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Process Costing

There is a marked paucity of empirical research on the subject of process costing.[1] The only literature surveying the methods used in practice is Horngren's 1967 article entitled 'Process Costing in Perspective — Forget FIFO' [8]. Using the same kind of title, this paper could be called 'Process Costing — Forget It'. My survey of practice in Britain and Australia indicates that firms engaged in continuous process manufacture do not use process costing. They use, instead, operation costing. For any of their output produced on a batch basis, they use batch costing (which is a form of job costing).

Process costing methods are described in nearly all the cost accounting texts (a selection of which are listed in the references at the end of this paper). Unfortunately, operation costing is described very briefly in the current editions of only four books — Gillespie ([5], pp. 15-16, [6], pp. 461-2, [7], pp. 7-10) and Dickey ([3], section 12, pp. 19-20). Operation costing may be characterized as being process costing with zero, or with negligible and/or constant, uncompleted work within each process. However, it would be a better representation of reality to characterize process costing as being operation costing with significant and fluctuating incomplete work within each operation. An illustration of operation costing is given in the penultimate section of this paper. One purpose of this paper is to propose that increased research attention should be devoted to operation costing, since it is well suited to form one of the bases of management-information systems in firms engaged in mass-production manufacture. A second purpose is to report the results of the empirical investigation mentioned above. The third purpose is to suggest that the sections on process costing in cost accounting texts should be deleted almost entirely, and be replaced by sections of almost equal length on operation costing.

Uses of Cost Data

Information on the actual cost of finished product units is needed for a number of different purposes:

[1] I am very conscious of the absence of references to recent journal articles in this paper. This does not indicate any want of effort on my part in searching the literature, but is evidence of the lack of relevant recent material.

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(1) To enable efficiency to be assessed, through the comparison of actual costs with standards (although the comparison will be partly carried out before units are finished).
(2) As a guide to short-run decision making, provided that the unit costs are analysed into fixed and variable elements.
(3) As a guide to price determination, in firms which use cost-plus pricing (probably a majority — see Skinner [13]).
(4) As a basis for valuing stocks of finished units, so that the firm's profit for the period can be computed and balance sheets compiled.

Decision making and price determination rely, of course, on predictions of future costs, but past cost data will usually be of considerable help in making such predictions.

Whether job or process costing is used, it is necessary, in order to compute the cost per unit finished during any period, to allocate the costs incurred during the period between work-in-progress and completed units. With job (and therefore batch) costing, this is no problem, since a separate cost account is kept for each job. A cumulative record of the costs incurred on each job is maintained, and there is no difficulty in finding the costs incurred up to any point in time, whether a job is in progress or complete. With continuous process production, however, there is a problem, since each process results in the continuous flow of a large volume of homogeneous units. The difficulty is resolved in process costing by use of the concept of equivalent (or effective) units: for example, ten units which are 60 per cent complete are treated, for costing purposes, as being equivalent to six fully-completed units. A cost per equivalent unit is computed, and is used in costing the units finished during the period and the units in process at the end of the period. The concept of equivalent units is the primary distinguishing feature of process costing. A secondary distinguishing feature is that, where the output of one process is processed further, costs are transferred in the accounts, so that the cost of the finished output of one process becomes part of the material cost of the next. Good descriptions of process costing can be found in Horngren [9], Shillinglaw [12], and Dopuch, Birnberg and Demski [4].

Product-Unit Costing

Although much of the discussion in this paper is expressed in terms of the calculation of product-unit costs, it is not suggested that management's need for cost information always requires the routine computation of product-unit costs. Indeed, one of the advantages of operation costing is that (as is illustrated later in the paper) it enables management to dispense, to a large extent, with such data. An approach to costing that appears to underlie much of the current cost accounting literature, and which is described explicitly in Staubus ([15], Ch. 8) is what may be called the cost-equation (or cost-function) approach. Under this approach, each of the firm's inputs is examined in turn to determine its causal factors, and the cost-output relationship ascertained is expressed in an equation. For each input, it is necessary to identify both

the relevant variables, and the numerical values to be attached to them. The outcome is a set of equations embracing all the firm's inputs.

