BONUS CHAPTER
Time and Productivity

Chapter Outline:

Why are time and productivity important?

To manage operations, the range of services and products provided by an organization are scheduled, using time as the common denominator. Similarly, the input/output ratio that comprises productivity is at the core of the drive for greater efficiency within organizations. The definition and composition of both time and productivity are, therefore, essential features of the task of managing operations.

Executive Overview

This chapter addresses two important dimensions that are central to managing operations:

- **Time** – measuring how long a job should take.
- **Productivity** – measuring the outputs from a system in relation to the inputs that go into their creation.

On reflection you will clearly recognize the link between these two aspects of operations, as the measurement of time will invariably form part of measuring the outputs and inputs (the numerator and denominator respectively) of the productivity calculation.

The layout of the chapter reflects the link between these two aspects by incorporating them in the same chapter and the separate perspectives involved by addressing each in its own section. First we will discuss the aspect of time, with the section on productivity coming later. An overview of the aspects covered in the chapter are:

- **Why time is the common denominator of operations management** with illustrations to highlight this issue.
- **Measuring the content of work** – measuring work sets out to answer the question, how long should a job take? This section overviews the approach to follow.
- **Approaches to measuring work content** – as jobs are different, the approach to measuring jobs will also differ. This section illustrates how the approaches to measuring short repetitive tasks, long non-repetitive tasks and techniques to measure capacity utilization and requirements differ, giving examples of each.
- **Productivity** – what it is and what, in general terms, it measures.
- **Productivity and efficiency** are compared to help distinguish between these two dimensions used in evaluating the improvement results.
- **Approaches to measuring productivity** are discussed and the difference between single-factor and multi-factor measures and the use of added value is explained.
- **Ways to improve productivity** are outlined and the link between these and the next chapter on the ways to improve performance in operations is established.
- **Service applications** – with the growing importance of the service sector in the more advanced economies, the need for and ways to secure productivity improvements in service businesses are discussed.

Time – the common denominator in managing operations

The two dimensions used by a business to control its activities are time and money. Time is the basis for tasks such as planning, estimating, costing and payment systems, and money is the basis for trading, accounting and financial reporting.

Whereas the money dimension is primarily explained through accounting and finance, it is through operations management that an understanding of the time dimension may be gained. It is essential, therefore, that operations managers fully understand how work may be measured and are able to choose the most appropriate method of measurement to meet a given requirement. This section explains these aspects of the task. Furthermore, operations managers must understand both the time and money dimensions in themselves and ensure that the translation from one to another is both accurate and appropriate. For, whereas operations is managed on a time base, the costs associated with services, products, customers and investments will be reported in terms of money.

This opening statement explains that operations uses time as the common denominator for assessing, controlling and managing many of its activities. The question is, why? To explain let us use three examples.

Example 1 – Conform

A glance back at Exhibit 8.3 shows that the nine products made on day 1 of that week all had different standard times. Therefore, to use the quantity of products made as the measure of how good a day was or as the basis for calculating capacity requirement would be of little value. Making 100 of product reference 2766 at 3.0 standard minutes each is not the same as making 100 of product reference 1229 at 36.0 standard minutes each.

Example 2 – Heath Motors

Heath Motors makes three small electric motors for a wide range of applications. As in Example 1, to use the quantity of products as the basis for calculating capacity requirements or to assess weekly performance would not provide a meaningful approach to these and other dimensions of operations, as Exhibits 1 and 2 illustrate. Using quantity as the basis for assessing output, Exhibit 1 shows that week 2 appears to be a much better period than week 1. The factor missing from this assessment is how long it takes to make each different motor. When these data are introduced (see Exhibit 2), it can be seen that, in terms of hours, the output for weeks 1 and 2 is very similar.

Exhibit 1:

Heath Motors – output in terms of units produced

Week	Electric motor type	Quantity produced	
		#	Total
1	HM 40	100	
	HM 60	100	440
	HM 80	240	
2	HM 40	480	
	HM 60	200	830
	HM 80	150	

Exhibit 2: Health Motors – output in terms of hours produced

Week	Electric motor type	Quantity produced (#)	Time per product (hours)	Hours produced	
				#	Total
1	HM 40	100	0.5	50	1160
	HM 60	100	1.5	150	
	HM 80	240	4.0	960	
2	HM 40	480	0.5	240	1140
	HM 60	200	1.5	300	
	HM 80	150	4.0	600	

Example 3 – John Michael

For the owner of John Michael (see Exhibit 8.4) to determine how many hairdressers would be required or to assess the output of a day based upon the number of customers served would be misleading. The time taken will depend on whether a customer has a simple wash, cut and blow dry or a perm. Yet the factor of time needs to be included when calculating capacity, scheduling appointments, measuring performance and determining costs.

Measuring the content of work

The purpose of measuring the content of work is to establish the time for a qualified person to complete a specified job at a defined level of performance.[1] In other words, measuring work sets out to answer the question, 'How long should this job take to complete?' As the time dimension is the basis for managing most key operations activities, establishing times and knowing what the statements used to express time comprise are essential operations management tasks.

Before describing the approaches used to provide this information, it is useful to first understand the reasons for and objectives of measuring work, and these are summarized in Exhibit 3.

Exhibit 3:

The reasons for and objectives of measuring work

With the continuous improvement approaches described in Chapter 16, measuring the content of work plays an essential role in tasks, such as to:

- eliminate ineffective time, with work content determining the extent of possible improvements
- allow comparisons of alternative methods to be made
- balance work members in a team
- determine an adequate workload for a person

As a basis for:

- planning and scheduling work
- estimating and costing
- staff and staff cost control
- payment and reward systems
- estimating future capacity requirements both in terms of staff and equipment
- establishing delivery promises

The simplest way to measure work is to time how long a task takes. However, the reality of work does not lend itself to such a simple method. In particular, there are three dimensions that can make a significant difference to the time it takes to complete a job. These are listed in Exhibit 4, together with the ways used to account for these factors.

