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The development of by-products in industry is one of the most outstanding phenomena in our economic life. During the earlier periods of American history our natural resources made it unnecessary from a cost standpoint to pay attention to efficient methods of production. However, rising costs of land, labor, and transportation in the last generation, coupled with the vastly increased per capita consumption of all products, have forced each industry to add to its operations, thus conserving and even synthesizing many commodities which otherwise would not have been available. From the viewpoint of individual business, this manufacture of by-products has turned waste into such a source of revenue that in many cases the by-products have proved more profitable per pound than the main product.

...hence one of the most important opportunities for gaining competitive advantage, or even for enabling an industry or individual business to maintain its position in this new competition, is to reduce its manufacturing expense by creating new credits for products previously unmarketable [Clemen].

Rudolf Clemen wrote these words in 1927, and they are as appropriate today as they were then, perhaps more so. Since that time, consumption has continued to expand, but resources have expanded at a slower rate, while the costs of producing many of the major products in industry have increased substantially.

Purpose of the Study

The purpose of this study was to examine the area of by-products and, in particular, accounting for by-products. One reason for the study is that historically, many minor products have changed to major products; e.g., gasoline was once a by-product of kerosene refining. Another reason for studying by-products and by-product accounting is the need for business to optimize profits. One firm which formerly paid a trucker to haul away waste discovered the waste was valuable as fertilizer, which became an additional source of revenue for the entire industry [Matz].

Still another reason for a current study of by-product accounting is the growing scarcity of valuable resources. The continuing depletion of oil, minerals, metal ores, etc., means that firms cannot continue to expect to have abundant resources from which to manufacture only major products. Each unit of raw material must be fully utilized; thus, by-products become important in order for firms to optimize the use of the raw materials.

Definition of By Product

A by-product is defined as an article of value incidental to the manufacture of the main product(s) or, alternatively, made from waste arising from such a manufacturing process [Lang]. A by-product is usually of minor value to the firm compared with the value of the major product(s). By-products may be classified into two major types: (1) those which need further processing, and (2) those which may be sold without additional processing.

Survey of Authoritative Literature

The first part of the study was a survey of methods for accounting for by-products which have been advocated in the past by accountants and accounting academicians. The methods most frequently found in the literature were:

1. Revenue from by-products sold is reported as additional revenue.
2. Revenue from by-products sold less separable costs of processing and disposal is reported as additional revenue.
3. Revenue from by-products sold is reported as other income.
4. Revenue from by-products sold less separable costs of processing and disposal is reported as other income.
5. Revenue from by-products sold is reported as a deduction from the cost of the major products sold.
6. Revenue from by-products sold less separable costs of processing and disposal is reported as a deduction from the cost of the major products sold.
7. Revenue from by-products sold is reported as a deduction from the cost of the major products produced.
8. Revenue from by-products sold less separable costs of processing and disposal is reported as a deduction from the cost of the major products produced.
9. Net realizable value of by-products produced is reported as a deduction from the cost of the major products produced.
10. Net realizable value less a normal profit margin of by-products produced is reported as a deduction from the cost of the major products produced.
11. Other methods.
    a. Replacement cost method.
    b. Standard cost method.

The choice of method for accounting for by-products is affected by the size of by-product sales, internal needs of management, and marketability of the by-product.

The most theoretically sound method to account for by-products generally has been concluded to be the "net realizable value" method, according to recent accounting textbooks [Horngren, Rayburn]. It advocates the deduction of net realizable value of by-products produced from the total cost of goods produced. Net realizable value is defined as expected revenues from sales of by-products, less separable costs. Separable costs may be additional costs of production after separation from the main product or selling or disposal costs. Among the drawbacks to this method are that it is more complicated and expensive to use than other methods and, it requires projections of future revenues and costs. Thus, it cannot be used in all cases. When by-product sales are small, other and less complicated methods may be used, but these methods either do not place a value on inventory or properly match revenues and expenses.

Design of the Study

The next part of the study was conducted to determine which of these accounting methods were used in practice. There are many instances when by-products became major products or additional sources of revenue for firms. For these reasons, businesses need information with which to monitor by-products for optimal profits. Since management must have sufficient information on which to base its decisions, it follows that it is the management accountant's role to provide this information.

