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"How Are We Doing?" Tracking Efficiency, Utilization, and Productivity

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Abstract Productivity gains lead to competitive advantages. To achieve success, managers need to know if they are making the most effective use of resources. Understanding how well a business is performing compared to other firms in an industry is vital. Efficiency and Utilization are two measures that can be used to answer the question "How are we doing?" Once you have defined key variables and established benchmarks, programs like Microsoft Excel make it easy to set up the necessary calculations and track performance over time. A spreadsheet application is demonstrated that illustrates the concepts discussed. Formulas are included and explained.

Keywords Efficiency, Productivity, Utilization, Operations Management, Excel, MIS

1. Introduction

In business, knowing how well we are performing and where we can improve is vital to success. Gains in productivity can lead to competitive advantages [1]. To achieve these gains, we need to know if we are making effective use of resources and getting the most out of what we have. Efficiency and Utilization are two measures that business can use to track "how we are doing."In this paper we define these terms, explain why they are important, discuss Productivity, and then illustrate methods for calculating all three using Microsoft Excel. Sample production data will be used to illustrate the features of the worksheet as well as the charting capabilities of Excel.

While the calculations themselves are not difficult, choosing exactly which performance measures to use and collecting the necessary data requires a thorough understanding of the industry. Once the variables we want to measure have been identified and the data has been collected, programs like Excel allow us to easily develop an application.

2. Materials and Methods

The first measure, Efficiency, is defined as the ratio of Actual Output to Effective Capacity [2]. To calculate Efficiency you must determine what the Effective Capacity of your operation is.For example, does your company already have a "target" or "benchmark" of some kind? Like total units produced per shift or customers served per hour. It helps to know what the ultimate Design Capacity of the system is because you can use that number in calculating Effective Capacity.

Design Capacity is defined as the maximum output achieved under *ideal* conditions but may never be realized under actual working conditions [2]. Design Capacity represents 100% of total output and places an "upper limit" on what can be produced. Effective Capacity then, under ordinary conditions, must always be less than Design Capacity because of machine breakdowns, maintenance, shortages of materials, scheduling, and quality problems. Likewise, Actual Output typically never exceeds Effective Capacity [1].

Utilization is defined as the ratio of Actual Output to Design Capacity [2] and gives a better picture of how the operation is making the most of its potential. To calculate Efficiency and Utilization, there are two basic formulas that can be used:

$$\text{Efficiency} = \text{Actual Output}/\text{Effective Capacity} \times 100\% \quad (1)$$

$$\text{Utilization} = \text{Actual Output}/\text{Design Capacity} \times 100\% \quad (2)$$

Consider the following example:
"A computer repair service center has a Design Capacity of 80 repairs per day. Its Effective Capacity is 64 repairs per day but Actual Output is only 62 repairs per day."

$$\text{Efficiency} = 62/64 \times 100\% = 96.875\%$$

$$\text{Utilization} = 62/80 \times 100\% = 77.5\%$$

There is a big difference between these two numbers. We often hear much about "improving efficiency" but when Effective Capacity is low relative to Design Capacity, simply relying on Efficiency as an indicator of performance can be a mistake. In the above example, the manager of the service center should work to increase Utilization. Some ways to increase Utilization include correcting quality problems, keeping equipment in good operating condition, training

employees, and eliminating bottlenecks [1].

Deciding what to use as a "benchmark" is extremely important as well. In selecting a measure of capacity, it is necessary to choose one that does not need to be adjusted for inflation or updated constantly [1]. The dollar value of output, for example, is often a poor indicator of capacity due to inflation or price fluctuations. Also, no single measure of capacity will be appropriate for every situation. Rather the measure of capacity selected must be specific to the business [1]. The following table lists examples of potential measures of capacity taken from various industries:

Table 1. Capacity Measures

Industry	Inputs	Outputs
Auto	Labor hours, machine hours	Number of cars produced
Steel	Furnace size	Tons of steel
Oil	Refinery size	Gallons of fuel
Farming	Number of acres	Bushels of grain
Restaurant	Tables, seating capacity	Number of meals served
Theatre	Seats available	Number of tickets sold
Retail	Square feet of floor space	Revenue generated

Benchmarking is an important step towards improving efficiency. Nokia Siemens for example, utilizes a three-step benchmarking process [3]:

1) Benchmark current operational efficiency against the most efficient service providers in mature and emerging markets.
2) Assess the efficiency of work processes to identify areas for improvement.
3) Develop solutions to raise performance in these areas.