Exhibit 4:

Factors affecting the time to complete a task and approaches to overcoming these factors

Factors affecting the length of time to complete a job	Approaches used to account for these factors
Different methods may be used to complete a task	The time to complete a task is based on an agreed method. A revised method would require a new time
The time taken directly relates to the speed and effort of the person doing the task	Variations in speed and effort are accounted for when assessing how long it takes and adjustments are made to account for such differences. This is known as 'rating'
Some tasks are more strenuous or difficult than others and require more time for a person to rest and recover	All observed rest time is excluded from the initial assessment of how long a job takes. This 'net' time is later increased uniformly to include an allowance for rest and personal needs in line with the type of job being undertaken

The steps to measure the work content of jobs are explained below, with a brief explanation of what is involved:

1. **Select, record and analyse the job:** which jobs to measure are selected to help undertake a number of tasks including continuous improvement, capacity planning, scheduling work and establishing delivery lead times (see Exhibit 3). Recording what is involved in the work selected, agreeing the method to be used and analysing what the work entails are the next steps.
2. **Measure the job and establish the time:** there are a range of ways to measure jobs. The choice will depend on the level of accuracy required and the length of time a job takes, for example short, repetitive tasks will normally be expressed in minutes and parts of minutes. Long jobs such as undertaking a management consultancy contract and building an oil tanker will normally be expressed in weeks and parts of weeks.
3. **Check that the measurement is accurate:** before the times for a job can be used, it is essential to complete studies to check that the calculations have been correctly made so that their use will lead to sound decisions.

Approaches to measuring work content

This section provides more detail on the approaches to measuring the work content of a task. To reflect the fact that different approaches need to be used depending on the nature of the task, the section is in three parts, giving the approaches to measure short, repetitive tasks, long, non-repetitive tasks and capacity utilization, with Exhibit 8 providing a summary of which approach would be the best in a given situation.

Approaches to measure short, repetitive tasks

As a general rule, the techniques used to measure short, repetitive tasks will be chosen to provide accurate information expressed in minutes and parts of a minute. The reason for this is fundamental to the task itself; as it only takes a short time to complete but will be completed on numerous occasions, the time taken to complete the task needs to be measured accurately.

The techniques most commonly used to provide this level of accuracy are time study, predetermined motion time standards and synthetics. The first of these will be described in more detail and will include the procedure to establish a 'standard time'. This will provide a sound basis for understanding how to measure the content of work. The other two approaches will then be described in less detail.

Time study

As providing a more accurate time is needed for work that is of short duration and repetitive in nature, the job under review is broken down into elements, enabling the time involved for each element to be more accurately assessed. When undertaking this type of measurement, the elements of work are further identified as being either:

- **repetitive** – occurring regularly in every work cycle or once in a given number of cycles
- **occasional and contingency** – occurring irregularly and, although not directly part of the job on hand, are part of the general working conditions, for example discussing work with a supervisor.

When the job is being studied, there will typically be activities other than the work elements described above. These will be either periods of rest or tasks not directly to do with the job under review (for example undertaking work on another job). These are duly recorded but are set to one side. An allowance for rest is added later but the activities that are unrelated to the job being reviewed are simply excluded from the calculations.

To establish how long to do a job under time study, a trained person measures the time taken to complete each element observed, while at the same time assessing the speed and effectiveness with which the person undertaking the task is working. Often the recording part of this procedure is completed by videoing the work. This facilitates the person doing the job to become involved and the time element is easily and accurately established. Assessing the speed and effectiveness of a person is known as 'rating' and takes into account a person's speed of movement, dexterity and consistency of application. Rating is based on a numerical scale, of which there are three in use, 60–80, 0–133 and 0–100, each serving the same purpose.

The role of rating is to allow the observed times for elements to be adjusted up or down to reflect the speed at which a person is working. In that way times are established based on a common rate of working (for example, at 100 on the 0–100 scale).

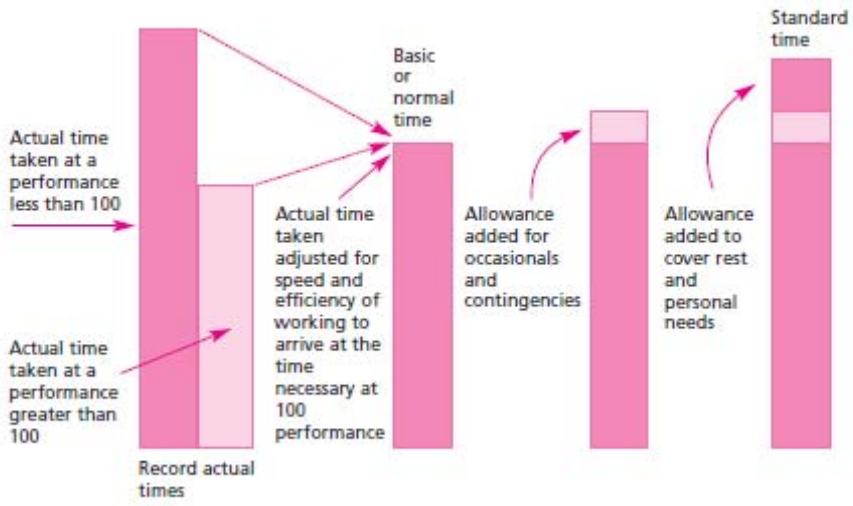
So far we have identified that, in time study applications, a job is broken down into elements, each element is measured and the time taken to complete an element is then adjusted by the rate at which the person observed was working. The same elements of work are measured on several occasions (ideally at least three different people on three different occasions) to provide an average. This is known as the 'basic time' or 'normal time'. A basic time is calculated for each element of a job, to which a percentage is then added to cover occasionals and contingencies, plus an allowance for rest to reflect the need for relaxation and personal time and compensation for more strenuous or demanding work. The various elements are added together and the total is known as the 'standard time' to complete the job under review. To help you put this description together, the procedure described here has been summarized in Exhibit 5 and illustrated in Exhibit 6.

