Chapter 2
Cost and Productivity Performances

Abstract This chapter faces the issue of company "cost" performances, i.e. performances that have a predetermined impact on the final performance of the business (in terms of profit and profitability) and can be expressed in mathematical terms. It not only refers to costs, but also to productivity performance, the level of inventories and the saturation of productive capacity. It goes on to provide an overview of the most recent innovations in Accounting Systems, the main financial ratios, Corporate Evaluation and Capital Budgeting for company investments. It concludes with an overview on modern Cost Accounting methods using Activity-Based Costing (ABC) systems, and examines the relationships between economic-financial results and "cost" performances, as these relationships are the core element when defining "cost" performance. This chapter comes to a close with information on Cost Performance Measurement and relationships between costs, productivity and efficiency.

2.1 Innovation in the Accounting Systems

In the past, accounting systems were the only type of performance measurement system available. Current performance measurement systems tend however to consist of, on one hand reviewed and updated accounting systems, and on the other by a section concerning customer satisfaction and non-cost performances (for a long time limited to times & methods and quality control only).

The latest innovations that were recently adopted by accounting systems include: company evaluation, capital budgeting and cost accounting, and the introduction of a hybrid accounting techniques, as shown in Table 2.1.

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Table. 2.1 Main innovations in accounting

	Traditional approach	Innovative approach
Company evaluation	• Reference to shareholders • ROE and ROI	• Reference to stakeholders • DCF • EVA
Capital budgeting	• Investment analysis and evaluation (pay-back, NPV, IRR, PI)	• Return map • CAGS
Cost accounting	• Indirect costs allocated on a single or multiple base	• Activity-based costing (ABC) • JIT Costing (Backflush costing and Throughput accounting) • Long-term Costing (Life-cycle costing and Target costing)
Hybrid techniques	• Not present	• Opportunity costs • Incoming and outcoming costs • Costs of quality

2.2 Balance Sheet Indicators and Corporate Value

The Annual Report is the main accounting document produced by companies. Further to being a statutory-tax obligation, it also constitutes an important overview of company performances, with regards to the economic and financial aspects.

In particular, it not only highlights *turnover*, breakdown of costs and therefore *profits* for the year, but it also allows readers to calculate a number of indexes starting with the company's rate of *profitability*.

In fact, the income statement provides extremely important partial subtotals, known as margins, such as EBIT (Earnings Before Interests and Taxes), EBITDA (Earnings Before Interests, Taxes, Depreciation, and Amortization), and EBT (Earnings Before Taxes).

By comparing various aggregates of balance sheet entries and items, it is possible to construct the *balance sheet indicators*, the most important being:

1. *Return On Equity* (*ROE*), ratio between profit and equity
2. *Return On Assets* (*ROA*), ratio of operating income including financial management (EBT) and total assets
3. *Return On Investiments* (*ROI*), ratio of operating income on core business operations (EBIT) and assets net of financial entries
4. *Return On Sales* (*ROS*), ratio of operating income on core business operations (EBIT) and sales revenue
5. *Rotation of invested capital,* the ratio between revenue and assets minus the financial entries
6. *Rotation of receivables,* the ratio between revenues and trade accounts receivable (the inverse determines the collection time of receivables)
7. *Rotation of payables*, the ratio between purchases and trade accounts payable (the inverse determines the accounts payable time; the difference, which is hopefully positive, between the payments time of accounts payable and the

collection time of accounts receivable determines the so-called *Cash Conversion cycle*)
8. *Liquidity*, ratio between immediate and delayed liquidity (the latter essentially referring to accounts receivable) and current liabilities (a good value for this indicator is equal to 1)
9. *Cash on hand*, ratio of current assets (given by cash in hand and deferred cash plus inventories) and current liabilities (a good value for this indicator is equal to 2)

ROE, which mainly interests shareholders can be broken down into three different elements factors, as a product of ROA, the *debt ratio* (the ratio between total assets and equity) and impact (return on operating income including financial management).

