Towards an integrated accounting framework for manufacturing improvement

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Towards an integrated accounting framework for manufacturing improvement

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Abstract

The accounting world is confronted with criticism on the relevance of its practices. This has led to improved allocation methods and improved methods for operational decision making. Until now few attempts are made to integrate these new accounting methods.

This paper presents an integrated accounting information framework to measure the economic consequences of manufacturing improvement decisions.

The notions "resource consumption" and "resource spending" are connected to build the framework. Within this context effectiveness, efficiency and productivity improvement are redefined. A project portfolio gives operations management the possibility to rank improvement projects based on magnitude, timing and economic results.

1. Introduction

Management accounting methods and techniques are developed for companies supplying standard products to a static market [1]. These companies set up a production plan for a limited number of product types on the basis of an annual sales estimate; the average production series, average stocks of semi-finished product, average use of available capacities and targets for material usage per lot as well as for direct labour and machine hours. "Production control" requires budgets per production department to enable real production and costs to be assessed every month.

The relatively low "overhead" costs are added to the finished product in the form of simple allowances. The main operations decisions aim at realisation of the production plan.

Costs per unit product can be kept low by "economies of scale", enabling the company to be competitive and increase its market share. There is a limited number of product variants and they are produced for stock, so that production is decoupled from fluctuations in demand. Operations management in such companies aims at improving efficiency by standardizing products at a high degree of utilisation of the available facilities for production and distribution. Management accounting provides the instruments for planning and control suitable for this situation: full cost product

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calculations, departmental budgets, cost variance analysis, economic lot sizing etc. A static market situation allows full management attention to be concentrated on the reduction of costs by improving operations efficiency.

Nowadays for many industrial enterprises in a dynamic market, the form of competition has shifted from low cost producing to offering value for the customer [2]. The planning horizon is relatively short and the demand for customer specific products changes frequently. The demand for special products is replacing the standard one. In addition, the product life cycle is much shorter. Because of the changing volume and mix of the order book, the decoupling stocks between sales and production keep increasing. Thus obliging companies to shift the decoupling point from the finished product to the semi-finished goods and purchasing parts [3]. In order to prevent the delivery time from becoming too long, customer-order-driven production, with no waiting time (Just in Time) is required. This means that speed after the decoupling point is more important than the lowest cost per unit. Given limited, adjustable short-term capacity, profitability of the company depends on service to the customer. Retention and growth of market share in a dynamic market is mainly determined by flexibility at operations level [4].

Production management must now concentrate on rapid throughput of the goods flow from the receipt of raw material till delivery of finished goods. Continuous adjustment of operations is required to ensure transformation of the goods between the department which follow one another in sequence. The importance of the financial results of an individual department is subordinate to achievement of market objectives by means of planning and control of the goods flow. In a dynamic market, good operations performance gives a positive contribution to the profitability of a company. Within the bounds of the investment in production and distribution facilities, management has to maintain the balance between the demand for, and the availability of capacity. Operations managers have to make decisions which involve the pros and cons of alternative measures and maximize the profit for the company within the planning horizon. Management accounting must indicate the extent to which the profitability of the company is influenced by operations changes in the short as well as the longer term. These changes alter the technical relationships in the transformation process and consequently the basis on which the standard costs and charges for manufacturing processes and products are calculated. That is the reason why the full costs concept (rates, intercompany prices etc.) can not be used for operations decisions in a dynamic market situation. The operations decisions change the technical relationships, on the basis of which the full costs are calculated. The problem posed in this article is how to measure the economic consequences of manufacturing improvement decisions.

We start Section 2 with the criticism on traditional management accounting systems and the research results on new methods for product costing [5]. Several authors have agreed that the new development accounting methods can help to increase the competitiveness of organisations. Others have denied that statement [6]. Anyhow, there is no general agreement about the role of management accounting systems in supporting manufacturing improvement. In Section 3 a cash flow approach to measure the economic consequences of manufacturing improvement projects is presented as an alternative to the traditional full cost approach. This economic view of a company focuses on the analysis of ingoing and outgoing company cash flows. The company cash flows are influenced by structural decisions affecting the installation of manufacturing resources and operations decisions affecting the use and improvement of available resources.

