# Chapter 11 Analytical Techniques

为了方便企业对收入成本进行精准的预算。首先我们要能预测总成本与产量之间的关系，收入变化的趋势，人工工时的变化规律，那么我们可以利用哪些数学方法去预测变量之间的关系呢？

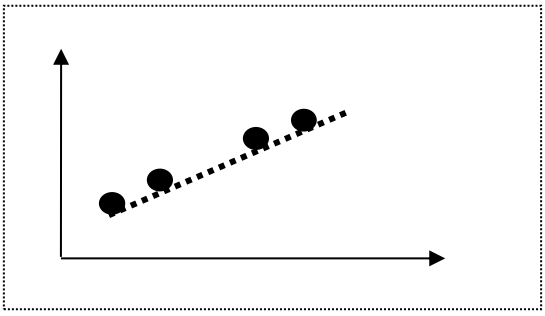
**Learning outcomes**

- Analyse fixed and variable cost elements from total cost data using the high-low method.
- Explain and apply analysis techniques including correlation, regression and time series.
- Estimate the learning rate and learning effect.
- Apply the learning curve to a budgetary problem, including calculations on steady states.
- Explain the limits of the learning curve.

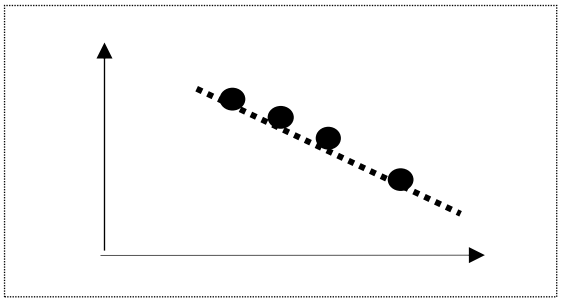
## 1. Correlation

**Two variables** are said to be correlated if a change in the value of one variable is accompanied by a change in the value of another variable. This is what is meant by **correlation**.

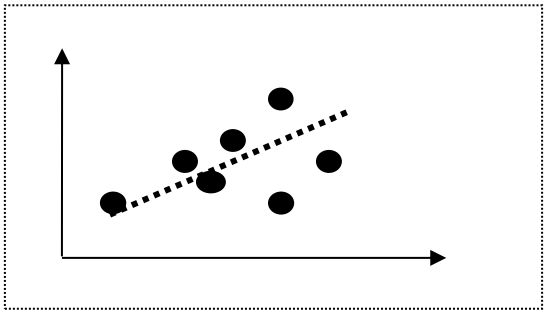
Perfect positive correlation（完全正相关） +1



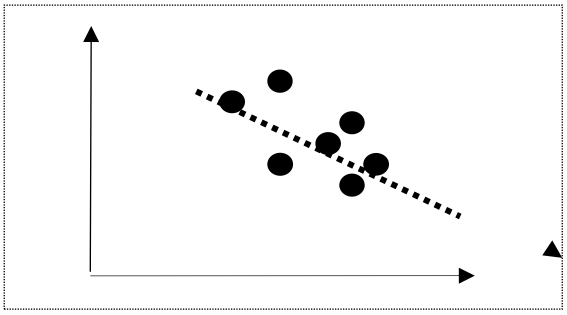
Perfect negative correlation（完全负相关） -1



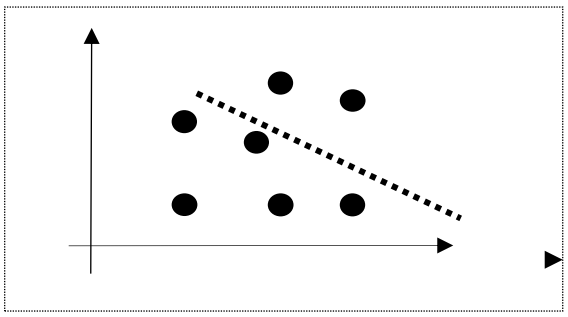
Partial positive correlation（部分正相关） (0,+1)



Partial negative correlation（部分负相关） (-1,0)



Uncorrelation（不相关） 0



1.1 The correlation coefficient（相关系数）

The **degree of linear correlation** between two variables is measured by the Pearsonian (product moment) **correlation coefficient**, r. The nearer r is to +1 or –1, the stronger the relationship.

Correlation coefficient, $r=\frac{n\sum xy-\sum x\sum y}{\sqrt{(n\sum x^2-(\sum x)^2)(n\sum y^2-(\sum y)^2)}}$

where X and Y represent pairs of data for two variables X and Y
n = the number of pairs of data used in the analysis

This formula is given on the MA formula sheet.
Note that this correlation measure measures the **strength** of **linear** relationships.

### Example 1: The correlation coefficient formula

The cost of output at a factory is thought to depend on the number of units produced. Data have been collected for the number of units produced each month in the last six months, and the associated costs, as follows:

| Month | Output '000s of units X | Cost $'000 Y |
|---|---|---|
| 1 | 2 | 9 |
| 2 | 3 | 11 |
| 3 | 1 | 7 |
| 4 | 4 | 13 |
| 5 | 3 | 11 |
| 6 | 5 | 15 |

***Required***

Assess whether there is any correlation between output and cost.

**Solution**

| X | Y | XY | $x^2$ | $y^2$ |
|---|---|---|---|---|
| 2 | 9 | 18 | 4 | 81 |
| 3 | 11 | 33 | 9 | 121 |
| 1 | 7 | 7 | 1 | 49 |
| 4 | 13 | 52 | 16 | 169 |
| 3 | 11 | 33 | 9 | 121 |

5 15 75 25 225

$\sum x = 18$ $\sum y = 66$ $\sum xy = 218$ $\sum x^2 = 64$ $\sum y^2 = 766$

$(\sum x)^2 = 324$ $(\sum y)^2 = 4,356$

n = 6

r = 1

There is **perfect positive correlation** between the volume of output at the factory and costs which means that there is a perfect linear relationship between output and costs.

## 2. The coeeficient of determination, $r^2$

The **coefficient of determination**（决定系数）**,** measures the proportion of the total variation in the value of one variable that can be explained by variations in the value of the other variable. It denotes the strength of the linear association between two variables.

## 3.Line of best fit（最佳拟合曲线）

Estimating the equation of the line of best fit

**Y = a + bX**

Where

X and Y are the related variables

a and b are estimated using pairs of data for X and Y.

### 3.1 Linear regression analysis（线性回归分析）

The least squares method of linear regression analysis involves using the following formulae for a and b in Y = a + bX.

$b = \frac{n\sum xy - \sum x \sum y}{n\sum x^2 - (\sum x)^2}$

$a = \frac{\sum y}{n} - b\frac{\sum x}{n}$

where n is the number of pairs of data

The formula will be given in the exam.

**Example2: The least squares method**（最小二乘法）

(a) Using the data below for variables X (output) and Y (total cost), calculate an equation to determine the expected level of costs, for any given volume of output, using the least squares method.

| Time period | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Output ('000 units) | 20 | 16 | 24 | 22 | 18 |
| Total cost ($'000) | 82 | 70 | 90 | 85 | 73 |

(b) Prepare a budget for total costs if output is 22,000 units.

**Solution**

(a) Workings

| X | Y | XY | $x^2$ | $y^2$ |
|---|---|---|---|---|
| 20 | 82 | 1,640 | 400 | 6,724 |
| 16 | 70 | 1,120 | 256 | 4,900 |
| 24 | 90 | 2,160 | 576 | 8,100 |
| 22 | 85 | 1,870 | 484 | 7,225 |
| 18 | 73 | 1,314 | 324 | 5,329 |

$\sum x = 100$ $\sum y = 400$ $\sum xy = 8{,}104$ $\sum x^2 = 2{,}040$ $\sum y^2 = 32{,}278$

n = 5

b = 2.6

a = 28

Y = 28+2.6X

(b) If the output is 22,000 units, we would expect costs to be

28 + 2.6× 22 = 85.2 = $85,200.

**3.2 High-low method**

**Example3: The high-low method using revenues**

The following information concerning sales revenues for a development, Cool Blue, for the last four months have been as follows.

| Month | Sales revenues | Website 'hits' |
|---|---|---|
| $ | | |
| 1 | 110,000 | 70,000 |
| 2 | 115,000 | 80,000 |
| 3 | 111,000 | 77,000 |
| 4 | 97,000 | 60,000 |

***Required***

Calculate the revenues that should be expected in month five when hits is expected to be 75,000 units. Ignore inflation.

