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A FRAMEWORK FOR OPERATIONS PERFORMANCE MEASUREMENT IN MANAGEMENT-BY-PROCESS ORGANISATIONS

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Abstract

The authors present a framework for the implementation of an operations performance measurement system in a manufacturing context where the management-by-process concepts are applied. The consequences of management-by-process on the requirements of the performance measurement system are indicated. The application of the framework to an important and innovative context - the biggest European producer of domestic appliances which is now introducing management-by-process procedures - furnishes useful elements to those firms that wish to review and update their operations performance measurement systems following the introduction of management-by-process principles.

Management-by-process and Performance Measurement Systems

The reconsideration of the operations performance measurement and control systems derives from both a revaluation of the strategic importance of production in achieving competitive advantages (Wisner, Fawcett, 1991) and the observation that the pursuit of excellence in production requires a proper mix of performances and continuous performance improvement (Cross, Lynch, 1991).
The new production paradigm - known as "lean production" - requires a performance measurement system that is formalized (Neely et al., 1994) and able to evaluate several performances (Tonchia et al., 1993) and their balanced combination (Kaplan, Norton, 1992). The management-by-process lean organizations (Harrington, 1991) should have a performance measurement system with precise characteristics.

Management-by-process as a consequence of the pursuit of excellence

A "process" is a sum of activities, each of them composed of elementary operations, consuming resources. A process can be interpreted as the place where the added-value grows (Raffish, Turney, 1991; Conti, 1991). Each process is directed towards the customer and contributes, with other processes, to his satisfaction. The need for management-by-process arises for two reasons: 1. the necessity to link all the activities in order to pursue a unified objective (the customer satisfaction); 2. the fact that the overall performance derives from an integration and co-ordination so that all responsible for the overall performance.
The management-by-process organisation was born to overcome functional organisation rigidity, where the single functions (or units) have always different and contradictory performance objectives (e.g. the efficiency of manufacturing and the amount of sales of marketing). In fact, traditionally each function or unit tries to maximize its own performance and looks to a good local performance as the sole condition for a good overall performance (Fry, Cox, 1989). Management-by-process co-ordinates the efforts and permits the simultaneous achievement of several performance (in terms of time and quality besides the cost productivity) as the new production paradigm requires.

Management-by-process is intrinsically oriented to the inter-functional effectiveness instead of functional efficiency. The effectiveness in reaching its objective derives from a harmonic composition and integration of sub-tasks, of functional responsibility but co-ordinated by the process logic: the performances are the result of the synergetic and synchronous effect of the single contributions along the operations value chain.

Management-by-process consequences on the performance measurement systems

The consideration of a production process as a chain of activities characterized, in each phase, by a "customer/supplier logic" (Schonberger, 1990) implies that everyone has a customer (even those far from the downstream activities) and everyone is served by someone else. So one bad performance in only one ring of the chain is sufficient to produce a poor global performance. Moreover, for the evaluation of the performances of a single ring of the value chain, the constraints (upward dependent along the chain) and the opportunities (downward dependent along the chain) in each phase must be considered.
In other words, management-by-process determines, for each process, a network of "focused sub-factories", independent of each other, with their own management criteria and responsibilities, but strictly linked together according to the customer/supplier logic (or "customer-in" concept). The above "sub-factories" can also be related to other processes.
In short, the consequences of management-by-process on the requirements of the performance measurement system regard at least four aspects:

- *overall* indicators must be constructed. These must be able to measure the process effectiveness in accomplishing the primary task of the process itself;
- the performances that measure the attainment of the *sub-tasks* (converging to ensure that the primary task is reached) must be identified. These performances are evaluated not only in *absolute* but also in relative *terms* between the performances, so as to achieve the best possible mix of performances with the resources available;
- the performances that the single functions and the single units should obtain must be defined and measured in relation to the sub-tasks that characterize the process. This is the *attribution* of the process sub-tasks to the single units;
- finally, the system must be able to identify, according to the customer/supplier chain logic, which performances can be ascribed to one process unit and which instead, though deriving from the activity of the unit itself, depend in a good measure on the performances of the unit backwards in the process. This is the *identification* of the true unit responsibility.