ROI is used to evaluate operating managers and can be broken down into two elements: ROS and the rotation rate of invested capital.

Turnover, EBIT, ROE and ROI are the primary indicators of a company's performance and consequently, over time, the value of the company itself (in addition to shareholders' equity).

Another version of the *debt ratio* is given by the ratio between liabilities (or borrowed capital) and equity. This ratio is considered in the *financial leverage* equation, which links ROE to ROI:

$$\begin{aligned}
\mathrm{ROE} &= \mathrm{NI/E} = \mathrm{OI/A} * \mathrm{A/E} * \mathrm{NI/OI} = \mathrm{ROI} * (\mathrm{L}+\mathrm{E})/\mathrm{E} * \mathrm{NI/OI} \\
&= \mathrm{ROI} * \mathrm{NI/OI} + \mathrm{ROI} * \mathrm{L/E} * \mathrm{NI/OI} = \mathrm{ROI} * (\mathrm{OI}+\mathrm{FI}-\mathrm{FC}-\mathrm{T})/\mathrm{OI} \\
&\quad + \mathrm{ROI} * (\mathrm{OI}+\mathrm{FI}-\mathrm{FC}-\mathrm{T})/\mathrm{OI} * \mathrm{L/E} \\
&= \mathrm{ROI} + (\mathrm{FI}-\mathrm{FC}-\mathrm{T})/\mathrm{A} + \mathrm{ROI} * \mathrm{L/E} + (\mathrm{FI}-\mathrm{FC}-\mathrm{T})/\mathrm{A} * \mathrm{L/E} \\
&= \mathrm{ROI} + \mathrm{ROI} * \mathrm{L/E} + (\mathrm{FI}-\mathrm{FC}-\mathrm{T})/\mathrm{E} \\
&= \mathrm{ROI} + [\mathrm{ROI} \; + (\mathrm{FI}-\mathrm{FC}-\mathrm{T})/\mathrm{L}] * \mathrm{L/E}
\end{aligned}$$

where NI is the net income, E the equity, OI the operating income, A the assets, L the liabilities; furthermore FI, FC, T refer respectively to financial income, financial costs, and taxes. The terms inside the square brackets refer to financial leverages, the difference between interest receivable (operating profitability) and interest payable (basically interest on borrowed capital); this difference is, in fact, the "leverage" on CT/CP. It is clear that satisfactory operating results (represented by ROI) may not necessarily correspond to a similar positive return on equity (ROE) due to a negative leverage effect (excessive financial costs).

Company assessment based on traditional financial indicators was revolutionised by the works of Rappaport (1986). His "value strategy" is not based on economic-financial indicators (such as ROE), but on "shareholder value", defined as "corporate value minus liabilities". Corporate value is given by current cash flow (Discounted Cash Flow – DCF) within an estimated deadline, plus a residual value, plus marketable securities.

More recently, the consulting firm Stern Stewart (http://www.sternstewart.com) developed a tool called EVA (Economic Value Added) used to measure company value which has been defined by the magazine Fortune as the most important and updated method, and the best proxy concerning the generating of economic value within a company. It is the difference between operating cash flow (after taxes and before interest) and the average cost of capital multiplied by invested capital (i.e. the sum of working capital and net fixed assets).

The “economic theory of value” that both these methods can be classified as, despite the objective difficulty in forecasting future cash flows and defining discounting ratios, make it possible to overcome the short-term characteristics of financial indicators and eliminate the effects of short-term accounting strategies.

2.3 Capital Budgeting: Investment Analysis and Evaluation

Cost management alone is not sufficient when contemplating cash flow variables: it is in fact standard practice to conduct a *financial* analysis in combination with the *economic* analysis, where all the costs are assigned a time span.

In particular, there are some corporate projects which distinguish themselves for the deferred collection dates compared to the outlay data: these refer to investments for which the capital required has been allocated over time (“Capital Budgeting”).

