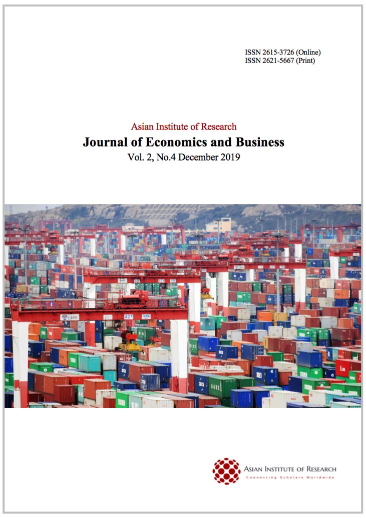

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Joint Products CVP Analysis – Time for Methodical Review

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Abstract
This paper compares the effectiveness of the Weighted-Contribution-Margin (WCM) and the Reversed-Contribution-Margin-Ratio (RCMR) in multiproduct Cost-Volume-Profit analysis applications. Using a rehashed-activity data and the OLS regression to analyse six joint-products over 42 weeks operation, it was found that the WCM lacks analytical efficiency and generates suboptimal products mix because it ignores the inverse relationship between a product's contribution-margin-ratio (CMR) and its breakeven point (BEP). These deficiencies present potential resource allocation problems during periods of low capacity utilization periods. The paper recommends the use of the RCMR which factors the tradeoff effects of the CMR/BEP in its measurement.

Keywords: Contribution Margin Ratio, Weighted Contribution Margin Ratio, Reversed Contribution Margin Ratio, Breakeven Point, Cost-Volume-Profit Analysis

1. Introduction

The survival, sustenance and competitiveness of any business in modern times are underscored by its ability to make effective business plans and respond to immediate challenges facing its operations and economic activities. Maximization of shareholders' wealth which often represents the broad objectives of a firm only applies when the profit-making machinery of the firm is appropriately aligned and correctly set in motion.

Profitability being the main focus of both long-term and short-term decisions takes more than basic economic strategies to keep a firm competitive in today's electronic and high-tech driven business environment. The speed at which a firm's management responds to business threats and opportunities defines the firm's extent of success in the economic market-place. However, for a firm to indeed survive in such a fast-moving global market with limited resource sources, the use of short-term decision models such as marginal costing and cost-volume-profit (CVP) analysis becomes desirable and inevitable.

Since the seminal work of Jaedicke and Robicheck (1964), CVP analysis has played a vital role in profit and activity planning, sensitivity analysis, short-term decision, marginal costing and budgetary control (Jaedicke & Robichek, 1964). Given that the CVP has been widely employed successfully in both teaching and actual application for analyzing a single product decision scenario under existing assumptions, the multiproduct application is still shaky because the various methods advanced for dealing with the analysis seem to suffer from one defect or the other.

1.1 Study Hypothesis

To advance the cause of this study, we propounded and evaluated the following major hypothesis using two other related hypotheses espoused for better understanding in the methodology section:

H_0: Using the Weighted-Average Contribution Margin (WCM) approach **Does Not** produce accuracy in the allocation of common ***fixed costs*** to individual products.

Rationale: The major source of misinformation in the computation of individual product's breakeven point comes from the inability to accurately estimate the attributable fixed costs to each product from the joint products' fixed costs estimate. Decision making on the basis of which product to produce, enlarge or discontinue during critical capacity utilization management periods rests squarely on the ability of the accountants to estimate individual product's attributable fixed costs with the required precision. Where this ability is lacking, the decision-making process will be faulty thereby leading to less optimal outcome. Preliminary analyses have shown that the WCM method seems to be flawed in this aspect, hence, the need for further statistical evaluation and comparison with a probable better technically and theoretically supported alternative.

1.2 Objectives of the paper

This paper aims to assess the efficiency and effectiveness of the widely accepted weighted contribution margin ratio (WCM) for distributing joint fixed costs and finding the individual products' breakeven points using a rehashed-operational data for six joint-products on table 2. It further aimed to compare the results obtained with those from a similar analysis employing the reversed contribution margin ratio (RCMR) introduced in Enyi (2012). The comparative test was intended to unveil which of the two models can deliver more on the accuracy of the individual share of the joint fixed costs and on the ability to align the aggregate of the individual products' breakeven points with the breakeven point produced using the fixed costs and contribution margin ratio (CMR) taking the entire operational analysis as one product line.

