Mix Matters

An Introduction
To
The Mysteries Of Volume and Mix Analysis
For
Financial Professionals

By Frank Warthen

A Bad Day at the Office…

John Hannell, the controller of WidgGig Video Cards, was apprehensive as he entered the office of Tom Ortsmond, president of the company. As John sat down, Tom immediately started firing questions. "John, I've just gotten the financial statements for this month and there is something I would like to know about. The gross profit rate for our WidgGigs came in at 54.7%; the budgeted gross profit rate was 62.4%, a whopping unfavorable variance of 7.7%. We missed our budgeted profit before taxes rate by only 3.2% so this ghastly unfavorable 'miss' in the gross profit rate more than accounts for our profitability problem. Our total sales were pretty much what we budgeted for. As far as I know, our costs and selling prices were pretty much in line with expectations. What is going on here?"

John, sweating a little, responded. "Tom, you are right about sales, costs and pricing being in line with the budget expectations. I guess that we must have had a little problem with the mix of WidgGigs that we sold last month; you know, Tom, some of them are less profitable than others." Tom's face darkened a bit as he gasped, "You 'guess'? John, this hardly seems like a 'little' problem. Can you be a little more definitive? We spent months developing a Product Sales Budget and, I must say, almost sent our poor product line and regional managers into nervous breakdowns with the level of detail that they had to provide. Is the answer that some of our WidgGigs are less profitable than others supposed to be enough? What can I possibly tell the Board of Directors that they will understand? They haven't a clue about what the word 'mix' even means. They will want some kind of answer with more exactitude than that. They will demand to know which of our WidgGig product lines and regions might have a problem."

John, now having an anxiety attack, started to get up from his interrogation. "Tom, I'll just have to review the Product Sales Budget so that I can try to see where there might be some differences. But, you know, that will take quite a bit of time because we have 23 product lines that sell WidgGigs, replacement parts, accessories and software and they are spread across 17 regions."

"John", said Tom "…the board meeting is tomorrow morning! I will need answers before then. I must say, John, I can't seem to see the point in preparing a detailed Product Sales Budget if it won't tell us what actually happened when we really need to know. Our business is not preparing Product Sales Budgets; it is one of making profits selling WidgGigs and when something is not right, we really need to know about it as soon as possible. Do you understand?"

"Yes," responded John as he grimaced with a pale face and painfully headed for the comfort of the door. "I'll do my best." "Be sure you do, John … be sure you do."

Does this oft-repeated uncomfortable scene sound familiar to you? Have you been in this unenviable position yourself? Have you repeatedly tried to define just what "Volume and Mix Variance" really means to upper levels of management? Would you like to end this aggravation once and for all? Would you like to get ahead of the curve? Before we explore the implications of a surprisingly simple algorithmic tool for relieving this management accounting frustration, however, let's "do the math" so that we are all on the same page.

Basic Analysis of Mix Variance

The primary objective of the analysis is the isolation of volume and mix variance components in actual vs. budget product profit analyses. Mix variance affects profitability rates whereas volume variances, in contrast, do not. Secondarily, the analysis must reflect logical consistency at all levels of the product hierarchy so that volume and mix variances can be easily "tracked" from top to bottom of the product sales budget.

Mix variance is a group dynamic. Mix variance does not exist when one considers a single product. At the single product level, there is only volume variance; there is no mix variance. Mix variance is created whenever 2 or more products are included in a "product group". The only profit rate required for any analysis of volume and mix variances is the budgeted profit rate. Budgeted profit rates are "locked in" at budget finalization.

Mix variance arises from 2 factors whenever a product is considered as part of a group. The first factor is the relationship between the product's budgeted profit rate and the aggregate budgeted profit rate of the group; the budgeted profit rate of a product may be higher or lower than the budgeted profit rate of the group. Note that the profit rate referred to here is the budgeted profit rate. This relationship is "locked in" at budget finalization and never changes during the budget year (a constant value). The second factor is the relationship between the actual sales mix of the product (as part of its group) and the budgeted sales mix of the product; the actual product sales mix changes throughout the budget year but the budgeted product sales mix remains constant. Note that the only factor, which varies during the budget year, is actual product sales mix.

