

Different Cost Allocation Methods in Material Flow Cost Accounting: a Case Study of Waste Reduction in Thai Meatball Production

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ABSTRACT

The objective of this research was to study the effect of applying direct or indirect cost allocation methods in Material Flow Cost Accounting (MFCA) analysis. Meatball production was selected as the case study. The direct method focused on the processes with large quantities of waste for improvement, without regard to the cost of the material wasted. On the other hand, the indirect method, which allocates cost based on the cost of materials, focused on the processes with the most costly waste in its improvement solutions. Thus, the different methods of cost allocation could target different process(es) for improvement. When materials used in a target product had the same cost and the quantity of waste was easily measured in the same unit, the direct and indirect cost allocation methods provided similar results. But when input materials differed in their costs and measurement units, the indirect cost allocation method was recommended.

Keywords: Material flow cost accounting, Process improvement, Environmental management accounting, Cost allocation

INTRODUCTION

Material Flow Cost Accounting, or MFCA, is a method of environmental management accounting first developed in Germany. MFCA, introduced into many industries, is a powerful method to simultaneously reduce environmental impacts and improve business efficiency by clearly identifying and reducing material losses (Environmental Industries Office of Japan, 2011). In the year 2000, more than 300 Japanese companies had successfully implemented MFCA, with the results encouraging further adoption of the method (Kokubu et al., 2004). MFCA focuses on both the cost of products and the cost associated with material losses, called “cost of positive product” and “cost of negative product”, respectively. The cost of positive product is the cost of the quantity of materials made into a company’s products; the cost of negative product is the cost from overall materials wasted.

The cost of positive and negative product can be separated into four parts: material cost (MC), system cost (SC), energy cost (EC) and waste cost (WC). All negative costs are considered in arriving at the improved state.

The critical step in any MFCA calculation is how to allocate costs. There are three main methods to allocate costs: direct mass balancing, indirect mass balancing, and a combination method. In practice, when the target process employs many material types with different measurement units and costs, different methods identify different way to improve the process.

Therefore, the objective of this study is to show the effects of applying two different cost allocation methods in MFCA: direct and indirect mass balancing methods, using the data from Chaiwan's et al.'s (2015) case study of meatball processing. We selected meatball processing to present the effectiveness of each cost allocation method in MFCA analysis, because of differences in measurement units and costs of raw materials.

MATERIALS AND METHODS

Preliminaries

The Environmental Industries Office of Japan (2011) has proposed seven steps to implement MFCA: (i) selecting the target product and process, (ii) collecting data and information, (iii) performing the MFCA calculation, (iv) identifying points for improvement, (v) introducing improvement methods, (vi) implementing improvement methods and (vii) evaluating improvement methods by performing the MFCA calculation again and comparing the results, as shown in Figure. 1

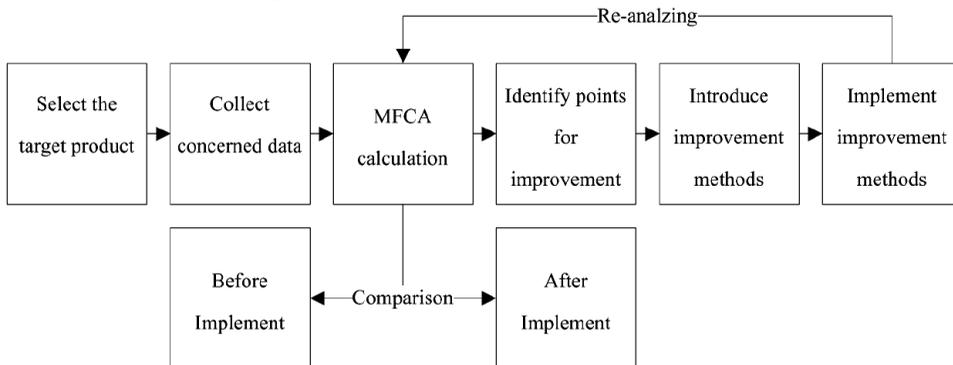


Figure 1. MFCA implementation approach.

The MFCA technique clearly identifies production waste in terms of cost, helping management better understand and realize its effects on the company's costs (Chaiwan et al., 2015). With MFCA, companies can improve environmental and financial performance simultaneously (Rieckhof et al., 2014).