2. Theoretical and Empirical Review

CVP analysis is one business model which is exhaustively useful and hallowed in directing activity flow in a firm and yet simple to understand and apply. However, this simplicity of the CVP has made it one of the most abused in terms of misapplication. According to Stefan (2012), CVP analysis helps to bridge the gap between accounting and budgetary control and financial economics models for evaluating flexibility in economic decisions. The original CVP model, presented by Hess, 1903 and Mann, 1903-07, has progressed from the basic one product model and no uncertainty, with fixed costs and variable costs, to a more diversified and complex design with multiproduct situations and uncertainty (Stefan, 2012). Ever since the works of Jaedicke and Robich (1964) many scholars have delved into the study of how the CVP analysis can be deployed to solve not only business but also socioeconomic problems (Himme, 2018; Cheung & Heaney, 1990; Choo & Tan, 2011; Ihemeje, Okereafor, & Ogungbangbo, 2015)

As a pointer to the diverse application of the CVP analysis, some scholars studied how profit margin persistence can influence a firm's choice of business model (Collins, Chan, & Román, 2011), and what level of profit is normal for power generation (Simshauser & Ariyaratnam, 2014). In the same vein, Magee (1975) opined that the CVP analysis is a crude device for sensitivity analysis in managerial decision-making when it comes to highlighting the effects on profit of different levels of activity (volume and mix) and different combinations of fixed and variable costs of production (Magee, 1975; Kee, 2007). Also, Blocher and Chen (2004) used the CVP to consider the strategic issues related to operating leverage and how this affects the choice of performers and contract, and pricing strategies in a service industry (Blocher & Chen, 2004).

2.1 Profit and activity planning

According to Guidry, Horrigan, and Craycraft (1998), the CVP analysis provides a sweeping financial overview of the planning process which allows managers to examine the possible impacts of a wide range of strategic decisions such as pricing policies, product mixes, market expansions or contractions, outsourcing contracts, idle plant usage, discretionary expense planning, and a variety of other important considerations in the planning process (Guidry, Horrigan, & Craycraft, 1998). This is in line with works of Navaneetha, et al. (2017) which informs that CVP helps to scrutinize the relationship between changes in activity level and changes in total sales revenue, cost and profit and also provide beneficial information particularly for a business that is commencing operations or facing difficult economic conditions. It determines how many units of a product that must be sold to reach the business's breakeven point (Navaneetha, Punitha, Joseph, Rashmi, & Aishwariyaa, 2017).

The CVP analysis can also be used to measure the impacts of the profitability factors on the capital structure of a firm in a way that it was used to establish that the capital growth of a firm does not depend on the profitability factors but are important in the determination of the liquidity position of a firm (Mehar, 2005). It can also be used to report income when both inventories and production costs change during the year (Clancy & Madison, 1997). The CVP analysis has also been used to predict or determine whether a stochastic price-demand relationship exists for the product and to identify whether production quantity fixed at the beginning of the period equals to the actual demand realized in the period as well as help with analyzing the difference between production quantity and realized demand (Lau & Lau, 1987).

When a CVP model incorporates uncertainty, it qualifies to be used for analyzing the complications associated with decision-making under uncertainty. Yunker and Yunker (2003) employed a model incorporating uncertainty conditions in a study. They reported that the simplicity of the model permits analytical solutions for five "special prices" - (1) the highest price which sets breakeven probability equal to a minimum acceptable level; (2) the price which maximizes expected profits; (3) the price which maximizes a Cobb–Douglas utility function based on expected profits and breakeven probability; (4) the price which maximizes breakeven probability; and (5) the lowest price which sets breakeven probability equal to a minimum acceptable level (Yunker & Yunker, 2003). The CVP is also believed to help in bringing together all the financial information of an enterprise. (Jakupi, Statovci, & Hajrizi, 2017)