. BPRDiff = (Budgeted Product Profit Rate - Budgeted Group Profit Rate)

. MixVar = (Actual Product Sales Mix - Budgeted Product Sales Mix)

The effect on mix variance of the group is a direct function of total actual sales for the group (TotActGrpSls). Given these component parameters, we can measure the impact of any given product's mix variance on the group (Mix Variance = MV) as follows:

. MV = (TotActGrpSls x MixVar x BPRDiff)

We can assume some example values for the purpose of illustrating the calculation:

. TotActPrdSls = $20,000 Total Actual Product Sales
. TotActGrpSls = $100,000 Total Actual Group Sales

. TotBudPrdSls = $30,000 * Total Budget Product Sales
. TotBudGrpSls = $200,000 * Total Budget Group Sales

. Actual Product Sales Mix = (TotActPrdSls / TotActGrpSls) = .20
. Budgeted Product Sales Mix = (TotBudPrdSls / TotBudGrpSls) = .15 *

. Thus MixVar = (.20 - .15) = .05 Mix Variance

. Budgeted Product Profit Rate = .34 *
. Budgeted Group Profit Rate = .46 *

. Thus BPRDiff = (.34 - .46) = -.12 * Budgeted Profit Rate Differential

. Thus MV = ($100,000 x .05 x (-.12)) = -$600

$600 Unfavorable Mix Variance

* Constant throughout Budget Year

The only other component of the product's profit variance is volume variance (VV). Order of calculation is important; MV must be calculated before VV. VV is a simple residual calculation:

. VV = [(TotActPrdSls - TotBudPrdSls) x Budgeted Product Profit Rate] – MV

. Thus VV = [(-$10,000 x .34) - (-$600)] = [-$3,400 + $600] = -$2,800

$2,800 Unfavorable Volume Variance

As a result of the above calculations, we have determined that this product contributed an unfavorable $2,800 toward its group's volume variance and contributed an unfavorable $600 toward its group's profit rate (mix) deterioration. We have successfully split the product's profit variance of $3,400 into the volume variance (-$2,800) and mix variance (-$600) components that affect the group. The next step would be to subject each component product of the group to this analysis, splitting each product's profit variance into its component volume and mix variance contributions.

The volume variance and mix variance of the total group are summations of the corresponding variances (VV and MV) of the individual products, which comprise the group. We might have calculated VV and MV for the total group by some other method but we would not have known about the contribution of the individual component products to the total group. Performing the above calculation on a product-by-product

basis gives the important advantage of knowing the sources of the volume and mix variance components of the total group; no other method provides us with such invaluable information.

. TVV = Total Volume Variance = ∑VV
. TMV = Total Mix Variance = ∑MV

Having reached this point in the analysis, we can create an illustration (lower half of Figure 1, ***Hierarchical Mix Analysis Protocol***), which diagrams the analysis. It shows the results of basic mix variance analysis for our foregoing Product (Product 0) and its associated grouping (Group 0). For our example, let's assume that Product 0 is now grouped together with other products (Product 1, 2, 3, n) to form Group 0; what we have, in effect, is a Group composed of Products. Performing the calculation on a Product-by-Product basis gives the important advantage of knowing the sources of the volume and mix variance components of the total Group (the Group comprised of Products).

Hierarchical Analysis of Mix Variance

The basic analysis can now be extended to higher levels of grouping. For our example, let's assume that Group 0 is now grouped together with other Groups (Group 1, 2, 3, n) to form Division 0; what we have, in effect, is a Division comprised of Groups. Performing the calculation on a Group-by-Group basis gives the important advantage of knowing the sources of the volume and mix variance components of the total Division (the Division comprised of Groups).

At this point the "hierarchical" aspect of the analysis begins and we must introduce the concept of rollup variance. Rollup variance is only applicable to levels of the hierarchy in which we deal with groups comprised of "groupings" (upper half of Figure 1, ***Hierarchical Mix Analysis Protocol***).

The upper half of Figure 1, ***Hierarchical Mix Analysis Protocol***, shows what is involved. The basic analysis computations (shown above) are now carried out on Group 0 at the Division 0 level; "Product" is now "Group" for purposes of the analysis. Note that, unlike Group 0, Division 0 is a group comprised of "groupings"; Group 0 was a group comprised solely of individual products. Group 0's Total Volume Variance (TVV) summation becomes a Volume Variance (VV) and a Mix Variance (MV) at the next higher level of grouping (Division 0); the Total Volume Variance (TVV) of Group 0 is precisely split into a Volume Variance (VV) and a Mix Variance (MV) for Division 0. The Total Mix Variance (TMV) of Group 0 becomes the newly formed (carried upward) profit rate variance called Rollup Variance (RV) of Group 0 at the Division 0 grouping level. The total volume variance of Division 0 is explained by its' TVV summation; the total profit rate variance of Division 0 is explained by the combination (simple addition) of Division 0's TMV and TRV (Total Rollup Variance). Once again, performing the calculation on a Group-by-Group basis gives the important advantage of knowing the sources of the volume and mix variance components of Division 0 (the Division comprised of Groups).