Solution

97,000 = 60,000b + a

115,000 = 80,000b + a

b = 0.9

a = 43,000

So, y = 0.9x + 43,000

Revenue for 75,000 hits

y =0.9*75,000+ 43,000

= 110,500

**3.2.1 The high-low method with stepped fixed costs**

Example4:

The following data relate to the overhead expenditure of contract cleaners (for industrial cleaning) at two activity levels.

| | | |
|---|---|---|
| Square meters cleaned | 12,750 | 25,000 |
| Overheads | $73,950 | $145,850 |

When more than 20,000 square meters are industrially cleaned, it is necessary to have another supervisor and so the fixed costs will increase $21,675.

*Required*

Calculate the estimated overhead expenditure if 22,000 square meters are to be industrially cleaned.

Solution

73,950 = 12,750b + a

145,850 = 25,000b + (a + 21,675)

So

b = 4.10

a = 21,675

Estimated overhead expenditure

If 22,000 square meters are to be industrially cleaned:

| | $ |
|---|---|
| Fixed costs 21,675 + 21,675 | 43,350 |

| | |
|---|---|
| Variable costs (22,000 × $4.10) | 90,200 |
| | 133,550 |

### 3.2.2The high-low method with inflation（通货膨胀）

Example5:

You may be asked to use the high-low method when cost inflation is included. You need to deflate (reduce) all the costs to a base year before the high-low method can be applied.

| | Year 1 | Year 2 | Year 3 | Year 4 |
|---|---|---|---|---|
| Sales/production (units) | 85,000 | 93,400 | 95,800 | 94,300 |
| Total costs | $337,500 | $365,670 | $379,080 | $382,395 |
| Cost inflation index | 100 | 102 | 104 | 106 |

*Required*

Establish a linear equation for total costs per annum (at Year 1 prices) using the high-low method.

Solution

Cost data has to be reduced by dividing by the inflation index before the high-low method can be applied.

| | Year 1 | Year 2 | Year 3 | Year 4 |
|---|---|---|---|---|
| Cost/inflation index | $337,500 | $365,670/1.02 | $379,080/1.04 | $382,395/1.06 |
| | = $337,500 | = $358,500 | = $364,500 | = $360,750 |

After adjusting for inflation, the year of highest output (Year 3) is now also the year of the highest cost. Using the high-low method for Year 1 and Year 3:

$$\begin{cases} 337,500 = 85,000b + a \\ 364,500 = 95,800b + a \end{cases}$$

$$\begin{cases} b = 2.5 \\ a = 125,000 \end{cases}$$

Total cost (y) = $2.50x + $125,000 (where x is the number of units)

Total cost (y) = $2.50x + $125,000 (where x is the number of units)

# 4.The components of time series

A **time series**（时间序列）is a series of figures or values recorded over time.

There are four components of a time series:

- ✧ **Trend**（趋势）**:** is the underlying long-term movement over time in the values of the data recorded.
- ✧ **Seasonal variations**（季节差异）**:** are short-term fluctuations in recorded values, due to different circumstances which affect results at different times of the year, on different days of the week, at different times of day, or whatever.
- ✧ **Cyclical variations**（周期差异）**:** are fluctuations which take place over a longer time period than seasonal variations.
- ✧ **Random variations**（随机差异）

Forecasting model

Additive model

Forecast= trend + variation

Multiplicative model

Forecast=trend * variation factor

Exercise

1.The following question is taken from the June 2013 exam paper.

An additive time series has the following trend and seasonal variations:

Trend Y=4,000+6X where Y=sales in units

X is the number of quarters, with the first quarter of 2014 being 1,the second quarter of 2014 being 2 etc.

Seasonal variation

| Quarter | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Quarterly variation(units) | -4 | -2 | +1 | +5 |

What is the forecast sales volume for the fourth quarter of 2015?

A. 4,029

B. 4,043

C. 4,048

D. 4,053

### 4.1 Finding the trend

There are a number of ways to distinguish trend from seasonal variations. One such

method is called **moving average.** This methods attempts to **remove seasonal (or cyclical ) variations from a time series by a process of averaging so as to leave a set of figures representing the trend.**

**Example6: Moving averages**

| *Year* | *Sales* units |
|---|---|
| 20X0 | 390 |
| 20X1 | 380 |
| 20X2 | 460 |
| 20X3 | 450 |
| 20X4 | 470 |
| 20X5 | 440 |
| 20X6 | 500 |

***Required***

Take a moving average of the annual sales over a period of three years.

**Solution**

| *Year* | *Sales* | *Moving total of 3 years' sales* | *Moving average of 3 years' sales* |
|---|---|---|---|
| 20X0 | 390 | | |
| 20X1 | 380 | 1,230 | 410 |
| 20X2 | 460 | 1,290 | 430 |
| 20X3 | 450 | 1,380 | 460 |
| 20X4 | 470 | 1,360 | 453 |
| 20X5 | 440 | 1,410 | 470 |
| 20X6 | 500 | | |

There is an **upward** trend in sales, which is more noticeable from the series of moving averages than from the original series of actual sales each year.

**4.2 Finding the seasonal variations**

**Additive model**

***Forecast = trend + variation***

Example7:

| *Year* | *Quarter* | *Actual* | *Trend* | *Seasonal variation* |
|---|---|---|---|---|
| 20X5 | 1 | 600 | | |

| | | | | |
|---|---|---|---|---|
| | 2 | 840 | | |
| | 3 | 420 | 650.00 | –230.00 |
| | 4 | 720 | 657.50 | 62.50 |
| 20X6 | 1 | 640 | 660.00 | –20.00 |
| | 2 | 860 | 662.50 | 197.50 |
| | 3 | 420 | 668.75 | –248.75 |
| | 4 | 740 | 677.50 | 62.50 |
| 20X7 | 1 | 670 | 683.75 | –13.75 |
| | 2 | 900 | 687.50 | 212.50 |
| | 3 | 430 | | |
| | 4 | 760 | | |

The variation between the actual result for any one particular quarter and the trend line is not the same from year to year, but an **average of these variations can be taken**.

| | *Q1* | *Q2* | *Q3* | *Q4* |
|---|---|---|---|---|
| 20X5 | | | -230.00 | 62.50 |
| 20X6 | -20.00 | 197.50 | -248.75 | 62.50 |
| 20X7 | 13.75 | 212.50 | | |
| Total | -33.75 | 410.00 | -478.75 | 125.00 |
| Average (÷ 2) | -16.875 | 205.00 | -239.375 | 62.50 |

Our estimate of the 'seasonal' or quarterly variation is almost complete, but there is one more important step to take. Variations around the basic trend line should cancel each other out, and add up to zero. At the moment, they do not. We therefore **spread the total of the variations** (11.25) **across the four quarters** (11.25 ÷ 4) **so that the final total of the variations sum to zero**.

| | Q1 | Q2 | Q3 | Q4 | Total |
|---|---|---|---|---|---|
| Estimated quarterly variations | –16.8750 | 205.0000 | 239.375 | 62.5000 | 11.250 |
| Adjustment to reduce variations to 0 | -2.8125 | -2.8125 | -2.8125 | -2.8125 | -11.250 |
| Final estimates of quarterly variations | -19.6875 | 202.1875 | -242.1875 | 59.6875 | 0 |
| These might be rounded as follows | -20 | 202 | -242 | 60 | 0 |

An additive model has the important **drawback** that when there is a **steeply rising or a steeply declining trend, the moving average trend will either get ahead or fall behind the real trend.**

**Multiplicative model**

***Forecast = trend × variation factor***

Example8:

| Year | Quarter | *Actual (Y)* | *Trend (T)* | *Seasonal percentage (Y/T)* |
|---|---|---|---|---|
| 20X5 | 1 | 600 | | |
| | 2 | 840 | | |
| | 3 | 420 | 650.00 | 0.646 |
| | 4 | 720 | 657.50 | 1.095 |
| 20X6 | 1 | 640 | 660.00 | 0.970 |
| | 2 | 860 | 662.50 | 1.298 |
| | 3 | 420 | | |
| | 4 | 740 | | |

Suppose that seasonal variations for the next four quarters are 0.628, 1.092, 0.980 and 1.309 respectively. The summary of the seasonal variations expressed in proportional terms is therefore as follows.

| *Year* | *Q1* % | *Q2* % | *Q3* % | *Q4* % |
|---|---|---|---|---|
| 20X5 | | | 0.646 | 1.095 |
| 20X6 | 0.970 | 1.298 | 0.628 | 1.092 |
| 20X7 | 0.980 | 1.309 | | |
| Total | 1.950 | 2.607 | 1.274 | 2.187 |
| Average | 0.975 | 1.3035 | 0.637 | 1.0935 |

**Instead of summing to zero**, as **with the additive approach**, the **averages should sum (in this case) to 4.0, 1.0 for each of the four quarters**.
They actually sum to 4.009 so 0.00225 has to be deducted from each one.

| | *Q1* | *Q2* | *Q3* | *Q4* |
|---|---|---|---|---|
| Average | 0.97500 | 1.30350 | 0.63700 | 1.09350 |
| Adjustment | –0.00225 | –0.00225 | –0.00225 | –0.00225 |

| | | | | |
|---|---|---|---|---|
| Final estimate | 0.97275 | 1.30125 | 0.63475 | 1.09125 |
| Rounded | 0.97 | 1.30 | 0.64 | 1.09 |

Note that the **proportional model is better than the additive model when the trend is increasing or decreasing over time**.