The cost equations can be purely descriptive, derived primarily from an analysis of past cost behaviour, or they can be prescriptive, derived by the normal procedures used in setting standards (such as work study and value analysis), or they can be a mixture of the two. The equations can be non-linear, where appropriate: for example, in some industries the material waste percentages required on long production runs are lower than the percentages needed for short runs. The equations can be multi-variable, where appropriate: for example, the cost of electricity used for heating will depend (at least) on the volume to be heated, the nature of the activity carried on in each work area, and the season of the year. The two characteristics just mentioned mean that the cost-equation approach is more sophisticated than the traditional device of analysing costs into variable and fixed elements relative to individual output factors. In using the equations, it is necessary to record deviations between predicted and actual input costs, and to alter the equations where necessary (a procedure similar to conventional standard-cost variance analysis). The cost-equation approach enables management, to a large extent, to dispense with product-unit cost data. Such data are of very limited use in controlling costs, which are most often controlled on a cost-centre, rather than a cost-unit, basis. They are also of limited use for short-run decision making, since only some decisions involve increases or decreases in the volume of final output. When management needs product-unit cost data, as a guide in periodic price revisions and for valuing stocks, they can be computed for the occasion, using the equations, adjusted (where necessary) in the light of the evidence relating to their precision.

It should be noted that the cost-equation approach does not avoid the need to use the device of equivalent units, in circumstances where the assumptions underlying process costing are valid. Given that an important determinant of the cost of a firm's inputs will be the volume of output, it will not be sufficient to relate the cost of even a single input to the completed units of a process: it must be related to the equivalent production of the process, computed using equivalent units. It is part of the purpose of this paper, however, to argue that the assumptions underlying process costing are not valid and that, therefore, the device of equivalent units is unnecessary, irrespective of the approach to cost accounting adopted. The alternative to job costing is operation (not process) costing. With an operation costing system, management has a choice between the cost-equation approach and the conventional product-unit cost approach, just as it has a choice between the computation of actual costs only and the use of standard costing. Operation costing, however, facilitates the use of the cost-equation approach. In the illustration of operation costing given later in the paper, the philosophy underlying the cost-equation approach is adopted insofar as it can be implemented using the conventional techniques of standard costing and cost-volume-profit analysis.

Equivalent Units

The concept of equivalent units can make process costing extremely complex. There

are two methods of computing actual cost per unit, FIFO and Average, each usually giving different figures; each involves, if not a different concept of equivalent units, at least a different cost denominator. If standard costing is used, this can reduce the complexity, since the same variances are obtained whether the FIFO or Average procedure is employed. A more significant complexity, in situations where the device of equivalent units must be used, is in accounting for process losses. It is often necessary to distinguish between waste (e.g., through evaporation or shrinkage), scrap and spoilage (output which cannot be converted to good units), and defective units (output which can be rectified into good units), since the type of loss involved in each is different. It is also necessary to distinguish within each type of loss between normal and abnormal, the latter being of interest to management for cost control purposes. The secondary distinguishing feature of process costing, that of transferring costs from one process to the next, adds further to the complexity, particularly in preserving the distinction between variable and fixed costs. The problems are discussed at greater length in Skinner [14].

The device of equivalent units is not required if it is unnecessary to value work-in-process (that is, the units within each process) in order to compute the cost per unit completed. It has long been recognized that that is possible in either of the following cases:

(a) where work-in-process is non-existent or negligible. The costs incurred in the process during any period can then be attributed (with complete or sufficient accuracy) to the units finished during that period (since all, or nearly all, of them will also have been started during the same period).

(b) where work-in-process, while being significant, is constant in quantity and type over time. Unless the production cycle is so long that inflation is a significant factor during the course of it, it is not necessary to value work-in-process in order to calculate the cost of finished units. It is necessary to estimate the cost of work-in-process only when stock values are required for inclusion in the annual financial statements.

Hitherto, the two cases described above have been regarded as being exceptional. My investigation suggests that they are, in fact, the rule. I have yet to find an accountant who has ever heard of the concept of equivalent units being used in real life. The explanation of that fact lies exclusively in the circumstances described in cases (a) and (b) above, work-in-process being always constant and usually negligible. The investigation is described in the next section. As a supplement to the empirical enquiry, I examined the three-volume *Encyclopaedia of Cost Accounting Systems* [11], which describes the systems used in 32 industries in the U.S.A. Unfortunately, this work has no index, but a study of those chapters devoted to the industries where continuous process manufacture might be used revealed no mention of equivalent units. As the title indicates, the work is encyclopaedic, and it is difficult to believe that the device of equivalent units would have been ignored if it were, in fact, used.