2.2 **Multi-product**

Since the business world has moved away from mono-product manufacturing, hardly would one find a single product producer, and this inadvertently renders the assumptions of the breakeven analysis on the basis of a single product moribund. The calls for multiproduct models were answered from different perspectives and according to the circumstances of each researcher. According to Gonzalez (2001), the two alternatives open to managers for analyzing the cost-volume-profit relationship in a multiproduct situation are to use a standard mix or to apply linear programming. However, each of these methods requires the model user to formulate a contribution rule that will allow computing, for each product, the output required to achieve a given (target) profit. (González 2001). The problem with the two methods is that a standard mix may not incorporate the optimality expected from the results of the analysis and the use of linear programming has to do with constraints that have exact input limitations. While a CVP analysis for a single-product company is relatively easier to illustrate, the CVP analysis for a multiproduct company takes extra steps and logic (Kim, 2015).

Building on the work of Enyi (2012), we present the model adopting the reversed contribution margin ratio (RCMR) as a credible alternative to the existing multiproduct models. The reversed contribution margin ratio (RCMR) as posited in Enyi (2012) builds on the fact that products with high contribution margin ratio attain breakeven point faster and at a lower activity level than products with lower contribution margin ratios; implying vividly that there is an apparent tradeoff between the contribution margin ratio and the product's breakeven point (Enyi, 2012). To further support this assertion, we use figure 1 and the data on table 1 to shed more convincing light on the subject. From Figure 1 it is evident that as the products' CMR (represented by the blue curve line) increases, the breakeven points (represented by the orange curve line) decreases; thereby proving that products' breakeven points are in inverse relationship with their CMRs and in fact decrease in response to the increase in their CMRs.

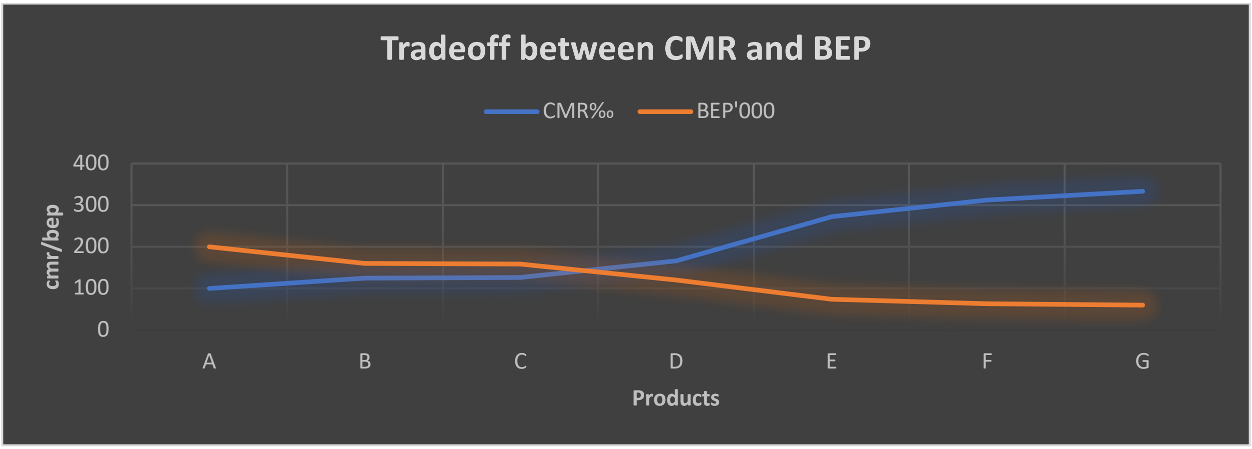

Figure 1: Comparative Chart showing the Tradeoff between CMR and Breakeven point

Table 1: Computation of Effects of Contribution Margin on Breakeven Point (Tradeoff Effect)

Product	**Attributable Fixed Costs**	**Unit Selling Price**	**Unit Variable Cost**	**Contribution Margin**	**Contribution Margin Ratio (‰)**	**BEP '000**
A	20,000	150	135	15	100	200
B	20,000	200	175	25	125	160
C	20,000	300	262	38	126.7	157.85
D	20,000	180	150	30	166.7	119.98
E	20,000	110	80	30	272.7	73.34
F	20,000	80	55	25	312.5	64
G	20,000	90	60	30	333.3	60

