JOINT PRODUCTION COST ALLOCATION: AN APPLICATION IN A MEAT MANUFACTURING COMPANY

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ABSTRACT

The present paper develops a model for allocating joint products' cost according to the participation of each product to the common contribution margin. The traditional approaches suggested, i.e., the relative sales value method or the physical volume method, refer only to the technical aspects of cost allocation without taking into consideration relative demand issues, implicitly assuming thus, the existence of no inventory. In contrast to the traditional approaches, the model developed here presents the following features: a) it provides a helpful tool in the hands of the production and marketing manager b) it provides a method of joint product cost allocation, and c) it is built on expected sales, allowing thus, the existence of ending inventory and therefore it provides the grounds for considering the common contribution margin as a means of evaluating the participation of each product to the total fixed costs. The purpose of the present paper is to develop a new unquestionable intuitive approach for joint product cost allocation that is of practical interest, especially for food manufacturing firms characterised by diversified and/or vertically integrated activities.

RÉSUMÉ

Ce travail présente un modèle pour l'allocation du coût des produits conjoints tenant compte de la participation de chaque produit à la marge de contribution commune. Les approches traditionnelles suggérées, à savoir la méthode de la valeur des ventes ou la méthode du volume physique, tiennent compte seulement des aspects techniques de l'allocation et non pas des problèmes de la demande relative, ce qui fait supposer, implicitement, l'absence d'un inventaire. Contrairement aux approches traditionnelles, le modèle développé ici est caractérisé par les aspects suivants: a) il fournit un outil précieux au gestionnaire de la production et du marché; b) il fournit une méthode d'allocation des coûts de produits conjoints, et c) il est basé sur les ventes attendues, permettant ainsi, l'existence d'un stock final fournissant les bases pour considérer la marge à la contribution commune en tant que moyen pour évaluer la participation de chaque produit aux coûts fixes totaux. Ce travail vise à développer une nouvelle approche intuitive incontestable pour l'allocation du coût des produits conjoints qui revêt un intérêt pratique, surtout pour les industries alimentaires dont les activités sont diversifiées et/ou intégrées verticalement.

It is the common practice, that a production process ends up with more than one final products.

The products that result from the same production process are termed as joint - products or by-products. Of course, the appropriate terminology is attributed according to the total value of sales of each product.

For instance, if the sales of each product are approximately of the same value, then the products are termed as joint - products. On the other hand, if some products have considerably smaller sales values than other products, then they are termed as by products.

In the present paper the focus lies with joint - products.

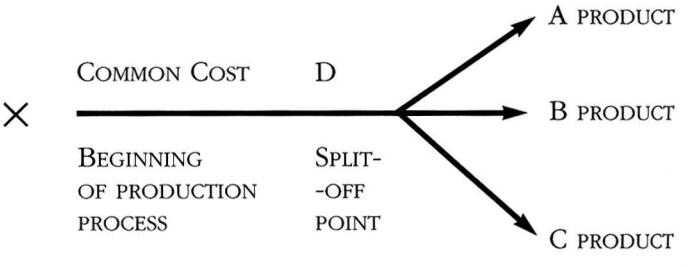
It is therefore assumed that the production process begins simultaneously for all joint products. Separate production requirements arise after a certain point broadly known as the split-off-point, as shown in figure 1. The question that emerges concerns the way of allocating the common production cost to each one of the resulting products. Of course there are several prevailing views on the subject. One of these, bases allocation on the physical volume of production. Another view advocates that allocation should be made according to the relative sales value, whilst an alternative view considers allocation according to the net realisable value of sales: (Manes and Smith 1965, Bierman 1967, Jensen 1974, Kaplan 1983, Thomas 1977).

A more recent view concerns the marginal approach to common cost (Manes and Cheng, 1988) which provides a thorough exposition of the marginal methodology of allocating common costs.

The marginal approach is in accordance with the classical microeconomic theory: profit maximisation is achieved when marginal revenue equal marginal cost.

However, despite the fact that this approach presents a high level of objectivity it suffers the disadvantage of not being easily implemented because it does not have a built-in mechanism to deal with difficulties arising in the process of costing certain products.