# 5. Learning curves

### 5.1 The learning rate and learning effect

The **learning effect** is that, as the workforce learns from experience how to make the new product, there is a big reduction in the time taken to make additional units.

Specifically, **every time that the cumulative output of the product doubles**, the average time to make all the units produced to date is a proportion of what it was before. This proportion is the learning rate.

The **learning rate** is expressed as a percentage value, such as an 80% learning curve or a 70% learning curve.

### 5.2 The two approaches to learning curve problems

There are two methods that can be used to deal with a learning curve scenario. Be prepared to use either or both in the exam.

· **Method 1**. The tabular approach

· **Method 2**. The algebraic approach

#### 5.2.1 The tabular approach

Example9：

For example, where an 80% learning effect occurs, the cumulative average time required per unit of output is reduced to 80% of the previous cumulative average time when output is doubled.

The first unit of output of a new product requires 100 hours. An 80% learning curve applies. The production times would be as follows.

| Cumulative number of units | Cumulative avg time per | Cumulative total time | Incremental number of units | Incremental total time | Avg time |
|---|---|---|---|---|---|

| unit | (hours) | (hours) | | (hours) | (hours) |
|---|---|---|---|---|---|
| 1 | 100.0 | 100.0 | – | – | - |
| 2* | 80.0 | 160.0 | 1 | 60.0 | 60 |
| 4* | 64.0 | 256.0 | 2 | 96.0 | 48 |
| 8* | 51.2 | 409.6 | 4 | 153.6 | 38.4 |

* Output is being doubled each time.

Example 10: The learning curve

Captain Kitts has designed a new type of sailing boat, for which the cost of the first boat to be produced has been estimated as follows.

| | $ |
|---|---|
| Materials | 5,000 |
| Labour (800 hrs x $5 per hr) | 4,000 |
| Overhead (150% of labour cost) | 6,000 |
| | 15,000 |
| Profit mark-up (20%) | 3,000 |
| Sales price | 18,000 |

It is planned to sell all the yachts at full cost plus 20%. An 80% learning curve is expected to apply to the production work. The management accountant has been asked to provide cost information so that decisions can be made on what price to charge.

(a) What is the separate cost of a second yacht?

(b) What would be the cost per unit for a third and a fourth yacht, if they are ordered separately later on?

(c) If they were all ordered now, could Captain Kitts quote a single unit price for four yachts and eight yachts?

Solution:

| Cumulative number of units | Cumulative avg time per unit | Cumulative total time | Incremental number of units | Incremental total time | Incremental average time |
|---|---|---|---|---|---|
| | (hours) | (hours) | | (hours) | (hours) |
| 1 | 800.0 | 800.0 | – | – | – |
| 2* | 640.0 | 1,280.0 ** | 1 | 480.0 | 480.0 |
| 4* | 512.0 | 2,048.0 | 2 | 768.0 | 384.0 |
| 8* | 409.6 | 3,276.8 | 4 | 1,228.8 | 307.2 |

* Output is being doubled each time.

** 640 × 2 = 1,280, 512 × 4 = 2,048

(a) Separate cost of a second yacht

| | $ |
|---|---|
| Materials | 5,000 |
| Labour (480 hrs x $5) | 2,400 |
| Overhead (150% of labour cost) | 3,600 |
| Total cost | 11,000 |

(b) Cost of the third and fourth yachts

| | $ |
|---|---|
| Materials cost for two yachts | 10,000 |
| Labour (768 hours x $5) | 3,840 |
| Overhead (150% of labour cost) | 5,760 |
| Total cost | 19,600 |
| Cost per yacht (x2) | 9,800 |

(c) A price for the first four yachts together and for the first eight yachts together

| | | *First four yachts* | | *First eight yachts* |
|---|---|---|---|---|
| | | $ | | $ |
| Materials | | 20,000 | | 40,000 |
| Labour | (2,048 hrs) | 10,240 | (3,276.8 hrs) | 16,384 |
| Overhead (150% of labour cost) | | 15,360 | | 24,576 |
| Total cost | | 45,600 | | 80,960 |
| Profit (20%) | | 9,120 | | 16,192 |
| Total sales price | | 54,720 | | 97,152 |
| Price per yacht | (*4) | 13,680 | (*8) | 12,144 |

This assumes that Captain Kitts is happy to pass on the efficiency savings to the customer in the form of a lower price

**5.2.2 Method 2 – The algebraic approach**

The formula for the learning curve is **$Y = ax^b$ (given in the exam)**

Where **Y** is the cumulative average time per unit to produce x units

**x** is the cumulative number of units

**a** is the time taken for the first unit of output

**b** is the index of learning (log LR/log 2)

**LR** is the learning rate as a decimal

Example 11: Using the formula

Suppose that an 80% learning curve applies to production of a new product item ABC. To date (the end of June) 30 units of ABC have been produced. Budgeted production in July is five units. The time to make the very first unit of ABC in January was 120 hours. The labour cost is $10 per hour.

Required

(a) Calculate the time required to make the 31st unit.

(b) Calculate the budgeted total labour cost for July.

Solution

To solve this problem, we need to calculate three things.

(a) The cumulative total labour cost so far to produce 30 units of ABC

(b) The cumulative total labour cost to produce 31 units of ABC

(c) The cumulative total labour cost to produce 35 units of ABC; that is, adding on the extra 5 units for production in July

(d) The time taken to produce the 31st unit is the difference between (b) and (a). The cost of production of 5 units of ABC in July, as the difference between (c) and (a).

Time to produce the first 30 units

$Y = ax^b$

b = log 0.8/log 2 = –0.09691/0.30103 = –0.3219281

$Y = 120 \times (1/30^{0.3219281}) = 120 \times 0.3345594 = 40.147$ hours

Total time for first 30 units = 30 × 40.147 hours = 1,204.41 hours

Time to produce the first 31 units

$Y = 120 \times (1/31^{0.3219281}) = 120 \times 0.3310463 = 39.726$ hours

Total time for first 31 units = 31 × 39.726 hours = 1,231.51 hours

Time to produce the 31st unit = (1,231.51 – 1,204.41) = 27.1 hours

Time to produce the first 35 units

Y = 120 × (1/350.3219281) = 120 × 0.3183619 = 38.203 hours

Total time for first 35 units = 35 × 38.203 hours = 1,337.11 hours

Budgeted labour cost in July = (1,337.11 – 1,204.41) hours × $10 per hour = $1,327

**5.3 Steady state**

Eventually, the time per unit will reach a steady state where **no further improvement** can be made. When a steady state is reached, a standard time and standard labour cost for the product can be established.

Example12: Learning curves and standard costs

A company needs to calculate a new standard cost for one of its products. When the product was first manufactured, the standard variable cost of the first unit was as follows.

*Cost per unit*

| | | $ |
|---|---|---|
| Direct material | 10 kg @ $4 per kg | 40 |
| Direct labour | 10 hours @ $9 per hour | 90 |
| Variable overhead | 10 hours @ $1 per hour | 10 |
| Total | | 140 |

During the following year, a 90% learning curve was observed in making the product. The cumulative production at the end of the third quarter was 50 units. After producing 50 units, the learning effect ended, and all subsequent units took the same time to make.

*Required*

What is the standard cost per unit for the fourth quarter assuming the learning curve had reached a **steady state** i.e. peak efficiency was reached after the 50th unit was produced?

Solution

$Y = ax^b$ where b = log 0.9/log 2.

b = –0.0457575/0.30103 = –0.1520031

So $Y = ax^{-0.1520031}$

For 49 cumulative units $Y = 10 \times (49^{-0.1520031}) = 10 \times 0.55346 = 5.5346$ hours.

Total time for first 49 units = 49 × 5.5346 hours = 271.2 hours.

For 50 cumulative units $Y = 10 \times (50^{-0.1520031}) = 10 \times 0.55176 = 5.5176$ hours.

Total time for first 50 units = 50 × 5.5176 hours = 275.88 hours.

Time for 50th unit = (275.88 – 271.2) = 4.68 hours

This is the standard time for the product when the steady state has been reached.

**Standard cost**

| | | Cost per unit |
|---|---|---|
| | | $ |
| Direct material | 10 kg @ $4 per kg | 40.00 |
| Direct labour | 4.68 hours @ $9 per hour | 42.12 |
| Variable overhead | 4.68 hours @ $1 per hour | 4.68 |
| Total | | 86.80 |

In practice, the standard time may be rounded to a more convenient number, such as 4.5 hours or 5.0 hours.