Table 2: Budgeted Activity of Sampan Inc. for the next period

Product	**Budgeted Sales Qty**	**Unit Selling Price**	**Total Budgeted Sales Value ($)**	**Unit Variable Cost**	**Total Budgeted Variable Cost**	**Unit Contribn Margin**	**Total Contribution Margin**
A	7000	140	980000	80	560000	60	420000
B	3000	140	420000	82	246000	58	174000
C	3000	160	480000	97	291000	63	189000
D	2000	160	320000	90	180000	70	140000
E	8000	60	480000	41	328000	19	152000
F	10000	30	300000	25	250000	5	50000
Total	**33000**		**2980000**		**1855000**	**275**	**1125000**

The company's budgeted fixed costs for the period is $402,000

As an elaborate illustration, we use the data on table 1, which have f = 420,000; s = 2,980,000, and c = 1,125,000 where f, s, and c represents fixed costs, sales revenue and contribution margin respectively (for a mono-product analysis), to generate the data and computations on tables 3 and 4. The data so generated on the two tables formed the main thrust of our analytical consideration and comparison; and to do the comparative test, using the outcome of the formula f/(s-c) as the control value, we break down the major hypothesis in 1.1 as follows:

H_0 1: Control value ≠ WCM value

H_0 2: Control value ≠ RCMR value

3. Methodology

This study employed an Ordinary Least Square (OLS) regression model and desk check computation technique on rehashed-operational data collected from real business operations of a confectionery company and bakery firm. The regression analysis made use of a control variable derived on the basis of a mono-product breakeven point computed using the sums of all sales, variable costs and the aggregate contribution margin from the joint products on the assumption of a single product. The following multiple OLS regression model was used to test the two hypotheses (H_01 and H_02):

$$\text{Control value} = \beta_0 + \beta_1 \text{WCM} + \beta_2 \text{RCMR} + \varepsilon \qquad (1)$$

The study also made use of extensive review of extant literature on the subject of cost volume profit analysis. Particularly, the study utilized the following theoretical foundation and formula to derive the multi-products' weighted contribution margin ratio (WCM) and the reversed contribution margin ratio (RCMR).

3.1 The Weighted Contribution Margin (WCM) approach

The WCM and the associated breakeven points (Table 3) were computed using the following steps:

i) To begin, we computed the weighted contribution margin (WCM) by
   a. First computing for each product the proportional share of the total sales revenue;
   b. Then we computed the contribution margin per product;
   c. Then we multiplied the answers in 'a' and 'b' and summed them up to obtain the WCM;
   d. We divided the answer obtained in i)b by the sum of the products in i)c to get the weighted contribution margin ratio (WCM) for each product.

ii) To get the joint-products' breakeven quantity when divided the total fixed costs with the WCM computed in i)c above.

iii) To get the individual breakeven points, we multiplied the breakeven quantity computed in ii) with the WCM per product derived in i)d above.

iv) To arrive at the breakeven sales revenue, we multiplied the figures derived in iii) with the individual product's selling price.

3.2 The Revised Contribution Margin Ratio (RCMR) approach

As with the WCM, the computational steps used for calculating the RCMR was derived from the model used in Enyi (2012) and are as follows:

a. First we computed the individual product's contribution margin ratio (CMR) by dividing the product's contribution margin with the selling price;
b. Secondly we summed up the CMRs computed in 'a' to get the total CMR (TCMR)
c. Then we divided the CMR per product with the TCMR computed in 'b' to get the proportional CMR (PCMR)
d. To reflect the CMR/BEP tradeoff we reversed the PCMR value by deducting the PCMR from 1 to obtain the reversed value (RV).
e. We then added up the RVs for all the products to get the total reversed value (TRV).
f. To obtain the individual reversed contribution margin ratio (RCMR), we divided the individual RV with the computed TRV.
g. To get the individual breakeven points, we multiplied the breakeven quantity computed in ii) with the WCM per product derived in i)d above.
h. To arrive at the breakeven sales revenue, we multiplied the figures derived in iii) with the individual product's selling prices.