Any kind of *investment* (in factory plants, in new products, the opening of a branch, etc.) can be defined as a succession of net cash incomes and net cash expenditure, structured in a manner where, at the beginning, the outlays (costs) prevail over income (revenue).

Any investment most undergo two typical phases of analysis and evaluation.

The *investment analysis* phase consists in:

– The quantification of incoming and outgoing cash flows pursuant to an investment, that is, respectively the estimated costs and expected returns
– The distribution of such cash flow over time
– The monetary value of such time, expressed by an interest-rate
– The risk level, that is the uncertainty of all three points above

The next *investment assessment* phase consists in:

– The identification, selection and application of one or more assessment criteria for the investment profile in view of the results of the previous phases
– The defining of acceptance criteria, which are consistent with corporate strategies, short, medium and long-term objectives, technical feasibility, risk exposure, compatibility with other current and future investments etc

Whilst the analysis phase depends greatly on the intrinsic nature of an investment, the evaluation phase uses a fairly standard set of methods, which aim to assess the following aspects of an investment:

• The increase in generated *net income* (the difference between revenues and costs)

- The *profitability* level (ratio between all revenues and costs incurred)
- The *risk* level (referring in this context to an economic not a technical risk)

The most common methods used to evaluate financial *performance* are:

1. The Net Present Value (NPV) for the evaluation of income
2. The Actual Rate of Return (ARR) for the evaluation of profitability
3. The Pay-back method to contain risks when calculating cash flow estimates
4. Internal Rate of Return (IRR) for the evaluation of the risk level when estimating discount rates

2.4 Cost Accounting

Costs are classified using a variety of methods: by nature or kind, by variability of volumes, by direct allocation – without objective criteria – by product and cost centre on a timeframe basis (Fig. 2.1).

One of the main problems in this respect is to achieve a calculation of any product cost which is as realistic as possible: in fact, the only objectively measurable costs are those defined as being original "by nature", related to the consumption of productive factors and quantified by invoices payable, that is purchase invoices.

In reference to Fig. 2.1, particular attention should be given to the distinction made between *variable* and *fixed* costs on the one hand, and *direct* and *indirect* costs on the other.

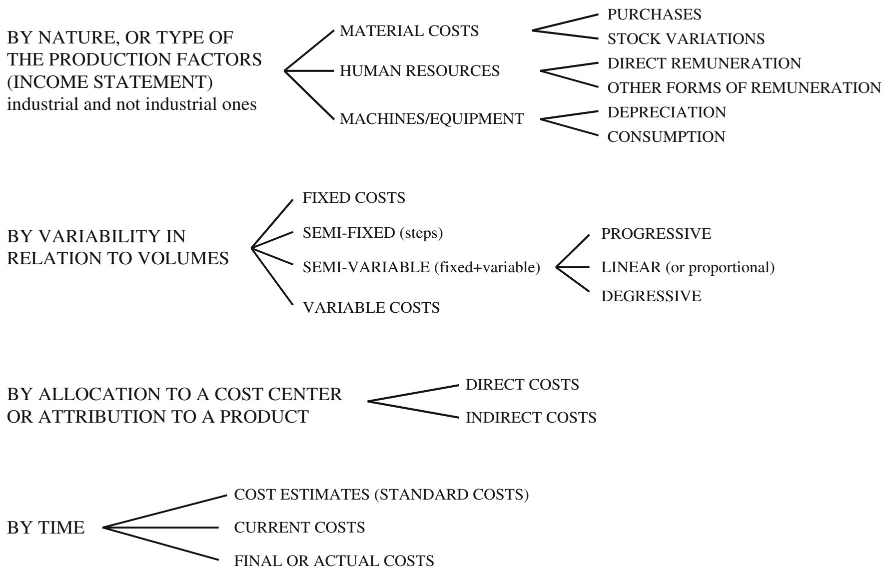

Fig. 2.1 Cost classification

As the variable costs are normally fairly simple to allocate to a specific product (such as materials, direct labour and energy expenses, the latter in relation to specific machines or single product lines and specific cycles in the case of multi-product lines), the synonyms variable costs and direct costs are often used. In actual fact, there are also indirect variable costs (for example, consumptions which are not specified in any specific production list) and direct fixed costs (for instance, depreciation of a single product line, which can be directly allocated to the product without any risk of subjective interpretations).