**5.4 The practical application of learning curve theory**

- Standard setting
- Budgeting
- Pricing decisions
- Work scheduling

**5.5 Limitations of learning curve theory**

- The learning curve phenomenon is not always present.
- We may not be able to calculate a rate.
- We may not know when production has reached a steady state.
- The rate may not necessarily be constant.
- It assumes stable conditions at work which will enable learning to take place. This is not always practicable; for example, because of labour turnover.
- It must also assume a certain degree of motivation among employees.
- Breaks in production may result in losing the learning effect.

# Chapter 12 Standard costing

企业的差异分析是建立在合理标准的基础上的，那么什么是标准成本以及标准成本法呢?企业又有哪些不同的标准呢？

Learning outcomes

- Explain the use of standard costs.
- Outline the methods used to derive standard costs.

## 1. The use of standard cost

A **standard cost** is an estimated unit cost.

**Standard costing** involves the establishment of predetermined estimates of the costs of products or service, the collection of actual costs and comparison of the actual costs with the predetermined estimates.

1.1 The uses of standard costing are as follows

- ✧ **Decision making**-prediction of costs and times.
- ✧ **Budgeting** – an accurate standard will increase the accuracy of budget.
- ✧ **Control** – the standard costs and revenues can be compared with the actual costs.
- ✧ **Performance evaluation** –it is a motivated way to assess cost center managers' performance.
- ✧ **Inventory valuation** – this is usually less time consuming than alternative valuation methods such as FIFO.

Standard costing is most suited to mass production and repetitive assembly work,where large quantities of a standard product are manufactured.

Exercise:

1.The following statements have been made about the application of standard costing system.

(1) Standard costing systems have been made about the application of standard costing systems.

(2) Standard costing systems are less commonly used in an industry that operates in a rapidly changing environment.

Which of the above statements is/are true?

A. 1 only
B. 2 only
C. Neither 1 nor 2
D. Both 1 and 2

2.Which TWO of the following points state why it is generally regarded to be more difficult to set standards for service function costs than for manufacturing costs?

A. There is often no measurable output from service functions
B. The activities of many service functions are of non-standard nature
C. The costs of many service functions are predominantly variable
D. Tasks in many service industry are usually quick and simple

## 2. Types of standard

There are four **types of standard: ideal, attainable, current** and **basic**. These can have an impact on employee motivation.

An **ideal standard** is a standard which can be attained under **perfect operating conditions**: no wastage, no inefficiencies, no idle time, no breakdowns.

An **attainable standard** is a standard which **can be attained** if production is carried out efficiently, machines are properly operated and/or materials are properly used. Some allowance is made for wastage and inefficiencies.

A **current standard** is a standard based on **current working conditions** (current wastage, current inefficiencies).

A **basic standard** is a long-term standard which **remains unchanged** over the years and is used to show trends.

Exercise

3.The following statements have been made about different types of standards in standard costing systems:

(1)Basic standards provide the best basis for budgeting because they represent an achievable level of productivity.

(2)Ideal standards are short-term target and useful for day-to-day control purposes.

Which of the above statements is/are true?

A. 1 only

B. 2 only

C. Neither 1 nor 2

D. Both 1 and 2

4.Which two of the following statements correctly describe an attainable standard?

A. This standard is the least useful and most rarely used type of standard.

B. This standard makes allowances for expected wastage and inefficiencies.

C. This standard is based on perfect operating conditions.

D. This standard should give employees a realistic,but challenging target of efficiency.

# Chapter 13 Variance analysis

差异分析是控制的重要环节，我们在管理会计的课程里已经掌握了基础的差异分析。在本章，我们需要对基本差异进一步进行分解，分解为组合和产出差异。那为什么要进行分解，怎么分解呢？本章我们会解决这些问题。

**Learning outcomes**

- Calculate, identify the cause of, and explain material mix and yield variances.
- Explain the wider issues involved in changing material mix.
- Identify and explain the relationship of the material usage variance with the material mix and yield variances.
- Calculate, identify the cause of, and explain sales mix and quantity variances.
- Identify and explain the relationship of the sales volume variances with the sales mix and quantity variances.

## 1. Basic variances

A **variance** is the difference between an actual result and an expected result. In standard costing, cost variances are the difference between the standard costs and actual costs of units produced.

**Variance analysis** is the process by which the total difference between standard and actual results is analyzed.

**Favourable variance** -- Actual results are better than expected results
**Adverse variance** -- Actual results are worse than expected results

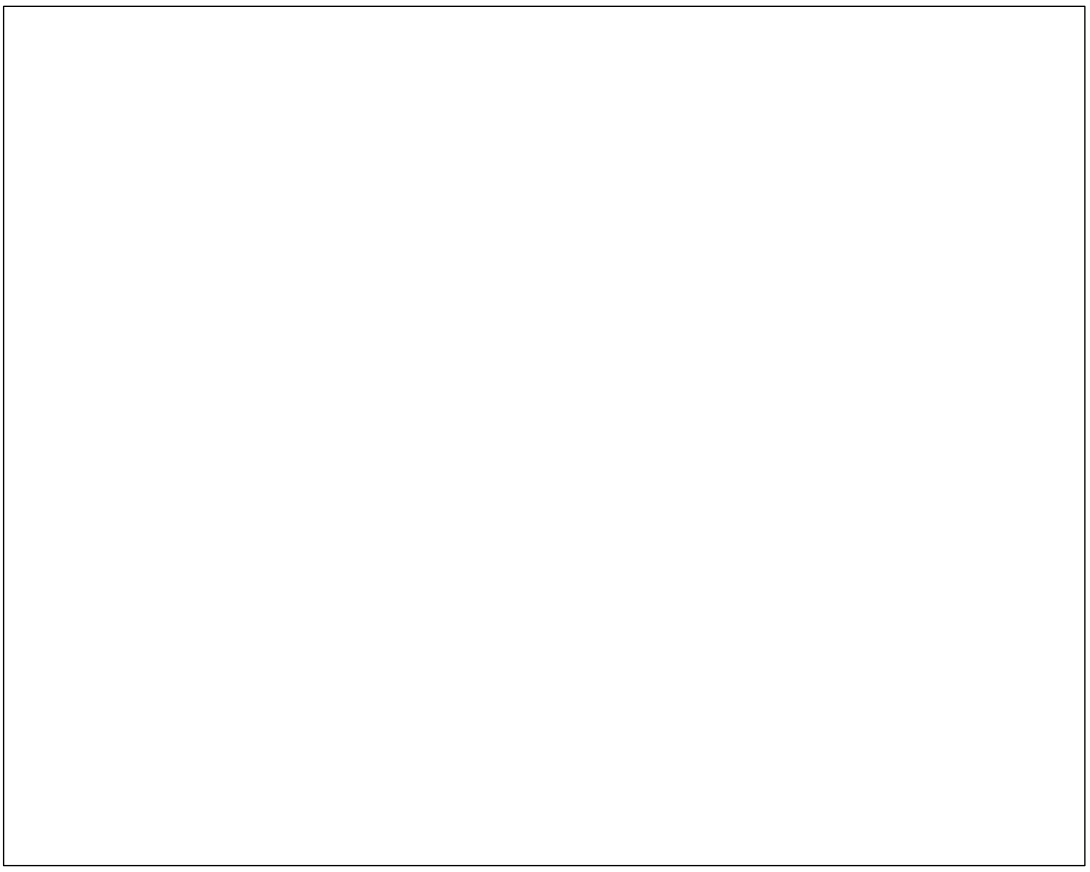
Basic variances can be calculated for sales, material, labor, variable overheads and fixed overheads.

| | | |
|---|---|---|
| Cost variance | Variable cost variance | Material variance |
| | | Labour variance |
| | | Variable OH variance |
| | Fixed cost variance | Fixed OH variance |
| Sales variance | | |

Fixed budget profit=budget units*budget unit profit

Flexible budget =actual units*budget unit profit

Actual profit=actual units*actual unit profit



Direct material cost variances

Total material cost = purchase kg *purchase price

Direct material price variance

=(actual price-standard price)*actual purchase activities

$/kg kgs

Direct material usage variance

=(actual production units*standard rate-actual usage )*standard rate

kgs $/kg

Total material variance

=actual production units*standard rate-actual material cost

$/unit

**labor cost variance**

Total labor cost = labor hours*labor rate

Labor rate variance

=(actual rate-standard rate)*actual labor hours
$/hr hrs
Labor efficiency variance
=(actual production units* standard rate-actual labor hours)*standard rate
hrs $/hr
Total labor variance
=actual production units*standard rate-actual labor cost
$/unit