MFCA calculates four main cost categories (Environmental Industries Office of Japan, 2011):

- (i) Material costs: costs of materials, including primary input materials, sub-materials introduced midstream, and auxiliary materials.
- (ii) System costs: processing costs, including labor, depreciation, and overhead costs.
- (iii) Energy costs: electricity, fuel, utilities and other energy costs.
- (iv) Waste treatment/management costs: costs of treating all waste, including cost of reworked parts and defects.

After that, these four costs are classified as the cost of positive and negative products, based on the mass-balancing concept. To allocate the positive and negative product costs of MC, positive and negative costs are directly calculated from the cost and quantity of each product (positive) and waste (negative) material. After that, the direct weight of the product and waste is used to calculate the ratio of positive and negative product cost for allocating positive and negative product costs of SC and EC. Then, all WC is classified as negative product cost.

For cases involving many material types with different measurement units, not only the weight of the material, but also the volume of fluid material or other units of material can be considered; in these cases, it is difficult to apply direct weight to find the ratio of positive and negative product costs. Thus, indirect mass balancing, based on cost of material, can be applied (Kasemset et al., 2014).

When there are i quality centers (QC) or processes, the serial QCs can be presented as shown in Figure 2.

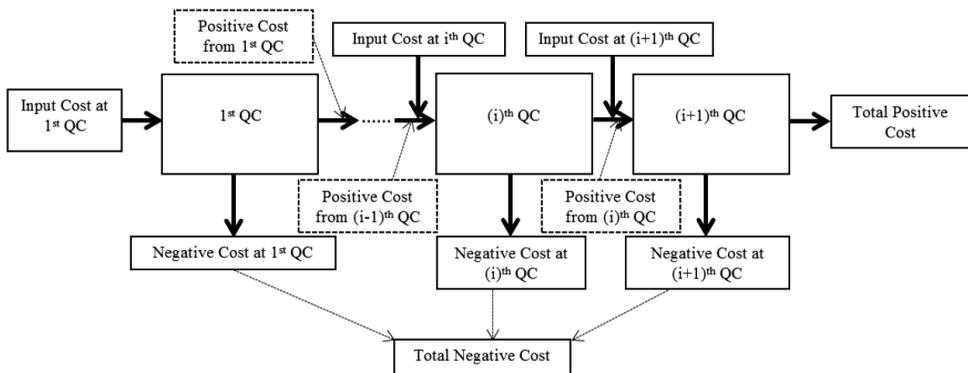


Figure 2. Serial QCs in MFCA analysis.

The accumulative total product cost (TC) at i^{th} QC is the sum of the positive product cost (PC) from the previous QC, or at $(i-1)^{th}$, and the new material, system, energy and waste management costs at current i^{th} QC, as in equation (1).

$$TC_i = PC_{i-1} + MC_i + SC_i + EC_i + WC_i \tag{1}$$

Output (positive) product cost at i^{th} QC or input cost (IC) at $(i+1)^{th}$ QC is the sum of the positive material cost (PMC), positive system cost (PSC) and positive energy cost (PEC), as in equation (2).

$$PC_i = IC_{i+1} = PMC_i + PSC_i + PEC_i \quad (2)$$

Waste (negative) product cost (NC) at i^{th} QC is equal to the sum of the negative material cost (NMC), negative system cost (NSC), negative energy cost (NEC) and waste management cost, as in equation (3).

$$NC_i = NMC_i + NSC_i + NEC_i + WC_i \quad (3)$$

The positive and negative product cost of the system cost can be allocated as shown in equations (4) to (6). When TSC_i is the accumulative total system cost at i^{th} QC;

$$TSC_i = SC_i + PSC_{i-1} \quad (4)$$

$$PSC_i = Rp_i \times TSC_i \quad (5)$$

$$NSC_i = (1-Rp_i) \times TSC_i \quad (6)$$

The positive and negative product cost of the energy cost can be allocated in the same way, as shown in equations (7) to (9). When TEC_i is the accumulative total energy cost at i^{th} QC;

$$TEC_i = EC_i + PEC_{i-1} \quad (7)$$

$$PEC_i = Rp_i \times TEC_i \quad (8)$$

$$NEC_i = (1-Rp_i) \times TEC_i \quad (9)$$

When Rp_i is the proportion of positive product cost at i^{th} QC.

To calculate Rp_i , two methods were used: direct mass balancing and indirect mass balancing (based on material cost).