Closely related to the concept of Efficiency and Utilization is Productivity [1]. Productivity can be calculated for a single input such as labor or energy, or it may be calculated for several inputs. The following formula calculates Productivity for a single input:

$$\text{Productivity} = \text{Output}/\text{Input} \quad (3)$$

Sometimes this measure of Productivity is referred to as "Process Efficiency" and is related to how well a given process achieves organizational strategy [4]. When Productivity is calculated for several inputs it is called "Multifactor Productivity" and indicates how well the organization is making use of all its resources.

The following formula calculates Multifactor Productivity for three inputs:

$$\text{Multifactor Productivity} = \text{Output}/(\text{Labor}+\text{Materials}+\text{Overhead}) \quad (4)$$

Productivity measures benefit a business in many ways. For an individual worker or department, productivity can be used to track performance over time. This allows managers to continually monitor a process and decide if any improvements are necessary. Productivity measures can also be used to assess the overall performance of a business, entire industry, or even a nation. These measures are often known as "aggregate measures." Global competition, increases in the standard of living, and national pride are directly tied to aggregate gains in productivity. Especially if they are accompanied by high growth rates [1].

As an example, using the formula (4) from above, we can determine the Multifactor Productivity for the following scenario:

Output: 7,040 units
Labor: $1,000
Materials: $520
Overhead: $2,000

Multifactor Productivity = 7,040/($1,000+$520+$2,000) =

2 units per dollar

Multifactor Productivity calculations such as this serve as a yardstick for the effective use of resources within an organization. Business decision-makers are especially concerned with productivity as it relates to competiveness. Simply stated, if two firms both have the same level of output but one requires less input because of higher productivity that one will be able to charge a lower price or earn a greater profit. To remain competitive in an increasingly competitive world, business must boost operational efficiency whenever possible. According to Laurie McCabe, Vice-President for AMI-Partners: "Sooner or later, any company not operating efficiently will be out of business." McCabe adds that this is especially important for Small to Medium sized business as they have more limited resources than large enterprises [5].

It is unfortunately quite easy to overlook the importance of productivity figures today. In the current economy there are so many other issues that vie for our attention. But that doesn't make productivity any less important. By calculating Efficiency, Utilization, and Productivity for our business we will have a good idea of where we stand in relation to our competition, the rest of the nation, or even the world. Productivity data for all sectors of the US economy may be found on the Bureau of Labor Statistics web site [6]. Data from the BLS website may be downloaded in Excel format which makes it easy to work with. Most data sets contain historical data going back at least 20-30 years or more.

The following chart (Figure 1) shows the growth in multifactor productivity for the Manufacturing sector from 1997 to 2011:

The Excel application presented in this paper will track daily Actual Production compared to Design Capacity and Effective Capacity. It will also calculate Efficiency and Utilization for each workday as well as the Percent Change from the previous day. Hours Worked will serve as one of the inputs. When considering labor as an input it is important to realize that people will not always be 100% productive. If a project's estimates are at all realistic, there should be an allowance for non-productive time in your calculations. Many organizations have a standard labor productivity rate

which can vary between 65% and 80%. In addition, as experienced managers know, labor productivity does not necessarily increase when more people are allocated to a task. Metrics on individual worker productivity from previous projects can be useful when estimating the number of hours required to complete a given task [7].