The process simply repeats as we extend the analysis to successively higher levels of "grouping". The Total Mix Variance (TMV) and Total Rollup Variance (TRV) of the "lower" group are combined (added together) before being carried upward to the Rollup Variance (RV) of the "higher" group.

A note about the volumes used in the analysis; we have assumed that the Actual and Budget Volumes used are dollar amounts. That is not necessarily the case because we could easily regard them as unit volumes if that makes sense for the particular company involved. Automotive companies (Ford Motor Company, for example) and others (perhaps even a video card company like WidgGig) are more concerned with the analysis of units than dollars. One could also argue that *both* dollar *and* unit analysis should be performed. This depends upon the homogeneity of the products sold by the particular company.

Analysis Summary

The Actual vs. Budget profit of each product and its' associated grouping has been broken out into 2 mix variances (MV and RV) and a volume variance (VV). The 2 mix variances are the variances that affect profit rate(s); the volume variance is the variance that does not affect profit rates. The volume and mix variances consistently "track" from group level to group level both up and down the product hierarchy. Now that we are familiar with the math of this algorithmic tool, let's explore its' implications for the management accountant.

Background and Analytical Perspectives

Product sales mix variance analysis is an essential element of management accounting. It is the analysis of the difference between actual and budgeted profit rates. This article explores a rigorous, disciplined, simple methodology that can be used to conduct that analysis for complex "hierarchical" (multi-level) product sales environments.

Accurate measurement of product sales mix profitability is an important responsibility of the profit accountability function. Those who provide input to the product sales budget (typically marketing personnel) should know that they would be held accountable for the realism of their projections. They should know that financial personnel could track down and accurately measure the profitability impact of mix variances. This area of responsibility accounting is integral to the management accounting function. Product sales budgets are all too often assembled with an attitude of, " . . . a little more of this and a little less of that."

Analysis of actual versus budgeted sales profitability is important because the profitability of sales dollars is the "engine that drives the rest of the income statement". Management must be concerned with achievement of profit per sales dollar (or per sales unit) targets and the timely analysis of trends. The mix of product sales budgets must be held as accountable as other areas of income and expense.

A great deal of time and effort is often expended in development of the product sales budget; it is mandatory that measurement of the achievement of budgeted sales profitability targets be carried out. The analysis method utilized should be practical and consistent with the way product sales budgets are assembled in "the real world".

The achievement of budgeted sales targets is important but it must not cover up an unprofitable product mix. The profitability impact of product sales mix is like an iceberg – most of it lies beneath the surface.

The product mix of sales budgets is often "fine-tuned" with an aggressively "rich" mix in order to achieve unrealistic profitability targets. Even when the overall actual profit rate turns out favorable versus the budgeted profit rate, it is instructive to carry out the analysis anyway. It is often possible to unearth instances within the bowels of the product sales budget in which favorable sales mix performances may have covered up for unfavorable instances. These "nuggets" are important for management's consideration.

The analytical methodology must be practical, easily understood and amenable to computer programming techniques. It must be easy to carry out with pencil, paper and calculator; sophisticated spreadsheet macros are certainly useful but they should not be mandatory in order to carry out the analysis. The author has no bias against sophisticated mathematical techniques but they are inappropriate for this area of financial analysis. Cloaking the analysis in mathematical notation provides little, if any, enhancement of the techniques involved. Development of appropriate mathematical notation for this analysis will be left as an exercise for those more mathematically adept than the author. Although the analysis initially appears mind boggling, the calculations are easily incorporated into that ubiquitous "lingua franca" of the financial world, the spreadsheet. Why not let the spreadsheet do the mental heavy lifting? Once and for all time, the legendary "Gordian knot" can be untied.

It must be possible to carry out the analysis expeditiously (as soon as period financial results are known) so that sufficient guidance information can be furnished to management; waiting weeks for complex analytical cost accounting techniques provides stale information. The division of the product sales budget across multiple departments and product lines should not be an obstacle that makes sales mix analysis difficult or impossible to implement expeditiously.

