1.4 Performance Indexes

Often it is necessary to present information from several related areas simultaneously. This is done to provide a statistical measure of how performance changes over time. The performance index is a management tool that allows multiple sets of information to be compiled into an overall measure. This section provides examples on different approaches that can be taken to develop a performance index.

Overview

Up until this point you've learned about developing and working with single performance measures. Now it is time to branch out into the world of performance indicators and indexes. For the purpose of this section, a performance indicator (PI) is defined as the result of the comparative analysis of a performance measurement outcome to a corresponding performance goal. These measurements give an indication of performance. However, when you have too many indications to consider, performance indexing becomes a useful performance management tool. The philosophy behind using performance indexes is simple: they condense a great deal of information into one number. We know that when dealing with a small number of indicators, PI-related information is easy to assimilate. But what happens when you're not dealing with just one or two PIs? What happens if you have 10, or 15, or 20 separate but related indicators to review. With some increasing, and others decreasing, while still others remain the same, how do you determine what is happening *overall*? The answer is to use an index.

Consider this: if I handed you a newspaper and asked, "How's the stock market doing?" would you examine the trend associated with each of the 5000+ stocks listed on the financial pages before giving me your answer? Hopefully, not. A quicker, simpler, and more efficient method would be to turn to the financial pages, and look at one of many business *indexes* that appear there, say the Standard and Poors 500 Index (S&P 500). The advantage of the S&P 500 Index is that it gives you a general indication of trends in the stock market at a glance. The downside of the index is that it will not give you specific information on any one particular stock.

So, what exactly is an index? Simply put, an index is a statistical measure of how a variable, or set of variables, changes over time. The purpose of an index is to give a quick, overall picture of performance.

The power of using indexes as management tools clearly resides in their ability to capture the information contained in a large number of variables in one number. For instance, economists can use one number, the Consumer Price Index (CPI), to capture pricing information on several hundred different consumer products. Now, instead of having to track over 400 different prices, they only need to track one number–the CPI. Economists place a lot of trust in this index; annual cost-of-living adjustments and retirement benefits for over *50 million* civil servants are directly linked to fluctuations in the CPI.

How do you create an index? This is not an easy question to answer because there is no one set formula or algorithm for generating indexes. However, there are certain concepts that apply to all indexes, the most important being that all indexes are designed for a particular purpose, and that the design process involves choosing the correct (related) indicators and then combining them in a manner that supports the intended purpose of the index.

Now, simply because there is no patent method for producing an index does not mean that creating one has to be a complicated matter. In fact, it can be as simple as computing the ratio between two numbers.

It is not the intent of this handbook to address each and every method that can be used to develop index numbers, nor will it make you an expert in the statistics behind developing indexes (for those interested in a more in-depth study of indexing methods, a list of references has been included). What it will do, hopefully, is give you an appreciation of the power of using performance indexes as a management tool, and provide you with a few examples of methods that are currently being used throughout the DOE complex and private industry to create performance indexes. These methods range from fairly simple to fairly complicated. They include:

- the DOE Occupational Injury/Illness Cost Index
- the Westinghouse Hanford Company Conduct of Operations Event Index
- the Eastman Kodak Company Safety Performance Index
- the Defense Programs Average of Performance Relatives

Each of these methods will be discussed in detail in the following section.

Examples

Example 1: The DOE Occupational Injury/Illness Cost Index

This index is the simplest of the three methods presented above. Essentially, the cost index is a linear combination of weighted parameters:

$$\text{Index} = (W_1 \times P_1) + (W_2 \times P_2) + \ldots + (W_n \times P_n)$$

where Ws are constant weighting factors, and Ps are individual measurable items. When determining the weighting factors, the following could be taken into account:

- Dollar Cost Analysis
- Probability Risk Assessment

- Cost/Benefit Analysis
- Expert Opinion

A strength of weighted linear combinations is that they can assist in determining how to allocate limited resources. That is, if $W_1 = 3$ and $W_2 = 1$, then, given limited resources, addressing P_1 provides more benefit than addressing P_2 and resources could be applied accordingly. Essentially, this is a "tradeoff" where one unit of improvement in P_1 is worth losing up to 3 units of P_2.

Caution! People will make these tradeoffs! If you mix safety and production indicators together, you may, unwittingly, be sending the signal that degradation in safety performance can be offset by increased production.