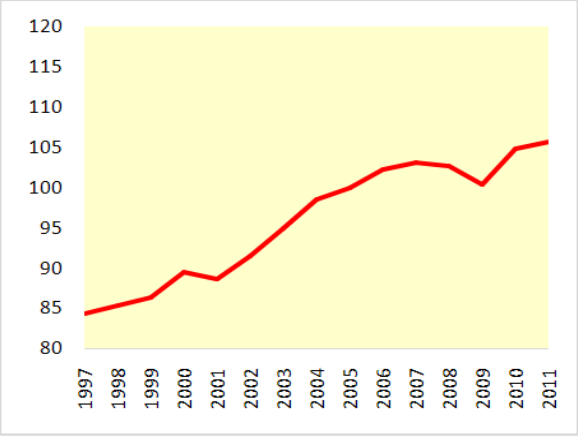

Figure 1. Manufacturing Productivity Trends

3. Conclusion

The ability to establish performance standards and track gains or losses over time is far more valuable than a single day's calculation to most managers. Microsoft Excel allows us to create a worksheet to capture weeks, months, or years of data. All that is needed to analyze the data is to enter the formulas. The Excel application presented in this paper includes calculations for Effective Capacity, Efficiency, and Utilization (Figure 2). In constructing this model, we are assuming that we have already established Design Capacity (Units) and the Maximum Hours/Day the plant is in operation.

We will also assume for simplicity, that at 100% of Design Capacity, the plant operates just one shift of 8 hours a day, seven days a week, and at that level, maximum output is 5275 units per day. Perhaps due to the factors stated earlier, Actual Hours Worked and Actual Production may be less. In our fictional scenario, the data for Actual Production in fact often turns out to be considerably less than Design Capacity and tends to fluctuate. This is reflected by the generally low Utilization figures for each day.

Efficiency however appears to score much better, sometimes even exceeding 100% of Effective Capacity. However, as we have seen, focusing entirely on Efficiency can be misleading. In our example, the low Utilization figures are most certainly a "red flag" and would need to be addressed if this were an actual company.

	A	B	C	D	E	F	G
1	Design Capacity (Units) =		5275				
2	Maximum Hours/Day =		8.0				
3							
4	Day	Actual Production (Units)	Actual Hours Worked	Design Capacity (100%)	Effective Capacity (Units)	Efficiency	Utilization
5	1/7/2013	5200	8	5275	5275	98.58%	98.58%
6	1/8/2013	4500	7	5275	4616	97.49%	85.31%
7	1/9/2013	5024	8	5275	5275	95.24%	95.24%
8	1/10/2013	5382	8	5275	5275	102.03%	102.03%
9	1/11/2013	4307	7	5275	4616	93.31%	81.65%
10	1/12/2013	4456	7	5275	4616	96.54%	84.47%
11	1/13/2013	4572	7	5275	4616	99.05%	86.67%
12	1/14/2013	4637	7	5275	4616	100.46%	87.91%
13	1/15/2013	4521	7	5275	4616	97.95%	85.71%
14	1/16/2013	3821	6	5275	3956	96.58%	72.44%
15	1/17/2013	3901	6	5275	3956	98.60%	73.95%
16	1/18/2013	2976	5	5275	3297	90.27%	56.42%
17	1/19/2013	3824	6	5275	3956	96.66%	72.49%
18	1/20/2013	3839	6	5275	3956	97.04%	72.78%
19	1/21/2013	4001	6	5275	3956	101.13%	75.85%
20	1/22/2013	4529	7	5275	4616	98.12%	85.86%
21	1/23/2013	4577	7	5275	4616	99.16%	86.77%
22	1/24/2013	4616	7	5275	4616	100.01%	87.51%
23	1/25/2013	5238	8	5275	5275	99.30%	99.30%
24	1/26/2013	5250	8	5275	5275	99.53%	99.53%
25	1/27/2013	5198	8	5275	5275	98.54%	98.54%
26	1/28/2013	4600	7	5275	4616	99.66%	87.20%
27	1/29/2013	4612	7	5275	4616	99.92%	87.43%
28	1/30/2013	4615	7	5275	4616	99.99%	87.49%
29	1/31/2013	3500	6	5275	3956	88.47%	66.35%