The difficulties encountered when attempting to conduct an accurate and reliable calculation of the full cost of a product, consist in the allocation of indirect costs which, by definition, are not easy to allocate immediately to a specific product. Figure 2.2 shows the traditional allocations of costs (classified as fixed/variable and direct/indirect costs) to the cost centres ("localisation") and to specific products ("allocation").

Activity-Based Costing (ABC) is one of the most important innovative techniques used in Cost Accounting and was developed to meet the need to provide full costing of a product based on the allocation of indirect costs using a single or multiple criteria (direct labour, cost of materials, total machine hours per product). In fact, the present variable direct costs decrease (especially the portion of labour costs) in relation to the increase in indirect production costs (due, for instance, to the depreciation of automated plant systems), design costs, sales and administrative costs; this can generate significant distortions in full costing calculations which are, however, fundamental for many strategic corporate decisions.

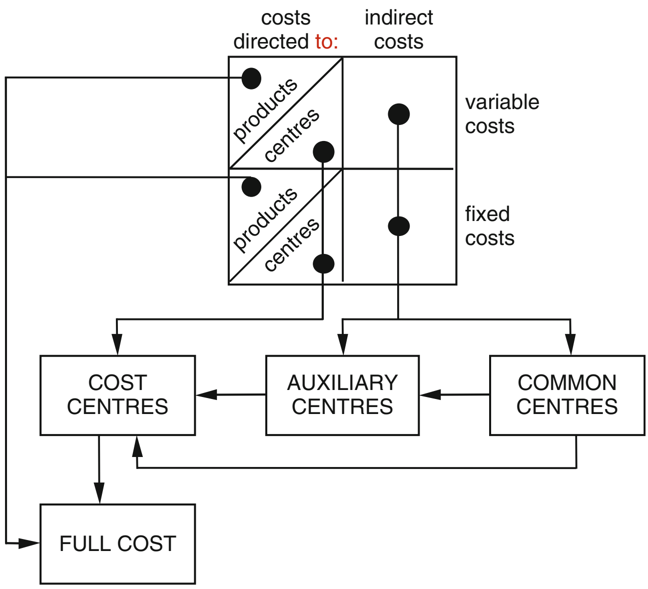

Fig. 2.2 Traditional allocation of indirect costs through cost centres

Miller and Vollmann (1985), in their renowned article in the Harvard Business Review, argued even then that indirect costs do not depend on production volumes, but on transactions, hence distinguishing between:

– Logistic transactions (such as customer orders and handling)
– Balancing transactions (i.e. all activities related to space–time availability of materials, manpower and machines to meet demands)
– Quality related transactions (e.g. quality procedures and control)
– Change related transactions (following the start up of new projects or modifications to existing ones)

Cooper and Kaplan (1991) on the other hand argue that indirect costs are "guided" by complexity, while direct costs on mainly variables and therefore guided by volumes; they identified four different types of activities that determine costs, each of which is guided by *drivers* ("cost causes") of a variety of different natures:

– Production activities (direct labour, materials and energy, whose driver is represented by production volumes)
– Activities which support the operating of manufacturing plant systems (such as maintenance)
– Activities which support the realization of manufacturing phases (such as machine tooling)
– Activities which support the product (such as product development)

ABC is a technique that aims to calculate the full cost of a product, starting from the cost of consumed resources. The allocation of resource costs to individual products is not performed via the cost centres, as is traditional common practice (Fig. 2.2), but it is mediated via the activities (Fig. 2.3): i.e. the activities consume resources but products consume activities and not resources.