Exhibit 5:

Steps to establish a standard time for a job

Step	Description
1	Select the task to be reviewed
2	To facilitate the accurate measurement of the task, it is broken down into the following elements: ● repetitive ● occasionals and contingencies These elements then become the basis on which the measurement is made
3	A person undertaking the task is observed and the time taken to complete the various elements is recorded. Often videoing is used to complete this step. Work not directly to do with the job under review is identified but excluded from the final calculations
4	At the same time that each element of a job is being measured, the rate the person undertakes these tasks is assessed
5	At the end of the study, the time recorded for each element of work is adjusted up or down to reflect the lower or higher rate compared to an agreed norm. On the 0–100 scale, this 'norm' is usually the rate of 100. The observed time adjusted for the recorded rating is known as the 'basic time' or 'normal time'
6	To the basic time is added an allowance for occasionals and contingencies (work to be done but not specific to any particular job) and rest. The result is called the 'standard time'
7	The respective elements are totalled together and this becomes the standard time for the job reviewed

Exhibit 6: Exhibit 5 details shown diagrammatically



Predetermined motion time standards (PMTS)

The essence of time study is to time and rate the task by direct observation. However, from the genesis of time study, the concept of having predetermined times for operations was recognized. Several effective systems have been devised that replace observations by highly

detailed method study in order to analyse and classify the motions used. Tables of predetermined times for each classified motion are drawn up, thus the total time for an operation can be calculated by adding together the predetermined times of its constituent parts. Later developments of PMTS systems provide higher level data that provide times for complete tasks (as opposed to the motions comprising a task) and this enables the time for a job to be calculated more quickly.

Synthetics
In the same way that PMTS systems provide predetermined times for basic operations, synthetic times can be built up from previous time studies carried out in an organization. In this way, times for completing part or all of a task can be calculated from numerous past studies, and used to build up the time to complete a range of similar work at a defined level of performance. Normally, these times would embody higher level data and cover much longer parts of a task than basic human movement, for example dust a chair, paint one running metre of window frame or make an outer carton.

Approaches to measure long, non-repetitive tasks
Many tasks have a long work cycle and will often occur infrequently. For such, time study and PMTS are not cost-effective ways of measurement. It is more appropriate to use one of the following forms of estimating.

Estimating
This form of measurement involves an 'assessment of the time required to carry out work, based on a knowledge and experience of similar types of work'.[2] This assessment is made on the total job without a breakdown into elements (Exhibit 7) and is thus dependent upon the knowledge and experience of the evaluator. In making an assessment, the evaluator will often use historical times in an informal way.

Analytical estimating
This is a refined form of estimating, in which 'the time to carry out elements (of a job) at a defined rate of working is estimated partially from knowledge and practical experience of the work concerned and partially from synthetic data'.[3] When using this technique, the work is broken down into suitable elements and the times for these are either estimated or taken from synthetic data (see Exhibit 7). Although more time-consuming to apply than estimating, it is normally more accurate.

Comparative estimating
This is a further development of estimating, in which the time taken for a task is evaluated by comparing the work involved with the work in a series of similar tasks. This method is based on the principle of using categories of work, where jobs are not given precise times but are placed in a time band (for example two to three hours – see Exhibit 7), and the use of benchmark jobs on which comparisons are based. These latter jobs are chosen as being representative of a time band, and their times are based on a primary method of work measurement (for example time study). The use of benchmarks makes for a speedy evaluation by slotting tasks into broad bands of time.

Exhibit 7: Types of estimating to determine the time to be allocated to complete a task

Task	Estimating	Analytical estimating	Comparative estimating
Office cleaning	An estimate of the time it would take to empty all the waste bins, vacuum and dust the office under review would be made. This would be based on the estimator's own past experience of similar work	The tasks involved in cleaning the office under review would be broken down into smaller parts, for example: Emptying 10 waste bins Dusting 10 desks Dusting 10 chairs Dusting 20 filing cabinets Dusting 50 metres of skirting board Dusting 10 window ledges Dusting 5 doors Vacuuming 150 square metres of carpet with a high level of furniture congestion The next step is to complete an estimate for each of these parts. The individual estimates would be added to give an overall time to complete the cleaning of this office. Again, the times should be based on the estimator's own past experience of similar work	From past experience of cleaning offices, a number of job categories would be compiled by the estimator. These would be chosen to reflect the different time bands of the work undertaken, and one or more benchmark jobs would be selected as being representative of each band. When selected, each benchmark job would then be analysed in greater depth, and a detailed study would be completed to check that the time band to which each job had been allocated was appropriate. A full description of the individual tasks involved in each job would also be recorded and filed for later use: Time band (hours) Benchmark job(s) 0.0–0.5 Partner's office, 8 Southall Gardens 0.5–1.0 Purchasing department, AB Imports, Floor 4, Bradley House 1.0–1.5 Drawing office, Markham, Roberts & Co. 1.5–2.0 General office, housing department, Bursley DC 2.0–3.0 Main open-plan office, British Energy, West Midlands And so on. All future jobs would then be compared to each benchmark job and, usually, the midpoint of the time band for the job to which it was most similar would be allocated and used in all the appropriate calculations

Techniques to measure capacity utilization and requirements

In many work situations it is important both to measure the extent to which existing capacity is being used and to be able to monitor utilization in the future. The techniques available to produce this information are described here.