The present paper proposes a way of allocating common costs according to the participation of each product to the common contribution margin which requires taking into account not only the contribution



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margin of each individual product but also the contribution of each product to the total sales of the company. Arguably, by taking into consideration both these factors the management of a company makes better pricing decisions that help improve the competitive position of the company, and forms a clearer idea as to whether it should discontinue the production of certain products. Finally, it should be noted that the proposed model does not prevent a company from pursuing the goal of profit maximisation. Therefore, the model proposed in the present paper appears to have more intuition since it offers a clearer insight of the factors mentioned above, and as will be shown with the use of a numerical example it may prove very useful tool in the hands of the management of food manufacturing companies.

Development of the basic model over a single period

The development of the proposed model requires the calculation of the following variables:

a) The required contribution margin of each product expressed as a percentage on sales price, which represents the minimum acceptable contribution margin of each product:

$$\frac{P_i - V_i}{P_i} \text{X100}$$

Of course, if the realised contribution margin is in excess of the respective marginal or required, the company's goal has been achieved.

b) Expected and not budgeted sales of each product. The determination of expected sales requires knowledge of the probability distribution of the demand of each product.

Probabilities can be assigned by using either historic data or some other statistical technique.

c) The estimation of the percentage contribution of each product to the company's total sales.

d) The preparation of a table that contains summary information for each product.

The information requirements consist of i) the required or marginal contribution margin of each product, ii) the percentage contribution of each product to the company's total sales, and iii) the product that results form multiplying contribution margins with percentage contribution to total sales.

e) The weight of each product to the common contribution margin (individual products' contribution margin times the percentage contribution of each product to the total sales of the company).

f) The total sum of the individual weights, and

g) The percentage contribution of each product to the common contribution margin.

Development of the Model

a) Let $\frac{P_i - V_i}{P_i}$ ..... $\frac{P_v - V_v}{P_v}$ (1) represent the required contribution margin of each product (i) expressed as a percentage on sales price, where

P_1 ..... P_n: The sales price of each product

V_1 ..... V_n: Average variable costs of each product

b) The expected sales function of each product can be determined by making the following distinction:

Expected total revenue (sales) are given by:

$$TR = \begin{cases} PQ_\pi if & Q_\pi < Q_s \\ PQ_s if & Q_\pi \geq Q_s \end{cases}$$

where:

Q_π: production of each product in terms of quantity

Q_s: demand of each product in terms of quantity.

Therefore, the expected sales functions of each product for all Q_s will be:

$$E(TR_1/Q_{s1}) =$$

$$= \left[\sum_{0}^{Q_{s1}} (P_1 Q_{\pi 1}) P_0 (Q_{\pi 1}/Q_{s1} + \sum_{Q_{s1}}^{\infty} (P_1 Q_{s1}) P_0 (Q_{\pi 1}/Q_{s1}) \right] \quad (2)$$

where:

$E(TR_1/Qs_1)$ ..... $E(TR_n/Qs_n$: Expected sales

Qs_1 ..... Qs_v = the demand of each product

$Q\pi_1$ ..... $Q\pi_v$ = the production of each product

$P_0 (Q\pi_1/Qs_1)$ ..... $P_0 (Q\pi_v/Qs_v)$: the probabilities of each product's actual output given the demand requirements.

c) Let $\alpha_1\%$ ..... $\alpha_v\%$: be the percentage contribution of each product to the total sales of all products (joint products)

d) Let x_1 ..... x_v be the weighted contribution margin of each product calculated by multiplying the contribution margin of each product

$$\left(\frac{P_1 - V_1}{P_1}\right)$$

with the percentage contribution of each product to the total sales ($\alpha_1\%$).

$$\left(\frac{P_1 - V_1}{P_1}\right) \cdot \alpha_1\% = x_1\%.$$

e) The company's common contribution margin is obtained by summing up the weighted contribution margins of all individual products $x_1\%$ ..... $x_v\%$

f) By expressing $x_1\%$ ..... $x_v\%$ as percentages on the common contribution margin we obtain the weights to be used in the joint cost allocation process.

