A performance measurement system using a profit-linked multi-factor measurement model

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Abstract

Purpose – The purpose of this paper is to re-introduce the APC model (developed by the American Productivity Center) through a spreadsheet application of the model in a real-world setting, with a case study of Harlingen Waterworks, Texas, USA.

Design/methodology/approach – This paper introduces a performance measurement system using a multi-factor productivity measurement model in a real-world setting. The model uses operational-level accounting data such as quantities and prices of inputs and outputs of a revenue-generating organization. Such operational data is rarely published or shared by for-profit organizations. Thus, the study focused on a government-run enterprise that cannot claim confidentiality. Since water utilities are experiencing financial pressures, this application is very timely. The spreadsheet-based implementation, using multi-period data, generates performance trend charts of productivity, price recovery and profitability contributions that give a better perspective to managers in identifying the problem areas.

Findings – As shown in this paper, the spreadsheet-based application using the APC model has provided a better understanding of problem areas at Harlingen Waterworks.

Originality/value – The contribution of this paper is the actual application of the APC model using multi-period data, and the outcomes of the application in a real-world setting. This application is useful to any public or private organization generating revenues. The APC model, in this instance, is intended to provide readily interpretable performance feedback for financial managers.

Keywords Performance measures, Spreadsheet programs, Productivity rate, Waterworks, Water industry, United States of America

Paper type Research paper

Introduction

Performance measurement and management is very important for business executives. Without appropriate measures and data we try to address many issues rather than concentrate on the vital few that will have a major impact on how we work and what we deliver to improve customer satisfaction (Millar, 1999). A good performance measurement system is a necessity for a company to grow and sustain industry leadership (Kuo *et al.*, 1999). It "supports sound management decisions." Thanks to the balanced scorecard, performance measurement has gained popularity over the last decade (Ittner and Larcker, 1998). There have been hundreds of articles in refereed journals including *Industrial Management & Data Systems*. In the last couple of years in *IMDS*, for instance, there were several performance-related papers in important

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areas such as knowledge management (Bose, 2004), ERP (Hsu and Chen, 2004), supply chain management (Caputo *et al.*, 2004; Lyons *et al.*, 2004; Yee and Tan, 2004), web applications (Iyer *et al.*, 2005), including portals (Chou *et al.*, 2005) and e-commerce (Liang *et al.*, 2004). Balanced scorecard also made non-financial measures popular (Ittner and Larcker, 1998). Many firms, however, believe that performance measures should be purely financial in order to focus efforts on the ultimate goals of the firm (Kurtzman, 1997; Newman, 1991). Financial measures, in general, are of greater import and used most often (Stivers *et al.*, 1998). More recently, a study of service industries shows that "the majority of performance indicators that companies have in place are financial ones" (Kueng, 2002). *Industry Week's* 27th annual survey of CEOs (Stevens, 1998) further showed that productivity and profit margins were the most important performance indicators for CEOs in their strategic decision-making. It is necessary, therefore, to understand the link between productivity, profitability and factors of production. This paper presents a financial model that links productivity to profitability.

Productivity and profitability of the organization can be tracked using total-factor productivity measurement models: specifically the APC model developed by the American Productivity Center (Rao, 2000). Although the model only requires two-period data for basic implementation, the use of data from additional periods generate more useful performance trends. As Peter Drucker said,

> . . . [w]hat matters . . . is not the absolute magnitude in any area, but the trend . . . that the measurements will give . . . no matter how crude and approximate the individual readings are by themselves (Drucker, 1992).

With the assistance of popular spreadsheet software such as Microsoft Excel, the APC model is viable for creating charts for trend analysis. This paper describes the application of a multi-period APC model in a real-world setting.

Several reasons exist for the use of the spreadsheet based APC model. The first reason is the availability and variety of benefits of spreadsheets. According to Fylstra *et al.* (1998), there were about 35 million users of office productivity (spreadsheets, word processing, etc.) software. The cost savings of desktop computing is continuing (Kreie *et al.*, 2000) implying greater usage of various and more powerful office software packages. Moreover, spreadsheet:

> . . . origins began primarily in the context of accountancy applications, which to this day still represent one of the spreadsheet's major uses with cash flow analysis, budgeting and planning typical of such applications (Pemberton and Robson, 2000).