Section 4 presents an integrated accounting framework for the different accounting methods proposed in literature. This framework can be used for justification of manufacturing improvement projects and it connects the cost approach to the cash flow approach.

The presented framework incorporates parts of the basic structure for Activity Based Costing and helps operations managers to evaluate the consequences of improvement decisions on resource spending and sales income. Within this framework three indicators for measuring progress in improvement processes are specified: the Effectiviness-, Efficiency- and Productivity-Indicator.

In Section 5 some possibilities for application of the integrated accounting framework are presented. Three categories of improvement are specified: structural improvement, optimization of operations and improvement of operations. For operations improvement a sequence of analysis and some procedures for evaluation of improvement projects are proposed.

2. Evolution in management accounting

The last decade, the accounting world was confronted with a lot of criticism on the relevance of its practices. Not the entire accounting domain was attacked. The evolving business environment, changing rapidly from sellers to buyers market introduced new manufacturing concepts and techniques. This was no longer in line with the traditionally used *management accounting* techniques, of which one of the basic assumptions was "a relatively stable and predictable market environment and long product lifecycle". The accounting community responded to these changes and provided new management accounting concepts and techniques [1, 2].

The research to provide new adequate management accounting concepts can be divided into two groups. The first group focuses on research on improving cost allocation practices. The focus of the second group is on research on improving accounting information for decision making and control purposes.

2.1. *Research focused on "improved allocation practices"*

Most of the criticism on traditional management accounting systems concerns *product-costing methods* (more specific *cost allocation practices*). The problem of obsolete accounting systems in this perspective is described by Johnson and Kaplan. We need product-costing for more than one purpose (e.g., product-pricing, inventory valuation, cost control). If cost allocation is based on wrong assumptions, the associated calculated product-cost is useless for these purposes. Due to the proportional growth of indirect costs, managers complained about *arbitrary or erroneous allocation.* A lot of research and development has been done to refine the existing cost allocation methods to adapt the current, intricate situation of industrial organizations. In this context we want to mention the broader use of multiple overhead allocation bases and the introduction of activity based accounting. The issue of this research was to define methods to allocate indirect manufacturing costs as accurately as possible to cost objects. As a result of this research Acitivity Based Costing (ABC) has become very popular [7, 8]. The basic premise of these new cost system designs is that the occurence of an activity causes resource consumption. Activities are driven by the demands placed by the products. However, the scope of inferences that can be made from cost data collected by these systems is limited, because of the assumption of a strictly proportional relationship between the level of demand for a given cost driver and the changes in the cost of those activities [9].

2.2. *Research focused on "improved decision making"*

As mentioned in the previous paragraph, ABC has become very popular in accounting. A number of authors consider ABC also as an accounting tool that can be used to support operational decision making. Some authors do not share this idea. They state that "*cost accounting information is in principal unsuitable for decision making*" [6, 10]. This controversy reminds us of the vivid discussions about issues as "fixed versus variable costs" and "resource spending versus resource consumption" [8, 9]. Management accounting textbooks state that for decision making one should consider the relevant, influenceable costs. However, most cost accounting systems are mainly based on the full cost concept, for the purpose of product costing. For allocation reasons, the main structure of the manufacturing operations is modeled in terms of activities, resource consumption drivers and resource spending. ABC, as a full cost concept, is primarily focusing on the long term and assumes that resource consumption is linearly proportional to resource spending.

For the short and medium term this assumption often proves to be invalid. There always will be a time lag between consumption and spending changes. For example, if a logistics manager uses an available resource with idle capacity, then this decision will lead to increased resource consumption, but not to increased resource spending.

Because of the long term perspective of ABC, also no distinction is made between constrained resources (such as bottlenecks) and nonconstrained resources. On the long run such constraints can be eliminated. For short and medium term decision making this distinction is very important [11, 12]. The assumed linear relation between resource consumption and resource spending, and the fact that constraint resources are not taken into account, makes ABC accounting systems unsuitable for operational decision making.