In formal algebraic terms, the proposed model will be as follows:

$$\left(\frac{P_1 - V_1}{P_1}\right) \cdot \alpha_1\% \cdot \left[\sum_{0}^{Q_{s1}} (P_1 Q_{\pi 1}) P_0 (Q_{\pi 1}/Q_{s1} + \right.$$

$$+\sum_{Q_{s1}}^{\infty}(P_1 Q_{s1})\, P_0\,(Q_{\pi 1}/Q_{s1})\Big] = x_1\%$$

$$\left(\frac{P_2 - V_2}{P_2}\right)\cdot \alpha_2\% \cdot \Big[\sum_{0}^{Q_{s2}} (P_2 Q_{\pi 2})\, P_0 (Q_{\pi 2}/Q_{s2} +$$

$$+\sum_{Q_{s2}}^{\infty}(P_2 Q_{s2})\, P_0\,(Q_{\pi 2}/Q_{s2})\Big] = x_2\%$$

$$\left(\frac{P_v - V_v}{P_v}\right)\cdot \alpha_v\% \cdot \Big[\sum_{0}^{Q_{sv}} (P_v Q_{\pi v})\, P_0 (Q_{\pi v}/Q_{sv} +$$

$$+\sum_{Q_{sv}}^{\infty}(P_v Q_{\pi v})\, P_0\,(Q_{\pi v}/Q_{sv2})\Big] = x_v\%$$

Total X%

(see table A)

And the allocation of common production costs (let it be A) is conducted using the weights $\Psi_1\%$ ... $\Psi_v\%$

3) The proposed model for allocating common costs as compared to other models is believed to provide a better method of common cost allocation since:

a) The required contribution margin of each product is not seen separately from other variables as the sales of each product expressed in terms of percentage on total sales. This allows that individual products may have a high contribution margins but low participation to the common contribution margin and small coverage to the company's common costs. Therefore, it may be argued that this signals a decision to be made as to whether the company should or should not discontinue the production of the certain product. Of course, this decision will be affected by the price of the product prevailing in the market which may necessitate the discontinuation of the production.

b) The required contribution margin for individual products is not arbitrarily selected. Usually, the selection process involves comparisons with the contribution margins of competitive products. Practically this implies that I) the certain product will not be a priori out of the market, and II)the certain product is competitive and therefore its production will be beneficial for the company.

4) The present model does not lack demand considerations. This implies that i) the company will be able to avoid storing excess inventories and use the saved funds to more productive courses of action, ii) the company will be able to avoid excess production and will not be forced to withdraw spoiled products form the market, as is usually the case with agricultural products. The proposed model requires that production is planned according to expected demand (the production is known relatively to a given demand quantity).

5) The mathematics of the proposed model for common cost allocating are simple and therefore the model can be easily applied. The model does not require a high level of expertise and the estimation estimation procedure derived may look complicated but its practical implementation does not involve high level of sophistication. It is firmly believed that both the easiness in implementation and the underlying rationale signify the importance of the proposed model for joint cost allocation.

6) In contrast to the marginal approach, the proposed model does not exclude any of the products form participating to the common production costs. The marginal approach requires that the products with high demand (therefore large sales) will bear the burden of common production costs. Products that are not demanded are stored and are excluded from common cost allocation. Therefore, it may be argued that under this approach, high demand products may suffer a competitive disadvantage because of the accumulated inefficiency of products that have been excluded from calculations.

7) As obvious from the common cost allocation base, the higher the demand of a product (and consequently the higher the contribution margin of this product) the higher its participation to the common contribution margin.

Therefore this product will absorb a high proportion of the common production costs and as compared to the marginal approach it will exhibit a more smoothed allocation of common production cost.

8) Finally, the proposed methodology assumes that the common contribution margin for the company as a

Table A

Products	Contribution Margin	X Percentage Contribution to total Sales	Common Contribution Margin (CCM)	CCM as a percentage of X%
Q_1	$(\frac{P_1 - V_1}{P_1})$ = percentage %	$\alpha_1\%$	$X_1\%$	$\Psi_1\%$
Q_2	$(\frac{P_2 - V_2}{P_2})$ = percentage %	$\alpha_2\%$	$X_2\%$	$\Psi_2\%$
Q_v	$(\frac{P_v - V_v}{P_v})$ = percentage %	$\alpha_v\%$	$X_v\%$	$\Psi_v\%$
		Total Common Contribution Margin =	**X%**	**100%**

whole will be calculated. Therefore, we are in the position to know in advance whether the company operates efficiently as compared to the competition. Moreover, calculating not only the contribution margin of each product but also its participation to the company's fixed costs enhances the decision as to abandon production for certain products if their market price makes it more beneficial to buy them from a third party. Furthermore, since the management can have an a priori insight to the company's contribution margin, it is able to form a production strategy that will lower the break-even point and reach faster to profit levels, a fact which is in accordance with the profit maximisation objective.