This means that there are actually two *stages*:

- Stage one, where the cost of resources are allocated to activities (by means of "first-stage drivers", also called "cost drivers" or "resource drivers")
- and Stage two, where the activities are related to the products (by means of "second-stage drivers" or "activity drivers")

2.5 Relationship Between Cost Performance and Economic-Financial Results

As shown in Fig. 1.3, *cost performances* are characterized by their direct and explicit impact, using mathematical expressions, on the company's final result (profit = revenue – costs, and profitability = profit/investment).

The *cost performances* include:

1. The *costs* of resources used in the production processes or to provide services

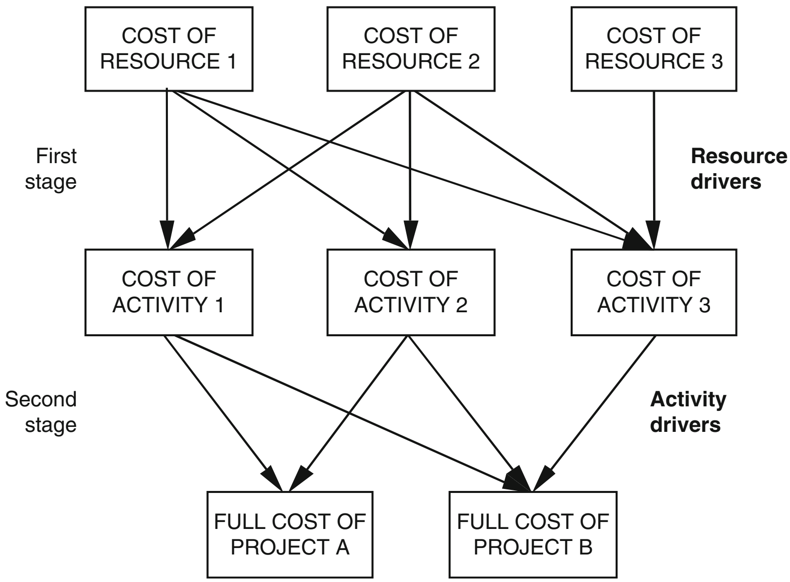

Fig. 2.3 Calculation of full product cost according to Activity-Based Costing (ABC)

2. The level of working capital, making particular reference to the physical aspects, i.e. *inventory*
3. The *saturation* level of plant, machinery and equipment, that is all resources subject to amortization
4. The employee *absenteeism* rate
5. The *productivity* of resources, human and otherwise

In the case of costs, the relationship is clear, as profit is the difference between revenue and costs. As far as inventory levels are concerned, it can be assumed that the impact on final performance is the cost of tied-up capital which is equal to the value of inventory multiplied by the average periodic costs of finance capital (interest payable). In the case where a saturation level occurs, a 100% non-use of an amortisable resource is classified as a waste of resources, i.e. an additional cost equal to the unused percentage.

The relationship between productivity and economic-financial results is less direct, especially profitability. There are, however, some accurate reports, the most famous being the one produced by Professor Gold (1955). In Gold's model, labour productivity (output/manpower hours), material productivity (output / material units) and capital expenditure productivity (Output/Technical Investments) are compared to total costs (TC) and one of the main profitability indicators (ROI = Profit/Total Investments).