When direct mass balancing was adopted, Rp_i can be derived as in equation (10).

$$Rp_i = \frac{(Positive/Product\ Mass\ at\ i)}{(Total\ Input\ Mass\ at\ i)} \quad (10)$$

When indirect mass balancing (based on material cost) was adopted, Rp_i can be derived as in equation (11).

$$Rp_i = \frac{(Positive/Product\ Cost\ at\ i)}{(Total\ Input\ Cost\ at\ i)} \quad (11)$$

This study tested and compared direct and indirect mass balancing to derive Rp_i for the cost allocation step of MFCFA using a case study of meatball production from Chaiwan et al. (2015).

RESULTS

The case study company produces meatballs in Chiang Mai Province, Thailand. The target product/process was set as one particular size of meatball product. Producing the meatballs required six steps: preparing raw materials, emulsifying, forming, cooking, reducing temperature and packing. The material flow process chart shown in Figure 3 presents the input and output of each process, including the main material, sub-material and auxiliary material.

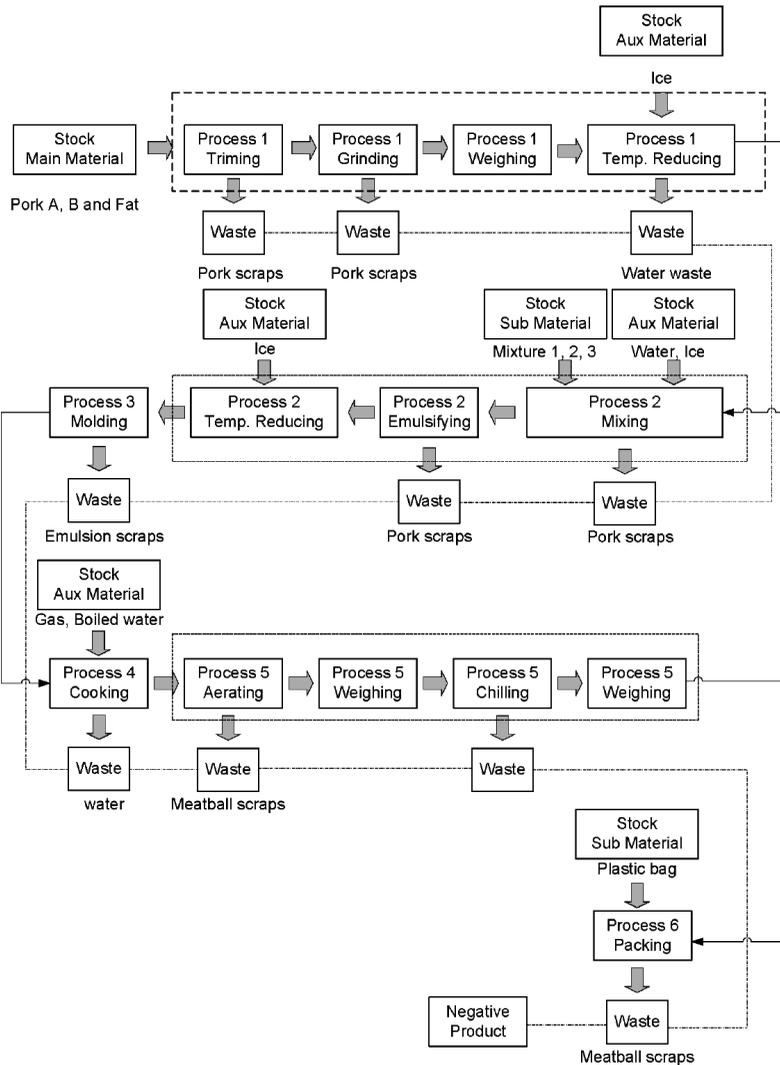


Figure 3. Material flow process chart of the case study.

First cost allocation method: direct mass balancing

Table 1 presents the quantities of positive and negative mass of all processes in the meatball production case study. The percentage from direct mass balancing can be calculated as in Table 1 and applied to allocate the positive and negative product cost of SC and EC for each process. For example, the raw material preparation process used 15,280 g of input materials (meat, lard and ice) to generate product material output of 7,980 g. From equation (10), this output represented 52.2% of positive product that was sent to the next process, with 7,300 g (47.8%) as wasted material. Thus, 52.2% and 47.8% were used to separate the mass of positive and negatives cost for SC and EC at this process, respectively.

Table 1. Percentage used in cost allocation from direct mass balancing method (Chaiwan et al., 2015).