Analysts often carry out laboriously complex analytical cost accounting techniques when analyzing profit variances; the variance that is "unexplainable" is often relegated to a mysterious variance labeled "Volume and Mix"; in terms of management accounting practice, this is analogous to "putting the cart before the horse". Product sales mix variance analysis is a "first line" approach; it is not a secondary or tertiary methodology. That said, however, it is obvious that elimination of sales dollar price variances prior to carrying out the analytical techniques (if that can be accomplished) constitutes a substantial improvement in the quality of the analysis because actual dollar sales volumes will be more accurate; actual costs are neither utilized nor needed in the analysis (with due apologies to my friends in the cost accounting department). The elimination of sales

price variances has no effect whatsoever on the analytical methodology or the interpretation of its results. Sales price variances are, however, a separate issue of obvious importance to management.

Successful product sales mix analysis is fundamental to computerized Business Intelligence for the organization as a whole. Without the correct analytical algorithm, however, the most powerful computers and database managers are completely ineffective. The analytical technique must be adaptable to computer programming practices and database management tools.

The analysis does more than add to management's control capabilities. It also adds to management's understanding of the business and it does so in a timely manner. In doing so, it can immeasurably improve the budgetary planning process.

Is there an elegant solution to this conundrum? Is this "a riddle wrapped in a mystery inside an enigma"? Let us go boldly forth where no man has gone before….

Profitability Analysis

Profitability analysis is concerned with profit rates, either per sales dollar or per sales unit. The most common usage is profit rate per sales dollar although it is also used to analyze profit rate per sales unit. There are potential applications in other "rate oriented" areas of financial analysis (e.g., Analysis of Inventory Turnover Rates, Hotel Occupancy Rates, Line of Business Reporting, etc.).

Pure Mix Analysis

This aspect of profitability analysis excludes price and cost variances (this is the area explored by conventional cost accounting techniques). For purposes of this analytical technique, actual profit rate = budgeted profit rate. The actual profit rate can be regarded as immaterial and inapplicable (except in the case of unbudgeted sales, as noted below).

Mix analysis requires only budgeted profit rates. Because only budgeted prices and costs are used in the analysis, the analysis can be performed independent of any other (traditional / cost accounting) profit analysis techniques. In fact, it can be utilized prior to applying traditional profit analysis techniques in order to determine how much those techniques need to account for. There is, however, an important implicit assumption; budgeted profitability rates are linear (uninfluenced by volume) over the relevant range of the analysis

Hierarchy of Mix Variances

Product sales budgets are hierarchical in nature; they are constructed in a fashion reminiscent of pyramids. Each level of the pyramid rests upon the base established by the building blocks ("groups") of the preceding level. Volume and mix variances have a tripartite nature so we have to conduct a 3-dimensional analysis of variance; the variances

are, in a way, “coming down in 3 part harmony”. The assembly of mix variances is analogous to a pyramid; data assembly via Business Intelligence is implemented via a cube.

Volume Variance: The volume portion of a component's contribution to total group profitability. The difference between actual and budgeted component sales is first extended at the component's (not the group's) budgeted profit rate. From this product, the component's volume variance is then deduced by simply subtracting the amount assigned to the component's mix variance (as calculated below). This means that the component’s mix variance must be determined prior to calculating the component’s volume variance. The total of all component volume variances reflects the profit effect of component volume changes for the group.

Mix Variance: This is the “keystone” / “heart” of the entire analysis; once the algorithm for mix variance is clearly comprehended, the remainder of the analysis flows easily from this essential “root” calculation. Defined as the profit effect of the group's actual component sales mix being different from its' budgeted component sales mix; it is calculated as the product of the difference between the component's actual and budgeted mix, the difference between the component's budgeted profit rate and the group's budgeted profit rate and the actual group sales volume. In other words, a mix difference, a profit rate difference and the actual group sales volume are all included in the calculation product of each component's contribution to total mix variance. The total mix variance reflects the profit effect of component mix changes for the group in question. The mix variance explains the profit rate variance between the actual and budgeted profit rates for a group when the originally budgeted component profit rates are used in the calculation; this is true for any group at any level. The remainder of the gross profit variance that is attributable to profit rate variances is covered by the group’s rollup variance (discussed below). It is important to note that any differences in profit rate between components’ profit rates and the group's profit rate are “locked in” by the budgeted sales mix used in preparing the budget.