The Horngren article [8] mentioned at the beginning of this paper might appear to suggest that the device of equivalent units is used, at least in the U.S.A. However, I suggest that such an inference is not necessarily correct. His survey involved fourteen

firms in eight industries in the Chicago area, and was carried out in 1965 by his students. The survey classified the 'overall product-costing systems' of the firms into variable-costing and absorption-costing systems, into those using actual costs only and those based on standard costing, and, for firms using actual costs only, into those using the FIFO method and those using the Average method. The device of equivalent units is not necessary in order to allow a firm a choice between variable and absorption costing, or between actual costs only and standard costing. However, a choice between the FIFO and Average methods for costing the output of each process makes no sense at all without the concept of equivalent units. None of the firms, however, used the FIFO method, and no direct enquiry was made about equivalent units. It is possible that the survey was not refined enough to distinguish between the use of the FIFO and Average methods in the manner relevant to this paper, and their use in computing the cost of raw materials issued to production and in computing the cost of goods sold.

The Empirical Investigation

I questioned the cost accountants of two samples of large manufacturing companies in industries where one would expect to find continuous process production in use. The companies in one sample were in Manchester, England, and those in the other sample in Melbourne. The enquiry was confined to large firms in the belief that large firms were more likely than small firms to employ well-qualified cost accountants, and because there is some evidence (see Skinner [13], pp. 210-11) that large firms use more sophisticated cost accounting methods than do small firms. In Manchester, the industries were: industrial chemicals (five companies), pharmaceuticals, soap, paints, oil refining, paper, steel. In Melbourne, the industries were: pharmaceuticals (two companies), soap (two companies), paints, rubber, glass, textiles, cement, confectionery, frozen food. The enquiry was initially intended to be a pilot study, to assist in designing a questionnaire that would be distributed by mail. However, the responses I received were so uniform that I switched the investigation to production engineers with first-hand experience of continuous process manufacture, seeking an explanation for the uniformity, and then terminated the enquiry. My samples were not random, but it may be doubted whether a postal enquiry of a random sample generating, say, a 50 per cent response rate would have given more reliable results. I certainly had no non-response problem.

The content of my conversations with the cost accountants was as follows:

(1) The initial question was, of course, whether their firms used continuous process manufacture. A surprising feature of the replies was that, for most of the firms, only some of their output was produced on a continuous process basis, the remainder being produced on a batch basis.

(2) The next question was explicitly directed towards the output produced on a continuous process basis. I asked whether, in costing the output of each process, the device of equivalent units was used. It was then invariably necessary to explain what equivalent units are. A brief explanation usually sufficed, since the accountants remembered the concept from the days when

they were studying for accounting examinations. I took considerable care to make sure that the accountants did understand the concept, for example, by distinguishing between the valuation of uncompleted units within each process, and the valuation of work-in-process over the factory as a whole: most work-in-process is fully complete as regards some processes and not started as regards other processes. The answer to the question, in all cases, was 'no'. Some of the accountants volunteered the information that, not only did their own firms not use the device of equivalent units, but they had never heard of it being used in any other firm. Cost accountants, typically, have had experience in firms other than those for which they now work, and have hearsay evidence relating to yet other firms. The accountants said that they related the cost of all the inputs of each process during any time period only to the units completed by the process in the same period, the cost of uncompleted units within each process being ignored. The word 'ignored' should not be misunderstood. The inputs of any process include, of course, the units transferred from the preceding process. What is ignored is the cost of the work done by a process on units which are inside it at the beginning and end of each reporting period.

(3) The final question asked the accountants to explain why they ignored the uncompleted units within each process in costing the completed units. They all said that the uncompleted work was constant in quantity and type at all times that the processes were operating. As regards the volume of such work, responses ranged from zero (at the end of each reporting period for processes which shut down overnight or over week-ends) to as much as 3 per cent of a month's output; in most cases it was negligible — a small proportion of 1 per cent of a month's output.

Although my enquiry was concerned with costing the completed output of each process, the problem of the valuation of work-in-process over the whole factory for the annual financial statements did arise. Even if the uncompleted work within each process is negligible, it does not follow that over all the processes taken together it is negligible; and even if it is constant in quantity and type at the beginning and end of each year, it is unlikely that its cost would be the same at each date. A few of the accountants volunteered information on this point: they said that they valued the uncompleted work within each process for this purpose at material cost only — at the cost of the finished output of the preceding process plus the cost of any additional materials introduced.

The uniformity of the responses from the cost accountants suggested that there were probably technical reasons, relating to the nature of process manufacture, which would explain the responses. I discussed the matter with production engineers having first-hand experience of continuous process manufacture (two in Manchester and one in Melbourne). The engineers were completely unsurprised by my findings. They explained that processes operate best when conditions are kept as constant as possible — constant temperature, input mix, rate of output, and so on. They also explained that process times are designed to be as short as possible, typically measured in minutes rather than hours (although the throughput time in some processes can be as

high as three hours). In these circumstances, it is only to be expected that the uncompleted work within a process will always be constant and will usually be negligible. The engineers also helped to explain the prevalence of batch costing, indicated in most of the answers to my first question. Batch production is used (in circumstances where continuous processing could technically be used) where production is discontinuous, either because of lack of demand for a firm's products, or because of the need for frequent changes in product specification.