Framework for an operations performance measurement system in a management-by-process organisation

Among the processes that can be distinguished in a manufacturing organisation, three are here considered to be fundamental: i. product development, ii. manufacturing (regarding materials processing), iii. logistics (regarding materials handling). The features that characterize "a process" are:
1. the presence of a primary task deriving from the harmonic composition of different and/or contradictory sub-tasks;
2. the synergetic effect of the single performances on the overall performance;
3. the transversal ("horizontal") involvement of several functions and units.
In table 1, for each of the three processes, organisational variables and performance measurement variables regarding the process are presented.
The framework is subdivided into three parts, in order to shows up, for each process, the key variables which determine, within each process, the differences in the performances to measure and the relative indicators:

- ❑ according to the phase (concept generation and product planning; product design and engineering; process engineering, pilot testing and production ramp-up) in the product development process. The main indicators (of time, quality and cost performances) are suggested and their use during the product development process is represented by the respective areas in table 2;

- ❑ according to the complexity of the product (width and depth of the bill of materials) and the type of production - intermittent or repetitive - (regarding the time interval - long or short - between the entry and the exit of the product) in the manufacturing process. The typical indicators to use are pointed out in table 3, classified as time, quality and cost performances. For more details on the indicators, see Maskell, 1991 and De Toni, Tonchia, 1994;
- ❑ according to the phase (in-bound, internal and out-bound logistics) (Porter, 1985) of the logistical flow (table 4). The time performances are prevalent, distinguished into timeliness and flexibility.

We can note the varying importance of the performances to be measured and the different indicators to be used in relation to the different situations. Space constraints prevent us from further investigating these arguements. For example - table 3 - independently of the complexity of the product, it can be noted that passing from an intermittent production to a repetitive one the performances regarding cost become more important than those regarding time (the quality performances being equal), while as the complexity of the product increases the quality performances become more important (the time performances being equal if the production is intermittent, but the cost performances being equal if the production is repetitive).

	ORGANIZ. VARIABLES			PMS VARIABLES			
PROCESS	no. of people dedicated to the process	no. of firm units involved	firm units frequency involvement	critical performance	no. objects to measure	total measurement cost	single measure frequency
PRODUCT DEVELOP.	low	medium	low	T/Q	low	low	low
MANUFACTURING	high	medium	medium	C/Q	high	high	high
LOGISTICS	low	high	high	T	medium	medium	medium

T = time performances; C = cost performances; Q = quality performances

Table 1 - Organizational variables and Performance Measurement System variables of the three processes.

<table>
<tr><th>PRODUCT DEVELOPMENT PHASES</th><th colspan="3">TIME PERFORMANCES</th><th colspan="2">QUALITY PERFORMANCES</th><th colspan="2">COST PERFORMANCES</th></tr>
<tr><td>CONCEPT GENERATION AND PRODUCT PLANNING</td><td rowspan="3">time to mkt</td><td>-</td><td>-</td><td>"fitness for use"*</td><td rowspan="2">number of change-overs**</td><td>-</td><td rowspan="2">design man-hour (included projects not completed)</td></tr>
<tr><td>PRODUCT DESIGN AND PRODUCT ENGINEERING</td><td rowspan="2">activities overlapping degree</td><td rowspan="2">work breakdown structure time adherence</td><td rowspan="2">product reliability</td><td>"carry over"***</td></tr>
<tr><td>PROCESS ENGINEERING, PILOT TESTING, PRODUCTION RAMP-UP</td><td>-</td><td>prototype cost</td><td>-</td></tr>
</table>

*this concept is due to Juran **including changeovers after the product launching
***it is the number of old parts among the parts of a new product

Table 2 - The product development performances (of time, quality and cost) in relation to the product development phases.