The DOE Occupational Injury/Illness Cost Index combines the following indicators:

- Number of fatalities (**D**)
- Number of transfers or terminations due to injury or illness (**T**)
- Number of lost workday cases (**LWC**)
- Number of days away from work (**WDL**)
- Number of restricted workdays (**WDLR**)
- Number of non-fatal cases without days away from work or restricted workdays (**NFC**)

The weighting factors were determined using dollar cost analysis.

- Index = 100[(1,000,000)(**D**) + (500,000)(**T**) + (2,000)(**LWC**) + (1,000)(**WDL**) + (400)(**WDLR**) + (2,000)(**NFC**)]/Total hours worked

Example 2: Westinghouse Hanford Conduct of Operations Event Index

Let's look at another example of an index based on linear combinations: the Conduct of Operations Event Index developed at the Westinghouse Hanford Company. This index is different from the previous example in that it does not utilize weighting factors for the components. Basically, this index measures the number of certain types of occurrence reports per 200,000 hours worked by an organization. This index uses information that can be obtained from the Occurrence Reporting and Processing System (ORPS). The following parameters are combined:

A. Skin and clothing contaminations: Number of Occurrence Reports with nature of Occurrence of 4B (Personnel Contamination).

B. Violations of Procedures: Number of Occurrence Reports with a Root Cause of 3C (Violations of Requirement or Procedure).

C. Procedure Problem: Number of Occurrence Reports with Root Cause of 2A or 2B.

2A - Defective or inadequate procedure

2B - Lack of procedure

D. Training Deficiency: Number of Occurrence Reports with Root Causes 5A through 5E

5A - No training provided

5B - Insufficient practice or hands-on experience

5C - Inadequate content

5D - Insufficient refresher training

5E - Inadequate presentation or materials

E. Management Problem: Number of Occurrence Reports with Root Causes 6A through 6F.

6A - Inadequate administrative control

6B - Work organization/planning deficiency

6C - Inadequate supervision

6D - Improper resource allocation

6E - Policy not adequately defined, disseminated, or enforced

6F - Other management problem

F. Lockout/tagout errors: Number of Occurrence Reports judged to be lockout/tagout related.

G. Work control errors: Number of Occurrence Reports judged to be work control related.

Note that some of the Occurrence Reports could fall into multiple categories and will be counted more than once.

H. Person-hours worked: Each facility determines which employees should be included in the person-hours calculation.

The index calculation is based on the number of occurrences that happened during the time period (as per the above criteria) divided by the opportunities for occurrences to happen (i.e., person-hours worked):

Index Calculation:

$$\textbf{Index} = \frac{(A + B + C + D + E + F + G)}{(H/200{,}000)}$$

The use of person-hours assumes that the larger the operating force of a facility, the more opportunity there is for Conduct of Operations type events. Dividing by person-hours worked is an attempt to express the conduct of operations as a rate identical to the method used for Lost Work Day Case Rate.

Example 3: Eastman Kodak Safety Performance Index

The Eastman Kodak company uses an interesting and effective methodology for creating performance indexes. Basically, the method used by Kodak involves mapping the range of performance for several metrics onto a fixed scale, applying a multiplier to the value extracted from the scale, and adding the results together. An example of how this index is computed follows (this example has been adopted from Kodak' handbook for Safety Performance Indexing and modified slightly for the purposes of this example).

Developing a Performance Matrix

The first step in the Kodak process involves developing a ***performance matrix*** that shows goals and ranges of performance for several metrics. Figure 1.8 is an example of a performance matrix.

At Kodak, developing this matrix is a 10-step process:

Step 1: Select indicators that are related to and that measure progress in the area for which you intend to develop an index. Kodak developed a Safety Performance Index. In this example, we will use the Kodak method to develop a Conduct of Operations Index. Remember to ensure that the performance indicators that are chosen are clearly defined. Once the appropriate performance indicators are chosen, list them down the left column of the matrix (see Figure 1.8).

	Performance Level										Calculations			
Performance Indicator (PI)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Value	Level	Wt.	Score
Unplanned Safety Function Actuations														
Violations of Operating Procedures														
Unplanned Shutdowns														
Number of Unusual Occurrences														

Figure 1.8
Example Performance Matrix

Step 2: For each of the component performance indicators, determine its relative importance and the impact that it should have on the index. The total of the weight for the constituent performance indicators must add up to 100%. Write the value of the weights in the "Wt." column. (See Figure 1.9).

