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Accounting for By-products, Co-products and Joint Products

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By John Arch White

1. The General Problem

Many methods of accounting for by-products, co-products and joint products are admittedly unsatisfactory. Present methods are the result of the experience and study of capable men, who have adopted available procedures seemingly best adapted to the particular business. In many instances practical considerations have defeated methods theoretically desirable. It appears that in studying the problem of improving our methods from both theoretical and practical standpoints, a clear definition of terms should be made.

The *by-product* is defined as any salable or usable value incidentally produced in addition to a main product without the necessity of any further manufacturing processes. Material separated from that entering into the article being fabricated becomes a by-product, provided it has value. This residual material has been changed in form or quality to such an extent that it can no longer be used in making the main product, but, nevertheless, it has a value recoverable through use or sale. The term by-product includes the terms scrap and waste in the sense in which these latter are customarily used. Examples of by-products are numerous—the waste of the cottonseed-oil mill and of the cotton mill; the scrap of the foundry and the fish cannery; the hides, fats, offal, etc., of the meat packing industry; and so on through numerous industries well known to the reader.

The *co-product* is that salable article resulting from the processing of one or more by-products—labor, other material and machine processes being applied in order to increase its marketability or profitableness. The co-product is a secondary aim on the part of the plant, being an effort so to change the form and usefulness of the by-products that the value of the material rejected from the processing of the main product may be more nearly realized on its sale. A most excellent example of a co-product may be taken from the hoop making industry. The

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manufacture of the smaller sizes of hoops is not profitable. The smaller sizes are usually made in order to utilize material not fitted for the making of larger hoops. The main product is the large hoop, which costs little more to manufacture than a small hoop but will bring a much higher price. The scrap and knotty logs are the by-products upon which are expended further expense and machine processes from which the small hoops result. In this way the value of a great deal of material is recovered, a value in excess of the fuel value of the by-product.

Joint products are those produced simultaneously by a common process or series of processes, each having more than a nominal value in the form in which produced. Where two or more marketable products of relatively substantial value are produced by a common process, the products are joint. The hog industry furnishes an excellent illustration of joint products. The hog is slaughtered and the carcass is cut up into hams, ribs, bellies, shoulders, loins, butts, etc. These are joint products.

But what is the essential difference between by-products and joint products? By-products are produced jointly with the main product at a joint cost, and thus possess the chief characteristics of joint products. From the accounting standpoint this question resolves into one of treatment. If the product is treated independently and an attempt is made to find its equitable share of the total cost, it is a joint product. If, on the other hand, the product is merely considered as a deduction from the cost of manufacturing a more important product, or as miscellaneous income, it is a secondary or by-product.

Some flour mills operate on the theory that they are chiefly engaged in the production of high grade flour, and that all other commodities milled from the wheat are by-products. In these mills the cost of manufacturing patent flour receives credit for the market value of clear flour, bran, shorts, mixed feeds, etc. This method in truth treats all commodities of the mill other than the patent flour as by-products. In other mills, the total manufacturing cost is pro-rated over all the products on some equitable basis, usually on the basis of relative sales prices. The products under this treatment are joint products.

2. Methods of Costing By-products

In realizing the value of by-products the industry must face the problem of accounting for that value. Competition is growing

more and more keen, and the margin between production cost and sales price is becoming smaller and smaller. As a consequence many managements have been forced against their will to pay increasing attention to the problem of waste and the recovery of residual materials and scrap in the plant.

The following outline contains the methods which are commonly used in accounting for the by-product. The operation of some of these is so varied in different industries that their kinship is often not recognized or is even denied. A combination of two or more methods is sometimes used, which explains to some extent the failure to classify existing methods into groups which would aid in the study of the problem.

Outline of Methods

I. Miscellaneous-income method.
II. Arbitrary-value method.
III. Current-market-valuation method.
IV. Standard-value method.