There is also another reason for the unsuitability statement. In a dynamic market, operational management is often changing the product cost allocation bases in the short run. Cost calculations, based on a "long term allocation base" are used to justify operational (short term) decisions. Let us consider an "improvement decision". An improvement decision preliminary compares a number of possible decision alternatives. Each alternative is judged using the results of allocation based calculations. Usually the "best" alternative is chosen to be implemented. It is possible that the actual implementation of the decision alternative influences the allocation bases that were taken into account to justify the improvement decision. This change in the allocation base might invalidate the reasons why the alternative was considered "the best", before we implemented it. Apparently, such a justification cannot be considered to be reliable. What is missing is a simulation capability to predict the impact of alternative operations changes on actual changes in resource spending [9, 13].

2.3. *Different accounting methods for different purposes*

An interesting research question is the possibility of an integration of the proposed different accounting systems. Analysing the recent management accounting literature we conclude that there is much confusion about the potential managerial support of the new accounting systems. We distinguish the "allocation school" and the "decision support school". They differ from each other in their basic approach. The "allocation school" accountants consider the structure of the enterprise (capacity, products, markets, ...) to be influenceable. Their main question is "What structure does the enterprise need to be profitable?" The "decision support school" accountants consider the structure of the enterprise to be given. Their main question is "How can I get the maximum profitability using the structure?"

Both are directed towards improving the organization and the business processes. The first kind of improvement decisions are structural or long term improvement decisions. All costs will be influenced by these decisions. The second kind of improvement decisions are short term operations decisions. Most accounting systems use cash flow calculations to support structural decisions on capacity and product/market combinations. Why cannot we use cash flow calculations in operations decision making? In several case studies we have applicated cash flow calculations to support the decisions of operations management in using the available resources in a way that maximizes the net cash flow of operations. In the next section we introduce a cash flow based accounting method for decision support of operations management.

3. Cash flow based accounting

Company managers are judged by the shareholders on their capability to earn money with the funds made available to purchase machines, buildings, installations and to keep good stocks. The capital thus tied up is known as *investment*.

Besides *investment*, labour, energy and third-party services are usually required to transform the purchased goods into products for which customers are willing to pay. Money which has to be paid by the company in order to keep the transformation process going, is called *input*.

An industrial company can earn money for the shareholders by transforming goods (changing

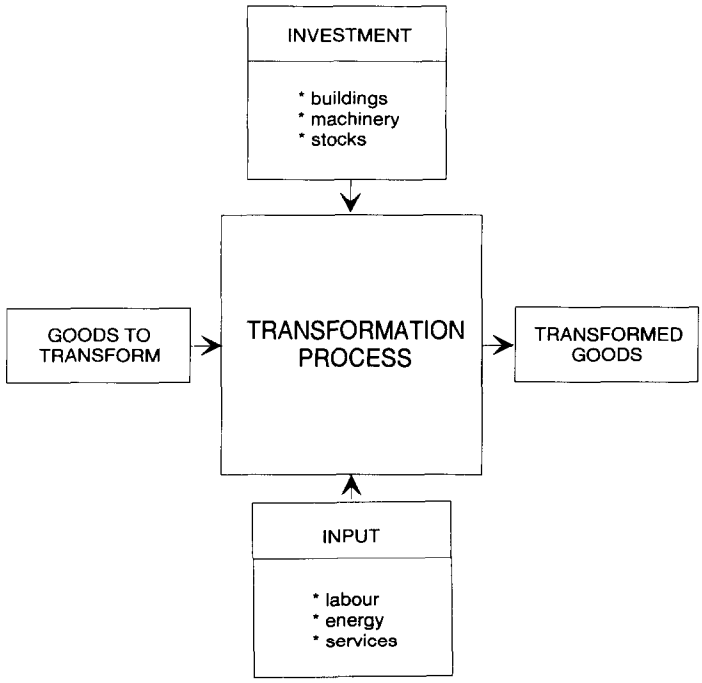

Fig. 1. Model of a manufacturing transformation process.

their shape, bridging time, or place) so that the customer is willing to pay more for these goods than the company has paid the suppliers of the raw materials. Fig. 1 is a model of this simple manufacturing transformation process.