**Variable OH variance**

Total variable OH = labor hours*OAR($/hr)
Variable OH expenditure variance
=(actual rate-standard rate)*actual labor hours
$/hr
Variable OH efficiency variance
=(actual production units* standard rate-actual hours)*standard rate
hrs $/hr
Total variable OH variance
=actual production units*standard rate-actual variable OH
$/unit

**Fixed OH variance**

Total fixed OH = production units*OAR($/unit)
= labor hours*OAR($/hr)
Fixed OH expenditure variance
=actual fixed OH-budget fixed OH
Fixed OH volume variance
=(actual production units-budget production units)*standard rate
units $/unit
Total fixed OH variance
=actual production units*standard rate-actual fixed OH
$/unit
Fixed OH efficiency variance
=(actual production units*standard rate-actual hours)*standard rate
hrs $/hr
Fixed OH capacity variance
=(actual labor hours-budget labor hours)*standard rate
hrs $/hr

**Sales variance**

Total sale revenue = sales units*sales price

Sales price variance

=(actual price-budget price)*actual sales units

$/unit units

Sales volume variance

=(actual sales units-budget sales units)*budget rate

units $/unit

Marginal costing:

Sales volume contribution variance

=(actual sales units-budget sales units)*budget unit contribution

Absorption costing:

Sales volume profit variance

= （actual sales units-budget sales units）*budget unit profit

Example 1：

Barmby Ltd uses a standard costing system. The standard cost card for one product is shown below:

| | | £ |
|---|---|---|
| Direct Material | 3 kg at £5 per kg | 15 |
| Direct Labour | 2 hours at £7 per hour | 14 |
| Variable Overhead | 2 hours at £3 per hour | 6 |
| | | |
| Total Variable Cost | | 35 |
| | | |
| Fixed Overhead | 2 hours at £6 per hour | 12 |
| | | |
| Total Product Cost | | 47 |
| | | |
| Standard Selling Price | | 70 |
| | | |
| Standard Profit Margin | | 23 |

The budgeted output and sales was 1,000 units

Actual output for the period was 1,400 units and actual sales for the period was 1,200 units

Actual cost and revenue were as follows:

| | | £ |
|---|---|---|
| Direct Material | 4,500 kg, costing | 21,700 |
| Direct Labour | 2,850 hours, costing | 20,000 |
| Variable Overhead | | 6,800 |
| | | |
| Fixed Overhead | | 13,000 |
| | | |
| Sales Revenue | 1,200 units at £65 per unit | 78,000 |

Required:

Calculate all possible variances.

Solution:

Direct material price variance

=(actual price-standard price)*actual purchase activities

= 21,700 - 4,500*5

= 800(F)

Direct material usage variance

=(actual production units*standard rate-actual usage )*standard rate

=1,400*3 - 4,500)*5

= 1,500 (A)

Labor rate variance

=(actual rate-standard rate)*actual labor hours

= 20,000 - 2,850*7

= 50(A)

Labor efficiency variance

=(actual production units* standard rate-actual labor hours)*standard rate

=(1,400*2 - 2,850)*7

=350(A)

Variable OH expenditure variance

=(actual rate-standard rate)*actual labor hours

=6,800 - 2,850*3

=1,750(F)

Variable OH efficiency variance

=(actual production units* standard rate-actual hours)*standard rate

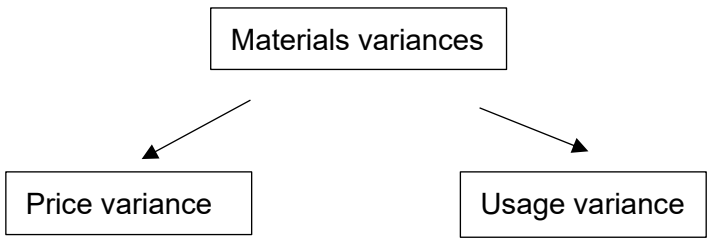
=( 1,400*2 -2,850)*3
= 150(A)

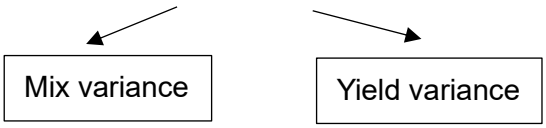
Fixed OH expenditure variance
=actual fixed OH-budget fixed OH
= 13,000 - 1,000*12
=1,000(A)
Fixed OH volume variance
=(actual production units-budget production units)*standard rate
=(1,000 - 1,400)*12
=4,800(F)

Sales price variance
=(actual price-budget price)*actual sales units
=7,800- 1,200*70
=6,000(A)
Sales volume contribution variance
=(actual sales units-budget sales units)*budget unit contribution
= (1,200-1,000)*35
=7,000(F)
Sales volume profit variance
=(actual sales units-budget sales units)*budget unit profit
=(1,200 - 1,000)*23
=4,600(F)

## 2. Material mix and yield variances

The **materials usage variance** can be subdivided into a materials **mix variance** and a materials **yield variance** when more than one material is used in the product and inputs can be substituted for one another(**interchangeable**).






**Mix variance**： A mix variance occurs when the **materials are not mixed or blended in standard proportions**, and is a measure of whether the **actual mix is cheaper or more expensive than the standard mix.**
The mix variance represents the financial impact of using a different proportion of raw material.

**Yield variance**: A yield variance arises because there is a difference between **what the input should have been (considering the output achieved) and the actual input.**
The yield variance represents the financial impact of the input yielding a different level of output to the standard.

Mix variance

| | Actual usage in Std Mix | Actual usage in Actual Mix | Variance | Std cost | Variance |
|---|---|---|---|---|---|
| | kg | kg | kg | $ per kg | $ |
| Material A | X | X | X | X | X |
| Material B | X | X | X | X | X |
| | X | X | | | X |

Yield variance

| | Standard usage in standard mix | Actual usage in standard Mix | Variance | Std cost | Variance |
|---|---|---|---|---|---|
| | kg | kg | kg | $ per kg | $ |
| Material A | X | X | X | X | X |
| Material B | X | X | X | X | X |
| | X | X | | | X |

Alternative methods for yield variance

| | *kgs* |
|---|---|
| Total material should input | X |
| Total material did input | (X) |
| x standard material price per kg | $ |
| Materials yield variances | $X |

Method 2

| | Units |
|---|---|
| Products of material should produce | X |
| They did produce | ( X) |
| *Standard material cost per unit | $ |
| Yield variance in $ | $X |

Example 2: Materials usage, mix and yield variances

A company manufactures a chemical, Dynamite, using two compounds Flash and Bang. The standard materials usage and cost of one unit of Dynamite are as follows.

| | | $ |
|---|---|---|
| Flash | 5 kg at $2 per kg | 10 |
| Bang | 10 kg at $3 per kg | 30 |
| | | 40 |

In a particular period, 80 units of Dynamite were produced from 600 kg of Flash and 750 kg of Bang.

**Required**

Calculate the materials usage, mix and yield variances.

**Solution**

**(a) Usage variance**

If we do not calculate a mix and yield variance, we would calculate a usage variance separately for each material.

| | Std usage for actual output of 80 units | Actual usage | Variance | Standard cost per kg | Variance |
|---|---|---|---|---|---|
| | kg | kg | kg | $ | $ |
| Flash | 400 | 600 | 200 (A) | 2 | 400 (A) |
| Bang | 800 | 750 | 50 (F) | 3 | 150 (F) |
| | 1,200 | 1,350 | | | 250 (A) |

The total usage variance of $250 (A) can be analyzed into a mix variance and a yield variance and these may be reported instead of the usage variance.

(b) Mix variance

To calculate the mix variance, it is first necessary to decide how the total quantity of materials used (600 kg + 750 kg) should have been divided between Flash and Bang. In other words, we need to calculate the standard mix of the actual quantity of materials used.

| | Actual usage | Actual usage in standard mix (5:10) | Mix variance |
|---|---|---|---|
| | kg | kg | kg |
| Flash | 600 | 450 | 150 (A) |
| Bang | 750 | 900 | 150 (F) |
| | 1,350 | 1,350 | 0 |

The mix variance in total quantities is always 0.

Mix variances

| | Actual Qty Actual Mix | Actual Qty Std Mix | Difference | Std price | Variance $ |
|---|---|---|---|---|---|
| | kg | kg | kg | $ per kg | $ |
| Flash | 600 | 450 | 150 (A) | 2 | 300 (A) |
| Bang | 750 | 900 | 150 (F) | 3 | 450 (F) |
| | 1,350 | 1,350 | 0 | | 150 (F) |

(c) Yield variance:

The yield variance can be calculated in total or for each individual material input.