In the miscellaneous-income method the net receipts from the sale of the by-product are added to the profit from operations and are not allowed to affect the cost of the main product. The advocates of this method contend that the recovery of waste and other by-products is the result of a provident management, and, consequently, has nothing to do with the cost of manufacture of the major product.

An example of this method may be taken from those industries which sell cinders from the power plant. The proceeds of such sales are treated as miscellaneous income. Of course, if a concern finds that it can sell its cinders regularly, the miscellaneous-income method should not be used, but some other method which allows the power department credit for the by-product value should be employed. The use of the miscellaneous-income method is common in small isolated plants of all industries. The small foundry has practically no demand for its slag; yet occasional sales are made to satisfy an infrequent demand in the community for the slag in the making of concrete and in the building of roads. In these cases the proceeds from the by-product slag should be treated as miscellaneous income. But in the larger foundries where it is possible to dispose of the slag consistently, some other method of accounting should be used.

A variation of the miscellaneous-income method is that in which certain ascertainable by-product costs due to wrapping, packing, selling, etc. are deducted from the proceeds of sale and the balance is treated as a miscellaneous income. This method should be used under the same conditions as mentioned for the straight miscellaneous-income method.

An arbitrary value is sometimes assigned to the by-product when made. This arbitrary value is debited to the by-product and credited to the manufacturing cost of the main product. The arbitrary value is sometimes set at a price somewhat higher than the lower range of the market price for the particular by-product. When the by-product is sold, cash or accounts receivable is debited, and, if the market is lower than the value assigned to the by-product, profit-and-loss is debited with the variance or loss. The by-product account is credited with the proceeds of the sale, and, if the market price is higher than the value assigned to the by-product, profit-and-loss is credited for the miscellaneous income.

The journal entries under this method are:

By-product	$ xxx	
Manufacturing expense		$ xxx
Assignment of arbitrary value to the by-product.		
By-product	xxx	
Selling expense		xxx
Other distributing expenses		xxx
To charge the by-product with distributing expenses incurred.		
Cash (or accounts receivable)	xxx	
By-product		xxx
To record sale of by-product.		
By-product	xxx	
(Or profit-and-loss)		
Profit-and-loss (miscellaneous income)		xxx
(Or by-product)		
To transfer profit or loss on sale of by-product to profit-and-loss.		

Perhaps the most widely used method in accounting for the by-product is the current-market-valuation method. The manufacturing cost of the main product receives credit for the by-product at the market value current at the time of production. The by-product is charged with this market value and receives credit for the proceeds of its sale. Since the market price will probably undergo a change between the time of production and

the time of sale, there will be a discrepancy between the value credited to the main product and the sales price. This difference is treated as a miscellaneous profit or loss, as the case may be. Some concerns using this method deduct from the market value the estimated expenses incidental to the packing and distribution of the by-product in finding the credit to the main product.

One of the chief objections made against the method is that profits are anticipated on the by-product when major product costs are given credit for by-products at current selling prices which may never be realized through sale. If a clear distinction is made between by-products and co- and joint products, it should be remembered that no profit is expected nor is any made on the by-product itself. It is true that the by-product is inventoried at the time of production in order that the best costs possible may be obtained immediately for the main product. If these inventory values decline, the decreases may be treated in the same manner as are decreases in the value of raw material inventory.

The following schedule illustrates the current-market-valuation method:

COSTING PRODUCTS IN A RICE MILL

Total cost of rough rice to the mill		$ xxx
Add: Cost of milling		xxx
Total manufacturing cost		$ xxx
Less: Market price of by-products—		
Screenings	$ xxx	
Brewers	xxx	
Bran	xxx	
Polish	xxx	
Chicken feed	xxx	
Hulls	xxx	
Total by-product credit		xxx
Cost of clean rice		$ xxx

The standard-value method establishes a normal value for each by-product based on respective sales prices over a long period of time. The manufacturing cost of the main product is credited with the by-product at this standard value. The journal entries for this method are the same as those given for the arbitrary-value method.