Activity sampling

Activity sampling involves making random observations over a representative period of time to provide information on:

- capacity utilization of the facilities or persons employed on a task or in an area
- the average time taken to complete a common task.

Applications of these techniques include operations areas with several pieces of equipment, warehousing and administrative or technical units. In each, an assessment of utilization or an average time taken can be established.

The overall time spent on a specified activity is deduced from a number of random observations. Owing to the limitations inherent in sampling, an error is introduced. The size of this error can be calculated statistically. For this purpose, a 95 per cent confidence limit is considered to give sufficient accuracy, and is built into the following formula:

$$N = \frac{4P\,(100 - P)}{L^2}$$

where N = number of random observations, P = percentage occurrence of the particular activity being reviewed and L the level of accuracy required. For example, if, through observation or pilot study, a PC (or other piece of equipment) is estimated to be unused, say, 35 per cent of the time, the number of observations required to determine the actual percentage of time unused to an accuracy of ± 5 per cent, with 95 per cent confidence in the answer, would be:

$$N = \frac{4(35)\ (65)}{5^2} = 364$$

Conversely, it may be that a study has been completed, and the level of accuracy obtained at 95 per cent confidence limits needs to be ascertained. The following equation would be used:

$$L = 2 \times \sqrt{\frac{P(100 - P)}{N}}$$

For example, if the percentage of time that warehouse staff were not working was 10.1 per cent of the time observed and the number of observations totalled 6500, the level of accuracy at 95 per cent confidence limit would be

$$L = 2 \times \sqrt{\frac{10.1(89.9)}{6500}} = 0.7$$

So, the warehouse staff were not working between 9.4 and 10.8 per cent of the time. If there were 20 staff observed, then the capacity needed to cope with present throughputs could be reduced by some 10 per cent.

So far the activity sampling study has revealed the percentage of time an activity has happened during the period of observation. To assess how long on average a task took, the percentage of time observed when staff were doing the task is first established in the way described here. A period of time (for example day or week) is then studied to determine on how many occasions the task was completed (for example orders dispatched, invoices processed or units produced). If, during an eight-hour day, four staff were employed 65 per cent of their time on dispatches and in that period completed 180 dispatches, the average dispatch time can be calculated as follows:

$$\frac{65 \text{ per cent} \times 4 \times 8 \text{ hours}}{180 \text{ dispatches}} = \frac{1248 \text{ minutes}}{180} = 6.9 \text{ minutes per dispatch}$$

Information provided in this way enables operations to establish the capacity required to handle the throughput observed during the period studied. Whether this is a normal load can be checked by comparing (say) the number of dispatches completed within the observed period with the number of dispatches completed in a reference period in the past.
This reference period is chosen to represent a period of normal working over a given time (for example three months).

When capacity required to handle a normal workload has been established, monitoring throughput against capacity levels on a regular basis can be put into effect. This is achieved by comparing (say) the weekly net hours available (that is, total hours less rest and personal time) in a finished goods warehouse with the amount of work completed in the same period (for example the number of dispatches made, deliveries received, stock checks

made and paperwork processed), the times for these activities having been established through activity sampling. Where work was not seen during the sample (for example tasks completed on a monthly basis only), estimates of the time taken to complete these tasks are established.

This comparison enables management to monitor any throughput changes and their effect on, in this instance, the warehouse and enables them to come to better decisions on whether to increase or decrease capacity on a temporary (through overtime or by making an internal transfer) or permanent (adding staff or natural wastage) basis.

Group capacity assessment (GCA)

Group capacity assessment (GCA) provides a basis for controlling staffing levels in indirect areas where more rigorous forms of work measurement are more difficult and expensive to apply. The first task is to establish times (that a trained person is expected to achieve on a day work basis without allowance for rest) for all the major tasks in a particular department. This is accomplished by using an appropriate form of work measurement, for example time study, synthetics, activity sampling or analytical estimating. Often a video recording is made (it is easy to do, reduces the levels of sensitivity that accompany observation and allows those videod to be party to the calculations) and the number of completed work cycles counted in that period. An average time is then established.

While this information is being generated, the number of tasks completed in the department each day is being recorded. The average number of tasks completed in this period is calculated and extended by the time allowed. The number of people required (making due allowance for rest and personal needs) can then be established.

As in activity sampling, the capacity required is agreed, and changes are monitored in the future. This is done by totalling the number of tasks completed each day, extending these by the agreed time and calculating the total staff content of the work done that day. This is compared to the hours worked during that day, and an 'efficiency percentage' is calculated. These daily controls are monitored at departmental level, with weekly controls for each department being provided for the next level of management.

Clerical work improvement programme (CWIP)

Banks and other high volume service sectors (for example insurance and other parts of the financial sector) often monitor staff requirements through a programme similar to that described under GCA, but specific to their own organization. One example is the clerical work improvement programme (CWIP) that measures staff requirements for different administrative units and centres. Synthetic times are established for the range of activities undertaken. One common approach is to video the tasks and watch the tape to observe and calculate the times for elements of work. Standard times (an allowance being added to the observed time to cover occasionals, contingencies, rest and personal needs) are established and used to calculate times for existing and future jobs. Typically, all times are verified by observing the tasks being completed, where possible, at a number of locations.

