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A comparison of product costing practices in discrete-part and assembly manufacturing and continuous production process manufacturing

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Abstract

Research into product costing practice has not studied whether there are differences in product costing practice between different types of manufacturing. This paper compares the product costing practices of operating units in discrete-part and assembly manufacturing, and continuous production process manufacturing. The results show that there are few differences in product costing practices between these two manufacturing methods. Similar proportions of operating units in these two manufacturing environments use similar methods to treat overheads and have similar experiences of activity-based costing. The only area of difference is in the use of overhead rates where significantly more units in discrete-part and assembly manufacturing use a direct labour hour rate and significantly more units in continuous production process manufacturing use units produced and production time-based rates.

Keywords: Product costing; Discrete-part and assembly manufacturing; Continuous production process manufacturing and activity-based costing

1. Introduction

Reeve (1991) points out that many of the articles and case studies about cost management are set in discrete-part and assembly manufacturing environments and that relatively little attention has been paid to continuous production process manufacturing environments (e.g. chemicals, food and paper manufacturing). Most discrete-part and assembly manufacturing are convergent manufacturing processes, whereby parts are manufactured into sub-assemblies that are combined to form the finished product. Reeve argues that the overhead costs relating to this type of manufacturing are high and can be as high as direct material costs, which explains why some of the initial efforts to describe the application of activity-based costing

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(ABC) were in this environment. Here ABC can be used to assign overheads, relating to the diversity and complexity of the manufacturing process, to products using batch-level and product-sustaining cost drivers. Reeve (1991) describes ABC systems in discrete-part and assembly manufacturing as being product orientated, in other words "activities consume resources, and products consume activities" (Reeve, 1991, p. 24). Activities are traced to parts by discrete and measurable events like set-ups, material movements, etc., and by implication the product is the main generator of activities.

Continuous manufacturing processes are divergent manufacturing processes. Here, common raw materials enter the production process and by the end of the production process this input is divided into many different products with differing colours and sizes, examples include, aluminium products produced in a rolling mill with varying widths and thickness, and paper products of different sizes, colour and coatings (Reeve, 1991). When compared to convergent manufacturing, the diversity and complexity of divergent manufacturing occurs further on in the production process. Reeve (1991) argues that the differences between convergent and divergent manufacturing lead to problems accepting ABC in the latter environment. For example, product changeovers in continuous production process manufacturing can be made while a machine is running, meaning that this activity is likely to be less important than it is in discrete-part and assembly manufacturing. Also, activities cannot be traced to discrete parts in continuous production process manufacturing because there are no parts. The materials input at the beginning of the manufacturing process lose their identity once manufacturing commences.

Reeve (1991) notes that in continuous production process manufacturing overheads relating, e.g., to raw material management and procurement do not make up a large proportion of overhead costs and hence it is less important to understand the cost drivers of these activities. Also, Reeve (1991) argues that unlike discrete-part and assembly manufacturing, products do not cause activities in continuous production process manufacturing, instead activities are caused by process conditions. Here, the production process, not the product, drives engineering, continuous improvement and maintenance activities. For example, maintenance activities are caused by process factors like machine speed, number of machine start-ups and the number of shutdowns not by the products produced.

Krumwiede (1998) and Ittner et al. (2002) have empirically tested Reeve's arguments and obtained the opposite result; namely that ABC is less likely to be adopted in discrete-part and assembly manufacturing environments. As a consequence, there is some doubt about the validity of Reeve's arguments, and furthermore, to the authors' knowledge prior, research has not examined whether product costing practices in general vary between these manufacturing environments. Given the above, the objective of this paper is to undertake exploratory research to compare product costing practices of manufacturing units in Great Britain which use discrete-part and assembly manufacturing, and continuous production process manufacturing to test if the practices vary between these types of manufacturing.

The research is organised in terms of the issues identified by Drury and Tayles (1995) which have preoccupied researchers of product costing practice. The results of prior research are examined in three areas which are (1) the allocation and assignment of overheads to products, (2) the bases used to calculate overhead rates and (3) the adoption of ABC. The remainder of the paper is organised into four further sections. Section 2 reviews prior research in the three areas listed above, and from this review three exploratory research questions are identified. Section 3 describes the research method using a postal questionnaire survey. Section 4 presents the results of the survey. Section 5 concludes the research and offers some suggestions for future research.