*Method 1*

| | Standard Qty Std Mix | Actual Qty Std Mix | Variance | Std price | Variance $ |
|---|---|---|---|---|---|
| | kg | kg | kg | $ per kg | $ |
| Flash | 400 | 450 | 50 (A) | 2 | 100 (A) |
| Bang | 800 | 900 | 100 (A) | 3 | 300 (A) |
| | 1,200 | 1,350 | 150 | | 400 (A) |

Method 2

The weighted average cost per kilogram of materials = $40/15 kg = $2.67 per kg.

| | kg |
|---|---|
| 80 units of product should use in total (x15 kg) | 1,200 |
| They did use (600 + 750) | 1,350 |
| Yield variance in kg | 150 (A) |
| Weighted average price per kg | $2.67 |

| | |
|---|---|
| Yield variance in $ | $400 (A) |

Method 3

| | Units |
|---|---|
| 1,350 kg of material should produce (x15) | 90 |
| They did produce | 80 |
| Yield variance in units of output | 10 (A) |
| Standard material cost per unit | $40 |
| Yield variance in $ | $400 (A) |

**Exercise 1:**

The mix variance $150 (F) plus the yield variance $400 (A) add up to the usage variance $250 (A).

The Organic Bread Company (OBC) makes a range of breads for sale direct to the public. The production process begins with workers weighing out ingredients on electronic scales and then placing them in a machine for mixing. A worker then manually removes the mix from the machine and shapes it into loaves by hand, after which the bread is then placed into the oven for baking.

All baked loaves are then inspected by OBC's quality inspector before they are packaged up and made ready for sale. Any loaves which fail the inspection are donated to charity.

The standard cost card for OBC's Mixed Bloomer, one of its most popular loaves is as follows:

| | | |
|---|---|---|
| White flour | 450 | grams at $1.8 per kg |
| Wholegrain flour | 150 | grams at $2.20 per kg |
| Yeast | 10 | grams at $20 per kg |
| | 610 | grams |

Budgeted production of Mixed Bloomers was 1,000 units for the quarter, although actual production was only 950 units. The total actual quantities used and their actual costs were:

| | Kg |
|---|---|
| White flour | 408.5 |
| Wholegrain flour | 152.0 |

| | |
|---|---|
| Yeast | 10.0 |
| Total | 570.5 |

Question

**1. What was the material mix variance for the period?**

A. favourable variance of $6.02
B. An adverse variance of $6.02
C. A favourable variance of $16.51
D. An adverse variance of $16.51

**2. What output would be expected, given that 570.5 kg of mix was used?**

A. 425 loaves
B. 935 loaves
C. 950 loaves
D. 1,000 loaves

**3. Which of the following might cause an adverse yield variance?**

1. The mix may not be removed completely out of the machine, leaving some mix behind
2. Since the loaves are made by hand, they may be made slightly too large, meaning that fewer loaves are baked
3. Errors or changes in the mix may cause some loaves to be sub-standard and therefore rejected by the quality inspector
4. The loaves might be baked at the wrong temperature and therefore be rejected by the quality inspector

A. 1, 2 and 4 only
B. 1 and 4 only
C. 2 and 3 only
D. 1, 2, 3 and 4

**4.** The production manager's annual appraisal is linked to the material mix, yield and usage variances. In order to get a better assessment, the manager is planning to vary the product mix by using a higher portion of white flour, and a lower portion of wholemeal flour, as this would lead to a favourable material mix variance.

**Which variances other than the material mix variance may be affected by the production manager's action?**

1. Yield variance

2. Sales price variance
3. Material price variance
4. Sale volume variance

A. 1 and 4 only
B. 2 and 3 only
C. 1, 2 and 4
D. 1, 3 and 4

**5.** OBC budgeted to sell 1,000 loaves at a budgeted selling price of $2 per unit. Actual sales volume in the quarter was 950 units and the actual sales price achieved was $1.80 per loaf. This was because a competitor launched a similar loaf at the same time. OBC had been unaware that this was going to happen when it prepared its budget and, had it known this, it would have revised its expected selling price to $1.70 per unit, which was the price of the competitor's product.

**What is the sales price planning variance?**

A. $285 Adverse
B. $285 Favourable
C. $95 Favourable
D. $95 Adverse

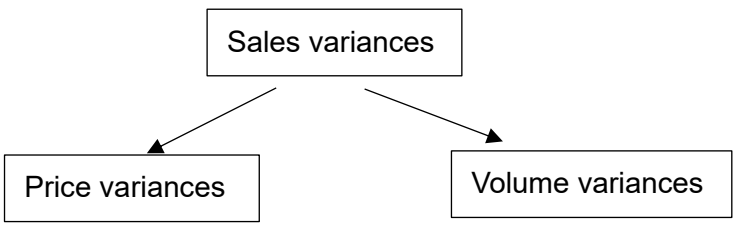
### 2.1 Interrelationship between mix and yield variance

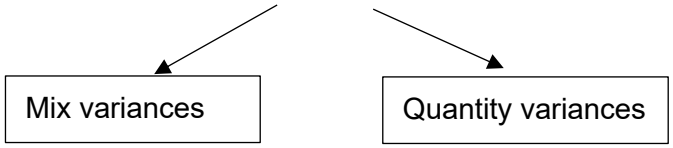
A **favourable mix variance** occurs when the **actual** mix of materials is **cheaper** than the standard mix.

As a consequence of using a cheaper mix of materials, it is possible that the output/yield will be less than the standard output. In other words, a **favourable mix variance may result in an adverse yield variance.**

# 3. Sales mix and quantity variances

The **sales volume variance** can be analyzed further into a sales mix variance and a sales quantity variance.






**The sales mix variance** occurs when the proportions of the various products sold are different from those in the budget

**The sales quantity variance** shows the total difference in contribution/profit because of a change in total sales volume from the budgeted volume of sales

Mix variance

| | Actual Qty Std Mix units | Actual Qty Actual Mix units | Sales mix variance units | Std margin $/unit | Sales mix variance $ |
|---|---|---|---|---|---|
| Product A | X | X | X | X | X |
| Product B | X | X | X | X | X |
| | X | X | X | | X |

Quantity variance

*Method 1*

| | Std Qty Std Mix (units) | Actual Qty Std Mix (units) | Sales quantity | Std margin $/unit | Variance $ |
|---|---|---|---|---|---|
| Product A | X | X | X | X | X |
| Product B | X | X | X | X | X |
| | X | X | X | | X |

| | Standard Qty Std Mix (units) | Actual Qty Std Mix (units) | Variance units | Std price $/unit | Variance $ |
|---|---|---|---|---|---|
| Product A | X | X | X | X | X |
| Product B | X | X | X | X | X |
| | X | X | X | | X |

*Method 2*

| | Units |
|---|---|
| Budget sales in total | X |

| | |
|---|---|
| Actual sales in total | (X) |
| Sales quantity variance in units | X |
| ×Standard weighted average profit per unit | $ |
| Sales quantity variance in $ | $X |

Example 3: Sales mix and quantity variances

Just Desserts Limited makes and sells two products, Chocolate Crunch and Strawberry Sundae. The budgeted sales and profit are as follows.

| | *Sales* | *Revenue* | *Costs* | *Profit* | *Profit per unit* |
|---|---|---|---|---|---|
| | Units | $ | $ | $ | $ |
| Chocolate Crunch (CC) | 400 | 8,000 | 6,000 | 2,000 | 5 |
| Strawberry Sundae (SS) | 300 | 12,000 | 11,100 | 900 | 3 |
| | | | | 2,900 | |

Actual sales were 280 units of Chocolate Crunch and 630 units of Strawberry Sundae. The company management is able to control the relative sales of each product through the allocation of sales effort, advertising and sales promotion expenses.

***Required***

Calculate the sales volume variance, the sales mix variance and the sales quantity variance

Solution

(a) Sales volume variance

| | *CC* | *SS* |
|---|---|---|
| Budgeted sales | 400 units | 300 units |
| Actual sales | 280 units | 630 units |
| Sales volume variance in units | 120 units (A) | 330 units (F) |
| x standard profit per unit | × $5 | × $3 |
| Sales volume variance in $ | $600 (A) | $990 (F) |

Total sales volume variance $390 (F)

The favourable sales volume variance indicates that profit was better than budget because on balance more units were sold than budgeted. However, the favourable variance may be due to selling a larger proportion of the more profitable product (sales mix variance) or selling more units in total (sales quantity variance).

Now we will see how to analyse this favourable volume variance into its mix and quantity elements.

(b) Sales mix variance

This is calculated in a similar way to the materials mix variance. Start with the total quantity of products sold and calculate what sales of each product would have been if they had been sold in the budgeted proportions.

| | Actual sales actual mix | Actual sales standard mix | Sales mix variance | Standard profit | Sales mix variance |
|---|---|---|---|---|---|
| | Units | Units | Units | $ per unit | $ |
| CC | 280 | 520 | 240 (A) | 5 | 1,200 (A) |
| SS | 630 | 390 | 240 (F) | 3 | 720 (F) |
| | 910 | 910 | 0 | | 480 (A) |

The total sales mix variance is $480 (A).