The assessment of staff needs is primarily based on the number of transactions completed. Daily volumes are recorded (normally as an automatic byproduct of the system) and continuously reviewed over a 20-day period. Four-weekly reports would form the basis by which a company monitors capacity and helps to control costs. Exhibit 8 provides a summary of some likely applications in the service sector of the approaches to measuring work that have been outlined.

Exhibit 8: Approaches to measuring work – some typical service applications

Approaches to measuring work	Some typical applications
Time study, PMTS and synthetics	Maintenance schedules (for example vehicles, aircraft and equipment) Cleaning services Secretarial and clerical tasks services and word processing Administrative functions
Estimating, analytical estimating and comparative estimating	Maintenance schedules Restaurants – back- and front-office operations Hotels – back- and front-office support services Consulting assignments Design services
Activity sampling	Warehousing and stores provision Equipment utilization Call centres Supermarkets – back- and front-office activities
GCA and CWIPs	Banking and financial services Administration Secretarial services and clerical tasks Warehousing and stores provision

Reflections

As time is the common denominator in managing many of the key tasks in operations, understanding the alternative approaches to measuring time and recognizing which alternative is the most appropriate to use is fundamental to an operations manager's role. Determining capacity requirements, setting realistic throughput targets and evaluating performance are core tasks. With typically 70–80 per cent of people and costs falling within the remit of operations, controlling and managing these large resources in line with budgets and customer needs is central to the overall success of a business.

Also, given the need to reduce costs and improve all dimensions of performance, evaluating and choosing alternatives is an essential part of securing the improvements necessary for the short- and long-term success of a business. Measuring time is a key facet of this task and provides essential dimensions of the need for continuous improvement in operations, the subject of Chapter 16.

Productivity

The prosperity of nations and organizations alike is recognized as being dependent upon their comparative productivity. At a national level, the relationship between the level of output per hour in the manufacturing sector from 1960 to 2000, the share of world trade in manufactured goods and the GDP per capita for seven more advanced economies is shown in Exhibits 9, 10, and 11 respectively. Productivity is a most useful comparative measure at a national, sector or individual business level to provide comparisons between relative performances and measure trends over time.

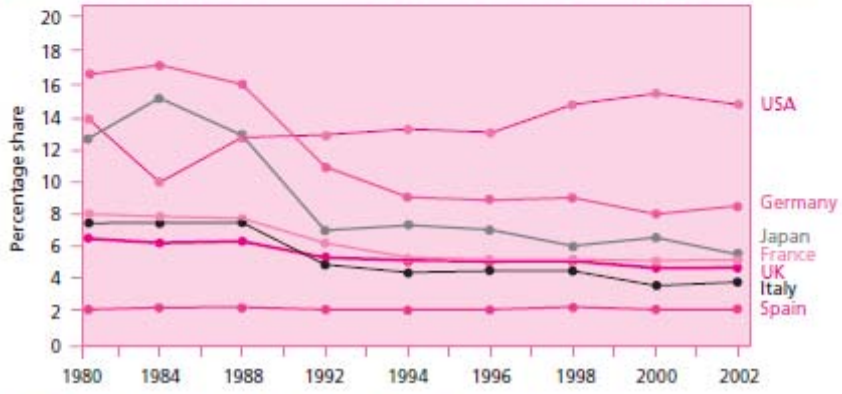
Exhibits 9 and 10

Trends in output per hour in manufacturing for selected countries 1960–2000 (1992=100)

Country	1960	1970	1980	1990	1995	1998	2000
Belgium	18	33	65	97	113	129	133
Canada	39	56	75	95	111	113	117
France	22	43	67	94	115	130	141
Germany	29	52	77	99	113	121	130
Italy	21	40	70	92	110	111	116
Japan	14	38	63	94	111	121	133
Netherlands	19	38	69	98	118	125	–
Norway	37	58	77	97	102	104	104
Sweden	27	52	73	95	122	140	150
United Kingdom	30	43	54	89	105	106	116
United States	53	62	71	97	114	127	145

Source *Monthly Labor Review*, Bureau of Labor Statistics, US Department of Labor, August 2001.

Share of world trade in manufactured goods for selected countries, 1980–2002



Source International trade statistics, World Trade Organization, 2003.

In general terms productivity expresses the relationship between the outputs from a system and the inputs which go into their creation, as shown below:

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

An increase in productivity, therefore, can be secured by changing either or both the numerator or denominator of this simple equation. However, it follows that an increase in output itself does not necessarily mean an increase in productivity unless there has been a less than pro rata increase in inputs.

Exhibit 11: GDP per capita for selected countries 1983-2002

Year	Canada	Germany	France	UK	Italy	Japan
1983	87.3	89.0	81.8	70.2	75.7	73.1
1984	86.1	86.4	77.9	67.6	73.1	70.8
1985	86.8	85.9	76.4	67.8	72.8	71.7
1986	85.9	85.8	75.9	68.6	72.7	71.7
1987	86.5	85.2	75.8	70.0	73.2	72.8
1988	86.9	85.1	76.3	71.0	73.7	75.1
1989	85.3	85.4	77.3	70.6	73.8	77.0
1990	83.5	87.9	78.3	70.4	74.8	80.2
1991	82.0	80.3	79.9	70.2	76.9	83.8
1992	80.1	79.8	78.9	68.7	75.7	82.6
1993	79.8	77.2	76.8	69.2	74.4	81.3
1994	80.2	76.4	75.7	69.9	73.7	79.6
1995	80.5	76.4	75.8	70.7	74.6	79.6
1996	78.8	75.3	74.6	71.1	73.8	80.0
1997	78.8	73.1	74.4	72.1	72.1	78.8
1998	79.0	72.4	74.6	71.9	72.6	75.4
1999	79.9	70.8	73.4	70.7	70.6	72.8
2000	81.0	69.7	73.1	71.0	70.0	72.6
2001	84.3	72.0	77.3	75.5	72.4	75.1
2002	84.9	71.3	77.7	77.0	71.2	74.0

Source DTI.