Process engineering can reduce the required *input* and *investment* while the quantity of transformed goods remains unchanged. The difference between the money paid by the company in purchasing materials and the money received for the sold goods, is the *economic value* which the company has created. This economic value, measured within a period, is known as *throughput performance*. This performance is created with an *investment* and an *input*, as a result of preliminary structural decisions on installing the transformation process. *Performance* is influenced by the prices on the purchasing and selling markets and by the amount of material required for the goods sold. Re-engineering the transformation process will improve the throughput performance. Product engineering has the assignment to reduce the use of material per product unit. Process engineering has to improve process reliability to reduce rejects and loss of material. A very important improvement in *performance* per period can be achieved by acceleration of the goods flow through changing the planning and control procedures. Increased performance, while keeping the *investment* and *input* unchanged, contributes directly to the company's aim, which is to earn money.

By every decision on adapting the operations to market changes, the operations manager can judge the extent to which *performance*, *investment* and *input* are influenced by his decision. This requires an insight into all technical and physical changes in the facilities and goods flow resulting from this decision.

Whether a possible change of operations is also an economically desirable one, depends on the amount of money that can be earned through the change. The alternatives to change the operations can be regarded as possible projects. The consequenses to expenditures and receipts of money

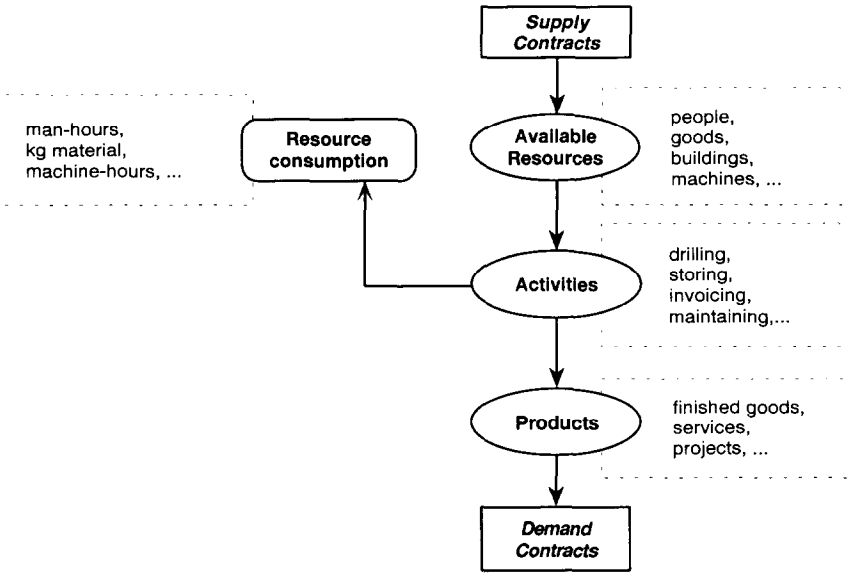

Fig. 2. Activity model of a manufacturing transformation process.

over the lifetime of each project can be calculated. The relative difference in earning power of the project alternatives determines the choice of a project. This can be measured by means of the operations cash flows. Applications of cash flow based accounting are presented by Corbey, Jansen and Wouters [14, 15].

Another example is the decision to invest in flexible manufacturing systems. These structural decisions are calculated on the basis of technical relationships of the existing transformation processes. Operations decisions change these relationships and cash flow based accounting enables management to forecast the real economic consequences of the operations decisions. Every potential operations decision can be regarded as a project with a specific cash flow potential. To estimate the consequences of operations decisions properly, insight is required into matters such as:

- the technical characteristics of the goods flow;
- the function of stock points;
- the possible volume bottlenecks in the production processes;
- the relationships between the goods flows and cash flows.

Industrial engineers and management accountants have to co-operate in developing information systems to support the operations decision making process.

In the next section we develop a framework for such information systems.

4. The integrated accounting framework

4.1. Framework description

We assume an industrial organization with a transformation process (see Fig. 2). In this transformation process, we achieve *products or services* by carrying out *activities*. An *activity* is defined as a set of actions to execute a certain function. Activities are usually identified with a verb (see Fig. 1: invoicing, drilling, drawing, ...). These activities consume resources (*resource consumption*). Resources are contracted with *supply contracts*. Products, services or projects (further on referred to as products) are sold by *demand contracts*.