An Historical Interlude

Given that the device of equivalent units is not used, it is interesting to speculate how the concept got into the cost accounting literature. I examined a large number of early cost accounting books, and the early issues of the National Association of Cost Accountants' *Bulletins* (later renamed the *N.A.A. Bulletin,* and now entitled *Management Accounting*). The earliest references to equivalent units that I found were in two textbooks: in Atkins ([1], Ch. 25), published in 1924, and in Lawrence ([10], Ch. 3), published in 1925. Atkins was described on the title page of his book as an Instructor in Manufacturing at the University of Chicago, and a consultant industrial engineer and accountant. Lawrence was described as the Director of the Cost Accounting and Statistics Department of the American Photo-Engravers Association, and Professor of Accounting at De Paul University. An examination of the N.A.C.A. *Bulletins* from the first issue (Volume 1, Number 1, published in December 1919) to the last number of Volume 12 (published in August 1931) revealed that the first (and only) reference to equivalent units was in an article by Barth [2], which was published in June 1928, and dealt with cost accounting in a tannery.

In none of these three references is the name 'equivalent units' used; in fact, no name is given to the concept, but the concept is clearly there. In these sources, the only degree of completion considered is 50 per cent: it is suggested that work within a process which is partly complete can reasonably be assumed to be, on average, 50 per cent complete. There is, of course, no discussion of different degrees of completion as regards the various elements of cost, such as raw materials and conversion cost. The concept of equivalent units obviously persisted in the cost accounting textbooks, was given a name, and was further developed. It is possible that, after being proposed, the concept was applied in real life, but was then later abandoned in practice. This last statement can be classed as only a tentative hypothesis. I do not, however, have the necessary expertise in historical research, or the inclination, to investigate the hypothesis further. It is interesting to note that the first reference to operation costing (although with no name given to it) pre-dates the references quoted above: it is discussed in an article by Williams [16], which was published in October 1923.

Operation Costing

If work-in-process can be ignored in computing the cost of the completed output of continuous process manufacture, the costing system then appropriate is that of operation costing. This system is not new to the literature, but it has never been

extensively described, and, as mentioned at the beginning of this paper, it appears very briefly in only a few cost accounting texts. Because the device of equivalent units is not needed, operation costing is considerably simpler than process costing. The system can (but need not) dispense with the other characteristic feature of process costing, that of transferring costs in the accounts from one operation to the next in the sequence: in other words, it is not necessary to accumulate routinely total cost per unit of output. A description of a typical operation costing system follows. I have chosen a type of product whose method of manufacture can be described reasonably intelligibly, and of which I have had first-hand experience.

My illustrative product is the cartons in which items such as cornflakes and detergent powders are sold. Typical manufacturing operations are:

(1) Printing. Sheets of cardboard, measuring three feet by four feet, or more, are printed with perhaps ten cartons (in flat form) on each sheet of card. The printing can be done in several colours in one passage through a printing machine, or each colour can be printed separately. (Strictly speaking, of course, the first operation is the issuing of the cardboard by the raw material stores.)

(2) Cutting and creasing. The cartons on each sheet of board are cut round, and the folds that will be needed in each carton are scored (or indented).

(3) Stripping. The cartons are stripped away from the surplus, unprinted, board which surrounds them. (Some machines can combine this operation and operation 2.)

(4) Folding, gluing and packing. The cartons, still in a completely flat and open form, are passed through a machine which folds them lengthwise and glues them along their side seams. The cartons are then inspected and packed into cases for despatch to the firms which manufacture their contents. (The manufacturers of the cornflakes, detergents, or whatever, open out the cartons, insert their contents, and glue the cartons along their bottom and top seams.)

The production process outlined above has a number of significant characteristics:

(a) Each machine can be used for a large range of cartons, by, for example, changing the formes or printing plates on the printing machines and the dies on the cutting and creasing machines. However, as Daz and Omo cartons, of a given size, are very much alike, output can be grouped into a restricted number of carton types. Because it takes significant time to change machines over from, say, a Daz to an Omo carton, long production runs are cheaper per unit than short runs, and short runs are discouraged through the pricing mechanism. For these two reasons, the use of standard costing is highly practicable, and in what follows it will be assumed to be used, based on expected (i.e., attainable, or medium-level) targets.