2. Product costing practice in manufacturing industry

2.1. The allocation and assignment of overheads

Some organisations simplify the first stage in the allocation and assignment of manufacturing

overheads to products by not allocating them to cost centres. Instead, they calculate a blanket overhead rate, for a factory, a group of factories or a company, and use this to assign overheads to products produced regardless of the production department where products were made (Drury, 2004). This rate is suitable in an accounting system designed to prepare the financial accounts; i.e., it is adequate for assigning overheads between cost of sales and stocks in the profit and loss account. In addition, it is suitable for assigning overheads to products when only one product is produced, or to each product produced in a factory which has more than one production department when products produced consume resources from the production departments in the same proportions (Drury, 2004). It is unlikely to be suitable when products consume resources from different production departments in differing proportions. In the UK, Drury et al. (1993) found that a significant minority (26%) of units assign overheads to products using blanket overhead rates, and similar proportions have been observed in Australia (Joye and Blayney, 1990), Ireland (Clarke, 1992), New Zealand (Lamminmaki and Drury, 2001) and the USA (Emore and Ness, 1991). Drury et al. (1993) noted that 19% of their sample used full product costs obtained using blanket rates for decision making in a multi-product firm and these costs may provide inaccurate costs for decision making.

Drury et al. (1993) noted that, in general, one of three methods was used to assign service/support department costs to products. The most accurate of these approaches (used by 21% of units) assigned service/support department costs to products using separate production and service/support department overhead rates. Of the other two methods, 45% allocated service/support department costs to production departments and assigned them to products using production department overhead rates and 27% included overheads in products using blanket overhead rates. A further 5% of units used other methods.

2.2. Bases used to calculate overhead rates

Product costing research in Europe has found that a significant proportion of units used a direct labour-based overhead rate (either direct labour cost or direct labour hour rates) or other volume-based overhead rates (e.g. machine hour, material cost, units produced and production time-based rates) have been used extensively (Brierley et al., 2001). In addition, this result have been confirmed in Australia (Joye and Blayney, 1990), New Zealand (Lamminmaki and Drury, 2001) and the USA (Cohen and Paquette, 1991; Emore and Ness, 1991; Green and Amenkhienan, 1992). Drury and Tayles (1994) note many firms are likely to incur overheads driven by direct labour hours, and hence it is not surprising that researchers have found direct labour being used as a basis for assigning overheads to products (see Brierley et al. 2001). However, given the relatively low proportion of product costs that are made up of direct labour costs it is perhaps surprising to see that it is the most commonly used overhead rate.

2.3. The application of activity-based costing

Research has shown that a non-insignificant minority of units are using ABC (in the UK, see Bright et al. (1992); Drury et al. (1993); Innes and Mitchell (1995); Drury and Tayles (2000); Innes et al. (2000) and for results for units in mainland Europe, see Bhimani (1996)). In addition, researchers have reported other experiences of ABC for units in the UK (results for units in mainland Europe are reported in Bhimani (1996)):

- intending to introduce/planning to use/implementing ABC (Drury et al., 1993; Drury and Tayles, 2000),
- considering and implementing ABC (Cobb et al., 1992),
- currently assessing/investigating ABC (Cobb et al., 1992),
- giving some consideration to introducing ABC (Cobb et al., 1992; Drury et al., 1993),
- rejected ABC (Cobb et al., 1992; Drury et al., 1993),
- given no consideration to ABC (Cobb et al., 1992; Drury et al., 1993).

2.4. Research questions

From this review of prior research, the following three exploratory research questions are addressed in this paper. They relate to the possible variation in product costing practices between discrete-part and assembly manufacturing and continuous production process manufacturing environments. The three questions are:

1. Do the methods used to allocate and assign overheads to products vary between the two manufacturing environments?
2. Do the types of overhead rate used to assign overhead costs to products vary between the two manufacturing environments?
3. Do the experiences of operating units of ABC vary between the two manufacturing environments?

3. Research method

3.1. The research questionnaire

The questionnaire consisted of 40 questions, 29 questions covered product costing and 11 questions covered background information about each respondent's operating unit. The first question identified the frequency with which product cost information is used in decision making and the responses to this question allowed the elimination from further analysis of operating units that do not use product costs in decision making.

Information about the allocation and assignment of overheads was obtained by responses to a question consisting of a blanket overhead rate, production department rates, production and service/support department rates, ABC, variable costing, and other. To ascertain the main types of overhead rates used respondents were asked to indicate whether they used a direct labour cost, direct labour hour, machine hour, material cost, units produced and/or production time overhead rates. Finally, details of respondents experience with ABC was obtained from a question with the responses of (1) currently using ABC, (2) intending to use ABC, (3) currently investigating using ABC, (4) intending to investigate using ABC, (5) rejected ABC, but established a system of activity analysis or cost driver analysis, (6) implemented ABC and subsequently abandoned it, (7) investigated using ABC and rejected it, (8) rejected ABC, but never investigated its possible use, (9) never considered using ABC or (10) other responses supplied by respondents.