APC model uses basic accounting data. We use Microsoft Excel for this application. According to Novak and Ragsdale (2003):

- Excel is the most widely distributed spreadsheet package in the world;
- Excel provides a user-friendly environment for setting up and solving various optimization problems; and
- Excel provides a robust set of built-in data analysis tools and features that can be used to sort, summarize and display important information used for decision-making.

Additional benefits include: standardized arithmetic and statistical functions, linking of one worksheet to another inside the workbook facilitating data sharing, "what-if" analysis, macro command capabilities and a user-friendly Graphic User Interface (Coles and Rowley, 1996). Second, spreadsheets are easy to interpret and provide a variety of easily understood outputs (e.g. reports, graphs) for managers (Kreie *et al.*, 2000; Miller and Rao, 1989). Further, spreadsheet modelling used in desktop DSS is increasing in popularity. The availability of spreadsheets and the ability to integrate spreadsheets via ODBC (Open Database Connectivity) provide additional flexibility for managers in decision-making processes (Coles and Rowley, 1996; Panko and Sprague, 1998). The importance of spreadsheet modelling in business is well documented and facilitates many "important organizational decisions" (Panko and Sprague, 1998). One could use customized software such as TOPROD (Saha, 1994) for total productivity measurement, but it lacks the flexibility of a general-purpose software such as Excel.

The purpose of this paper is to re-introduce the APC model through a spreadsheet application of the model in a real-world setting. The contribution of this paper is the actual application of the APC model using multi-period data, and the outcomes of the application in a real-world setting. The APC model, in this instance, is intended to provide readily interpretable performance feedback for financial managers (Miller and Rao, 1989). Hansen *et al.* (1992) point out that there are two inefficiencies of managers: inefficient use of inputs and improper control of input or both. While APC is not new, it potentially provides an additional, easy to use, more efficient managerial tool for any organization. It provides a single output for managers reducing interpretation time. Owing to ease of use, and data availability, this APC application was developed for a water utility; however, the APC model is viable for any organization generating revenue. Further, the output of the application and the underlying formulas are included to help facilitate application.

Water utilities are facing intense financial pressures due to increasing costs of service and constrained budgets (Kucera, 2003). Despite the trend of privatization to curb losses and inefficiencies, many public utilities wish to remain public (Segal, 2003; Segal and Moore, 2003). One solution to reducing costs and becoming more efficient is to measure and monitor performance so that the management can take appropriate actions in a timely fashion.

The paper follows this outline:

- introduction;
- performance measurement models, including the APC model;
- water utilities and their problems with an illustrative case;
- data collection and model setup using the APC model;
- interpretation of the results, including analysis beyond the measurement results; and
- managerial implications and conclusions.

Performance measurement models

Profit-linked total-factor productivity measurement models are well suited to the organization-level performance measurement. Two of the established profit-linked total-factor productivity measurement models are the APC model (Rao, 2000) and the PPP (profitability = productivity + price recovery) model (Miller, 1984). The models use basic accounting data, and provide resulting productivity and price recovery contributions in dollar figures as opposed to indexes, which is very appealing to accountants and business executives. Further, the models use base-period data as the standard against which the performance of future periods is measured. The only difference between the models is the deflating techniques used (Miller and Rao, 1989). The PPP approach uses cumulative deflation (Miller, 1984; Miller and Rao, 1989; Singh *et al.*, 2000). Further, Banker *et al.* (1996), Banker *et al.* (1989) and Hansen *et al.* (1992) propose variations and extensions to the PPP/APC model. Those changes decompose profitability into such things as productivity, capacity utilization, sales activity, and technical efficiency. For general managerial use, the decompositions may be overly complicated and less effective, thus we recommend the use of the original APC model.

The APC model

The attraction of the APC model for the business community is the use of readily available accounting data and it provides performance results in dollars as opposed to abstract indexes (Rao, 2000). The APC model was developed in 1980 at the American Productivity and Quality Center (formerly called The American Productivity Center – APC). The model allows both total-factor and multi-factor analysis. When no factors of production are used in the model, total-factor becomes a multi-factor measurement model (Sink *et al.*, 1984). However, the terms total- and multi-factor are sometimes used interchangeably.