(b) Each machine, or group of machines, has a fixed labour crew which is constant irrespective of the volume of output. For example, a group of three printing presses may require three printers, and one labourer to load unprinted board onto one end of each machine and to remove the printed board at the other. As a result, assuming there is no distinct trend in the total volume of output, production wages will be primarily a fixed, rather than a variable, cost. In short,

raw materials will be the main variable cost, the only others being expenses like electricity.

(c) Work-in-progress on each operation is both negligible and constant over time. It may even, at relevant times, be non-existent, for example, on a printing press that does not operate through the night. Obviously, the device of equivalent units is unnecessary.

With the system outlined above, all the needs of management for cost information can be met without computing the total actual cost of product units. It is not even necessary to compute actual cost per unit at each operation. Some of the advantages of such a system stem from the use of standard costing rather than operation costing, but the latter adds significantly to the system's simplicity. It has long been recognized that, with a standard costing system, it is unnecessary to compute both actual costs and variances: if and when actual costs are needed, they can be computed by adjusting standard costs by the variances. The only formal cost accounts needed (in addition to variance accounts) is one account for each department (not each operation), to record all the production costs of each department.

Consider the major purposes for which management needs cost data:

(1) Cost control. For this purpose, management is interested, not in actual costs, but in variances: for example, it is not interested primarily in the amount of material used, but in the amount of material wasted (relative to the standard waste allowances). As regards wages, management is again interested in variances rather than actual costs, but if wages are primarily a fixed cost in the short run, it may be doubted whether it is helpful to production management to assign money values to labour efficiency variances. It is probably sufficient to compare the actual volume of output (of each product) from each operation every day (or week) and compare this with the standard volume of output (alternatively, actual and standard labour hours can be compared). Similarly with idle time: a comparison of actual and budgeted hours will probably be sufficient for production management's needs. All variances, however, will need to be given a money value eventually, to enable actual output costs to be estimated when necessary, and to permit the actual profit for the period to be reconciled with the budgeted profit. The standard cost of each period's inputs is computed by reference to the completed output of each operation.

(2) Decision making. For short-run decision making, standard costs need to be divided into fixed and variable elements. The process of analysing and explaining variances will reveal any inaccuracies in this classification. For decision making, past data is of interest mainly as a guide to future costs. Standard costs, adjusted (where necessary) for variances, should be entirely satisfactory as such a guide. When information is required on the total variable cost of product units, it can be computed by adding together the unit variable costs of the relevant operations (including selling and distribution operations).

(3) Price determination (on a cost-plus basis). For this purpose also, past costs are of interest primarily as a basis for predicting future costs. In addition, however, it will be necessary to check at least occasionally the accuracy of the cost

estimates on which prices are based. Since the estimates of unit cost will be built up operation by operation, it should be completely satisfactory to compute the actual cost of each operation by adjusting standard costs by variances. (It will be necessary, of course, to record the types of product, as well as the operations, that have given rise to the variances, but such a record will be necessary anyway in order to assess labour efficiency.)

(4) Stock valuation. Stock can, in principle, be valued at standard cost, provided that the standards are attainable. If the variances are significant, however, standard costs can be adjusted by them. Almost all partly completed work will be fully complete as regards some operations, and not started so far as other operations are concerned. It will merely be necessary, in taking stock, to record for all uncompleted work the last operation that was performed on it. If the uncompleted work within the operations is significant in total, it can be valued, for each operation, at the cost of the finished output of the preceding operation; alternatively, it can be valued at the arithmetic mean of that cost and the cost of the finished output of the operation where it is situated.

It is, perhaps, worth summarizing the main features of the above illustration:

(a) The omission of the uncompleted units within each operation in computing the standard cost of each period's inputs.
(b) The computation of actual output costs primarily by means of the adjustment of standard costs for observed variances.
(c) The computation of product-unit costs only as and when required.
(d) The computation of total cost, whether per product unit or not, by adding together the cost of the relevant operations.

Conclusion

Accountants and prospective accountants who study cost accounting systems in the literature are told that all systems are either job costing or process costing, virtually no mention being made of operation costing. They are forced to invest considerable time and trouble in the study of process costing. If the evidence and arguments presented in this paper are valid, that effort is largely wasted, since process costing is not used in the real world. On the other hand, operation costing (I believe) is even more common than job costing, since it is probably the primary method used in mass-production manufacture. It is particularly well suited to companies which wish to make as little use as possible of product-unit cost data. Considerably more attention (I believe) should be devoted to operation costing by accounting teachers and research workers.

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