Part of your task in understanding operations is to assimilate the technical differences between the concepts and dimensions that make up the field. One key difference concerns that between productivity and efficiency, the explanations for which follow:

- **productivity** measures the amount of input required to achieve a given output or, expressed the other way, the amount of output resulting from a given input
- **efficiency** measures how well resources have been used by comparing actual output with the expected or standard output that should have resulted from the use of these resources:

$$\text{Efficiency} = \frac{\text{Actual output}}{\text{Expected or standard output}}$$

Approaches to measuring productivity

Single-factor and multi-factor are the commonly used measures of productivity. As an example of single-factor measurement, staff productivity typically measures output per hour.

Multi-factor productivity, on the other hand, includes not only labour but also other inputs such as processes, energy and materials. All productivity measures are exposed to a number of indirectly acquired sources of improvement. For example, technological change and the increasing skills base and know-how of people would, in themselves, typically lead to an increase in productivity in related areas but may not appear to be directly associated with the improvement. However, as a measure to reflect trends and compare performance, productivity is a simple and effective way of providing these insights.

Examples of single-factor, multi-factor and added value measures are now provided.

Exhibit 12

European Automotive Productivity Index, 2002: top five and bottom five

Manufacturer	Plant	Country	# Vehicles	
			produced	per employee
1 Nissan	Sunderland	UK	296,489	95
2 Ford	Saarlouis	Germany	408,405	87
3 Toyota	Burnaston	UK	156,000	87
4 Fiat	Melfi	Italy	350,756	82
5 GM	Eisenach	Germany	137,272	77
5 PSA	Rennes	France	305,472	38
4 Volvo	Born	Netherlands	122,071	36
3 GM	Russelsheim	Germany	165,009	36
2 PSA	Suschaux	France	384,644	36
1 VW	Baden	Germany	258,600	32

Single-factor productivity measures

● **Staff productivity** is the most commonly used measure and relates output to hours worked. Its universal application derives from several factors including that it is easy to calculate and the like-for-like dimension of staff/labour, both within and between nations, sectors and businesses, as illustrated in Exhibits 9 and 12:

$$\text{Staff productivity} = \frac{\text{Output (£s)}}{\text{Hours worked}}$$

● **Process productivity** measures the value of the outputs produced in relation to the process time involved:

$$\text{Process productivity} = \frac{\text{Output (£s)}}{\text{Process time (hours)}}$$

Another means of evaluating process productivity is to compare the value of goods sold (£s) to the fixed asset investment in the processes under review.

Multi-factor productivity measures

The single-factor dimensions of staff/labour and process measures of productivity provide one view of a total picture and when using them, this needs to be borne in mind. However, by using a multi-factor measure of productivity, certain of these problems will be overcome.

Multi- (also called total) factor productivity includes not only staff/labour inputs but also some or all of the costs of capital, energy, materials and other purchased services:

$$\text{Multi-factor productivity} = \frac{\text{Output (£s)}}{\text{Costs (£s) of staff, capital, energy, materials and other purchased services}}$$

This measure provides an improved framework for assessing the whole of operations and gives a basis for analysing productivity changes due to substituting or improving one or more of the factors involved.

Added value

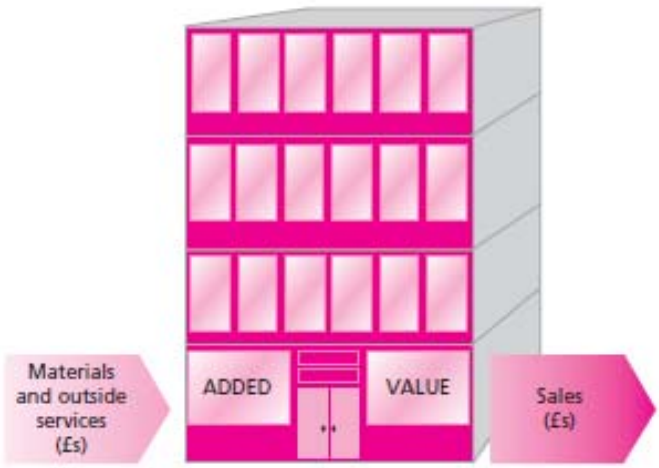
One useful refinement to measuring productivity is to relate factors to added value. The latter refers to the value added to a service or product by a business and is, therefore, the difference between sales revenue and all material and service costs incurred to make those sales. These costs include materials and components, stationery, subcontract and any other elements of material or staff costs purchased from outside a business (see Exhibit 15.13):

$$\text{Added value} = \frac{\text{Sales revenue minus materials and service costs purchased from outside a business}}{}$$

Thus, over the period being reviewed, the added value measures the wealth produced by a unit. The added value index (AVI) is also a useful overall measure because it relates the added value to total employment costs (for example salaries, pensions and other state contributions). It is calculated as follows and is often expressed as a percentage:

$$\text{Added value index} = \frac{\text{Total employment costs}}{\text{Added value}}$$

Exhibit 13: Added value in relation to bought-out materials/services and sales



The ratio is a valuable measure of operations management's performance because, unlike profit, it is less affected by factors outside a manager's control (for example inflation) and it focuses on a fundamental aspect of management's task, that of being responsible for employee productivity.