The research method we used here is the case study approach. Case studies provide a special way of collecting, organizing, and analyzing data to gather comprehensive, systematic, and in-depth information about each case of interest (Kuo *et al.*, 1999). In the following sections, we present a multi-period application of the APC model at a municipal water utility. However, it should be noted that this model is viable for any organization that generates profits. First, we begin with a brief history of the problems faced by water utilities.

Water utilities and a case study

Water utilities are facing intense financial pressures and increasing costs of service due to several reasons (Kucera, 2003):

- utilities need to replace aging infrastructure;
- water systems need to comply with increasingly more stringent drinking water standards under the Safe Drinking Water Act and related state laws;
- municipalities need to expand treatment facilities and mains to satisfy the demands of customer growth;
- utilities need to implement costly and ongoing enhanced security measures to protect sources of supply, water facilities and finished water; and
- water systems need to respond to diminishing sources of supply due to drought, over-withdrawal, or contamination.

These pressures could be alleviated by water rate increases. In a study of small public water systems published by Southern Illinois University in 2000, the need to increase water rates was identified by 66 percent of the utilities surveyed as the most important management decision they will need to make in the next five years (Kucera, 2003).

Some communities could face increases of over 35 percent in water rates in order to provide for the capital and the employment of new technologies necessary in meeting federal requirements. Given the fact that 80 percent of Americans currently are serviced by municipally owned water utilities, this could have a big impact on most families and businesses (Correll, 1996).

Although the water rate increase seems to be the answer, many municipalities are looking for better management of facilities and are turning to private sector management with payments linked to performance (Segal, 2003; Segal and Moore, 2003). Firms such as Southwest Water are benefiting significantly from the growing trend of removing water systems from the public domain in the interest of greater economy and efficiency (Liu, 2000). The City of Indianapolis has selected US Filter Operating Services, Inc., a subsidiary of US Filter Corp., to manage the city's waterworks system under a 20-year public-private partnership valued at approximately $1.5 billion (Reagin, 2002). Under that plan, a portion of the company's fees will be paid only if the company meets specified customer service, water quality, operations, and other performance measures. A new model in outsourcing waterworks has evolved due to linking performance with compensation (Soltis, 2002).

Harlingen waterworks

Harlingen waterworks is a municipal utility that serves the citizens of Harlingen and surrounding areas. The waterworks is responsible to the Harlingen City Commission. This categorizes the waterworks as a municipal utility as well as an agency that exists to serve the community. Harlingen waterworks has water and sewer divisions. The water division consists of wholesale water, retail water and reverse osmosis water. In the following, we describe the APC model application for the water division with a multi-period data in spreadsheet software that is easy to use and allows one to draw performance trend charts that provide a better perspective for management.

Data collection and model setup

Data collection is the most difficult part of setting up this model for an outsider because businesses rarely want to share their operational data with others. This could be the reason that few published papers or case studies are presented using these models. Further, this paper describes the systematic processes so that companies can readily implement the model. The cooperation of the Harlingen waterworks has enabled us to develop this application using a revenue-generating enterprise under a city government whose data are not confidential. It should be noted that the waterworks is a public entity and as such, operational data is not confidential; however, it does not mean that management is forthcoming or cooperative in sharing the data. This observation is extendable to many other organizations. We were unable to get the data from a similar facility in another city. There could be several reasons why organizations do not want to divulge their operational data:

- they do not want problems or mismanagement exposed; and
- they may feel that it is a waste of their time, with little or no benefits.

As stated earlier, the APC model could be used with data from two or more periods. The first-period data is assumed the standard against which the performance of other periods is measured. In this case, data from five quarters (quarter 1-4 of 2001, and quarter 1 of 2002) is collected and used (Table I). The required data for the APC model is any two of the following three: quantities, prices, and values. “Value” is the product of quantity and price. These data are required for both outputs (products and services sold) and inputs (resources used). In the context of the Water division, the output is processed water and the inputs are chemicals, labor, electricity, capital, and miscellaneous.