Developing the ROI seen below with a Profit (P) figure given by Total Revenue (TR) minus Total Costs (TC), where C is the production Capacity and TT the Technical investments:

$$\begin{aligned}\mathrm{ROI} &= \mathrm{P/TI} = (\mathrm{P/O}) * (\mathrm{O/TI}) = (\mathrm{TR} - \mathrm{TC})/\mathrm{O} * \mathrm{O/C} * \mathrm{C/TT} * \mathrm{TT/TI} \\ &= (\mathrm{TR/O} - \mathrm{TC/O}) * \mathrm{O/C} * \mathrm{C/TT} * \mathrm{TT/TI}\end{aligned}$$

ROI is expressed accorded to:

– The unit price of the product (TR/Output)
– The unit cost of the product (TC/Output)
– The productivity of capital expenditure (Output/Technical Investments), factored as (Output/Capacity) × (Capacity/Technical Investments), where the first factor (Output/Capacity) corresponds to the degree of saturation of the plant, whilst the second factor (Capacity/Technical Investments) indicates whether or not the purchases made were correct
– The relationship between capital expenditure in technical investments and total investments

At this point, the unit cost of the product (TC/Output) is given by the sum of Salary Costs (SC), the Cost of Materials (MC), and Fixed Costs (FC), which can be broken down even further as follows:

$$\begin{aligned}\mathrm{TC/O} &= \mathrm{SC/O} + \mathrm{MC/O} + \mathrm{FC/O} \\ &= \text{hour cost} * (\text{manhours}/\mathrm{O}) + \text{material unit cost} * (\text{material units}/\mathrm{O}) \\ &\quad + (\mathrm{C/O}) * (\mathrm{FC/TT}) * (\mathrm{TT/C}) \\ &= \text{hour cost/labour productivity} + \text{material unit cost/material productivity} \\ &\quad + \text{depreciation rate/capital expenditure productivity}\end{aligned}$$

where the "depreciation rate" is defined as FC/TT, while (Output/Capacity) * (Capacity/TT) is already the defined productivity of capital expenditure.

Thus, physical technical productivity has therefore been linked explicitly to profitability.

2.6 Cost Performance Measurement

Production costs – but also, sales and administrative costs when correctly allocated – can be grouped into three types according to the three main production factors (Fig. 2.1):

1. *Materials*, referring generally to all raw materials, semi-finished and assembled materials which form an end product, further to other consumables (such as lubricating oils of stationary). These costs are measured by adding the value of purchases to the changes in inventory within a specified period.
2. *Human resources* (costs related to direct salaries or wages, and deferred remuneration such as severance pay).

3. *Machinery, plants and equipment*, i.e. depreciable assets. This term refers to all assets that are used over a number of years and are subject to technical and economic depreciation; for these assets, the purchase value is distributed over time, using a depreciation plan: a cost referred to as "depreciation expense" is therefore charged to a specific period. The cost of these production factors is hence given by depreciation expense plus the cost of consumables directly allocated to the machines themselves, such as lubricating oils and spare parts.

The three main production factors can therefore be summarised into two: materials and productive capacity, the latter consisting of labour and machines: the ratio between costs of machinery and labour costs is an indicator of the *level of automation*.

Apart from measuring the cost itself, it is particularly important to control the variations that occur compared to the set standards or targets, usually found in the document called the "Budget". The *variance analysis* makes it possible to identify the causes of variations in product costs (or contract expense) as a result of the interaction of changes in prices and production efficiency (of a resource or resource group, and between different resources: materials, human resources, machines).

Referring to Fig. 2.4, it is possible to initially estimate a cost, for each product and each resource used to produce a single product, which derives from a combination of the cost or unit price of the resources required (the ordinate) and the utilisation rate of that same resource to realise one product unit (the abscissa); for example:

$$\text{€/manhour} * \text{manhours/product} = \text{€/product.}$$

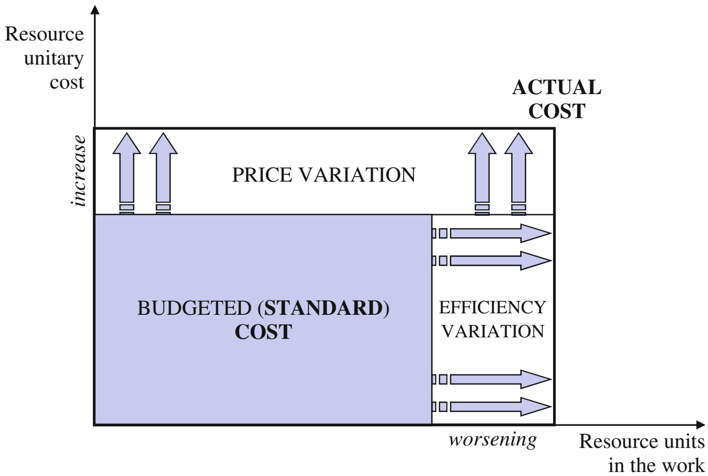

Fig. 2.4 Variance analysis between budgeted and actual costs due to variations in the price of the resources and in efficiency

The total area of the actual cost is given by the sum (algebraic) of the three areas: the estimated cost, the change in resource prices, changes in production efficiency in resource consumptions (which worsens when moving to the right and improves when moving to the left, because in the latter case fewer resources have been used – in fact in the abscissa we have the inverse of productivity – See next paragraph). It should be noted that the area undergoing price variations is not only generated by the estimated cost, but also by the deterioration (or improvement) in production efficiency.

The term *working capital* is used to describe the short-term assets on the balance sheet. As far as the production systems are concerned, what is of interest for operational purposes is the physical working capital, i.e. inventories (raw materials, semi-finished and finished products) and the Work-In-Progress – WIP (material currently being processed), and not all the working capital, which also includes immediate (e.g. cash) and delayed (such as trade receivables) liquidity.

Once again, when referring to inventory, the *stock rotation ratios* can also be calculated:

- Finished goods, as the ratio of sales turnover (annual) on finished product inventory (value indicated on the balance sheet as at December 31)
- Semi-finished goods, as the ratio between periodic consumption and average stock for the period
- Raw materials, as the ratio of purchase values (annual) and raw material inventory (again on the balance sheet as at December 31)

The saturation of production capacity (referring to both personnel and depreciable assets, such as machinery, plant, equipment, etc.), generates a "cost" performance, because – as mentioned earlier – it can be valued in terms of waste due to its non-use value.

In the case of depreciable assets, this value refers to the average percentage of non-use, applied to periodic depreciation expense.

In the case of human resources, the value corresponds to the absence rate multiplied by company personnel costs. The diagram in Fig. 2.5 shows how *practical availability*, minus absenteeism, does not provide the number of production hours,

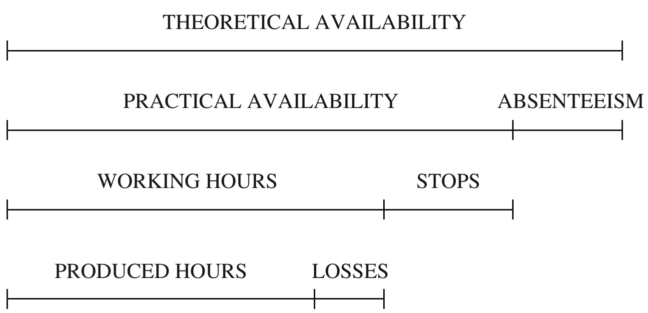

Fig. 2.5 Personell saturation

as the calculation also has to take into account *down-times* (for maintenance, tooling, startup, etc.) and the *losses* (relative to scrap and reworking); the production hours correspond to the "good" quality amount produced per cycle time.

2.7 Efficiency and Productivity Performance Measurement

To start with, it is best to clarify what the terms productivity and efficiency actually mean as they are often mistakenly used as synonyms: productivity is a ratio between output and input, while efficiency is the ratio between productivity and a standard:

$$\text{productivity} = (\text{actual output})/(\text{actual input});$$

$$\begin{aligned}\text{efficiency} &= [(\text{actual output})/(\text{actual input})]/[(\text{standard output})/(\text{standard input})]\\ &= [(\text{actual output})/(\text{standard output})]/[(\text{actual input})/(\text{standard input})].\end{aligned}$$

Productivity is therefore expressed by a ratio between quantity (or value) of a realised product and the quantity (or value) of used resources, while efficiency is expressed by a number, usually less than one unit (if the set goals or standards are ambitious, rigorous).