Under the job-order cost system, the credit for the by-product should be passed to the work-in-process account, if it is possible to determine the amount of such value applicable to each job. If not, the credit should be made to the burden account. The materials-in-process account should be credited with the by-product under a process cost system.

3. Methods of Costing Co-products

Methods of costing co-products depend to a large extent on those used in costing by-products, since the most uncertain element in that cost is the value of the by-product being converted. Once the value of the by-product material is obtained, it is not so difficult to segregate the direct expenses of processing and apply together with an equitable share of burden to the co-product.

The following outline contains the methods most commonly used in costing co-products.

Outline of Methods

I. No-residual-material-value method.
II. Residual-material-cost method.
III. Reversal method.

In the no-residual-material-value method no charge is made to the co-product for the by-product or waste material. This method is used only when the waste material is of a relatively small value. The cost of the co-product is composed of the costs of processing, labor and other material added in fabricating the co-product. An equitable share of distribution costs is also charged against the co-product. The cost thus obtained subtracted from the receipts from sales is transferred to profit-and-loss as miscellaneous income or loss, as the case may be.

The residual-material-cost method utilizes a by-product material value found by one of the methods described for by-products. This value constitutes the material cost, and is charged against the co-product and credited to the manufacturing cost of the main product. To this material cost are added the expenses of processing and a just share of the overhead.

The reversal method calculates the charge against the co-product for the by-product material by working backward from the sales price. A normal profit, administrative and selling expenses applicable to the product, and the cost of processing are

deducted from the sales price of the co-product. The remainder is the credit to be allowed the main product for the by-product material furnished the co-product.

CO-PRODUCT A

Selling price		$242.00
Less: 10% profit on total cost		22.00
Total cost to make and sell		$220.00
Less: administrative and selling expenses—10% of manufacturing cost		20.00
Manufacturing cost		$200.00
Less: cost of manufacture (other than by-product)—		
Material (other than by-product)	$20.00	
Labor	50.00	
Burden	30.00	100.00
Credit to main product for by-product used		$100.00

This illustrates the method of working backward from selling price to obtain the by-product credit to main product and the amount to be charged against the co-product.

4. METHODS OF COSTING JOINT PRODUCTS

Joint-product costs are characterized by the fact that a common process at a joint cost produces several products, the aggregate cost of which may readily be obtained, but the absolute cost of each can not be calculated. A practical solution to this problem has been found in several industries through scientific tests and studies. An attempt will be made to summarize the results of some of these studies.

Outline of Methods

I. Unit basis.
   1. Total cost apportioned on basis of actual number of articles of each product.
   2. Total cost pro-rated on weight basis.
   3. Total cost pro-rated on basis of theoretical production.

II. Sales-allocation method.

III. Standard-ratio method.

Apportioning cost among the joint products on the basis of the number of physical units of each produced is seldom attempted,

for the method would be satisfactory only in unusual circumstances. The market values would have to be practically the same, or else the individual costs under the method would be all out of reasonable proportion. For example, 100 units of X and 200 units of Z are produced at a joint cost of $600. Allocating this cost on the basis of the number of each produced gives a cost of $200 for X and $400 for Z. But if the market value of X is $5 a unit and that of Z, $1 a unit, a gross profit of $300 is made on X, and a gross loss of $200 on Z. Obviously this is illogical. A close relationship exists between the market value of the raw material and that of the finished product, and it is natural and logical to assume that X is made from the most valuable part of the material, and, consequently, should bear a larger part of the material cost.