	Performance Level										Calculations			
Performance Indicator (PI)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Value	Level	Wt.	Score
Unplanned Safety Function Actuations													***20***	
Violations of Operating Procedures													***30***	
Unplanned Shutdowns													***30***	
Number of Unusual Occurrences													***20***	

Figure 1.9
Example Performance Matrix with Weights

Step 3: Establish the baseline value for each performance indicator. In the matrix, *level 7* represents the baseline. A good baseline might be a four-quarter average.

Step 4: Determine a goal for each measure. In the matrix, performance *level 3* represents the goal.

Step 5: Determine a "stretch goal" for each performance indicator. This goal should be attainable, but only if your facility performs superbly. In Figure 1.10, the stretch goal is represented by *level 1* in the matrix.

	Performance Level										Calculations			
Performance Indicator (PI)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Value	Level	Wt.	Score
Unplanned Safety Function Actuations	***15***		***30***				***50***						20	
Violations of Operating Procedures	***8***		***25***				***45***						30	
Unplanned Shutdowns	***10***		***20***				***30***						30	
Number of Unusual Occurrences	***20***		***35***				***60***						20	

Figure 1.10
Example Performance Matrix with Baselines and Goals

Step 6: Establish intermediate goals for levels 4, 5, and 6 in the matrix. These may be specific milestones determined by line management, or they may be simple numeric increments between the baseline and the goal.

Step 7: Determine values for levels 8, 9, and 10. It is possible that performance can be worse than the baseline. To account for this, set appropriate values for levels 8, 9, and 10.

Step 8: Assign a value to Level 2 PIs. You should now have all performance levels filled in as shown in the example in Figure 1.11.

	Performance Level										Calculations			
Performance Indicator (PI)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Value	Level	Wt.	Score
Unplanned Safety Function Actuations	***15***	20	***30***	35	40	45	***50***	60	70	80			20	
Violations of Operating Procedures	***8***	15	***25***	30	35	40	***45***	50	55	60			30	
Unplanned Shutdowns	***10***	15	***20***	23	25	27	***30***	34	38	42			30	
Number of Unusual Occurrences	***20***	25	***35***	45	50	55	***60***	65	70	75			20	

Figure 1.11
Example Performance Matrix with Completed Performance Levels

Step 9: Debug the matrix. Use stakeholder feedback to evaluate the initial selection of performance indicators, the performance levels, assigned weights, and so on. Make necessary changes.

Step 10: Develop a system for scoring and displaying results. It is important to assign the responsibility for collecting, calculating, plotting, and disseminating performance index information. It is equally important to set up a mechanism for the periodic review and updating of each performance matrix.

Remember, for each of the PIs chosen in this example, an increase in value represents a *decrease* in performance. This may not always be the case. For this reason, it is important to understand how increases and decreases in each indicator relate to performance, and to determine the baseline values, goals, and stretch goals accordingly.

Calculating the Performance Index

The first step in calculating the index is to measure the current value for each performance indicator. Then, using the matrix, determine the corresponding performance levels. In situations where the value for a performance indicator falls between performance levels, choose the next higher level. For instance, say that during the last measuring period there were 53 unusual occurrence reports (UORs). Since there is no performance level that corresponds exactly to 53 UORs, you would choose the next higher level, or 55, which corresponds to *performance level 6*.

For illustrative purposes, assume that measuring the performance indicators that make up our hypothetical Conduct of Operations Index yields the following results:

- Unplanned Safety Function Actuations — 38 events
- Violations of Operating Procedures — 50 events
- Unplanned Shutdowns — 23 events
- Number of UORs — 53 events

Based on the above values, the completed performance matrix would appear as it does in Figure 1.12.

	Performance Level										**Calculations**			
Performance Indicator (PI)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Value	Level	Wt.	Score
Unplanned Safety Function Actuations	***15***	20	***30***	35	40	45	***50***	60	70	80	38	5	20	100
Violations of Operating Procedures	***8***	15	***25***	30	35	40	***45***	50	55	60	50	8	30	240
Unplanned Shutdowns	***10***	15	***20***	23	25	27	***30***	34	38	42	23	4	30	120
Number of Unusual Occurrences	***20***	25	***35***	45	50	55	***60***	65	70	75	53	6	20	120

Figure 1.12
Example Completed Performance Matrix

The score for each performance indicator is determined by multiplying the *level* times the *weight*. Once this is done, the scores are added together to determine the composite results. In this case, it yields a value of (100 + 240 + 120 + 120) = 580 for the index. This could be compared to a baseline value for the index of 700 (performance *level 7* for all indicators), and a goal of 300 (performance *level 3* for all indicators). Ideally, values for this index would be calculated every month, quarter, or whatever time period is chosen, and tracked over time.