Rollup Variance: This arises from the preceding/lower group(s)' combined mix variance(s) and rollup variance(s). It is essentially an “accumulator” in that it is the summation of all lower level mix and rollup variances. Rollup variance is the “key” to conducting the analysis in multi-level (“hierarchical”) environments. Each rollup variance is a “pointer” to the next lower level's mix and rollup variances; the next lower level itself may contain a group of mix and rollup variances which point to a lower level and so on and so on; mathematicians would refer to this as a “series” or a “sequence”. Rollup variance is the network protocol that wires levels together in hierarchical product mix analysis; each hierarchical mix variance has “origins” in lower levels’ mix and rollup variances. In spite of this seeming complexity it is easy to deal with, however, because it can initially be thought of as nothing more than the total variance between actual and budgeted component profits less the amounts already calculated for the component's volume and mix variances; it is an amount which can ultimately be “explained” by examining the mix and rollup variances of successively lower levels of the product sales hierarchy.

Mix variance and rollup variance sound similar; in fact they are very different. Mix variance serves to identify and isolate those mix variances that are directly attributable to mix changes *within* a given group; the operative word here is "direct". Rollup variance serves merely as a container for mix variances that are "indirect"; it shows the profitability effect of mix variances that have originated at lower levels of the product sales budget's hierarchy. Separation of the 2 types of mix variance is the "key" to understanding the power of this analysis; it gives us the ability to pinpoint variances and drill down to their origins.

Actual versus budgeted profit is completely accounted for by the 3 variances. The difference between actual and budgeted profit dollars for any component or group is completely explained when its' volume variance, mix variance and rollup variance are added together. This is true for any component or any group at any level of the analysis; indeed, it is true for the analysis as a whole entity. As will warm the cockles of any accountant's heart, the entire analytical crosstab "foots and cross foots".

The analysis is consistent from top to bottom or bottom to top. Volume variance "splits" as the hierarchy is ascended; it splits into the next higher level's volume and mix variances. Mix variance and rollup variance "combine" (accumulate) as the hierarchy is ascended; they "combine" (accumulate) into the next higher level's rollup variance. Rollup variance "splits" as the hierarchy is descended; it "splits" into the next lower level's mix and rollup variances.

No rollup variance exists for the bottom group. This bottom group is the "terminator"; it represents the "origin" of all higher-level rollup variance combinations/accumulations. It has only volume variances and mix variances.

The analysis can be used to analyze downward or upward; this makes it a consistent technique that can be applied at all levels of the product sales organizational pyramid. Analysts can drill down to the appropriate analytical breakouts from whatever level is appropriate.

At the very bottom group, the only inputs needed to start the analysis on its upward course are the actual sales volume, the budgeted sales volume and the budgeted profit rate for each component product; these 3 elements are the primary building blocks and all calculations (from bottom to top) can be carried out with them as a starting point. The component products of the very bottom group can be thought of as atomic elements of the periodic table; they cannot be further broken down. The individual component products are then assembled into the bottom group and the analysis can begin its upward rollup journey through the hierarchy.