Pro-rating cost to the joint products on a weight basis is similar to the physical-unit method and is subject to the same limitations. The bulky product is often the least valuable of those produced, and it logically follows that it is made from the least valuable parts of the material and should bear the smallest share of the cost. In the cottonseed-oil industry, the products are oil, cake, hulls and lint. The cake from a ton of seed weighs about the same as all the other products together, but it is not nearly so valuable as the oil. To charge the cake with fifty per cent. of the cost would be unjustly to burden it with a cost the larger part of which is material cost. Undoubtedly the oil is the essence of the seed and by far the more valuable part of the raw material and, therefore, should be allotted the larger portion of the cost.

Another unit basis method for allocating cost over joint products is the *theoretical-production method.* For example, a concern produces two joint products, X and Y. The theoretical production of the first for a period is 1,500 units and of the second, 2,400 units. If the actual production for a period is 2,000 units of X and 1,900 units of Y at a joint cost of $25,500, the allocation will be as follows:

Production ratio: 2,400 ÷ 1,500 = 1.6

Product	Actual production		Ratio		Basis of Y
X	2,000	x	1.6	=	3,200
Y	1,900	x	1.0	=	1,900
Total production, basis of Y					5,100

$25,500 ÷ 5,100 = $5 unit cost on basis of Y
1.6 x $5 = $8 unit cost of producing X
2,000 x $8 = $16,000 total cost of X
1,900 x $5 = $9,500 total cost of Y

The sales-allocation method is based on the fairly constant relationship existing between the market value of the raw material and the realizable value of the finished product. The total cost of manufacture is allocated among the joint products on the basis of their relative sales values. Where fluctuations in the market prices of the several products synchronize, the relative costs derived through use of the method remain constant. Should some of the joint products be subject to violent, short-term fluctuations in the market, while other products of the group maintain fairly stable prices, the sales-allocation method is obviously not suitable for pro-rating costs. A sudden but short-lived change in the price of a finished product is not likely to affect substantially either the cost of material used to manufacture that product or its conversion cost. The higher price of the finished product, however, would radically change the portion of the total cost to be charged to the particular product. Should the relative change in price be more or less permanent, then there would be reason for placing a larger share of the total cost on those products, increasing their value in greater proportion than the remaining products of the joint group. These permanent changes in the prices of the finished product are almost always accompanied by similar changes in raw material cost.

An example of the method may be taken from the lumbering industry. Assume that a sawmill finds that its total cost per thousand feet, board measure, for all grades of lumber produced is $20. The following table spreads this cost over the several grades on the basis of relative sales values:

Grades	Percentage yield (1)	Market value (2)	Market basis (3)	Prorata of cost (4)	Cost per M feet (5)
Firsts and Seconds..	10	$90.00	$ 9.00	$ 3.60	$36.00
No. 1 common.....	50	60.00	30.00	12.00	24.00
No. 2 common.....	20	30.00	6.00	2.40	12.00
No. 3 common.....	20	25.00	5.00	2.00	10.00
	100		$50.00	$20.00	

Column one contains the percentages of the several grades obtained in each one thousand board feet milled. The market

values are current quotations. The figures in column three are obtained by applying the yield percentages to the market values; these represent the market values of the several grades in every one thousand feet of all grades milled. The prorata cost for each grade in column four is obtained by pro-rating the total cost ($20.) among the grades on the basis of the ratio which the total market value of each grade produced bears to the total market value of all grades. The cost per thousand feet for each grade in column five is obtained by dividing column four by column one.

Pro-rating joint cost by standard ratio is believed by some accountants to be a superior method. This method consists of deriving through experience and scientific tests standard or normal ratios for the products by which their joint costs may be equitably pro-rated. It is possible through this method to secure the chief advantages of the sales-allocation method and at the same time to avoid the disadvantages of the latter which accompany an unstable market. Incidental and day-to-day fluctuations of the violent sort are not allowed to disrupt the cost figures so as to make them of much less use for comparative purposes. The bases are not changed until the circumstances warranting change are recognized to be permanent.

The following illustration is taken from an article by J. H. Tuttle in the *Petroleum News* of January 12, 1927. The standard ratios are based on the realization figures of the bureau of the census for the year 1921.