3.2. Questionnaire respondents

Questionnaire respondents were obtained initially from a list of 854 members of the Chartered Institute of Management Accountants (CIMA) whose job titles were either cost, management or manufacturing accountant and worked in British manufacturing industry. An introductory letter was sent to all potential respondents, which explained the objective of the research, informed the potential respondents that they would receive a questionnaire in two weeks time and assured them of the confidentiality of their responses. The questionnaires were sent out two weeks later and each was accompanied by a covering letter and stamped addressed envelope. Any non-respondents to the initial mailing of the questionnaire were sent a follow-up letter 2 weeks later, and a further follow-up letter and questionnaire was sent to non-respondents 4 weeks after the initial questionnaire had been sent out. After identifying operating units which had closed down, and potential respondents who worked in the same operating unit had left their operating unit and were not involved in manufacturing or product costing, the total potential subjects declined to 673. Of these a total of 280 useable responses were received (effective response rate = 41.6%).

3.3. Manufacturing method

Details of the type of manufacturing undertaken was obtained by asking respondents whether they used discrete-part and assembly manufacturing, continuous production process manufacturing or some other method. Of the 270 respondents from operating units that answered the question, 112 used discrete-part and assembly manufacturing and 131 used continuous production process

manufacturing. Of the other 27 operating units, 6 used neither of these methods, 13 used both of them and 8 used job and batch manufacturing which can entail either discrete-part and assembly, or continuous production process manufacturing. The 27 other respondents are excluded from further analysis, and results are reported for the 243 respondents using one of the two manufacturing methods.

4. Results

Of the 243 respondents manufacturing in either discrete-part and assembly manufacturing or continuous production process manufacturing, a total of 238 operating units use product costs in decision making, of which 109 use discrete-part and assembly manufacturing and 129 use continuous production process manufacturing.

Table 1 shows the methods used to allocate and assign overheads to products. The methods are used to a similar extent in each of the two groups. The most common method of allocating and assigning overhead costs to products is to use a production department overhead rate. A minority of operating units use a blanket overhead rate. Two of the total of 30 using a blanket rate produce a single product (both in continuous production process manufacturing), so for the remainder a blanket rate may result in the reporting of distorted product costs. For both types of manufacturing a similar proportion of units use production and service/support department overhead rates and variable costing, and only a few operating units use ABC. Table 1 indicates that there is no significant difference ($p > 0.05$) between units that include and do not include overheads in product costs.

Table 2 shows that the most popular overhead rates are the direct labour cost, direct labour hour, machine hour and units produced rates. The direct labour hour rate is the most popular in discrete-part and assembly manufacturing and the machine hour rate in continuous production process manufacturing. The X^2 statistical tests shows that the direct labour cost, machine hour and material cost-based rates are used to a similar extent in each manufacturing environment. In contrast, the direct labour hour rate is used significantly more often in discrete-part and assembly manufacturing, while units produced and production time rates are used significantly more often in continuous production process manufacturing ($p < 0.05$).

Table 3 shows the operating units' experience with ABC and a X^2 statistical test reveals there is no significant difference between the two manufacturing environments. Only a few operating units use ABC and slightly more units in continuous production process manufacturing

Table 1
Overhead cost allocation and assignment methods (useable $n = 203$)

	Discrete-part and assembly manufacturing		Continuous production process manufacturing		Total	
	n	(%)	*n*	(%)	*n*	(%)
A blanket overhead rate	15	(15.8)	13	(12.1)	28	(13.8)
Production department rates	44	(46.3)	53	(49.1)	97	(47.8)
Production and service/support department rates	17	(17.9)	17	(15.7)	34	(16.8)
ABC	2	(2.1)	5	(4.6)	7	(3.4)
Variable costing	16	(16.8)	20	(18.5)	36	(17.7)
Other	1	(1.1)	—	(0.0)	1	(0.5)
Total	95	(100.0)	108	(100.0)	203	(100.0)

To meet the requirements necessary to perform a X^2 test, the variable costing category is compared with all the other categories (representing full costing) there is a no significant difference between these two groups ($X^2 = 0.009$, df = 1, $p = 0.926$, 2-tailed test).