The impact of the method of joint cost allocation to the income tax of the company

It is well known that the contribution margin determines the cost of goods sold and consequently the gross profit of the company. Therefore, given the administrative expenses and the promotion expenses we can proceed to the calculation of the net taxable income. Changes in the method of inventory valuation affect the cost of goods sold and consequently the company's gross profit. The amount of income tax payable within a period is not only an accounting expense but also a cash outflow which is deducted from the amount all funds that will be used for production and investment purposes.

Therefore, conflicting profitability and liquidity goals arise if we consider that all attempts to maximise profits result in higher tax expenditures.

This problem becomes even more severe if the company does not manage to achieve a contribution margin that is competitive to the respective ones of other companies in the same industry. Here lies one of the disadvantages of the marginal approach. In particular, some products will be stored as inventories with a lower than realised written-down cost. This will result in an increase to the amount of inventories and a decrease to the cost of goods sold which in turn will lead to an increase in gross profit which however is ficticious and does not represent an improvement in the company's net position.

The result however, will be that the company faces an increased obligation to pay taxes. In addition, if the selected method for joint costs allocation results in a change in the company's contribution margin this may cause a number of problems. For instance it may be that the new contribution margin is smaller than the industry average causing suspicion to the tax authorities and preventing management from making optimal decisions. It is well known and accepted that the contribution margin should not vary considerably among firms in the same industry so as not to cause confusion among users of financial statements. Another serious problem that may arise from this situation is that companies may be led to erroneous pricing strategies that will result in losing their competitive advantage in the market. Consequently, a great deal of attention is required to achieve the profit maximisation goal and to create a tax expenditure that is considered normal for the company's level of production. In this sense, a paper by Barton and Spiceland (1985, 1987) that provides a method of estimating common costs relatively to the taxable income and which is based on intuitive analysis and not on expected sales, appears to be very interesting.

An application in a meat manufacturing company

We examine the case of a company that breeds, oxes, processes and sells meat products, produces fifty(50) oxes during a twelve month costing period. The required period for the oxes to gain the required weihgt is also twelve months. The average weight of the live oxes reaches 450 kgr. On the other hand, the carcasses maintain only 55% of the live ox weight of which only 70% consists of edible meat. The rest of the meat is considered as by-product and is treated as a deductible item from total costs.

Thus, the above mentioned company produces: Oxes 50X450 kilos/ox X55%X70% = 8,665 kilos of marketable edible meat (**table 1** and **1a**).

The total common cost assigned to the quantity of edible meat sums to the amount of 12, 237,000 drachmas (**table 2**).

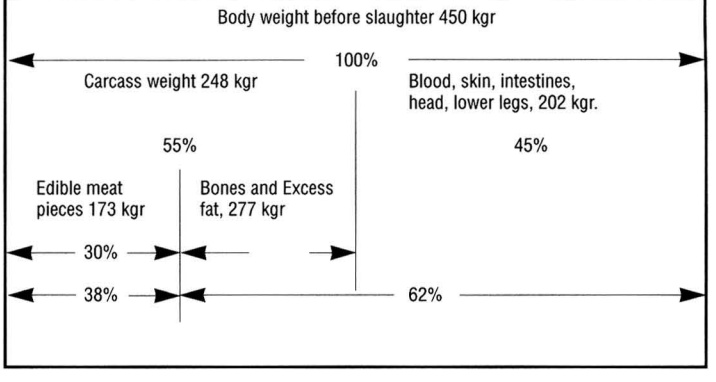
According to the files of the company, the quantity of edible meat is sufficient for the company to process and produce the joint-products (shown in **table 1**).