REALIZATION (in cents per gallon)

	Gasoline	Benzine, etc.	Kerosene	Fuel oil	Gas oil	Lubricating	Asphalt
Realization	16.4	14.8	7.8	3.3	5.0	21.0	4.6
Selling expense	4.0	4.0	4.0	.1	.1	4.0	.1
	12.4	10.8	3.8	3.2	4.9	17.0	4.5
Manufacturing cost	1.0	1.0	1.0	...	.3	3.5	.5
	11.4	9.8	2.8	3.2	4.6	13.5	4.0

The production of each product from 100 gallons of crude oil in column one times the realization values in column two gives the total realization value of all products in column three. Each figure in column three is expressed as a percentage of the total of the column. These percentages are the standard ratios for allocating the total cost of 100 gallons of crude ($3.81). The

Product	Product in gals. from 100 gallons crude	Realization per gallon	Total realization from products in terms of crude oil value	Per cent.	Allocation of cost of 100 gals. crude to products	Material value in finished gallon product	Manufacturing cost	Finished cost of products of refinery
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Gasoline	24.79	$.114	$2.83	49.05	$1.87	$.0754	$.010	$.0854
Benzine, etc.	2.00	.098	.20	3.47	.13	.0650	.010	.0750
Kerosene	9.96	.028	.28	4.85	.19	.0191	.010	.0291
Lubricating	4.47	.135	.60	10.40	.40	.0895	.035	.1245
Fuel oil	51.26	.032	1.64	28.42	1.08	.0211		.0211
Gas oil	3.00	.046	.14	2.43	.09	.0300	.003	.0330
Asphalt	1.93	.040	.08	1.38	.05	.0259	.005	.0309
Loss	2.59							
	100.00		$5.77 per 100 gals.	100.00	$3.81 per 100 gals.			

costs in column five are divided by the number of gallons of each product produced (column one) giving the cost per gallon of each product in column six. The manufacturing cost in column seven added to the material cost in column six gives the total cost in column eight.

5. Illustration of Costing for Multi-product Operations

The products of the manufacturing concern have now been classified and each class has been isolated for study. Some attention must be directed to the more complex situation in industries producing all three classes of products. The hog slaughtering industry produces joint products and in addition recovers several by-products. Some of these by-products may be further processed, and in that case co-products add to the problem of accounting.

For purposes of illustration assume a concern producing three products, X, Y, and Z, of substantial value from the same material and through joint operations. In addition two by-products, A and B, are recovered. Since there is very little market for B in its raw state, the concern converts B into product M by the application of further expense and manufacturing processes. The following schedules illustrate the procedure for costing the several products.

Statement of Cost of Manufacture

Material		$5,000
Direct labor and expense		3,800
Burden		2,000
Total manufacturing cost		$10,800
Less: By-product credit—		
By-product A (current market)	$500	
By-product B (charged to co-product M, standard value)	300	800
Cost of joint products X, Y, and Z		$10,000

Statement of Cost of Co-product M

By-product B (credited to joint products at standard value)	$300
Other material	100
Direct labor and expense	200
Burden	100
Total manufacturing cost of M	$700

Schedule pro-rating cost to joint products

Product	Production	Market (per unit)	Total market values	*Per cent. of cost	Cost of product
X	1,000	$5	$5,000	25%	$2,500
Y	2,000	3	6,000	30	3,000
Z	4,500	2	9,000	45	4,500
	7,500		$20,000	100%	$10,000

* Based on relative sales prices.

CORRECTION

In the January issue of THE JOURNAL OF ACCOUNTANCY an error occurred in the descriptive list of authors of articles. It was stated that Harry H. Wade was a certified public accountant of Iowa in practice in Chicago. As a matter of fact, Mr. Wade is assistant in accounting in the college of commerce of the University of Iowa and his practice, in which he represents a Chicago firm, is a subordinate part of his activity.