Process	Positive material weight (g.)	Negative material weight (g.)	Total (g.)
1. Raw material preparation	7,980.00	7,300.00	15,280.00
Rp_1 and (1- Rp_1)	52.23 %	47.77%	100.00%
2. Grinding and mixing	11,150.00	400.00	11,550.00
Rp_2 and (1- Rp_2)	96.54%	3.46%	100.00%
3. Forming	11,103.00	47.00	11,150.00
Rp_3 and (1- Rp_3)	99.58%	0.42%	100.00%
4. Cooking	12,091.76	511.24	12,603.00
Rp_4 and (1- Rp_4)	95.94%	4.06%	100.00%
5. Temperature reduction	11,354.43	474.51	11,828.94
Rp_5 and (1- Rp_5)	96.00%	4.00%	100.00%

The results of the MFCA analysis using the mass balance method of the current meatball production line are presented in Table 2. The total cost of meatball production was THB 1,378, consisting of MC (THB 1,025), SC (THB 108), EC (THB 243) and WC (THB 2). The total cost can be seen as the cost of the positive (THB 1,213) and negative (THB 166) product. MC was the largest portion (77.4%) of the cost of negative product.

Table 2. Cost allocation of meatball production line using direct mass balancing method (cost unit: THB) (Chaiwan et al., 2015).

	MC	SC	EC	WC	Total
Total Cost	1,025.33	108.36	243.13	1.55	1,378.36
	74.39%	7.86%	17.64%	0.11%	100.00%
Positive Cost	897.04	92.71	223.03	-	1,212.78
	73.97%	7.64%	18.39%	-	100.00%
Negative Cost	128.29	15.64	20.10	1.55	165.58
	77.48%	9.45%	12.14%	0.93%	100.00%

Second cost allocation: indirect mass balancing, based on cost of material

The positive and negative product costs of each SC and EC were allocated using the percentage from indirect mass balancing based on material cost as shown in Table 3. For example, in the raw material preparation process, the total material cost was THB 864. The positive/output material from this process was THB 821, or 95.0%, as per equation (11), and wasted material of THB 43.0, 5.0%. Thus, 95.0% and 5.0% were used as Rp_1 and $(1-Rp_1)$ to separate the cost of positive and negative products for SC and EC at this process.

Table 3. Percentage used in cost allocation from indirect mass balancing method.

Process	Positive material cost (THB)	Negative material cost (THB)	Total (THB)
1. **Preparing raw material	820.80	43.00	863.80
Rp_1 and $(1 - Rp_1)$	95.02%	4.98%	100.00%
2. Grinding and mixing	882.58	36.76	919.34
Rp_2 and $(1 - Rp_2)$	96.00%	4.00%	100.00%
3. Forming	878.86	3.72	882.58
Rp_3 and $(1 - Rp_3)$	99.58%	0.42%	100.00%
4. **Cooking	887.86	5.89	893.75
Rp_4 and $(1 - Rp_4)$	99.34%	0.66%	100.00%
5. Reducing temperature	852.34	35.62	887.96
Rp_5 and $(1 - Rp_5)$	95.99%	4.01%	100.00%

Note: **QC with Rp_i and $(1 - Rp_i)$ differed compared with Table 1.

The results of the MFCA analysis using material cost balancing method for the current production line of meatballs are presented in Table 4. The total cost of meatball production was THB 1,378, consisting of MC (THB 1,025), SC (THB 108), EC (THB 243) and WC (THB 2). Of the total cost, the positive and negative product costs were THB 1,228 and THB 150, respectively.

Table 4. Cost allocation of meatball production line using indirect mass balancing method (cost unit: THB).

	MC	SC	EC	WC	Total
Total cost	1,025.33	108.36	243.13	1.55	1,378.36
	74.39%	7.86%	17.64%	0.11%	100.00%
Positive cost	897.04	101.07**	230.28**	-	1,228.39**
	73.03%	8.23%	18.75%	-	100.00%
Negative cost	128.29	7.29**	12.85**	1.55	149.97**
	85.54%	4.86%	8.57%	1.03%	100.00%

Note: **Differed compared with Table 2.

Figure 5 compares the results of the two cost allocation methods; the positive products costs were similar, while the negative product costs differed.

DISCUSSION

From the results, when comparing the two cost allocation methods as shown in Figure 5, the difference was the cost of negative material – 77.5% with the direct method and 85.5% with the indirect method. Similarly, the two methods gave different results for the negative product costs of EC and SC.