Research Questions

This study of accounting for by-products sought to answer, in part, the following questions:

1. Are the by-product accounting methods which historically have been recommended by accountants being used in practice?
2. Do businesses believe that by-products are important?
3. Do businesses actively search for alternate methods for processing by-products or alternate markets for by-products?
4. What methods do firms use to evaluate alternate processing methods and alternate markets for by-products?
5. How is the determination made that a by-product has reached the status of a major product?
6. What is the internal process by which management officially changes the status of a by-product to a major product?

Sample and Questionnaire

Data for the study were gathered through a mail survey followed by telephone interviews. The survey included companies in the extractive industries; that is, oil and gas, coal mining, metal mining and smelting, mineral mining and refining, and forestry and forest products. These particular industries were chosen for two reasons: (1) Historically they have been involved with by-products and by-product accounting [Greer], and (2) the size of the study needed to be reduced to a reasonable level. The questionnaire was sent tot he controllers of firms chosen within these extractive industries. In addition to Parts I, II, and III, the fourth part of the questionnaire asked for general demographics of the firm.

The master list of 2,483 firms was compiled from Dun & Bradstreet's *Million Dollar Directory.* Standard Industrial Codes (SIC) were used to determine the firm's activity in the extractive industries, and a random sample of 589 firms was chosen from this list. After the responses were received, telephone interviews were then conducted to furnish additional information or clarify the data. Usable responses were received from 190 firms.

Results of the Survey - Part I

Part I of the questionnaire asked about the methods these firms used for accounting for by-product sales, inventories, and adjustments of the cost of major products. The purpose of these particular questions was to determine if the companies actually use the methods that historically have been advocated by accounting theoreticians and whether by-products were believed to be important (Research Questions 1 and 2). Respondents were asked to divide their answers between Type A and Type B by-products. Type A by-products were defined as those that are sold after separation from the main product without additional processing, and Type B by-products were defined as those that require additional processing. Of the 190 respondents, 183 had Type A by-products and 34 had Type B by-products.

Sales Accounting Methods

Some 53.0 percent of firms with Type A by-products and 58.8 percent of firms with Type B by-products reported that they frequently did not segregate total by-product sales into "other revenue" or "miscellaneous" income but included them in total sales. In addition, 19.7 percent of firms with Type A by-products and 17.6 percent of firms with Type B by-products reported that they used "other" methods. When the questionnaires were analyzed to determine what "other" methods meant, it was found that most of the firms reduced either cost of goods sold or cost of goods produced for by-product sales. When this question was analyzed by industry, for Type A by-products, oil and gas reported the highest percentage using "other revenue" (31.3 percent). For Type B by-products, minerals reported the highest percentage using "other revenue" (28.6 percent).

Methods used for Reduction of Cost of Goods Sold or Cost of Goods Produced

The second question asked for the method used for reduction of cost of goods sold or goods produced. The method most frequently used for Type A by-products (57.4 percent) and Type B by-products (44.1 percent) was "no adjustment". The second most frequently used method for firms with Type A by-products was "reduction of cost of goods produced for actual by-product sales" (16.4 percent), and for firms with Type B by-products the next most frequently used method was "joint cost allocation" (20.6 percent). Both Types A and B by-product firms in the oil and gas and coal industries used "joint cost allocation" more frequently (12.5 percent, Type A; 50 percent, Type B) than the averages for all industries in the study.

Inventory Methods

Overall, the most frequently used inventory method for Type A by-products was "no value assigned" (62.3

percent), and the next most used method was "additional costs after separation" (13.1 percent). For firms with Type B by-products, the most frequently used methods were "joint cost plus separable costs" and "additional costs after separation" (29.4 percent each).

Reasons for Choosing a Specific By-Product Accounting Method

For Type A by-products, the most frequently cited reason for selecting a specific by-product accounting method was ease (83.1 percent). The next most frequently cited reasons were the opinions of other professional accountants (76 percent) and the opinion of the independent auditor (68.9 percent). Internal Revenue Service regulations (13.7 percent) and the size of by-product sales (9.8 percent) were also listed frequently. Firms in the energy-related industries listed the Department of Energy (37.5 percent) and Federal Power Commission (18.8 percent) as having an effect upon the choice of a by-product accounting method more often than the average for all industries in the survey.