The selling prices for each product are as follows:

Table 1

α) prime steak	6%	520 kgr
β) red meat	69%	5,979 kgr
γ) steaks	10%	866 kgr
δ) ribs	15%	1,300 kgr
	100%	**8,665 kgr**

Table 1a



Prime Steak 2.500 drachmas/kilo, steaks 1900 drachmas /kilo, Ribs 1800 drachmas /kilo and red meat 2100 drachmas /kilo

The required or marginal contribution margins for each joint - product are as follows: a) prime steak 22%, b) steaks 21% c)ribs 22% and d) red meat 20%

The probabilities of demand for each joint product are

Table 2

Cost of Animal feed consumed per head (in kgr)

1. Mixted grain meal 2,184 kgr X 80 δρχ/kgr	174,720
2. Lucerne and Wheat Straw 233 kgr X 25dr./kgr	5,825
3. Purchase of 65 days old animals	70,000
4. Other Expenses (Overheads, Labour etc.) 294,745	44,000
5. Total cost 50 oxes X 294,745	14,737,250
6. From the total cost we deduct any proceeds from by- products (heads, intestines, skin etc.)	2,500,250
Total common cost of production	**12,237,000**

Table 3

Kind	Production of kgrs	Probability that $_{\pi}$ Qσ is less than production Q	Probability that Q_s is equal to/or in excess of production Q_{π}	Minimum expected quantity of demand (Q_s in kgr)
prime steak	520	0.02	0.98	424
steak	866	0.10	0.90	660
ribs	1,300	0.10	0.90	990
red meat	597	0.05	0.95	4,177
Total	8,665			

Table 4

Prime Steak Production Total: 529 kgr scaled every 200 kgr (estimate)	Probability that the Quantity of Demand Q_s Equals the Respective of Q_{π}	Minimum Expected Quantity
0	0.00 P_0 (Q_s = 0)/ Q_{π} = 0	0
200	0.15 P_1 (Q_s = 0.15)/ Q_{π} = 200	30
400	0.40 P_2 (Q_s = 0.40)/ Q_{π} = 400	160
520	0.45 P_3 (Q_s = 0.45)/ Q_{π} = 520	234
1,120	1.0	E (Q_s) = 424

Table 5

Steak Production Total: 866 kgr scaled every 200 kgr (estimate)	Probability that the Quantity of Demand Q_s Equals the Respective of Q_{π}	Minimum Expected Quantity
0	0.00 (P_0)Q_s = 0 / Q_{π} = 0	0
200	0.10 (P_0)Q_s = 0 / Q_{π} = 0	20
400	0.15 (P_0)Q_s = 0 / Q_{π} = 0	60
600	0.20 (P_0)Q_s = 0 / Q_{π} = 0	120
800	0.25 (P_0)Q_s = 0 / Q_{π} = 0	200
866	0.30 (P_s) Q_s = 0.30/ Q_{π} = 866	
260		
	1.00	**E (Q_s) = 660**

Table 6

Rib Production Total: 1,300 kgr scaled every 200 kgr (estimate)	Probability that the Quantity of Demand Q_s Equals the Respective of Q_π	Minimum Expected Quantity
0	$0.00\ (P_0)Q_s = 0/Q_\pi = 0$	0
200	$0.05\ (P_0)Q_s = 0/Q_\pi = 0$	10
400	$0.08\ (P_0)Q_s = 0/Q_\pi = 0$	32
600	$0.10\ (P_0)Q_s = 0/Q_\pi = 0$	60
800	$0.10\ (P_0)Q_s = 0/Q_\pi = 0$	80
1,080	$0.15\ (P_0)Q_s = 0/Q_\pi = 0$	150
1,200	$0.18\ (P_0)Q_s = 0/Q_\pi = 0$	216
1,300	$0.34\ (P_7)Q_s = 0.34/Q_\pi = 1,300$	442
	1.00	$E\ (Q_s) = 990$

Table 7

Red Meat Production Total: 5,979 kgr scaled every 500 kgr (estimate)	Probability that the Quantity of Demand Q_s Equals the Respective of Q_π	Minimum Expected Quantity
0	0	0
500	0.01	5
1,000	0.02	20
1,500	0.03	45
2,000	0.05	100
2,500	0.08	200
3,000	0.08	240
3,500	0.08	280
4,000	0.12	480
4,500	0.12	540
5,000	0.12	600
5,500	0.14	770
5,979	0.15	897
	1.00	$E\ (Q_s) = 4,177$