	LOW PRODUCT COMPLEXITY	HIGH PRODUCT COMPLEXITY
INTERMITTENT PRODUCTION (JOB-SHOP)	SPECIAL PARTS: T - cycle time T - queue time T - machine flexibility Q - quality level	ENGINEERING PRODUCTS: T - adherence-to-schedule Q - production & assembly quality conformance C - cost variance
REPETITIVE PRODUCTION (PRODUCTIVE LINE)	STANDARD PARTS: T - throughput time Q - quality conformance C - production costs C - capacity utilization	HIGH VOLUME & COMPLEXITY PRODUCTS: Q - production & assembly quality conformance C - machine & labour productivity

Table 3 - The manufacturing performances in relation to the type of the production and the complexity of the product (T= time performance; Q= quality performance; C= cost performance).

	TIME PERFORMANCES		QUALITY	COST
LOGISTICS	TIME	FLEXIBILITY*	PERFORM.	PERFORM.
IN-BOUND	supply readiness, punctuality and reliability (quantity & mix)	supply volume & mix flexibility	in-bound statistical control results	raw materials & parts storage level and stock rotation
INTERNAL	materials availability and flow synchronization	alternative routings and over-capacity availability	statistical process control (SPC) results	work-in-progress level and stock rotation
OUT-BOUND	delivery readiness, punctuality and reliability (quantity & mix)	delivery volume & mix flexibility	final testing and transportation security	finished products storage level and stock rotation

*flexibility is a time performance because it regards the time required to change something (volume, mix etc.) or, alternatively, the amount of change during a time interval

Table 4 - The performances of the logistics (time, quality and cost performances) in relation to the logistical flow.

The application of the framework

On the basis of the reference framework presented, a case-study was carried out: Zanussi Elettrodomestici S.p.A., a company of the Swedish Electrolux holding, is the biggest European producer of domestic appliances, with 1750* milliard Italian lire of revenues (around 0.92 milliard ECU), 7600** employees and several monoproductive plants (which belong to the washers, dish-washers, fridges & freezers, cookers divisions) [*2450 and **7900 with the commercial companies Zanussi Italia S.p.A. and Zanussi International S.p.A.].

Management-by-process and new "organisational figures"

At the present time, the company is introducing management-by-process by three new "organisational figures": 1. "Integrated Process Manager" (IPM), 2. "Integrated Management Areas" (IMA), 3. "Supply Centre Manager" (SCM), which are referable to the three processes indicated in the framework: 1. product development, 2. manufacturing and 3. logistics. This organisational revision took place after some pilot tests and now is operative in each division, except for the Integrated Process Manager and the Supply Center which are not a reality everywhere yet.
IPM is held responsible (a sort of "business process owner" - Rummler, Brache, 1990) for managing all the activities which lead to the industrialisation of a new product, planning the

resource utilisation and co-ordinating both all the phases of the product development and the involved departments (R&D, Engineering, Production, Purchasing).
IMAs figure as focused sub-plants, which co-ordinate on the shop floor, the activities of production, production planning, technology management, quality control and maintenance as one unified system, referring - if it is necessary - to the respective departments / staff units (Engineering, Quality Assurance, Marketing&Sales, Information Systems etc.). As a consequence, people involved in IMAs are both full time (as machine workers) and part time (as, for example, maintainers): these latter can work in more than one IMA and train and update themselves in the Engineering department. The typical configuration of IMAs is that of three IMAs, called "technology", "sub-assembly" and "assembly": each IMA is a ring of the manufacturing chain and operates in a "customer-in" logic. Each IMA manager is directly responsible to the division manager.
SCM controls the purchasing activities, in-bound logistics, material management and out-bound logistics; in other words he presides over the logistic flow which links the suppliers to the buyers, integrating a series of responsabilities which had been previously distributed within the organisation. The objective pursued is the flow link up, without interruption, from the entry to the exit of the firm.

