ALLOCATION OF FIXED EXPENSES IN DIVERSIFIED FOOD MANUFACTURING COMPANIES USING OPERATIONAL LEVERAGE

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ABSTRACT

This paper examines how diversified firms operated in competitive markets – like the food markets – characterised by a high risk can allocate their fixed expenses in order to increase profitability and to reduce business risk. After an extensive study of alternative methods simple way based on the operational leverage is chosen for the appropriate allocation of fixed expenses over a wide range of products. An example of the application of this method is the case of a food manufacturing company producing canned peaches, apricots and pears is presented to illustrate the proposed allocation of fixed cost.

RÉSUMÉ

Ce travail examine comment différentes entreprises présentes sur des marchés compétitifs – tels les marchés alimentaires – et caractérisées par un risque élevé, peuvent allouer leurs dépenses fixes pour accroître la rentabilité et réduire le risque. Après une étude étendue des méthodes alternatives, on choisit une manière simple basée sur l'imposition de leviers opérationnels afin de parvenir à une allocation appropriée des dépenses fixes sur une vaste gamme de produits. Pour illustrer l'allocation proposée du coût fixe, on présente un exemple d'application de cette méthode se référant à l'entreprise alimentaire des pêches, des abricots et des poires.

One of the problems involved in the determination of the break-even point of each product is the problem of allocation and allocation of the common fixed cost to the enterprise of each of its various products. If the break-even point for each product is determined we are in a position to seek maximisation of profit for each product and consequently for the whole of the enterprise. Many authors have occupied themselves with the allocation of indirect costs to departments, instead of the allocation to specific products. Examples of this are Thomas (1971, 1974), Farret (1983), Sanella (1986, 1991), Horngren and Sundem (1994). The object of this paper is somewhat related, as it considers fixed cost as indirect in the determination of net profit. The allocation of the common fixed costs of an enterprise must be correlated on one hand to the profit policy by product and on the other to the level of risk involved in that policy. We must determine the optimal allocation factor and the optimal profit figure for each product, albeit with the minimal business risk. Furthermore, as far as the basis for allocation is concerned, as employed by the greatest number of enterprises, is indicatively in the following order: sales, production (volume), participation of each product in the common contribution margin, duration of machine usage, etc. (Dhavale, 1989; Kerremans, 1991; Kellet, 1991). Irrespective of the specific method used, nevertheless, the method employed must have as its measure the allocation of profits before tax and the danger, which stems from that allocation. The connecting link between the changes in the volume of sales by product and the pre-tax profits is the operational leverage factor, which is at the same time the measure of the business risk involved. Quantitatively, the operational leverage factor at a sales level of Q units is given by the formula

$$\frac{Q_s\,(P-V)}{Q_s\,(P-V)-\text{FIXED COST}_1}$$

where

Q_s = units sold by product
P_1 = sales price
V_1 = variable cost by unit
FIXED COST_1 = fixed cost, which has been allocated to the specific product.

In this paper, we will examine various ways to allocate fixed expenses for specified production levels, so that, after FIXED COST allocation, the operational leverage factor may be calculated for the group of products, which corresponds to the selected allocation method. Thus the above operational leverage factor will be examined by product group and by individual product. Finally we will propose that method for the allocation of the common fixed cost, where the allocation basis in the specific product group presents the optimal operational leverage factor, a minimum of 50-60% on total sales to be realised, since it may be impossible for an allocation basis to achieve the optimal operational leverage factor for all goods produced and sold. Nevertheless, apart from the above prerequisite, the following must be satisfied, as well: for the products or product which correspond to the balance 40-50% of sales, the operational leverage factor should not differ from the operational leverage factors of the previous goods by more than 2 or 3 units.

PROPOSED ALLOCATION

Allocation methods

We consider that an industrial enterprise produces $Q_1 \ldots Q_n$ products to which the total fixed cost (FIXED

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COST) must be allocated. We furthermore consider that the following allocation methods are to be used, albeit this does not preclude any other allocation method:
a) Allocation on the basis of production of goods $Q_1 \ldots Q_n$.
b) Allocation on the basis of expected sales of the above goods $P_iQ_{si} \ldots P_nQ_n$.
c) Allocation on the basis of the participation of each product to the common allotment margin of all products.
d) Allocation on the basis of machine usage period by each product, during the production process.