Table 2
Types of overhead rate used

Type of overhead rate	Discrete-part and assembly manufacturing		Continuous production process manufacturing		Total			
	n[a]	(%)[a]	n[b]	(%)[b]	n[c]	(%)[c]	X^{2}[b,d]	p
Direct labour cost	23	(25.8)	20	(19.6)	43	(22.5)	0.732	0.392
Direct labour hour	51	(57.3)	37	(36.3)	88	(46.1)	7.634	0.006
Machine hour	35	(39.3)	41	(40.2)	76	(39.8)	0.000	1.000
Material cost	17	(19.1)	15	(14.7)	32	(16.8)	0.381	0.537
Units produced	19	(21.3)	38	(37.3)	57	(29.8)	5.009	0.025
Production time	7	(7.9)	21	(20.6)	28	(14.7)	5.175	0.023

[a]The number and percentage of responses for each rate is based on total usable responses from 89 operating units.
[b]The number and percentage of responses for each rate is based on total useable responses from 102 operating units.
[c]The number and percentage of responses for each rate is based on total useable responses from 191 operating units.
[d]The results of a X^2 test (2-tailed test) derived from a 2×2 contingency table of the difference between the extent of use of each type of overhead rate between the two manufacturing methods.

Table 3
Operating units' experience of ABC (useable $n = 233$)[a]

	Discrete-part and assembly manufacturing		Continuous production process manufacturing		Total	
	n	(%)	n	(%)	n	(%)
Currently using ABC	3[b]	(2.8)	5	(3.9)	8[b]	(3.4)
Intending to use ABC	8	(7.5)	8	(6.3)	16	(6.9)
Currently investigating using ABC	8	(7.5)	9	(7.1)	17	(7.3)
Intending to investigate using ABC	11	(10.3)	21	(16.7)	32	(13.7)
Rejected ABC, but established a system of activity analysis or cost driver analysis	13	(12.1)	17	(13.5)	30	(12.9)
Implemented ABC and subsequently abandoned it	3	(2.8)	1	(0.8)	4	(1.7)
Investigated using ABC and rejected it	24	(22.4)	22	(17.5)	46	(19.7)
Rejected ABC, but never investigated its possible use	6	(5.6)	5	(4.0)	11	(4.7)
Never considered using ABC	28	(26.2)	35	(27.8)	63	(27.1)
Other	3	(2.8)	3	(2.4)	6	(2.6)
Total	107	(100.0)	126	(100.0)	233	(100.0)

[a]To meet the requirements necessary to perform a X^2 test comparing the frequency of responses for the two manufacturing methods, the respondents currently using and intending to use, currently investigating and intending to investigate ABC are combined into a group, and the other two groups are those who have rejected or abandoned ABC and those who have never considered it. A X^2 test comparing the frequency of responses reveals that there is no significant difference between the two manufacturing methods across these three groups ($X^2 = 1.5234$, df $= 2$, $p = 0.467$, 2-tailed test).
[b]Table 1 also indicates that two rather than three operating units are currently using ABC in discrete-part and assembly manufacturing. This is because the respondent coded as "other" in Table 1 also uses ABC as an alternative method of costing for the purpose of comparison.

use this costing method. In addition, a relatively low proportion of respondents are intending to use and currently investigating ABC. The largest percentage for both types of manufacturing methods are those who have never considered ABC.

5. Conclusion

This paper has compared product costing practices in manufacturing units which use discrete-part and assembly manufacturing and continuous production process manufacturing based on three areas identified by Drury and Tayles (1995). Reeve (1991) highlights the differences between these two manufacturing environments and, by implication, that there may be differences in the product costing practices between them. The results of this research do not support the idea of differences in product costing practice between these two environments. Similar percentages of operating units in each manufacturing environment allocate and assign overheads in similar ways. Significant differences were observed in the application of certain overhead rates. Direct labour hour rates were used significantly more often in discrete-part and assembly manufacturing, and units produced and production time-based rates were used significantly more often in continuous production process manufacturing. There were no significant differences in the frequency of direct labour cost, machine hour and material cost-based rates. It is unclear why these significant differences arose and this is a subject for further research. Very few operating units use ABC and contrary to Reeve (1991), but consistent with Krumwiede (1998) and Ittner et al. (2002), more units use it in continuous production process manufacturing, although the extent of this difference is not significant.

The limitations of this research arise from using the research questionnaire. The results may be affected by the misinterpretation of questions; the measures used are single items and have unknown psychometric properties. As a result of these limitations it may be difficult to make generalisations to other populations. Although this is exploratory research, it raises as many questions as it answers. The paper shows that unlike as speculated by Reeve (1991) there does not appear to be any differences in product costing practice between discrete-part and assembly manufacturing and continuous production process manufacturing. This means that the selection of which product costing practices to use is not dependent on the type of manufacturing environment. It is important that further research should be carried out to corroborate the results of this research and use interview and case study research methods to understand the reasons as to why there are no major differences between product costing practices in these two manufacturing environments.

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