The architecture of the performance measurement system and the indicators used in the management of the processes

The operations performance measurement system in Zanussi is subdivided according to process (IPM, IMAs, SCM), and regards three kinds of performances (cost, quality and time) and is summarized weekly in a "production performance report" and monthly in a "operational/financial report" and in a "quality report". Production managers, accountants and people from the Quality Assurance staff are involved. Now we will briefly describe the indicators used, following the framework proposed as an interpretative key of the performances in management-by-process.
IPM counts both costs and time spent by workers in product development activities, according to specific codes (regarding the type of activity, the product, the function or unit to which the worker belongs). The "carry over" index and the rate of parts reduction are other cost indicators used. Quality (reliability) performances are measured after having classified defects into four categories: critical (C), primary (P), secondary (S), tertiary (T), respectively regarding: the user safety, the product not working, the product efficiency decrease, and the product aesthetics. Quality (reliability) indices are calculated as the percentage of these defects emerging after pre-determined product working cycles (1, 6, 60); a weighted quality index for all kinds of defects is also calculated.
IMA performances are indicated in the "production performance report", which contains:
- the production levels (including line saturation);
- the productive line stops due to both lack of materials and machine breakdown (with the cost of maintenance), indicating causes and responsibilities (at the level of activity inside the IMA);
- the amount of rejects and scraps, with the specification of the causes and responsibilities (at the level of activity inside the IMA);
- the direct labour and total labour productivity (output per man-hour), and the machine efficiency (output per machine-hour, output per maintenance cost), where output is measured as first-pass quality and maintenance costs are both preventive and reactive;
- the variance-to-standard of each activity, so the time delays can be explained;
- the net machine working time in relation to the total time and the improvement in this ratio (corresponding to a reduction in set-up time);
- the work-in-progress and final stock levels.

All the information regards both the single IMAs and the whole manufacturing process, as a series of IMAs; some information also concerns the single activities which constitute one IMA. According to the scheme in table 3 and the comment in the text, we can find the confirmation that, for high production volumes and high product complexity (the Zanussi's context), the quality and cost performances are the most important.
SCM and the performances of the logistics are evaluated in terms of timeliness, quality and cost. The in-bound performances are not as crucial as the out-bound ones, due to the Zanussi's

advanced comakership policy and the E.D.I. (Electronic Data Interchange) with the suppliers; nevertheless vendor quality performances are monitored. The nature of "consumer products" requires complete customer satisfaction both as regards product reliability and mix availability. Final testing, packaging and stock management are therefore very important.
The "quality report" furnishes more detailed information on quality performances, while the "operational/financial report" links operational results to the economic ones (variance analysis and a progressive - from the beginning of the year - "profit and loss account" are drawn up). This latter is monthly compiled by the controller, integrating information from the weekly "production performance report" and the production resource consumption costs (materials, energy, depreciation quotas, wages etc.).

Conclusion

In this paper, the authors present a framework for the implementation of an operations performance measurement system in a manufacturing context where the management-by-process concepts are applied. The consequences of management-by-process on the requirements of the performance measurement system are underlined; the main performances and indicators to be used are specified for the processes considered fundamental in a manufacturing organisation: for each process, the performance characteristics and the differences in performances are underlined.
In addition, the application of the framework to an important and innovative context such as Zanussi, by means of the interpretation of the indications resulting from the empirical investigation, regarding the use of the indicators and the architecture of the performance measurement system, can furnish further useful elements to the firm that wishes to review and update its operations performance measurement system following the introduction of management-by-process and its advantages.
The process performances are considered in both an overall and an analytical way (for example, the whole manufacturing as a series of IMAs, each IMA as a set of activites). Customer satisfaction is the result of time and quality performances, with the indication of the responsibilities *along* the process which makes up the final value. Productivity and efficiency are considered cost performances, *linked* to the financial results, but have an impact on quality and hence *team responsibility* (regarding activities and processes) is more important than the individual one (regarding single workers and units).

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