Determination of expected sales

Considering on one hand that the selling prices and the variable unit costs are known, and on the other hand knowing the quantities produced, then the expected income by product will be:

$$TR_1 = \int_{P_1 Qs_1 \ \gamma\iota\alpha \ Qn_1 \geq Qs_1}^{P_1 Qn_1 \ \gamma\iota\alpha \ Qn_1 < Qs_1}$$

$$\text{or} \quad \epsilon\,(TR_1) = \sum_{0}^{Qs_1} (P_1 Qn_1)\, P_0 \left(\frac{Qn_1}{Qs_1}\right) + \qquad (2.2.1)$$

$$+ \sum_{Qs_1+1}^{\infty} (P_1 Qs_1)\, P_0 \left(\frac{Qn_1}{Qs_1}\right)$$

consequently, the total expected income will be:

$$\epsilon\,(TR) = \sum_{i=1}^{n} \epsilon\,(TR) = \sum_{i=0}^{Qs_n} (P \cdot Qn)\, P_0 \left(\frac{Qn}{Qs}\right) +$$

$$+ \sum_{Qs_n+1}^{\infty} (P \cdot Qs)\, P_0 \left(\frac{Qn}{Qs}\right) \qquad (2.2.2)$$

Taking formula 2.2.1 as a percentage ratio to formula 2.2.2, which represents total sales, we can determine the per cent ratio of partial sales of goods sold, i.e. $a_1\% \ldots a_n\%$.
This ratio will be used for the allocation of total fixed costs, whereas for the corresponding allocation of fixed costs on the basis of goods production we will use the per cent ratio of the specific products to total production.

Determination of contribution percentage to total allotment margin

Knowing the expected sales of each product as have been calculated in the previous paragraph, while at the same time we have the per cent ratio (%) on total sales, we may proceed to the determination of the allotment margin of each product, in accordance with the following formula:

$$\frac{P_1 - V_1}{P_1} = b_1\% \qquad (2.3.1)$$

where P_1 is the selling price of each product and V_1 the variable unit cost for each product.

To proceed, we multiply the allotment margin of each product $b_1\% \ldots B_n\%$ with the per cent ratio of each product sales $a_1\% \ldots a_n\%$, and thus obtain the contribution percentage of each product to the common allotment margin of all products.

Thus $a_1\% \times b_1\% = c_1\%$

$$\vdots$$

$$a_n\% \times b_n\% = \underline{c_n\%} \qquad (2.3.2)$$

$$\text{total} \sum_{i=1}^{n} c$$

Therefrom, correlating the contribution percentage of each product to the common margin we can find the per cent ratio (%). That ratio will be used as the allocation basis for the total fixed expenses, in contrast to the other two methods mentioned above.

Determination of productivity on the basis of duration of usage

The fixed cost, which is allocated to each product is a function of the duration of machine usage by each product for its manufacturing cycle.

We thus have: FIXED COST$_i$ = t_iX_i (2.4.1)

where
FIXED COST$_i$ is the fixed cost which corresponds to the production of product i
t_i is the time during which the machines have been used for the production of product i
and X_i is the cost co-efficient per hour of production
Hourly productivity of product i will be equal to

$$Q_0 = \frac{Q_i}{Q_0} \cdot X_i \qquad (2.4.2)$$

Consequently:

$$t_i = \frac{Q_i}{Q_0} \qquad (2.4.3)$$

By replacing equation (2.4.3) in (2.4.1) we obtain the following

$$FC_i = \frac{Q_i}{Q_0} \cdot X_i \qquad (2.4.4)$$

while the surcharge co-efficient becomes

$$X_i = \frac{\sum_{i-1}^{n} FC_i}{\sum_{i-1}^{n} t_i} \qquad (2.4.5)$$

after combining equations (2.4.4) and (2.4.5).
If we further multiply lengths of time $t_i \dots t_n$ with the common surcharge co-efficient X_i, we obtain the corresponding amount of fixed expenses, which refer to each product, which in fact gives us the allocation basis we have been looking for.