Table 8 ***Calculation of sales volumes and contribution margins.***

Expected Sales	Percentage % on Total Sales
a) prime Steak = (2,500 · 520) 0.98 + (2,500,424) · 0.02 = 1,295,000	= 7.37%
b) steak = (1,900 · 866) · 0.90 + (2,500,660) · 0.10 = 1,606,260	= 9.14%
c) ribs = (1,800 · 1,300) · 0.90 + (1,800,990) · 0.10 = 2,284,200	= 13.01%
d) red meat = (2,100 · 5,979) · 0.95 + (21,004,177) · 0.05 = 12,366,690	= 70.48%
Total 17,552,350	100%

as follows

a) for the prime steaks: the probability that the demand exceeds the production is 98%, while the rest 2% refers to the probability that the production is equal or in excess of the demand.

b) For the steaks: The respective probabilities are 90% and 10%

c) For the ribs: The respective probabilities are 90% and 10%

d) For the red meat: The respective probabilities are 95% and 5%.

Using the above data we can calculate the common contribution margin and afterwards we will use the appropriate weights to allocate common production costs. Finally, we will calculate the gross profit per product as well as the gross margin of the company as a whole.

Conclusions

The development and presentation of the joint - product cost allocation model leads to the following conclusions:

a) In the present state of knowledge, the assumption that the company's total production will be absorbed by the demand and that there will be no ending inventory (Homgren 1987, Foster 1987, Deakin and Maher 1984) is very restrictive, if not impossible to accept. Total production quantity may be absorbed by the market but there is always the possibility that it will not. Inventories play a significant role in determining the cost of goods sold and therefore any reasonable allocation

Table 9 ***Common contribution margin.***

Required Contribution Margin	Percentage on Total Sales	Required Common Contribution Margin	Percentage on Common Contribution Margin
α) 22% (prime steak)	X 7.37%	1.62%	7.91%
β) 21% (steak)	X 9.13%	1.91%	9.32%
γ) 22% (ribs)	X 13.01%	2.86%	13.96%
δ) 20% (red meat)	X 70.48%	14.09%	68.81%
		20.48%	100%

Table 10 ***Common cost allocation.***

	Common Cost	Percentage %	Respective Monetary Amount	Production	Unit Cost
μα) prime steak	12,237,000	: 7.91%	= 967,947	: 520	= 1,861 δρχ/**kilo‰**
β) steak	12,237,000	: 9.32%	= 1,140,448	: 866	= 1,317 δρχ/**kilo‰**
γ) ribs	12,237,000	: 13.96%	= 1,708,285	: 1,300	= 1,314 δρχ/**kilo‰**
δ) red meat	12,237,000	: 68.81%	= 8,420,280	: 5,979	= 1,408 δρχ/**kilo‰**
			12,237,000		

Table 11 ***Contribution Margin per joint-product and gross profits.***

a) prime steak	$\frac{2,500 - 1,1861}{2,500} = 25.56\%$	331,053
b) steak	$\frac{1,900 - 1,317}{1,900} = 30.68\%$	492,801
c) ribs	$\frac{1,800 - 1,314}{1,800} = 27\%$	616,734
d) red meat	$\frac{2,100 - 1,408}{2,100} = 32.95\%$	4,074,482
	Total Gross Profit	**5,515,073**

method should take into account demand considerations.

b) It is difficult to accept that certain products should suffer the burden of the total common costs whilst some others are excluded from allocation. This strategy will undoubtedly create problems which however are difficult to predict.

c) The simplicity of the proposed model for allocating joint-product costs is believed to contribute highly to the practical implementation of it. The casestudy presented in the paper provides ample evidence in favour of this statement.

d) Some objections against the proposed model may refer to the need to assign probabilities in order to estimate expected sales. We believe however, that this problem can be overcome by drawing histograms using past sales data. Of course this method is not a hundred percent accurate, but it allows to have a clear idea of the shape of the demand probability distribution and to estimate expected revenues.

e) On the assumption that there are or there are not ending inventories, expected revenues and expected cost can be estimated using the same procedure, defining thus the profit function which in turn can be used to determine the conditions for profit maximisation.

f) The application of the model in a meat manufacturing company shows that there are no deviations from the lower levels of the contribution margins imposed by the model. All the coefficients that have been estimated are in excess of the required margins. ●

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