Data regarding gallons of water produced and the price charged per gallon were taken from the accounts receivables system. The type and amount of chemicals used as well as the cost of each chemical were found in logs that are kept at the water and sewer treatment plants. The number of labor hours as well as labor positions and hourly wages were found in the payroll systems and are flagged by work order indicating whether the work occurred for water or sewage processing. Data regarding the amount of kilowatt-hours and price paid per kilowatt-hour were taken from the accounts payable system, which also categorizes expenditures as being either water or sewage related. The capital expenditures and the accumulated depreciation figures were taken from the fixed asset system. Miscellaneous expenses were transcribed from departmental expense reports. When available, amounts were crosschecked with other documentation in order to establish validity as to be relevant to the process. This was done for a “random sample” of expense items. The cost for chemicals did not fluctuate between quarters because they are purchased on an annual contract. This contract is renewed from year to year, often at the same cost.

The next step was to enter the quantities and prices for the relative inputs and outputs for water into the spreadsheet (Table I). The data consist of input and output quantities and dollar values for material, labor, electricity, capital, and miscellaneous expenses. Material and labor expenses are a total of several subcategories. For example, polymer, caustic, chlorine, ammonia, and carbon are among the chemicals used in the processes. Examples of labor categories are construction, carpenters, foreman, and system engineer, among others. In this paper, we will focus on examining the macro expense items and ignore the impact of subcategories. The reason for not using subcategories is that many of the items have negligible impact on the category-level performance. The quantity and price data in Table I, therefore, show every element in every category except labor. Although every element is used in calculations, it is not shown in Table I.

The APC model requires a series of calculations:

- calculation of deflated values;
- calculation of change ratios;
- calculation of performance ratios; and
- calculation of performance contributions.

With the quantities and prices entered, costs and revenues were calculated. Along with the costs and revenues, deflated values were calculated for periods 2-5 (Table II). Deflated values are established by calculating quantities in periods 2-5 with the price of period 1 (Rao, 2000). This is necessary to remove the price effects of the inputs and outputs so that productivity within the periods can be measured. For example, period 2 is compared against period 1 in period-1 prices. This step is done in order to calculate the change ratios in the model.

Table I.
Quantities and prices of inputs and outputs

APC method for a multi-period performance evaluation

	Quantity					Price				
	Period 1 Q1	Period 2 Q2	Period 3 Q3	Period 4 Q4	Period 5 Q5	Period 1 P1	Period 2 P2	Period 3 P3	Period 4 P4	Period 5 P5
Water	896,190,000	1,195,006,000	1,304,781,000	1,011,367,000	1,159,405,000	0.001480	0.001410	0.001290	0.001290	0.001190
Total sales										
Alum	968,554	1,181,616	1,248,748	1,011,416	1,158,434	0.0305	0.0305	0.0305	0.0305	0.0305
Polymer	17,790	21,781	24,268	20,155	25,362	0.3200	0.3200	0.3200	0.3200	0.3200
Caustic	273,235	341,695	344,913	290,750	259,987	0.0755	0.0755	0.0755	0.0755	0.0755
Chlorine	81,867	95,562	109,402	92,877	82,148	0.1445	0.1445	0.1445	0.1445	0.1445
Ammonia	118,098	173,815	223,286	141,988	159,595	0.0585	0.0585	0.0585	0.0585	0.0585
Carbon	26,868	29,800	30,450	33,700	21,356	0.3300	0.3300	0.3300	0.3300	0.3300
Copper sulfate	450	900	1,200	950	750	0.5220	0.5220	0.5220	0.5220	0.5220
Sodium chlorite	49,290	63,877	56,865	52,370	42,870	0.4980	0.4980	0.4980	0.4980	0.4980
Material										
Constructions	7,110	5,597	6,946	5,093	5,810	9.112	8.865	8.843	8.960	8.949
Electrician journeyman	1,303	946	1,118	1,552	1,169	16.913	19.417	19.612	19.308	18.450
Electrician master	638	471	566	467	669	17.277	19.336	19.583	19.875	18.250
Engineer tech	536	464	464	464	520	19.811	19.810	18.317	20.820	20.820
System engineer	536	504	1,236	464	528	39.362	38.466	38.466	28.915	31.139
Draftsman	1,152	928	1,144	928	1,056	11.510	12.697	12.154	13.166	13.166
Foreman	5,875	4,888	6,742	4,988	6,164	10.315	10.192	10.204	11.128	11.158
Outside opr. asst.	1,072	928	1,067	928	1,056	21.781	21.781	21.874	22.664	22.664
Operator B license	3,505	2,889	3,331	2,887	3,350	10.706	10.946	10.870	11.297	11.403
Operator D license	1,096	960	1,120	1,250	1,075	7.873	7.914	8.588	8.212	8.642
Equip. opr. II	2,336	1,959	2,719	1,415	1,702	10.876	10.660	10.660	11.189	11.191
Equip opr I	3,313	2,924	4,635	2,864	3,667	8.702	8.751	6.728	9.154	8.719
Superintendent	512	440	520	520	512	26.970	26.970	26.970	26.970	26.970
Labor										
Electricity	3,239,203	2,597,112	3,476,991	3,587,735	3,979,592	0.035	0.035	0.035	0.035	0.035
Energy										
Capital invest.	1,498	1,503	1,518	1,529	1,540	244.240	248.710	317.840	277.600	290.450
Capital										
Misc. expense	6	5	4	7	5	1488.000	9580.000	2714.360	2653.320	987.900
Miscellaneous										
Total costs										

