% of ratios could be computed, but the information procedures must be developed; 19% of cases can not be determined because the information and procedures do not exist yet.

6. Conclusions

In this paper, we have shown the application of a methodology to the management ratios construction in a functional area of a sanitary firm. This methodology has implemented rationales of systems dynamics and multicriteria decision aid. Although the application area was a marketing function, we think this method may be applied in other functions also. However, our experience has revealed some weak points: 1) the risk analysis phase must be incorporated: managers are enthusiastic in the ratios modelling, but they do not necessarily anticipate the information and information procedures availability; 2) this methodology is relatively time consuming: it takes a lot of time the elaboration of ratios; 3) we think the elaborated ratios are very obvious: managers are inclined to modelling their experience more intuitive and explicit, thus, some implicit practices may be hidden.

Some strong points may be obsevred: 1) managers are invited to think the ratios in a strategic perspective: the key factors are directly associated and the strategic thinking is enhanced; 2) some management practices are explicitly revealed in the process: the decision and action rules are identified and structured; 3) the necessity of information and information procedures is identified: there is a better agreement between information systems and the management and strategic perspectives of the organization.

7. References

[1] J. Amat. *El Control de Gestión: Una perspectiva de dirección*. Ed. Gestión 2000 S.A., Barcelona, Mayo de 1998.
[2] C. Argyris y D. Schön. *Organizational learning II: theory,method and practice*. Adisson-Wesley, 1997.
[3] S. Certo y J. Peter. *Dirección Estratégica*. Ed. McGraw-Hill/Irwin, 3ª Edición, Colombia, marzo de 1998.

[4] J..W. Forrester. Policies, decision and information sources for modeling. In *Modeling for learning organizations*, J.D. Morecroft y J.D. Sterman ed., System Dynamics Series, 1994.
[5] P. Jiménez. *Control de Gestión*. Ed. Jurídica ConoSur Ltda., Santiago, 1996.
[6] F.A. Lootsma. A model for the relative importance of the criteria in the Multiplicative AHP and SMART. *European Journal of Operational Research*, 94, 467-476, 1996.
[7] J. López y A. Gadea. *El control de Gestión en la Administración Local*, Ed. Gestión 2000 S.A., Barcelona, 1992.
[8] J.C. Pomerol et S. Barba-Romero. *Choix multicritère dans l'entreprise: principe et pratique*. Hermès, Paris, 1993.
[9] B. Roy. Un chaînon manquant en RO-AD, les conclusions robustes. Cahier du LAMSADE nº144, Université de Paris-Dauphine, mai 1997.
[10] B. Roy. The outranking approaches and the foundations of ELECTRE methods. Theory and Decision, (31) :49-73, 1991.
[11] B. Roy. *Méthodologie multicritère d'aide a la décision*. Economica,Paris, 1985.
[12] R. Stephen. *Comportamiento Organizacional*. Editorial Prentice Hall, 3ª edición, México, 1987.
[13] P. Vincke. *Multicriteria Decision-Aid*. Wiley, 1992.
[14] A. Zerilli. *Fundamentos de organización y dirección general*. Eds. Deusto, Bilbao, 1990.