The framework is expanded with the notions resource spending, sales income and company earnings in Fig. 3.

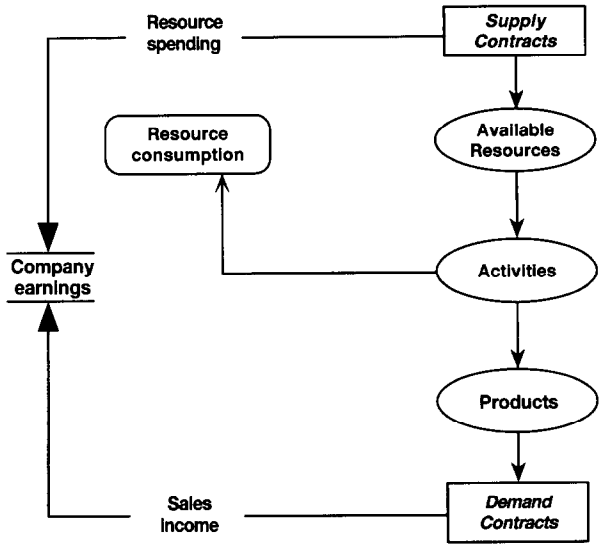

Fig. 3. Activity–Cash flow model of a manufacturing transformation process.

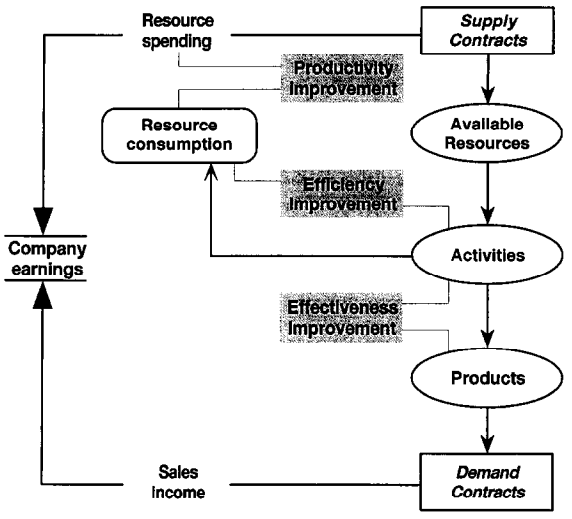

Fig. 4. Types of improvement.

Resource spending is the consequence of entering supply contracts (labour market, material market, services market). Sales income is the consequence of demand contracts between the customers and the enterprise, requesting for delivery of goods or services. Company earnings (or economic yield) are the results of sales income and resource spending, as a function of time.

Assuming that manufacturing improvement decisions aim for economic yield, information to support this type of decisions have to be expressed in terms of cash flows, in the sense of incoming and outgoing money, as explained in Section 3.

These cost approaches like ABC concentrate on the resource consumption. Reduction of resource consumption by reduction and control of product cost drivers results in reduction of allocated cost of resources. Replacing products with a high amount of activities by simple products reduces the resource consumption and in the long run the cost of resources for the sales mix.

For the short term there always will be a time lag between the reduction of resource consumption and the reduction of the cash flows for the contracted resources. To support the decisions of operations managers on manufacturing improving projects, cash flow based information will be more suitable than cost based information. These two types of information are connected in the framework (Fig. 3). Information on the contract conditions is the pivot of this integrated accounting framework.

4.2. *Definitions*

Using the framework (Fig. 3) it is possible to typify manufacturing "improvements". We introduce three types of improvement:

1. effectiveness improvement,
2. efficiency improvement,
3. productivity improvement.

A graphical representation is given in Fig. 4.