In comparing the results from Tables 1 and 3, the biggest difference was in the first process, the material preparation step. With the direct method, the R_p ratio was 52.2% and $(1-R_p)$ was 47.8%. On the other hand, with the indirect method, the R_p ratio was 95.0% and $(1-R_p)$ was 5.0%.

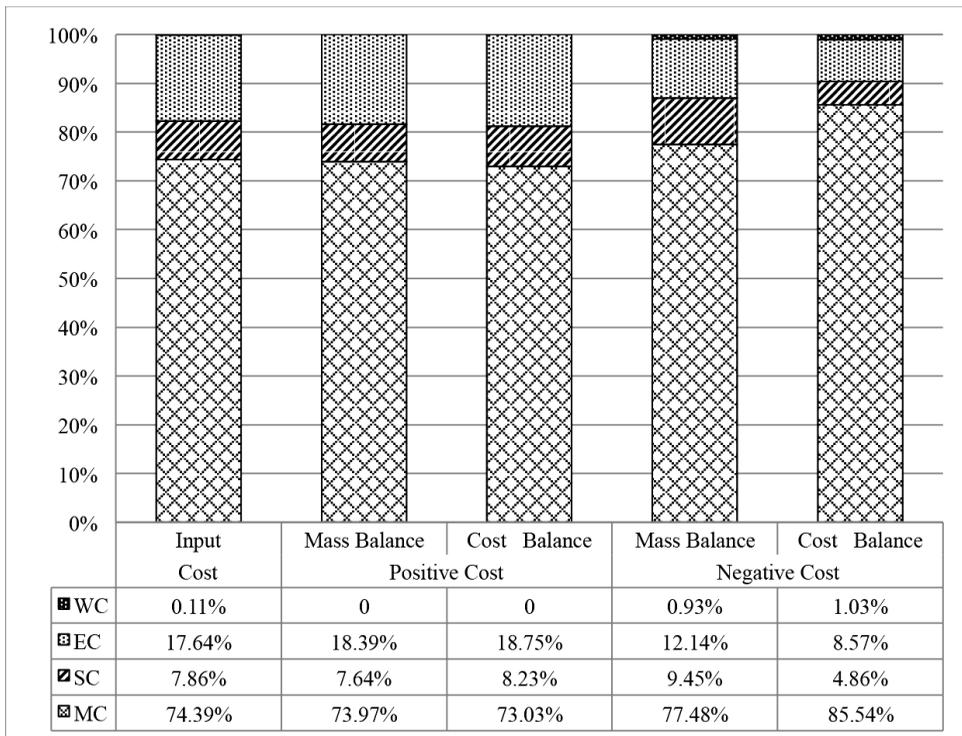


Figure 5. Cost diagram comparison between the two methods.

As Chaiwan et al. (2015) applied the direct cost allocation in the MFCA calculation, the results from their study showed that negative product cost of MC was the biggest part (77.4%) of the total negative cost. Thus, reducing waste material in the material preparation step was proposed as the improvement solution for their study. They found two kinds of material waste: wastewater from melted ice and pork scraps. The quantity of wastewater was more than the quantity of pork scraps. Thus, they proposed eliminating the wastewater by introducing a refrigerator, instead of ice, for cooling the pork mixture.

The indirect cost allocation method revealed three processes with negative material costs: material preparation (5.0%), grinding and mixing (4.0%), and cooking (4.0%). Thus, this method points to improving three processes, rather than concentrating on only one, as in the direct cost allocation method. This will help the company to reduce more waste along the entire production line. Moreover, the indirect cost allocation method focuses first on the high cost material for improvement. As for meatball production, the primary material wastes were pork scraps and wastewater, with pork scraps the more expensive of the two. Thus, in proposing a reduction in pork scraps, the concept of design of experiment (DOE) can be applied to optimize machine parameters or the optimal portion of ingredients used in pork mixing to reduce the pork scarp that is generated during the three processes mentioned above. Recent research that applied DOE with MFCA can be found in Chompu-inwai et al. (2013).

CONCLUSION

Different cost allocation methods resulted in different improvement solutions. This study recommends applying the direct method when the quantity of waste is huge, the cost of each material is similar, and the quantity of waste is easy to measure using the same unit of measurement. The indirect cost allocation method based on cost of material should be applied when the quantity of waste is low, but its cost is very high or when there are many material types with different measurement units and it is difficult, therefore, to use a single unit to find the *Rp*.

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