The above steps were compiled into the following individual product's breakeven point (BEP) formula using the RCMR procedure:

$$b = \text{individual product's breakeven point} = \frac{fsy_t}{c}$$

Where,

y_t = RCMR = $\frac{e_t}{\sum_{t=1}^{n} e}$

w = product's CMR = $\frac{Contribution\ per\ unit}{Selling\ Price}$

c = total overall contribution = Total Sales Value – Total Variable Cost

f = total fixed costs

d_t = proportional CMR (PCMR) = $\frac{w_t}{\sum_{t=1}^{n} w} 100$

e_t = reverse value = 100 - d_t

n = number of products;

s = total budgeted sales value

n = number of joint products.

4. Data Analysis, Findings and Discussions

The analytical overview of the first step of the comparison was clearly visible when we computed the breakeven points using the two models with the budgeted operational data on table 2.

With the WCM model, the joint-products BEP = $\frac{402{,}000}{49.137}$ = 8,182 units approximately; tables 3 and 4 provide details on how this figure was shared among or allocated to the joint products. However, to obtain the overall breakeven point using the RCMR model, we divided the total fixed costs with the overall contribution margin ratio which was obtained by dividing the total budgeted contribution margin with the total budgeted sales revenue. This overall CMR translates to 1,125,000/2,980,000 = 0.3775168, using the data presented on table 2.

Consequently, using the RCMR model, the joint-products BEP in sales revenue = $\frac{402{,}000}{0.37752}$ = \$1,064,853.33. This breakeven sales figure was then appropriated to the individual products using the computed RCMR. To obtain the breakeven quantity for each product, we divided the product's share of the breakeven sales figure with the product's selling price.

The litmus test in this analysis is to compare the accuracy and effectiveness of the weighted contribution margin ratio (WCM) approach with that obtained using the reversed contribution margin ratio (RCMR) given the same operating condition.

Table 3: Weighted Contribution Margin Ratio (WCM) computations'

Prod A	**Sales Prpn b**	**Unit CM c**	**WCM d b*c**	**WCM e = (d/∑d)**	**BEP e * 8182**	**BEP $ 8182**
A	$\frac{98}{298} = 0.3289$	60	19.734	$\frac{19.734}{49.1379}$ = 0.4016	3,285	459,900
B	$\frac{42}{298} = 0.1409$	58	8.1722	$\frac{8.1722}{49.1379}$ = 0.1663	1,361	190,540
C	$\frac{48}{298} = 0.1611$	63	10.1493	$\frac{10.1493}{49.1379}$ = 0.2065	1,690	270,400
D	$\frac{32}{298} = 0.1074$	70	7.518	$\frac{7.518}{49.1379}$ = 0.1530	1,252	200,320
E	$\frac{48}{298} = 0.1611$	19	3.0609	$\frac{3.0609}{49.1379}$ = 0.0623	510	30,600
F	$\frac{30}{298} = 0.1007$	5	0.5035	$\frac{0.5035}{49.1379}$ = 0.0103	84	2,520
Total	= 1.0000	275	49.1379	= 1.0000	8,182	1,154,280

Table 4: Reversed Contribution Margin Ratio (RCMR) Computation

Product A	**CMR b = (u/p)100**	**PCMR*100 c = (b/∑b)100**	**RV d = 100 - c**	**RCMR e = (d/∑d)**	**BEP e * (fs/c)**
A	$\frac{60}{140} = 42.86$	$\frac{42.86}{215.75} = 19.86$	80.14	$\frac{80.14}{500} = 0.1603$	170,695.99
B	$\frac{58}{140} = 41.43$	$\frac{41.43}{215.75} = 19.20$	80.80	$\frac{80.80}{500} = 0.1616$	172,080.30
C	$\frac{63}{160} = 39.37$	$\frac{39.37}{215.75} = 18.25$	81.75	$\frac{81.75}{500} = 0.1635$	174,103.52
D	$\frac{70}{160} = 43.75$	$\frac{43.75}{215.75} = 20.28$	79.72	$\frac{79.72}{500} = 0.1594$	169,737.62
E	$\frac{19}{60} = 31.37$	$\frac{31.67}{215.75} = 14.68$	85.32	$\frac{85.32}{500} = 0.1706$	181,663.98
F	$\frac{5}{30} = 16.67$	$\frac{16.67}{215.75} = 7.73$	92.27	$\frac{92.27}{500} = 0.1846$	196,571.93
Total	= 215.75	= 100	= 500	= 1.0000	1,064,853.33