AVI measures operations by relating the current AVI against a previously agreed standard, with a lower figure indicating an improvement in this ratio. Added value reward schemes are also used by some organizations.

Ways to improve productivity

There are three levels at which productivity improvements can be made:

- **scientific**, involving research leading to new knowledge in, for example, materials, processes and IT chips
- **technical,** which comprises the adaptation or application of new scientific knowledge to replace existing ideas or introduce new ways to complete tasks
- **operational,** where the aim is to develop procedures that make the best use of technical developments.

In terms of productivity improvements, the activities at the scientific and technical levels provide the principal increases. However, they will also be more expensive to fund and take much longer to bring to fruition than activities at the operational level, where the investments are relatively inexpensive but yield quick, although less significant results (see Exhibit 14). Consequently, many organizations have pursued productivity improvements solely at the operational level. The methods adopted, however, vary. Some improvements come through experience, trial and error or ingenuity. Other ways of studying work have been developed that provide a systematic approach to investigating existing methods and developing and implementing improvements as ways to increase the productivity of existing resources.

Exhibit 14:

Approaches to improving productivity and some of the trade-offs involved

Aspects	Approaches		
	Scientific	Technical	Operational
The cost of providing the necessary facilities and staff to complete these activities	High	→	Low
The potential for improving productivity	High	→	Low
The length of time to yield the productivity gains	Long	→	Short

Service applications

The growing importance of the service sector within more developed economies places increasing emphasis on the need to improve productivity in this sector. Past trends indicate that, even in the USA which is often regarded as having the most developed of all service sectors, productivity improvements lag behind. Exhibit 15 shows that whereas manufacturing productivity has been increasing year on year since the mid-1980s, total business (excluding farming) productivity in the USA has been declining year on year, which suggests that service sector productivity has also been declining over the same period.

Exhibit 15:

Percentage changes in productivity for the total business (excluding farming) and the manufacturing sectors in the USA (1984–2003)

The need to improve and measure productivity in service businesses (and the whitecollar/ service dimension in goods-producing firms) is a significant and necessary task. As the service element of economies grows, productivity in this sector has an increasing bearing on the living standards of nations.

It is important, therefore, to accomplish this in an effective way. In so doing, organizations should remember to incorporate lessons from the past and recognize the expectations and abilities of the staff involved. Essential to the successful introduction and maintenance of approaches to measuring and improving productivity are the following:

● **Involve those concerned** – the failure of companies to involve blue-collar workers in the past led to resentment and resistance at the time, an attitude which sometimes prevails even today. The success achieved by other nations (for example Japan) has, in part, been based upon appropriate high levels of involvement. Including people in the process needs to be undertaken as early as possible, particularly in service industries where procedures are less rigid and the outputs less tangible. Discussing the purpose of the measures and their ultimate use will allay fears, reduce resistance and match the expectations of incumbents concerning levels of responsibility and their role in the interpretation of the service and managing and improving the delivery system.

● **Establish the purpose** – starting with the goals of the organization, measures should be developed to fit relevant targets. Congruency between measures and objectives ensures relevance of effort and consistency and coherence of purpose. In the service sector this linkage is normally inherently less defined than its goods-producing counterpart.

● **Determine appropriate measures** – be aware of using existing output/input ratios as this approach brings with it the potential problem of modifying, at a later date, a measure which is not fit for purpose. The approach should be to determine first the outputs, then the inputs and lastly the ratios. This will enable the different factors to be assessed independently of one another, then later assessed within the relevant measures. Defining each part separately simplifies the task.

● **Output measures** – by electing to define outputs first, the more difficult and important factor in the equation is addressed without introducing additional complexity. As output measures are often difficult to determine directly, surrogate measures are sometimes used. It is most important, therefore, to involve those concerned in such decisions to ensure that what a measure is intended to accomplish is understood and deemed suitable. This avoids

unduly emphasizing non-critical factors which may distort what constitutes good performance. Group consensus not only reduces this possible outcome but also creates the opportunity to refine measures over time.

● **Input measures** – should be chosen to reflect the task. Choices between single-factor and multi-factor measures were discussed earlier and some illustrations are given in Exhibit 16. When choosing which inputs to use, the need to relate them to the output measures must also be appreciated. One aspect to consider here is the appropriate time base of the input(s) compared to the output(s) involved. Thus, clerical staff inputs may be measured in hours or days, whereas a research department would be more appropriately described by the numbers of people or salary bill.

Exhibit 16: Examples of single-factor and multi-factor productivity measures

Organization	Single-factor measure	Multi-factor measure
Law firm	# briefs filed / Lawyer	# briefs filed and court attendances undertaken / Lawyer
Bookshop	# customers served / Full-time equivalent staff	# customers served, deliveries handled and despatches sent / Full-time equivalent staff
University	# student contact hours / Faculty member	# student contact hours, research assistants supervised (hours) and administrative tasks (hours) / Faculty member
Consultancy firm	# consultancy days billed / Total consultancy days available	# consultancy days billed, training undertaken (days) and administrative tasks (days) / Total consultant days available
Engineering design firm	# design projects completed / Engineering staff days	# design projects completed, tenders submitted and site visits undertaken / Engineering staff days

● **Ratios** – the last step in defining the measures is to select the ratios. The multiples on hand will be many. Some factors to consider in general terms, as well as to do particularly with service applications, include:

● Keep the number of measures small and focused. Avoid any measures that are not central to a review.