Effectiveness improvement focuses on the reduction of activities per product by simplifying and redesigning products and/or elimination of non-income-adding activities. The aim is "doing the right things seen through the customer's eyes". Nonincome-adding activities are activities for product properties and product qualities the customer does not notice and/or does not want to pay for. Since *all* activities are *drivers* for contracting resources (with their associated spending), a continuous strive to eliminate unnecessary activities

will lead to a reduction of resource consumption and to more effectiveness. The progress in the effectiveness improvement process is measured by the *effectiveness indicator*. This indicator expresses the number of necessary activities per sold product. In the accounting literature this indicator is called "product cost driver", because product costs are caused by the amount of activities to produce the product.

Efficiency improvement focuses on reduction of resource consumption per activity type. The aim is "doing the right things right". Improvement is caused by process re-engineering and results in changes of manufacturing procedures and working methods. Changes in manufacturing processes are directed toward reduction of the amount of resource consumption per activity. Sometimes there will be some economic trade-off between the replaced and the replacing resources. Replacing labour forces by machine capacity, for instance, may reduce the total amount of resource spending. The progress in the efficiency improvement process can be measured by the *efficiency indicator*. The efficiency indicator measured over several periods expresses the development of the resource consumption per type of activity. Based on the analogy of "product cost driver" one could call this ratio "activity cost driver". Activity costs are caused by the amount of resource consumption for executing the activities in the transformation process.

Productivity improvement focuses on the available resources of the company. The aim is reduction of resource spending per unit of consumed resource, by "contracting the right volume of resources". Improvement actions of this type call for changes in processes and in supply contracts.

First, one has to contract the resources in line with the pattern of the resource consumption. The consumption required can be derived from the market demand pattern. Overcapacity causes relatively high spending for the consumed resources.

Secondly, one can improve the resource quality. Bad quality implies partly useless, but paid for resources. It also implies relatively high spending for the resource units that are in fact available for consumption.

The progress in the productivity improvement process can be measured by the *productivity indicator*. The productivity indicator expresses the amount of resource spending per resource consumption unit. Based on the same analogy one could call this ratio "resource cost driver": the costs of consumed resource units are caused by the amount of resource spending for that resource. This amount is a result of the supply contracts to make the resource available.

4.3. Economic manufacturing improvement

Effectiveness as well as efficiency improvements may lead to a reduction of resource consumption. This does not necessarily imply a productivity improvement: a lot of resources are contracted for long term and cannot be balanced at once to the resource consumption, which is needed for execution of the activities for the current order portfolio. Examples of such resources are buildings, installations, machinery and some types of labour contracts. In a dynamic market there usually is no linear relationship between the resource consumption and the spending associated with the contracted resources. Therefore one should express first effectiveness and efficiency improvement by means of their impact on the resource consumption. Secondly, one should investigate how much and when the reduction of resource consumption will have impact on resource spending. A process oriented activity network provides the information to assess the resource spending consequences of possible improvement alternatives [9].

As long as manufacturing improvement projects only lead to a reduction of resource consumption, more idle capacity of available resources is created. An improvement of operations generates economic results, only if company earnings will increase.

The presented framework helps the operations manager to set the right priorities for manufacturing improvement projects.

5. Applications of the integrated accounting framework

The integrated framework for management accounting can be applied on three different

categories of manufacturing improvement: structural improvement, operations optimization and operations improvement.

Structural improvement is associated with investment decisions on (re)install engineering, production, distribution or marketing resources.

Operations optimization deals with matching the order portfolio to the available manufacturing resources.

Operations improvement deals with slight changes in the consumption of recources for products and processes (altering routings, raw materials, and so on).

5.1. Structural improvement

Structural improvement deals with the key question: "What resources do we need in the long term to ensure that the organization can perform its tasks to deliver the products requested by the market, in order to maximize the future net cash flows?"

An important part of the decision support information is the economic justification of the decision. Accounting textbooks and empirical surveys show that capital budgeting uses cash flow accounting (discounted cash flow, payback method, accounting rate of return, internal rate of return, net present value) to evaluate project alternatives economically. In the world of finance, we judge investment projects on their *net present value*. The net present value is the cumulative difference of cash expenditure and cash receipt, over the period of the project. All cash flows influenced by the evaluated decision alternative are considered [16, 17].

The amount of available transformation resources is determined by effectuating the best alternative for structural improvement. Often a structural decision immediately invokes outgoing money, and implies future outgoings (maintenance contracts, insurance policies, leasing, ...). We refer to these outgoings as *resource spending*, caused by supply contracts.