(c) Sales quantity variance

The standard weighted average profit per unit of sale, taken from the budget, is $2,900/700 = $29/7

| | Units |
|---|---|
| Budgeted sales in total | 700 |
| Actual sales in total | 910 |
| Sales quantity variance in units | 210 (F) |
| Standard weighted average profit per unit | $29/7 |
| Sales quantity variance in $ | $870 (F) |

Sales mix variance $480 (A) + Sales quantity variance $870 (F) = Sales volume variance $390 (F).

# Chapter 14 Planning and operational variances

继上一章，我们把基础差异分解为组合和产出差异。本章我们又会把基础差异差分为计划和运营差异。那为什么分解，又如何分解呢？让我们继续学习。

**Learning outcomes**

- Calculate a revised budget.
- Calculate, identify the cause of and explain planning and operational variances.
- Explain and discuss the manipulation issues involved in revising budgets.

## 1. Planing and operational variance

Occasionally,it may be appropriate to revise a budget or standard cost.when this happens,total variance should be divides into those variances which have arisen because of **inaccurate planning** or **fault standard**(planning variance) and those variance which have been caused by adverse or favourable operational performance,compared with a standard which has been revised in hindsight(operational variance).

## 2.Planning and operational variances for sales: market size and market share variances

(a) A **sales volume planning variance**, or **market size variance**, which is caused by the difference between the sales volume in the original budget and the sales volume in the revised budget

(b)A **sales volume operational variance**, or **market share variance**, which is caused by the difference between actual sales volume and the sales volume in the revised budget.

Sales volume planning variance (market size variance)

| | |
|---|---|
| Original sales volume | X |
| Revised sales volume | (X) |
| Sales volume planning variance in units | X |
| ×standard profit/contribution per unit $ | $/unit |
| Sales volume planning variance | $X |

Sales volume operational variance (market share variance)

| | |
|---|---|
| Revised sales volume | X |
| Actual sales volume | (X) |
| Sales volume operational variance in units | X |
| ×standard profit/contribution per unit $ | $/unit |
| Sales volume operational variance | $X |

Example 1: market size and market share variance

Dimsek budgeted to make and sell 400 units of its product, the Role, in the four-week period no. 8, as follows.

| | $ |
|---|---|
| Budgeted sales (100 units per week) | 40,000 |
| Variable costs (400 units x $60) | (24,000) |
| Contribution | 16,000 |
| Fixed costs | (10,000) |
| Profit | 6,000 |

At the beginning of the second week, production came to a halt because inventories of raw materials ran out, and a new supply was not received until the beginning of week 3. As a consequence, the company lost one week's production and sales. Actual results in period 8 were as follows.

| | $ |
|---|---|
| Sales (320 units) | 32,000 |
| Variable costs (320 units x $60) | (19,200) |
| Contribution | 12,800 |
| Fixed costs | (10,000) |
| Actual profit | 2,800 |

In retrospect, it is decided that the optimum budget, given the loss of production facilities in the third week, would have been to sell only 300 units in the period.

Required

Calculate appropriate planning and operational variances for sales volume.

Solution

The **sales volume planning** variance **compares the revised budget** with the **original budget**. It may be called a market size variance.

| | |
|---|---|
| Revised sales volume, given materials shortage | 300 units |
| Original budgeted sales volume | 400 units |
| Sales volume planning variance in units of sales | 100 units (A) |
| x standard contribution per unit | × $40 |
| Sales volume planning variance in $ | $4,000 (A) |

There is a sales volume variance which is an **operational variance**, as follows.

| | |
|---|---|
| Actual sales volume | 320 units |
| Revised sales volume | 300 units |
| Operational sales volume variance in units | 20 units (F) |
| (possibly due to production efficiency or marketing efficiency) | |
| x standard contribution per unit | × $40 |
| Operational sales volume variance in $ contribution | $800 (F) |

The operational variance for sales volume may be called a market share variance. These planning and operational variances for sales volume can be used as **control information** to reconcile budgeted and actual profit.

| | $ | $ |
|---|---|---|
| *Operating statement, period 8* | | |
| Budgeted profit | | 6,000 |
| Planning variance: sales volume | 4,000 (A) | |
| Operational variance: sales volume | 800 (F) | |
| | | 3,200 (A) |
| Actual profit in period 8 | | 2,800 |

In this example, sales volume variances were **valued at contribution forgone**. This is because it is assumed that a marginal costing system applies.

# 3. Planning and operational variances for sales price

Sales price planning variance

| | |
|---|---|
| Original sales price | $ |
| Revised sales price | ($) |
| | $ |
| ×actual sales units | X |
| Sales price planning variance | $X |

| | |
|---|---|
| Sales price operational variance | |
| Revised sales price | $ |
| Actual sales price | ($) |
| | $ |
| ×actual sales units | X |
| Sales price operational variance | $X |

Example 2:Planning and operational variances for sales price
KSO budgeted to sell 10,000 units of a new product during 20X0. The budgeted sales price was $10 per unit, and the variable cost $3 per unit.

Actual sales in 20X0 were 12,000 units and variable costs of sales were $30,000, but sales revenue was only $5 per unit. With the benefit of hindsight, it is realised that the budgeted sales price of $10 was hopelessly optimistic, and a price of $4.50 per unit would have been much more realistic.

***Required***
Calculate planning and operational variances for sales price.

Solution:
The only variances are selling price variances.
**Planning (selling price) variance**

| | $/units |
|---|---|
| Original budgeted sales price | 10.00 |
| Revised budgeted sales price | 4.50 |
| Sales price planning variance in unit price | 5.50 (A) |
| ×actual sales units | 12,000 |
| | $66,000 (A). |

**Operational (selling price) variance**

The sales price operational variance is calculated in the same way as a 'normal' sales price variance, except that the sales price in the revised budget is used, not the original budget.

| | $/units |
|---|---|
| Revised sales price | 4.5 |
| Actual sales price | 5.0 |
| Sales price operational variance in unit price | 0.5(F) |
| ×actual sales units | 12,000 |
| Operational (selling price) variance | 6,000 (F) |

# 4. Planning and operational variances for materials

Planning and operational variances can be reported for direct materials, when the standard cost is revised for the material price, material usage per unit, or both.

**Material price planning variance**

| | |
|---|---|
| Original standard price | $ |
| Revised standard price | ($) |
| | $ |
| ×actual purchase kg | X |
| | $X |

**Material price operational variance**

| | |
|---|---|
| Revised standard price | $ |
| Actual price | ( $ ) |
| | $ |
| ×actual purchase kg | X |
| | $X |

**Material usage planning variance**

| | |
|---|---|
| Actual production should use @ original standard kg | X |
| Actual production should use @ revised standard kg | (X) |
| | X |
| **×original** standard cost | $ |
| | $X |

**Material usage operational variance**

| | |
|---|---|
| Actual production should use @ revised standard kg | X |
| Actual production did use | (X) |
| | X |
| **×original** standard cost | $ |
| | $X |

Example 3 : Planning price and usage variances

The standard materials cost of a product is 5 kg x $7.50 per kg = $37.50. Actual production of 10,000 units used 54,400 kg at a cost of $410,000.

In retrospect it was realized that the standard materials cost should have been 5.3 kg per unit at a cost of $8 per kg. The standard cost was revised to this amount.

*Required*

Calculate the materials planning and operational variances in as much detail as possible.

Solution

Original standard cost: 5 kg x $7.50 per kg = $37.50 per unit of product

Revised standard cost: 5.3 kg × $8 per kg = $42.40 per unit of product

In this example, both the material price and the material usage per unit have been revised. There are planning variances for both material price and material usage.

Material price planning variance

This is the difference between the original standard price and the revised standard price.and converted into a monetary amount by multiplying the actual quantity of material purchase.

| | $ per kg |
|---|---|
| Original standard price | 7.50 |
| Revised standard price | 8.00 |
| Material price planning variance in unit price | 0.50 (A) |
| ×actual purchase kg | 54,400 |
| | $27,200 （A） |

Material price operational variance

This is calculated using the actual quantity of materials used.

| | $ |
|---|---|
| 54,400 kg of material should cost (revised standard $8) | 435,200 |

| | |
|---|---|
| They did cost | 410,000 |
| Material price operational variance | $25,200 (F) |

Material usage planning variance

This is the difference between the original standard usage and the revised standard usage for the quantity of units produced.and is converted into a total monetary value by applying the original standard price for the material.

| | kg |
|---|---|
| 10,000 units of product x should use: original standard | 50,000 |
| 10,000 units of product x should use: revised standard | 53,000 |
| Material usage planning variance in kg of material | 3,000 (A) |
| x Original standard price per kg of material | $7.50 |
| Material usage planning variance in $ | $22,500 (A) |

The planning variance is adverse because the revised standard is for a higher usage quantity (so higher cost and lower profit).