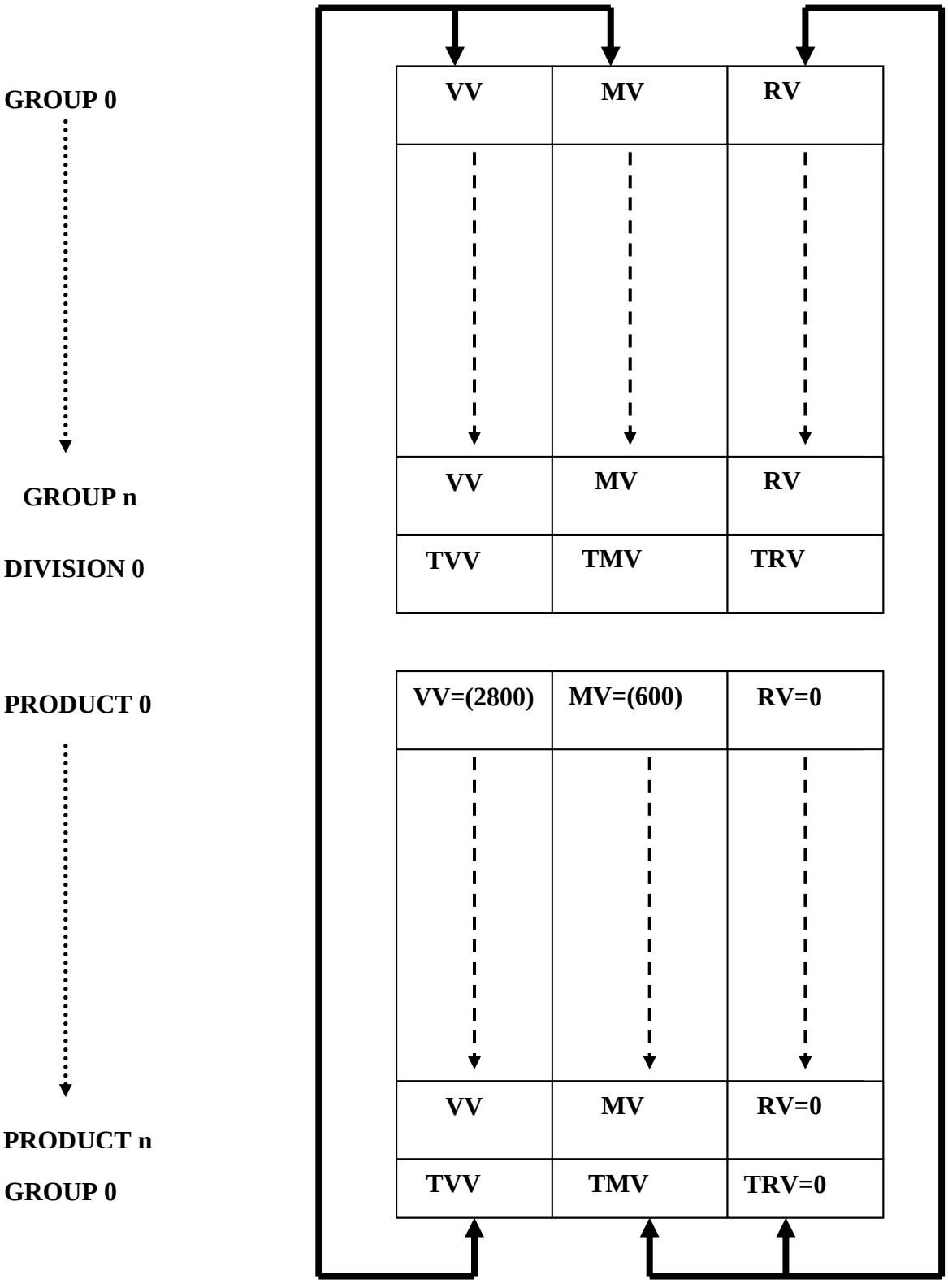
Dynamic Mix

The mix analysis becomes dynamic if we properly include "unbudgeted sales". The "unbudgeted sales" are merely assigned a budget volume of 0 ($0 or 0 units). In the case

of “unbudgeted sales”, the budget profit rate = actual profit rate (usually). This is the only case, for this analysis, in which the actual profit rate is of any use. In this case, the actual profit rate can be used merely as an approximation of what the budget profit rate would have been. The budget profit rate assigned is the profit rate that would have been utilized if it had been known at budget preparation time; this may or may not be the same as the actual profit rate.

As a practical matter, there typically are unbudgeted sales during the year. This can be due to new products but, more frequently, they are due to “specials”, “promotional packaging”, “sales programs” or the like that are concocted during the budget year by marketing personnel; these volumes are in place of (or deduct from) the originally budgeted component volumes and they typically have different (usually lower) profit rates than the components for which they substitute. Because we can include these “unbudgeted component” sales volumes it is finally possible to provide full accountability for the effect of sales programs. The ability to dynamically include the profitability impact of these “unbudgeted sales” is an important tool for the management accountant. The importance of being able to easily include these “unbudgeted sales” should not be understated. One of the big problems with static product sales budgets is that they are often obsolete shortly after their labored preparation. Often, after the preparation of the product sales budget, management simply says, “Gee, that was a wonderful cathartic exercise!” and puts it on the dusty shelf. The ability to include “unbudgeted sales” gives the product sales budget a life of its own; it becomes a dynamic management tool for use throughout the entire budget year. The product sales budget becomes, to use a popular vernacular, a “living document”. For the marketing types, there is now no place to hide.

Figure 1



Hierarchical Mix Analysis Protocol

And now, Back to John Hannell . . .

This algorithm is easily set up in spreadsheet form. One of the benefits of a spreadsheet analysis is that it can be prepared and ready before the actual results roll in. The Budget Volumes and the related Budget Profit Rates are available at all levels before the actual results arrive. Once the actual results arrive, we can merely enter the Actual Volumes, hit the "CALCULATE" button and our analysis is completely finished; you still have to explain the results to management but that is a challenge for another day. Take the night off, John Hannell!