Example 4: Defense Programs Average of Performance Relatives

This method is based on determining incremental changes in a number of indicators, relative to a baseline period in time, and then averaging these changes or ratios. It is similar to methods used to compute certain economic indexes. The incremental changes are referred to as "performance relatives" (i.e., performance during a given period *relative* to performance during a set baseline period). Remember that this index it is not an absolute indicator. It is only meaningful when tracked over time and compared to past performance.

Performance Relative

A performance relative is a number that compares the value for a certain measure in a given period to the value for the same measure at some fixed period in the past. The best way to demonstrate this idea is by example. This example refers to price relatives rather than performance relatives; however, the two are conceptually identical.

• Example 1: Say you have three commodities, rice , barley, and oats, whose prices in 1970 were $1.00/bushel, $1.25/bushel, and $1.50/bushel, respectively.

In 1980 the prices for these same three commodities were: rice, $1.25/bushel, barley, $1.10/bushel, and oats, $1.75/bushel.

Using 1970 as the baseline year, the price relatives (PR) for these three items would be:

$PR_{rice} = Price_{1980}/Price_{1970} = \$1.25/\$1.00 = 1.25$

$PR_{barley} = Price_{1980}/Price_{1970} = \$1.10/\$1.25 = .88$

$PR_{oats} = Price_{1980}/Price_{1970} = \$1.75/\$1.50 = 1.17$

The price relatives computed in Example 1 give a good indication of how the prices for these commodities fluctuated from 1970 to 1980 — the prices for rice and oats increased, while the price for barley decreased. This is a good indicator of what happened individually, but what about what happened overall?

Average of Performance Relatives

The next step is to compute an average of performance. Many sources agree that the most balanced method for doing this is to use a geometric mean. The reason behind using the geometric mean is beyond the scope of this handbook. However, those who would like to gain a better understanding of the statistics behind this method may consult the **Suggested Reading** on Page 71.

- Geometric mean of performance relatives:

$$I = \frac{\text{antilog}\left(\sum \log P_i/P_o\right)}{n}$$

P_i = series performance indicator
P_o = baseline value
n = number of performance indicators in the series

The formula above may seem a bit imposing at first; it isn't. It is simply one way to compute an average. Instead of adding (PR_{rice} + PR_{barley} + PR_{oats}) and dividing by 3, which would give you a simple arithmetic mean, you are multiplying (PR_{rice}) x (PR_{barley}) x (PR_{oats}) and taking the nth root, or cube root, which gives you a simple geometric mean.

- Example 1 (continued): Using the above formula, the index value for the three commodities in 1970 would be 100 — this is our baseline value. The value for 1980 would then be:

$$\text{Index} = [(1.25 \times 1.17 \times .88)^{1/3}] \times 100 = 109 \text{ points}$$

The index value in 1980, 109, is meaningless in absolute terms. It only takes on meaning when compared to the baseline value for the index, or 100, and, as you can see, the value of the index increased by 9 points from 1970 to 1980.

Next, let's assume that twice as much rice is consumed as either barley or oats. It follows that rice should contribute more heavily to the index, say twice as much. Here's how this weighting factor could be handled:

$$\text{Index} = [(1.25 \times 1.25 \times 1.17 \times .88)^{1/4}] \times 100 = 113 \text{ points}$$

The increased emphasis on rice (PR 1.25) increased the value of the index by 4 points.

Suggested Reading

1. Clark, Charles T., and Schkade Lawrence W., *Statistical Analysis for Administrative Decisions,* South-Western Publishing Co., 1979.

2. Fisher, Irving, *The Making of Index Numbers,* Houghton Mifflin Company, 1927.

3. Persons, Warren Milton, *The Construction of Index Numbers*, Houghton Mifflin Company, 1928.

4. *Safety Performance Indexing: Metrics for Safety Performance Improvement Projects*, Eastman Kodak Company, 1994.