	Value					Value in first period price				
	Period 1 V1	Period 2 V2	Period 3 V3	Period 4 V4	Period 5 V5	Period 1 VL1	Period 2 VL2	Period 3 VL3	Period 4 VL4	Period 5 VL5
Water	1,326,361	1,684,958	1,683,167	1,304,663	1,379,692	1,326,361	1,768,609	1,684,958	1,541,558	1,541,558
Material	108,249	134,899	139,758	118,674	113,072	108,249	134,899	134,899	134,899	134,899
Labor	459,188	386,971	501,436	404,413	446,727	459,188	386,577	386,971	380,193	392,617
Electricity	113,372	90,899	121,695	125,571	139,286	113,372	90,899	90,899	90,899	90,899
Capital	365,872	373,811	482,481	424,450	447,293	365,872	367,093	373,811	477,714	417,233
Miscel.	8,928	47,900	10,857	18,573	4,940	8,928	7,440	47,900	13,572	13,267
Total	1,055,609	1,034,479	1,256,227	1,091,681	1,151,317	1,055,609	986,907	1,034,479	1,097,276	1,048,914

Table II.
Values (revenues and costs) and deflated values

Change ratios are calculated for quantities, prices and values in each period (Table III). The change ratios for quantity are calculated by dividing the quantity in each period by the quantity in period 1. Similar change ratios are calculated for prices and values.

The change ratios are used to calculate performance indexes of productivity; price recovery and profitability (Table IV). The performance indexes of productivity, price recovery, and profitability are calculated using the following formulas:

$$\text{Productivity index} = \frac{\text{Quality change ratio of total output}}{\text{Quantity change ratio of total input}} \tag{1}$$

$$\text{Price recovery index} = \frac{\text{Price change ratio of total output}}{\text{Price change ratio of total input}} \tag{2}$$

$$\text{Profitability index} = \frac{\text{Value change ratio of total output}}{\text{Value change ratio of total input}} \tag{3}$$

Performance measures in dollars, as shown in Table V, would be more meaningful to managers than the indexes. The dollar contributions can be calculated as follows:

$$\begin{aligned}&\text{Productivity contribution}\\&\quad = (\text{Quantity change ratio of outputs} - \text{Quantity change ratio of inputs}) * \text{Price}\\&\qquad \text{of input in the base period}\end{aligned} \tag{4}$$

$$\begin{aligned}&\text{Profitability contribution}\\&\quad = (\text{Value change ratio of outputs} - \text{Value change ratio of inputs}) * \text{Price}\\&\qquad \text{of input in the base period}\end{aligned} \tag{5}$$

$$\text{Price recovery contribution} = \text{Profitability contribution} - \text{Productivity contribution} \tag{6}$$