The framework (Fig. 3) can be used to simulate the effects of a structural improvement. The framework can be filled with information about resources, activities and/or products needed to create the new structure of the enterprise. Then the related supply and demand contracts can be added, enabling the system to predict resource spending, sales income and consequently company earnings as a function of time.

Since influencing this resource spending is impossible or at least expensive in case of intended breach of contract, structural decisions determine the available resources and *decision freedom* of operations managers who use these resources. Within this decision domain, they are responsible for optimization and improvement of these resources.

5.2. Operations optimization

Optimization of resources deals with the key question "How to realise the optimal fit of customer orders to the available resources?" The operations decision domain is restricted by the structural decisions on resources which are made on a higher hierarchical level.

We can identify the "economic optimum" using the same evaluation techniques as used for structural decisions: cash flow based accounting. Every optimization decision is considered as a project. The cash flows taken into account are the cash flows caused by tne decision alternatives. The decision horizon equals the planning period for manufacturing operations (predictable future). We will use the framework to evaluate the economic consequences of decision alternatives. First we assume *a given order portfolio*, unchanged during planning, scheduling and executing of the manufacturing operations. Later on we take *an influenceable order portfolio* into account.

5.2.1. Operational optimization with a given order portfolio

We can rephrase the key question mentioned above as "Which available resources do I use and how much do I consume for production of the contracted order portfolio within the requested lead time?" [3].

The available capacity consists of structural available resources (*long term contracts*) and *flexible resources* (such as overtime, hired forces and

outsourcing). The maximum amount of flexible resources is also limited by structural decisions made on a higher hierarchical level. Operations managers are instructed to produce the given order portfolio on time, with minimum outgoing cash flows. Operations management has to decide whether to spend more for flexible resources, or to reject potential customer orders. The optimizing criterion is: optimize the difference between the spending for the extra contracted resources and the incoming money caused by the extra sales demand contracts. We refer to these revenues as *sales income*. The responsibility of the decision makers is to maximize the difference between the incoming and outgoing money, given an order portfolio on the short term.

Using the framework, operations managers can determine the possibilities to produce this order portfolio within the requested leadtime. To achieve this mission they are allowed to use the available resources in any way they think appropriate (e.g. re-routing) as far as resource spending is not influenced. If the order portfolio cannot be produced within the requested leadtime, the framework will help to indicate how much flexible resources will be necessarily associated to the resource spending. Based on this information operations management can decide on flexible resources (overtime, outsourcing, postponing due-dates, and so on) within the given limit.

5.2.2. *Operations optimization with an influenceable order portfolio*

When the operations manager is allowed to influence the order portfolio, two decisions are possible: "extra sales" and "better sales".

Here we have to distinguish between limited and nonlimited resources.

In an environment with enough available resources, operations management can contract specific extra orders generating extra sales, by using these available resources. The framework can be used to simulate the results of the operations decisions on resource consumption and resource spending.

In an environment where resources are constraints for the production of potential orders, the available resources are insufficient and potential sales orders have to be passed. In such cases bottleneck calculations or optimization routines (e.g. linear programming techniques) are used to maximize the economic yield [17]. These techniques indicate which orders to select from the order portfolio to generate the maximum sales income. Bottleneck calculations can be carried out to determine the optimal product mix. Using the integrated accounting framework consequences of product mix changes for total resource consumption, sales income and resource spending can be simulated to support decisions on manufacturing operations.

5.3. *Operations improvement*

Operations improvement deals with the key question: "How to reduce the resource consumption by slight engineering changes of products and manufacturing processes?"

The economic consequences of each improvement project can be evaluated using the scheme of the integrated accounting framework.

5.3.1. *Sequence of improvement actions*

A certain sequence should be followed to avoid noneconomic improvement projects. Anyhow improving the efficiency of nonincome-adding activities is useless. Therefore we suggest the following sequence for analyzing for manufacturing improvement possibilities.

Step 1. Analysis of existing products, answering the question: "Can small engineering changes lead to a reduction of the necessary activities to produce and deliver the product with the same quality for the customer?"