Material usage operational variance

This variance is calculated by comparing the actual material usage with the standard usage in the revised standard, and is then converted into a monetary value by applying the original standard price for the materials.

| | kg |
|---|---|
| 10,000 units of product X should use (x 5.3 kg) | 53,000 |
| They did use | 54,400 |
| Material usage (operational) variance in kg of material | 1,400 (A) |
| x Original standard price per kg of Material M | $7.50 |
| Material usage (operational) variance in $ | $10,500 (A) |

The variances may be summarized as follows.

| | $ | $ |
|---|---|---|
| 10,000 units of product at original std cost ($37.50) | | 375,000 |
| Actual material cost | | 410,000 |
| Total material cost variance | | 35,000 (A) |
| Material price planning variance | 27,200 (A) | |
| Material usage planning variance | 22,500 (A) | |
| Material price operational variance | 25,200 (F) | |
| Material usage operational variance | 10,500 (A) | |

| | |
|---|---|
| Total of variances | 35,000 (A) |

# 5.Planning and operational variances for labour

Planning and operational variances can be reported for direct labour, when the standard cost is revised for the labour rate per hour, the standard labour time per unit, or both.

Labour rate planning variance

| | |
|---|---|
| | $ |
| Original labour rate | ($) |
| Revised labour rate | $ |
| *actual labour hours worked | X |
| | $X |

Labour rate operational variance

| | |
|---|---|
| | $ |
| Actual number of hours worked @ revised std rate | X |
| They did cost | (X) |
| | X |

Labour efficiency planning variance

| | |
|---|---|
| | hrs |
| Actual production @ original standard work hour | X |
| Actual production @ revised standard work hour | (X) |
| | X |
| *original standard rate $ | $ |
| | $X |

Labour efficiency operational variance

| | |
|---|---|
| | hrs |
| Actual production @ revised standard work hour | X |
| Actual production did work | (X) |
| *original standard rate $ | $ |
| | $X |

Example 4:Planning and operational variances for labour

A company makes a single product. At the beginning of the budget year, the standard labour cost was established as $8 per unit, and each unit should take 0.5 hours to make. However, during the year, the standard labour cost was revised. A new quality control procedure was introduced to the production process, adding 20% to the expected time to complete a unit. In addition, due to severe financial difficulties facing the company, the workforce reluctantly agreed to reduce the rate of pay to $15 per hour.

In the first month after revision of the standard cost, budgeted production was 15,000 units but only 14,000 units were actually produced. These took 8,700 hours of labour time, which cost $130,500.

Required

Calculate the labour planning and operational variances in as much detail as possible.

Solution:

Original standard cost = 0.5 hours × $16 per hour = $8 per unit

Revised standard = 0.6 hours × $15 per hour = $9 per unit

Labour rate planning variance

This is the difference between the original standard rate per hour and the revised standard rate per hour.The variance is converted into a total monetary amount by multiplying the planning variance per hour by the actual number of hours worked.

| | $ per hour |
|---|---|
| Original standard rate | 16 |
| Revised standard rate | 15 |
| | 1 (F) |
| *actual labour hours worked | 8,700 |
| | $8,700(F) |

The planning variance for labour rate is favourable, because the revised hourly rate is lower than in the original standard.

Labour rate operational variance

This is calculated using the actual number of hours worked and paid for.

| | $ |
|---|---|
| 8,700 hours should cost (revised standard $15) | 130,500 |

| | |
|---|---|
| They did cost | 130,500 |
| Labour rate operational variance | 0 |

In this example, the workforce was paid exactly the revised rate of pay per hour.

Labour efficiency planning variance

This is the difference between the original standard time per unit and the revised standard time, for the quantity of units produced.and it is converted into a total monetary value by applying the original standard rate per hour.

| Hours | |
|---|---|
| 14,000 units of product should take: original standard (× 0.5) | 7,000 |
| 14,000 units of product should take: revised standard (× 0.6) | 8,400 |
| Labour efficiency planning variance in hours | 1,400 (A) |
| x **Original standard rate per hour** | $16 |
| Labour efficiency planning variance in $ | $22,400 (A) |

The planning variance is adverse because the revised standard is for a longer time per unit (so higher cost and lower profit).

Labour efficiency operational variance

This variance is calculated by comparing the actual time to make the output units with the standard time in the revised standard. It is then converted into a monetary value by applying the original standard rate per hour.

| | Hours |
|---|---|
| 14,000 units of product should take (× 0.6 hours) | 8,400 |
| They did take | 8,700 |
| Labour efficiency (operational variance in hours) | 300 (A) |
| **Original standard rate per hour** | $16 |
| Labour efficiency (operational variance in $) | $4,800 (A) |

The variances may be summarized as follows.

| | $ | $ |
|---|---|---|
| 14,000 units of product at original standard cost ($8) | | 112,000 |
| Actual material cost | | 130,500 |
| Total material cost variance | | 18,500 (A) |
| Labour rate planning variance | 8,700 (F) | |
| Labour efficiency planning variance | 22,400 (A) | |
| Labour rate operational variance | 0 | |
| Labour efficiency operational variance | 4,800 (A) | |

| | |
|---|---|
| Total of variances | 18,500 (A) |

# 6.The value of planning and operational variances

**Advantages of a system of planning and operational variances:**

- Distinguishes between those variances caused by bad planning or unavoidable factors and those which are the result of operating factors.
- Adverse operating variances provide feedback control on processes which need correcting.
- Planning variances can be used to update standards to current conditions.
- Motivation may improve if managers know they will only be assessed on variances under their control (i.e. operational variances).

**Limitations of planning and operational variances:**

- Extra data requirements (e.g. market size).
- More time consuming.
- Managers may claim that all adverse variances have external causes and all favourable variances have internal causes (i.e. manipulation of revised standards).
- Operational managers may claim that all adverse variances are due to poor standard setting at the planning stage (but take credit for all favourable variances)

Exercise 1：

Marcus manages the production and sales departments for product MN at Grayshott Co. Marcus has been asked to attend a meeting with Grayshott Co's finance director to explain the results for product MN in the last quarter.

Budgeted and actual results for product MN were as follows:

| | *Budget* | *Actual* |
|---|---|---|
| Sales volume (units) | 40,000 | 38,000 |
| | $000 | $000 |
| Revenue ($65 per unit) | 2,600 | 2,394 |
| Material (5.2 kg at $4 per kg) | (832) | (836) |
| Labour (2 hours at $8 per hour) | (640) | (798) |

| | | |
|---|---|---|
| Variable overheads (2 hours at $4 per hour) | (320) | (399) |
| Fixed overheads | (220) | (220) |
| Profit | 588 | 141 |

There was no opening and closing inventory in the last quarter. Grayshott Co operates a marginal costing system.

Marcus is angry about having to attend the meeting as he has no involvement in setting the original budget and he believes that the adverse results are due to the following circumstances which were beyond his control:

1. A decision by Grayshott Co's board to increase wages meant that the actual labour rate per hour was 25% higher than budgeted. This decision was made in response to a request by the production department to enable it to meet a large, one-off customer order in the last quarter.
2. Due to the closure of a key supplier, Grayshott Co agreed to a contract with an alternative supplier to pay 6% more per kg than the budgeted price for material. The actual cost per kg of material was $4.40.
3. Difficult economic conditions meant that market demand for product MN was lower by 10%.

At present Grayshott Co does not operate a system of planning and operational variances and Marcus believes it should do so.

**1. What was the market share variance for product MN for the last quarter?**

$ [ ]

**2. What was the adverse materials price planning variance for product MN for the last quarter?**

**$** [ ]

**3. What was the labour rate operational variance for product MN for the last quarter?**

A.$159,600 Favourable

B.$159,600 Adverse

C.$160,000 Favourable

D.$160,000 Adverse

**4. Which of the following would explain a labour efficiency planning variance?**

1. A change in employment legislation requiring staff to take longer rest periods
2. Customers demanding higher quality products leading to a change in product design

3. The learning effect for labour being estimated incorrectly in the production budget

A.1 and 2 only

B.2 and 3 only

C.3 only

D.1, 2 and 3

**5. Which of the following statements regarding the problems of introducing a system of planning and operational variances is/are true?**

1. Operational managers may argue that variances are due to the original budget being unrealistic
2. Operational managers may seek to blame uncontrollable external factors for the variances

A.1 only

B.2 only

C.Both 1 and 2

D.Neither 1 nor 2