● Select measures with the following characteristics:

- – data are readily available
- – reflected performance is understood by all concerned
- – some control is exercised by those being measured.

● Measures for one function are compatible not only with other parts of an organization but also with the corporate measures in use.
● **Revise** – implementing a productivity measurement system is not a one-off project. In service industries particularly, changes in mix, the continuous reinterpretation of tasks, the application of technology and changes in organizational goals will bring about short- and long-term implications for a business and may change the best measures to evaluate performance and improvement. Periodic revision needs to be built into the system, in relation to productivity measurement in particular and as part of an ongoing, corporate review in general.

Case example 1 PRODUCTIVITY AT CONVERGYS

Convergys, one of the biggest US suppliers of outsourced customer services, has a number of call centres for customers across the country. In the South Jordan centre a team of 14 staff handle calls from customers of Direct TV, the satellite television company. These call centre staff have to handle 63 calls during a seven-hour shift. But this is a relaxed pace by US industry standards. A worker in a unionized call centre averages 73 per day while at non-unionized centres this can rise to 108 calls per day.

The modern call centre is not all about numbers, however. Companies are increasingly interested in the quality of service that callers receive. To cut costs they are looking for ways of creating different tiers of service, encouraging many callers to use automated services while saving human contact for high spending customers or those who might buy additional products and services.

www.convergys.com

Case questions

1 How is the number of calls handled per day a useful measure of productivity?
2 Why do you think the number of calls handled would vary by as much as almost 50 per cent in the figures quoted above?

Reflections

While factors such as national resources will play a major part in determining a country's level of wealth, the prosperity of a nation and the living standards enjoyed by its people are also bound up with productivity. The standard of living enjoyed today by many of the more advanced economies has its roots in the primary (mining and farming) and secondary (manufacturing) sectors' productivity gains over the last several decades. The improvements secured in these areas of the economies of many nations have been significant.

The increasing importance of service industries in the more developed economies has switched the spotlight onto the need to improve productivity in this sector. Only in this way will the improvements in national prosperity and individual living standards be sustained. Current overall performance, as shown in Exhibit 15, points to a current

Exhibit 17:

Comparative prices for a three-minute international telephone call for selected countries (1994–2003)

Country	Price (US$) for a three-minute international call				Index 2003 (1994 = 100)
	1994	1997	2000	2003	
Australia	3.13	3.14	0.60	0.50	16
Canada	2.67	1.10	0.71	0.48	18
Denmark	3.70	2.56	1.11	0.71	19
France	2.91	1.27	0.62	0.28	10
Germany	3.49	2.18	0.61	0.33	9
Italy	4.28	1.87	1.00	0.78	18
Japan	6.98	3.57	1.70	1.48	21
Singapore	5.81	2.50	1.66	0.66	11
South Africa	6.43	3.23	1.86	1.12	17
Spain	4.50	1.96	1.03	0.69	15
Sweden	2.62	1.44	0.58	0.31	12
UK	1.90	0.98	0.95	0.94	49
USA	3.32	0.36	0.36	0.45	14

Note 1 US$ per three minutes in peak hours to USA (for USA to Europe).

Source The World Competitiveness Report 1994 and 2004.

failure to meet these expectations. In part this may be explained by a failure in some elements of the service sector to acknowledge this essential task. However, there are other parts where this need has been fully recognized. Often this goes hand in hand with the increasing move of services from a sheltered to a traded environment, a factor often enhanced by the progressive privatization in many countries of large service industries that had historically been developed and managed in the public or government domain. The results, as Exhibit 17 illustrates, can be as dramatic as many of the earlier gains in the primary and secondary sectors.

Exhibit 17 shows that all thirteen countries now provide a three-minute international telephone call at a significantly lower price than in 1994. In fact, while the average price for all these countries was $3.98 in the mid 1990s, it had fallen to $0.67 by 2003. Also, as the figures do not take into account inflation in the period, the reduction in prices are, in real terms, even more pronounced. Underpinning these significant decreases was a parallel improvement in productivity, driven by a combination of technology investment and continued improvements in all areas of telephone provision.

The need for and benefits that accrue from sustained productivity improvements are central to the continuing prosperity of nations, whatever their level of development. Bringing this about is a central feature of operations management.

Key Elements of Time and Productivity

- The fundamental nature of time in managing operations is often overlooked or not fully recognized. Assumptions are typically made about the origins and appropriateness of this fundamental input into key operations activities such as cost data, capacity calculations and work schedules. Functions in a business use the data and assume them to be accurate and a sound basis on which to undertake calculations and make decisions.
- The chapter started by illustrating why time needs to be an essential part of assessing,

controlling and managing many of the activities within operations. Specific illustrations of the role of time in key activities were then provided.

- With an understanding of the essential role of time in so many aspects of operations management, the approaches to measuring the content of jobs were reviewed. At the start the need to recognize that the time taken would need to reflect the agreed method, take account of how effectively the work was completed and provide allowances for rest and personal needs was emphasized.
- Then followed a description of the principal approaches used and the types of work where they were most appropriate to determine the question, how long should this job take to complete?
- The second major topic of the chapter addressed productivity. The national as well as corporate dimensions provided context and background before introducing the definitions of productivity, the difference between this measure and that of efficiency and the perspectives provided by added value calculations.
- The final section addressed the ways to improve productivity and the key role of service sector improvements in sustaining the productivity gains made in the primary and secondary sectors particularly during the last century.

Exploring further

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[1] Definitions of work measurement are provided in the British Standard 3138 (1992).
[2] Ibid.
[3] Ibid.