Determination of profit by product before tax

As we have mentioned above, we consider that the selling prices and the variable costs by product are pre-determined and constant. If we now make the assumption that the function of demand density $P_I(Qn_i)$ is known, then the maximum profit in relation to the quantity Qn_i produced for each product is in accordance with the following equation:

$$\epsilon\left(\frac{P_1}{Qn_1}\right) = \sum_{0}^{Qn_1}\left[Qs_1\,(P_1 - V_1 - F_1 + Z_1) + F_1Fn_1 - \right.$$
$$\left. - Z_1\,Fn_1\right] P_1Qs_1 + \sum_{Qn_1}^{\infty}\left[\left(P_1 - V_1\right) Qn_1 - \right. \quad (2.5.1)$$
$$\left. - P_1\left(Qs_1 - Qn_1\right)\right] P_1Qs_1 - FC_1$$

where FIXED COST_1 = fixed production cost
$P(Qn\text{-}Qs)$ = escaped revenue due to unabsorbed production
$P(Qs\text{-}Qn)$ = escaped revenue when demand is greater than production
Z(Qn-Qs) = loss due to wear & tear and amortisation

and $$\frac{FC_1}{Qn} = F$$

the fixed expense per unit.
The equation (2.5.1) above is maximised if and when the following relationship applies:

$$\sum_{0}^{Qn_1} {}_1P_1\left(\frac{Qs_1}{Qn_1}\right) \leq \frac{2P_1 - V_1 + 1}{2P_1 - V_1 - F_1 + Z_1 + 1} \quad (2.5.2)$$

From equation (2.5.1) above we may formulate a table which should contain the following data:
a) The consecutive values of Qn for each product
b) The probabilities of Qs for the corresponding values of Qn
c) The cumulative probability of Qs/Qn
d) Replacing the above data and the values of P and V, we find the corresponding 1st differences
e) From the column of 1st differences, we find the 2nd differences
When the table is completed, then we find that value of Qn for which the following equations are simultaneously valid:

$$\epsilon f(P_0) \geq \epsilon f(P) \quad \text{and} \quad D^2\,\epsilon f(P_0) \leq 0$$

where these conditions are sufficient but not necessary.

Determination of the degree of operational leverage

In accordance with the equation that determines the degree of operational leverage (DOE) for a given sales volume by product, say Q_1 and the fixed costs FIXED COST_1 which have been allocated by one of the above methods, the leverage will be:

$$\text{DOE} = \frac{Q_1\,(P_1 - V_1)}{Q_1(P_1 - V_1) - FC_1} \quad (2.5.3)$$

A group of co-efficients in relation to the allocation method of fixed cost is formed, i.e. a group for the allocation on the basis of production, a group for the allocation on the basis of expected sales, a group for the allocation on the basis of the per cent contribution to the common allotment margin, and finally a group for the allocation on the basis of the duration of machine usage. Further on a comparison is run between these groups. The selection goes to that group of products on the basis of fixed costs allotment, which gives maximum profits, in accordance with the method we have established previously, as well as lowest degree of operational leverage, at the same time. Consequently, the allotment basis to be selected should represent at least 50-60% of total sales, as has been mentioned above, but at the same time, the degree of operational leverage for the rest of the products must not differ by more than 2 or 3 units in each allotment basis. In this manner, a table is formed allowing comparison between the operational leverage co-efficients, having in advance determined the maximum profit and the products.

Conclusions - Proposals

In this paper we have examined various methods for the allocation of fixed costs in order to determine the breakeven point in a multi-productive enterprise. We believe the conclusions thus drawn to be both useful and easily implemented by the enterprises management. Namely:
a) It is difficult to accept that an enterprise in its effort to maximise the expected profitability, will completely disregard the risks involved in such an endeavour. As a consequence we believe that the combination of profit maximisation with the minimal possible risk is the most appropriate direction its management should take. Of course, we cannot preclude the possibility that an enterprise will support the notion it is primarily concerned with increased profits and have only a secondary concern regarding the dispersion risk and/or vice versa. Thus we fully support the proposition that the optimum combination is the allocation of fixed costs on all products which the company produces and sells with the criterion of the degree of operational leverage.