Figure 2. Microsoft Excel Worksheet Example

Recall that Design Capacity was originally set at 5275 units which, according to our definition represent the uppermost limit of production capability. To increase this number a major facilities expansion or scheduling additional shifts would have to occur. It is interesting to observe that in our example Design Capacity was exceeded on at least one occasion. This is reflected in the very high Efficiency and Utilization figures of 102.03% for 1/10/2013.For the first month, Efficiency averages 98% while Utilization averages approximately 87%. The low point for Utilization occurs on 1/18/2013 with a figure of 56.42%. Our fictitious company is actually doing very well: 90% efficiency is considered quite good. To compare this to something we are all familiar with, most gasoline powered cars are only about 30% efficient [8]

To create this worksheet, we began by entering "Design Capacity (Units) =" in Cell A1, the number 5275 in Cell C1, "Maximum Hours/Day =" in Cell A2, and the number 8 in Cell C2. We then entered the headings in Row 4 as shown in Figure 2.Starting in Row 5, the Date was entered in Column A, Actual Production Units were entered in Column B, and Actual Hours Worked were entered in Column C. Formatting was applied where appropriate to indicate percentages and dates. Cell shading and grid lines were added later to enhance readability.

The formulas used in this worksheet were:

Cell D5, Design Capacity (100%): =$C$1

Cell E5, Effective Capacity (Units):=C5/$C$2*G5

Cell F5, Efficiency:=B5/D5

Cell G5, Utilization: =B5/G5

Once Row 5 was completed, these formulas were copied down to Row 89. Once the worksheet was complete, the next step was to create a line chart comparing Actual Production to Design Capacity and Effective Capacity. This is shown in Figure 3.Using the same type of graph, one could just as easily track Efficiency and Utilization. This example covers the period from January 7 to April 1.

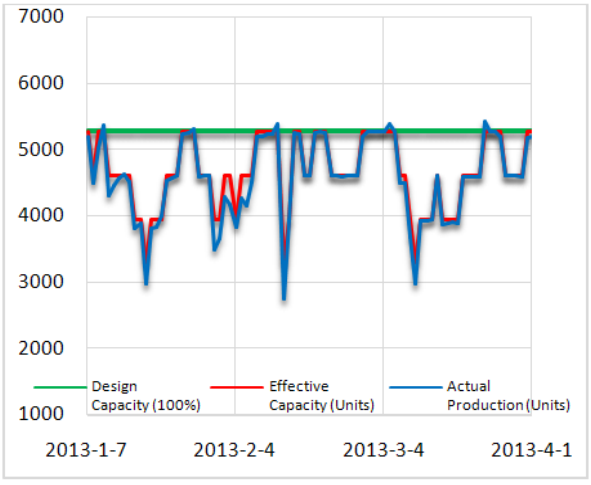

Figure 3. Microsoft Excel Chart

Looking at the chart, Actual Production (Units) and Effective Capacity (Units) appear to vary quite a bit. Of course for our example we have deliberately entered a wide range of data to illustrate the calculation and charting capabilities of Excel. It would be expected that if this were an actual company, the"real" manufacturing data would not be as volatile. This makes including a chart to track daily performance even more valuable since any periods of exceptional performance or under-performance would be easier to spot than by simply looking at printed reports or figures.

By modifying the model presented in this paper many possible variations of this worksheet could be created. For example, different time periods or number of shifts might be used. A second chart may be included that tracks Efficiency and Utilization. Statistical calculations such as Means or Standard Deviations can also be incorporated. Even a control chart could be developed based on Actual Production. Perhaps the biggest advantage of using a program such as Excel to develop an application like this one is the design flexibility and calculation power of the software itself [9].

With a basic understanding of Efficiency, Utilization, and Productivity, combined with a working knowledge of Microsoft Excel, anyone can quickly develop an application and know exactly how they are doing.

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