For firms with Type B by-products, the most frequently cited reason was the opinion of the independent auditor (67.7 percent), followed by the ease of the method (64.7 percent) and the opinion of other professional accountants (55.9 percent). The size of the by-product's sales (29.4 percent) and Internal Revenue Service regulations (26.5 percent) were also listed frequently. Firms in the mineral industry listed the size of the by-product's sales and the Internal Revenue Service as having an effect on their choice more frequently than the average for all industries in the survey.

Results of the Survey - Part II

Part II of the questionnaire asked questions to determine if companies actively search for alternative processing methods and markets for by-products and, if so, how this is done. Positive responses that firms do actually seek alternatives would also indicate the relative importance of by-products (Research Questions 3 and 4).

Fourteen firms (7.4 percent) reported they had experience with by-products becoming major products. Eleven of the fourteen responded that a significant increase of by-product sales as a percentage of total sales was the major determinant in the decision to reclassify a by-product to the status of a major product. Ten of the fourteen firms agreed that it took more than two years for a by-product to become a major product. Ten of the fourteen also responded that a manager or officer in the corporate headquarters had the authority to reclassify a by-product to a major product. The particular division of the company with the authority was divided among production, accounting, and administrative personnel.

Conclusions

Since there were six research questions, the conclusions based on the results above address these six questions.

Question 1: Are the by-product accounting methods which historically have been recommended by accountants being used in practice?

The answer appears to be in the negative for most companies in the study. The majority chose the lease complicated methods for reporting sales of by-products, reducing cost of goods sold or produced, and valuing by-product inventories. The methods selected were chosen because of the ease of the method, or the opinions of other accountants. From examination of the inventory methods and cost reduction methods used by firms with Type A and Type B by-products, firms in the oil and gas and coal industries were found to use "joint cost allocation" more frequently, possibly because of the influence of regulatory groups. Less than 10 percent of the firms that responded to this study used the most theoretically preferred method, "net realizable value".

Question 2: Do businesses believe that by-products are important?

From the overall results, it can be concluded that many of the firms in the survey did not assess by-products as sufficiently important to use a complicated accounting method. However, when the responses were analyzed by size of by-product sales, firms that had larger amounts of total sales of by-products or larger percentages of by-product sales did use more complicated methods more often. As total sales of by-products increased, firms more frequently used "joint cost allocation" for assigning a cost to by-products. This is logical since, as total sales of by-products increase, the by-product approaches major product status.

Question 3: Do businesses actively search for alternate methods for processing by-products or alternate markets for by-products?

Most of the firms in the survey did not look for alternative processing methods or markets for by-products, which suggests these firms do not consider by-products important enough to warrant the time and expense. However, when the responses were analyzed by size of product sales, firms with large total by-product sales and relatively large percentages of by-product sales did look for those alternates for by-products.

Question 4: What methods do firms use to evaluate alternate processing methods and alternate markets for by-products?

The survey showed that most firms (76.5 percent) relied on sales departments to suggest alternates for by-products. This suggests that they looked for new places to sell the by-products, not new ways to process them, since most marketing departments probably do not have the technical expertise necessary to derive new processing methods for by-products. Another explanation is that marketing departments reported back to management the specifications that buyers required for the purchase of by-products.

All but two companies used at least one quantitative method to determine the feasibility of new methods for by-products. This suggests that firms do commit some resources in the explanatory stages of the search for alternate by-product processing methods and markets.

Question 5: How is the determination made that a by-product has reached the status of a major product?

Since so few firms responded to Part III of the questionnaire, only limited conclusions can be made. Most of the responding firms agreed that an increase in the percentage of total sales represented by by-product sales was the major factor in deciding to reclassify a by-product to a major product. This seems logical, because sales revenue is the most commonly used measure of the importance of a product.

Question 6: What is the internal process by which management officially changes the status of a by-product to a major product?

Most firms in the survey stated that it took more than two years for a by-product to become a major product. The internal decision to change the status was generally made at the corporate level. However, the particular division which made the decision varied among administration, accounting, or production.

Overall

This study was conducted in an effort to provide some empirical evidence about accounting for by-products. The study has not provided all the answers, but it does indicate the need for more research in this neglected area of accounting.

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