b) If the allocation of fixed costs followed another method that might be described as fair, as is the duration of machine usage, we could not know what influence that allocation method would have and if eventually there was a relationship between cause and effect.
c) The simplicity in the implementation of the proposed allocation basis (degree of operational leverage) we believe it gains support for its easy application.
d) The possibility exists that there might be objections as far as the process is concerned, which we have followed until the degree of operational leverage is determined for each product and for each allocation basis. We believe nevertheless, that with the creation of a computer software programme, adopted to the requirements of each enterprise under consideration, which programme will include all data, similar to our table in annex, we see that the calculations process is both made simpler and results may be obtained shortly.
e) Finally, the relationship required to have the maximum profit, as that has been presented in the relative paragraph, we believe that it satisfies all possible cases of demand and this by itself is indeed a contribution.

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Annex

A fruit industry produces peach, apricot, and pear preserves. The quantities produced are: 100,000 cans of three litres capacity, 80,000 cans and 70,000 cans, respectively. The selling prices for these products respectively are:

$$P_1 = 1{,}100 \text{ Drs/can}, \; P_2 = 1{,}400 \text{ Drs/can}, \text{ and } P_3 = 800 \text{ Drs/can},$$

The variable cost per unit for each product respectively is:

$$V_1 = 850 \text{ Drs}, \; V_2 = 850 \text{ Drs}, \text{ and } V_3 = 450 \text{ Drs}$$

The total fixed cost is 50,000,000 Drs.
Productivity of these products per hour respectively is $Q_1 = 1{,}250$ cans, $Q_2 = 1{,}000$ cans, and $Q_3 = 1{,}400$ cans / hr
So the total hours on the basis of productivity are:

$$Q_1 = \frac{100{,}000 \text{ cans}}{1{,}250 \text{ cans/hr}} = 80 \text{ hours}$$

$$Q_2 = \frac{80{,}000 \text{ cans}}{1{,}200 \text{ cans/hr}} = 50 \text{ hours}$$

$$Q_3 = \frac{70{,}000 \text{ cans}}{1{,}400 \text{ cans/hr}} = 50 \text{ hours}$$

$$X = \frac{50{,}000{,}000 \text{ fixed costs}}{197 \text{ hours}} = 253{,}800 \text{ Drs/hour}$$

Consequently, by using a total of hours 80 + 67 + 50 = 197 hours, the co-efficient X of surcharge becomes: 253,800 Drs/h.
Now, the cumulative probability of demand Qs of the above products is:

$$P_1\,(Qs_1) = 0{,}85 \qquad P_2\,(Qs_2) = 0{,}92 \qquad P_3\,(Qs_3) = 0{,}94$$

respectively.
On the basis of the above data we proceed to filling in the following **tables 1 and 2**.

Table 1 ***Allocation of fixed cost (FC = 50,000,000 Drs).***

On the basis of production

$Q_1 = 100{,}000 \times 200 = 20{,}000{,}000$

$Q_2 = 80{,}000 \times 200 = 16{,}000{,}000$

$Q_3 = \underline{70{,}000 \times 200} = 14{,}000{,}000$
$\quad 250{,}000$

given that FC / Q =
$50{,}000{,}000/250{,}000 = 200$ Drs

in which case
$FC_1 = 20{,}000{,}000$
$FC_2 = 16{,}000{,}000$
$FC_3 = \underline{14{,}000{,}000}$
Total $50{,}000{,}000$

On the basis of expected sales

$P_1\, Qs_1 =$
$100{,}000 \times 0{,}85 \times 1100 = 93{,}500{,}000$ or 37.5%

$P_2\, Qs_2 =$
$80{,}000 \times 0.92 \times \underline{1400 = 103{,}040{,}000}$ or 41.35%

$P_3\, Qs_3 =$
$70{,}000 \times 0.94 \times 800 = \underline{52{,}640{,}000}$ or 20.1%
Total $249{,}180{,}000$

So:
$FC_1 = 50{,}000{,}000 \times 37.50\% = 18{,}750{,}000$
$FC_2 = 50{,}000{,}000 \times 41.35\% = 20{,}675{,}000$
$FC_3 = 50{,}000{,}000 \times 20.15\% = \underline{10{,}575{,}000}$
Total $50{,}000{,}000$

On the basis of common contribution margin
Per cent sales × contribution margin (P-V) / P