Table 5: WCM and RCMR Comparative Analysis

Product	**WCM**	**RCMR**	**Difference**
A	459,900	170,695.99	289,204.01
B	190,540	172,080.30	18,459.70
C	270,400	174,103.52	96,296.48
D	200,320	169,737.62	30,582.38
E	30,600	181,663.98	-151,063.98
F	2,520	196,571.93	-194,051.93
Totals	1,154,280	1,064,853.33	89,426.66

4.1 Statistical findings

Table 6: **Descriptive Statistics**

	Control	**WCM**	**RCMR**
Mean	1063.15	1202.49	1063.16
Std. Dev	187.267	208.921	187.255
Obs	42	42	42

The regression line produced by the analysis using the OLS equation [Control value = $\beta_0 + \beta_1$WCM + β_2RCMR + ε] is presented with other resulting analytical figures as follows:

y = 0.0221 – 0.0031$_{WCM}$ + **1.0035**$_{RCMR}$ + e
Durbin Watson statistics = 2.3086;
Correlation coefficient (r): WCM = 0.962; RCMR = 1.000
The relationship between the Control variable and the WCM is given by:
$\beta = -.003$, $t = -1.439$, $p = .158$
While the Control variable related with the RCMR using:
$\beta = 1.003$, $t = 439.779$, $p = .000$
Overall model fit is given by $Adj.R^2 = 1.000$, $F_{(2, 39)} = 1293991.321$, $p = .000$

4.2 Discussions

Drawing from Tables 3, 4, and 5 we found that the RCMR has two major areas of divergence from the WCM. First, rather than use the weighted contribution margin (WCM), it uses the overall contribution margin ratio (CMR) to divide the total fixed costs for the breakeven point computation. This implies that the RCMR model treats the sums of the multiproduct operational data as single product data. It achieves this by dividing the total contribution margin with the total budgeted sales revenue to generate the overall CMR which is then applied to divide the total fixed costs to arrive at the joint-products breakeven sales. Secondly, the other area of divergence is the reversal of the individual product's CMR ranking to reflect the negative relationship or tradeoff between the CMR and the breakeven point not factored into the generation of the WCM method.

The joint-products breakeven analysis outcome also revealed that it will take more resources to reach the breakeven point with WCM ($1,154,273.60) than with the RCMR ($1,064,853.53) as it is apparent that the WCM has deviated from the established mathematical relationship between the fixed costs and contribution level in normal CVP analysis. This shift implies that products with lower contribution margins and a higher proportion of total sales will be allocated more resources at a low capacity utilization stages than products with higher margins and lower sales proportion. Further problems may set in if the favored products carry higher prices which may be more difficult to sell than the lower priced ones as it is the case with Sampan Inc operational data, and this will happen at the expense of the firm's profitability. Table 5 shows the result of neglecting the CMR/BEP tradeoff as the WCM allocates abysmally low quantities to products E and F while overloading the allocations of the first four products with the resultant effect of pushing the spuriously computed breakeven beyond the actual breakeven point by more than $89,000. Furthermore, we use figure 2 to confirm the accuracy of the breakeven point produced by the RCMR .