Efficiency should not be confused with efficacy; *efficacy* is the ratio between actual output (or performance) and the desired output (or performance). Therefore efficacy measures the ability to achieve goals, regardless of the input (resources) used.

Productivity can be measured by quantity or value, if we refer respectively to output ratios and physical or monetary input; this choice is related to the homogeneity of the numerator products and/or denominator resources. If such homogeneity exists, it is preferable to refer to physical quantities, to avoid the problem of variability of prices over time (e.g. the same performance in productivity may appear different simply due to changes in inflation). It is however possible to use "deflators" for prices or consider products and resources to be "equivalent" (for example, a medium sized car can be indicated as 1.4 in relation to a small car).

The inverse productivity of a resource is represented by the *standard cost* for a resource; the latter is in fact the optimal cost in relation to one unit of output (given by the ratio: input value/output quantity, which is the exact inverse of productivity).

Productivity can be measured as:

- Organisational performance as a whole (*total productivity*)
- Performance in relation to the use of a specific resource (*partial* or "single-factor productivity")
- Performance obtained as a synthesis of partial results (*weighted productivity*, weighted sum of partial productivity)

- *Value-added productivity* (where value added, defined as the difference between output value and input value, is compared to value of input after deducting the cost of materials)

One should remember that, among the many types of partial productivity (defined by the O/I_i ratio), we also have:

- Labour productivity (direct and/or indirect)
- Material productivity (which considers the quantified amounts of raw materials and components used to obtain the finished products)
- Energy productivity (which compares machinery consumptions with the amount of production obtained)

It is therefore to consider the productivity of a combination of resources such as: $O/\Sigma_i I_i$.

It is obvious that productivity must not be achieved at the expense of quality, and therefore the output used in the productivity rate must refer to good products. To take this aspect into account, some variations have been proposed when measuring productivity, including the *Overall Equipment Effectiveness (OEE)*, which not only takes into account Efficiency, but also includes Machine Availability (available time/total time) and Quality Yield (good pieces/total pieces):

$$\text{OEE} = \text{Availability} * \text{Efficiency} * \text{Yield}$$

As we will see in the chapter on time performances, Machine Availability is, on one hand, given by the ratio between available time and total time, on the other hand it is the result of Machine Reliability (how often the machine breaks down) and Machine Repairability (how long it takes on average to repair it).

Machine Availability should not be confused with Machine Saturation; the latter measures how much of the available time was actually used.

The measurement of productivity also raises other issues:

- Attention must be paid to “double counting”, i.e. intermediate outputs that become inputs for the next processing phases.
- Proper time intervals must be considered so that certain inputs correspond to the output generated by the same input.
- Productivity must be calculated using produced units, and not sold units, and take into account the risk of not being able to sell all the products at a certain price in the case of an excessive increase in quantity.
- Increased productivity must not deteriorate other performances, such as the aforementioned quality, or the financial expense on current assets, nor increase maintenance costs as a result of overuse of plant systems; it must not be achieved at the expense of performance levels in another department: for example, causing downstream congestion and consequent delays.
- In order to achieve comparability over time, all changes made to product and mix specifications must be taken into consideration, further to innovation (with expensive investments) of production processes.

Productivity can increase, or due to an increase in output with equal input, or due to a decrease in input with equal output, or following the occurrence of both conditions: $(O+\Delta O)/(I-\Delta I)$.

It is possible to measure productivity changes in percentages as $100(P_t-P_{t-1})/P_{t-1}$, considering the percentage change in productivity over time, with a sufficiently long timeframe, and in the absence of seasonal phenomena. However, especially when referring to efficiency, the definition of standards must include the *learning curve*, i.e. the fact that, over time, one learns to do the same work in less time.

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