$Q_1 = 37.50\% \times 0.227 = 8.50\%$ or 27.80
$Q_2 = 41.35\% \times 0.321 = 13.27\%$ or 43.40
$Q_3 = 20.15\% \times 0.437 = \underline{8.80\%}$ or $\underline{28.80}$
Total 30.57 100.00

So:
$FC_1 = 50{,}000{,}000 \times 27.80\% = 13{,}900{,}000$
$FC_2 = 50{,}000{,}000 \times 43.40\% = 27{,}000{,}000$
$FC_3 = 50{,}000{,}000 \times 28.80\% = 14{,}400{,}000$

$FC_1 = 80 \times 253{,}800 = 20{,}340{,}000$
$FC_2 = 67 \times 253{,}800 = 17{,}046{,}000$
$FC_3 = 50 \times 253{,}800 = \underline{12{,}614{,}000}$
Total $50{,}000{,}000$

Table 2 ***Degree of operational elevation, according to the allocation method and the volume of expected sales.***

On the basis of production

$$Q_1 = \frac{85{,}000 \times (1{,}100 - 850)}{85{,}000 \times (1{,}100 - 850) - 20{,}000{,}000} = 17$$

$$Q_2 = \frac{73{,}600 \times (1{,}400 - 950)}{73{,}600 \times (1{,}400 - 950) - 16{,}000{,}000} = 1{,}94$$

$$Q_3 = \frac{65{,}800 \times (800 - 450)}{65{,}800 \times (800 - 450) - 14{,}000{,}000} = 2{,}55$$

On the basis of expected sales

$$Q_1 = \frac{85{,}000 \times (1{,}100 - 850)}{85{,}000 \times (1{,}100 - 850) - 18{,}750{,}000} = 8{,}5$$

$$Q_2 = \frac{73{,}600 \times (1{,}400 - 950)}{73{,}600 \times (1{,}400 - 950) - 20{,}675{,}000} = 2{,}66$$

$$Q_3 = \frac{65{,}800 \times (800 - 450)}{65{,}800 \times (800 - 450) - 10{,}575{,}000} = 1{,}84$$

On the basis of the common allocation margin

$$Q_1 = \frac{85{,}000 \times (1{,}100 - 850)}{85{,}000 \times (1{,}100 - 850) - 13{,}000{,}000} = 2{,}7$$

$$Q_2 = \frac{73{,}600 \times (1{,}400 - 950)}{73{,}600 \times (1{,}400 - 950) - 21{,}700{,}000} = 2{,}9$$

$$Q_3 = \frac{65{,}800 \times (800 - 450)}{65{,}800 \times (800 - 450) - 14{,}400{,}000} = 2{,}66$$

On the basis of duration of machine usage

$$Q_1 = \frac{85{,}000 \times (1{,}100 - 850)}{85{,}000 \times (1{,}100 - 850) - 20{,}340{,}000} = 23{,}35$$

$$Q_2 = \frac{73{,}600 \times (1{,}400 - 950)}{73{,}600 \times (1{,}400 - 950) - 1{,}704{,}000} = 2{,}06$$

$$Q_3 = \frac{65{,}800 \times (800 - 450)}{65{,}800 \times (800 - 450) - 12{,}614{,}000} = 2{,}21$$

Our remarks regarding conclusions to be drawn from the tables above are as follows:
1 - **Table 1** shows the allocation of fixed cost according to the four representative methods we have chosen, having in advance taken into consideration that the expected sales and the allocation margin by product. In the manner, we obtain the amount for fixed costs which corresponds to each product, but differs for each allocation basis.
2 - **Table 2** shows the degree of operational elevation by product and allocation basis.
3 - Studying **table 2**, we conclude that the basis of allocation of fixed costs according to the contribution margin is preferable, because both the prerequisites set in the theoretical section of this paper are satisfied. This is because, whichever combination we select, we will see that (a) in approximately 60% of sales, the degrees of operational elevation give better results than those which correspond to other allocation methods, and (b) none of the operational elevation indices differs in amount by more than 2 or 3 units, as it happens with the other allocation methods (17, 1.94, 2.55), (8.5, 2.66, 1.84), and (23.35, 2.06, 2.21).