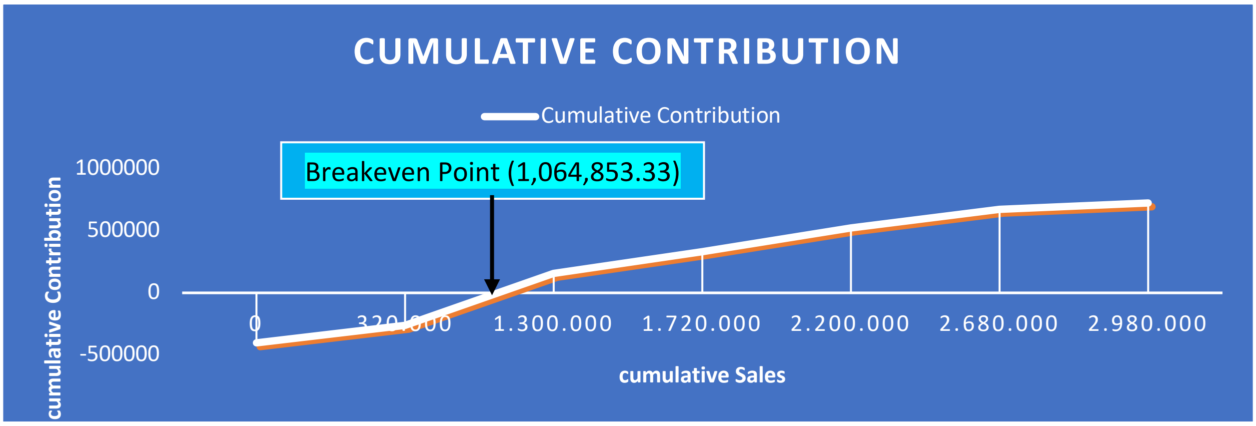

Figure 2: Cumulative Contribution and Breakeven Point (Sales revenue)

Table 7: WCM and RCMR with $75,000 Profit

Product		USING WCM MODEL			USING RCMR MODEL			
		WCM	BEP QTY	SALES	RCMR	BEP QTY	SALES	Difference
A	140	0.402	3,902	546,280	0.1603	1,393	202,163.20	344,116.80
B	140	0.166	1,612	225,680	0.1616	1,400	204,690.24	20,989.76
C	160	0.207	2,010	321,600	0.1635	1,238	205,953.76	115,646.24
D	160	0.153	1,485	237,600	0.1594	1,207	200,899.68	36,700.32
E	60	0.062	602	39,120	0.1706	3,470	216,061.92	-176,941.92
F	30	0.010	97	2,910	0.1846	7,571	233,751.20	-230,841.20
Totals			9,708	1,373,190		16,279	1,263,520.00	109,670.00

Table 8: Comparative Income Statement Analysis

Product		USING WCM MODEL			USING RCMR MODEL		
		Qty	$	$	Qty	$	$
		Sales		1,373,190	Sales		1,263,520
A	80	3,902	312,160		1,393	111,440	
B	82	1,612	132,184		1,400	114,837	
C	97	2,010	194,970		1,238	120,064	
D	90	1,485	133,650		1,207	108,630	
E	41	602	24,682		3,470	142,290	
F	25	97	2,425		7,571	189,275	
		Total Variable Costs		800,071			786,536
		Contribution Margin		573,119			476,984
		Less: Fixed Costs		402,000			402,000
		Expected Profit		171,119			74,984

As further proof, we extrapolate the Sampan Inc operational data on table 2 with a profit plan of $75,000 as the operating income expectations for the coming period. The CVP analysis for the six products under the two models as presented in tables 7 and 8 revealed that the WCM model overshot the expected target profit of $75,000 by a whopping $96,119 due to the inaccuracies embedded in its assumptions, while the RCMR slightly undershot the same target by just $16 which may probably be attributable to rounding errors in computation. From this simple analytical illustration, we can deduce that the use of the WCM is capable of distorting activity schedules and profit plans for multiproduct CVP analysis in an organization that depends on its use.

To further corroborate the foregoing, the descriptive statistics in table 6 showed how closely related the RCMR model figures are with the Control figures with the means and standard deviations of the two basically the same. This is a sharp contrast with those of the WCM which showed a 13.1% difference in means and 11.6% difference in standard deviations. Again, looking at the model output, it would be seen that the WCM is negatively congruent to the control variable (used as the model's dependent variable) while the RCMR is almost perfectly congruent to it on one-on-one basis meaning that the control variable figures are basically similar to the values produced by the RCMR model. This is even more evident when you consider the beta values of -0.003 with an insignificant p value of 0.158 for WCM and 1.003 with a significant p value of 0.000 for the RCMR. The correlation coefficients of 0.962 and 1.000 returned by the WCM and RCMR respectively against the control variable further confirmed the superiority of the latter over the former.

Conclusion and recommendations

This study concludes that despite the seeming simplicity in understanding and application, the Weighted Contribution Margin (WCM) approach to multiproduct CVP analysis suffers from many inaccuracies and is capable of misguiding decision makers on multiproduct profit planning and activity budgeting. The use of the RCMR as an alternative model was shown to have the capability of effectively overcoming the flaws of the WCM and promises to offer a big improvement in CVP pedagogy and applications in an expanding business environment.

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