This analysis may lead to an improvement of the effectiveness indicator.

Step 2. Analysis of all current activities, answering the question: "Are the activities carried out still necessary to produce and deliver products to the customer? Can we eliminate the nonincome-adding activities?"

This analysis may also lead to an improvement of the effectiveness indicator.

Step 3. Analysis of all income-adding activities, answering the question: "Can we carry out the necessary activities with less resource consumption?"

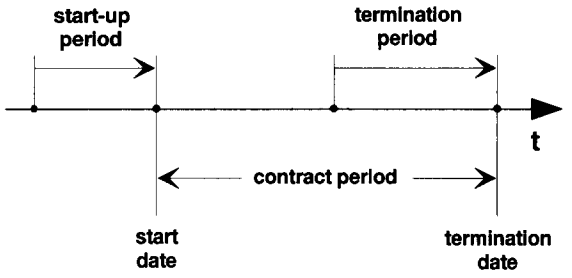

Fig. 5. Contract characteristics determining influenceability of cash flows.

This analysis may lead to an improvement of the efficiency indicator.

Step 4. Analysis of resource consumption in relation to the resource spending, answering the question: "Can we reduce the resource spending? Can we eliminate the unused resources?"

This analysis may lead to an improvement of the productivity indicator.

Effectiveness and efficiency improvement influence total resource consumption. If this leads to less resource spending and/or more sales income, an economic manufacturing improvement will be reached.

5.3.2. Influenceability of resource spending

Whether, and within which time frame total resource spending can be influenced depends on the supply contracts related to the available resources. Fig. 5 represents possible characteristics of contracts that may determine the influence. Management accounting has to provide information on these spending profiles for all resource categories.

The *start-up period* is the time needed between the date the demand for the supplied resource is given to the supplier, and the date the resource is actually available.

The *start date* is the date the resource will be available (planned start date), or was actually available (actual start date).

The *termination period* is the time needed between the demand for termination of the contract to the supplier, and the actual termination date of the contract. The termination date is the date the resource will no longer be available. The actual termination date is the date the supplier has been notified. Otherwise the termination date is planned.

The difference between the start date and the termination date is the *contract period.*

A contract information system should indicate the contracted and available amount of resource within the decision horizon for manufacturing improvement projects.

This contract information gives the possibility to predict if, and within which time frame, a reduction or expansion of resource consumptions will lead to a reduction or expansion of resource spending.

5.3.3. Sensitivity analysis of improvement projects

To support the decision on manufacturing improvement projects, the possible economic results of each alternative have to be quantified. This can be executed by the following procedure.

1. Determine the projected effect on sales income (within the chosen period).
2. Determine the projected effect on total resource consumption.
3. Determine the influence on total resource spending based on the projected resource consumption (2).
4. Determine the projected effect on company earnings (income-spending) within a time frame, and rank the projects by magnitude (amount of earnings). Information on economic positive projects is stored in a portfolio of improvement projects.

The output of a sensitivity analysis can be stored in an *improvement project portfolio.* As time goes on, this project portfolio will focus management efforts to the most promising manufacturing improvement projects, that can become active within the decision horizon. Based on magnitude, timing and necessary effort, the possible improvements can be given priority for execution.

There is also another advantage of a project portfolio. It is possible that improvements do affect resource consumption, but not enough to affect resource spending on its own. Instead of cancelling these ideas, one can store them in the project portfolio, because a combination of projects might later on affect resource spending. Incremental reduction

of resource consumption will reduce resource spending.

Economic improvement should be directed towards manufacturing changes, that leads to higher company earnings. However, it might be relevant to carry out improvement projects that reduce resource consumption, without reducing resource spending. For instance, extra idle capacity can be used to increase the multi-functionality of the contracted workers (spending the idle time on training, "on-the-floor" quality meetings, supporting product engineers, and so on) without spending extra money. Another example: "idle" workers increasing the capacity of a constraint resource. In both cases the initial improvement will not have impact on the company earnings within a period chosen for improvement projects; however later on the manufacturing flexibility will be improved by this kind of consumption of unused resources.

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