Interpretation of results

Table V and Figure 1 show overall performance results for water in terms of productivity, price recovery, and profitability contributions. As Figure 1 shows, the overall productivity contribution over five quarters is positive. However, the trend in productivity contributions after period 2 is of little concern. Price recovery seems to be a matter of great concern since it remains negative – mostly with a downward trend. Profitability, although positive in the first three periods, has a downward trend moving towards negative profits. Price recovery contributions are a result of inflationary effects on outputs and inputs. Negative price recovery suggests that there is much more inflation on resources used that is not factored into the prices of goods sold. If one looks more closely at Table I, the price of water has come down since period 3, while there is no significant change in the prices of resources used. This price recovery contribution is decreasing the profitability. Profitability contribution is the sum of productivity and price recovery. The overall results suggest that the management review water-pricing strategy.

Table III.
Change ratios for water

	Change ratios														
	Period 1	Period 2 Q2/Q1	Period 3 Q3/Q1	Period 4 Q4/Q1	Period 5 Q5/Q1	Period 1	Period 2 P2/P1	Period 3 P3/P1	Period 4 P4/P1	Period 5 P5/P1	Period 1	Period 2 V2/V1	Period 3 V3/V1	Period 4 V4/V1	Period 5 V5/V1
Water		1.3334	1.2704	1.1622	1.1622		0.9527	0.9989	0.8463	0.8950		1.2704	1.2690	0.9836	1.0402
Material		1.2462	1.2462	1.2462	1.2462		1.0000	1.0360	0.8797	0.8382		1.2462	1.2911	1.0963	1.0446
Labor		0.8419	0.8427	0.8280	0.8550		1.0010	1.2958	1.0637	1.1378		0.8427	1.0920	0.8807	0.9729
Electricity		0.8018	0.8018	0.8018	0.8018		1.0000	1.3388	1.3814	1.5323		0.8018	1.0734	1.1076	1.2286
Capital		1.0033	1.0217	1.3057	1.1404		1.0183	1.2907	0.8885	1.0720		1.0217	1.3187	1.1601	1.2225
Miscellaneous		0.8333	5.3651	1.5201	1.4860		6.4382	0.2267	1.3685	0.3723		5.3651	1.2161	2.0803	0.5533
Total		0.9349	0.9800	1.0395	0.9937		1.0482	1.2144	0.9949	1.0976		0.9800	1.1900	1.0342	1.0907

Table IV.
Performance indexes

	Productivity					Price recovery					Profitability				
	Period 1	Period 2	Period 3	Period 4	Period 5	Period 1	Period 2	Period 3	Period 4	Period 5	Period 1	Period 2	Period 3	Period 4	Period 5
Water															
Material		1.0700	1.0194	0.9326	0.9326		0.9527	0.9642	0.9620	1.0678		1.0194	0.9829	0.8972	0.9958
Labor		1.5839	1.5074	1.4037	1.3593		0.9517	0.7709	0.7956	0.7866		1.5074	1.1621	1.1169	1.0692
Electricity		1.6631	1.5844	1.4496	1.4496		0.9527	0.7461	0.6126	0.5841		1.5844	1.1822	0.8881	0.8467
Capital		1.3290	1.2434	0.8901	1.0192		0.9356	0.7739	0.9525	0.8349		1.2434	0.9623	0.8479	0.8509
Miscellaneous		1.6001	0.2368	0.7646	0.7822		0.1480	4.4070	0.6184	2.4038		0.2368	1.0435	0.4728	1.8801
Total		1.4263	1.2963	1.1181	1.1697		0.9089	0.8226	0.8507	0.8154		1.2963	1.0664	0.9511	0.9537

Table V. Productivity, price recovery, and profitability

	Productivity					Price recovery					Profitability				
	Period 1 Prodv1	Period 2 Prodv2	Period 3 Prodv3	Period 4 Prodv4	Period 5 Prodv5	Period 1 PRec1	Period 2 PRec2	Period 3 PRec3	Period 4 PRec4	Period 5 PRec5	Period 1 Prof1	Period 2 Prof2	Period 3 Prof3	Period 4 Prof4	Period 5 Prof5
Water															
Material	0	9,444	(3,944)	8,499	13,909	0	(6,827)	1,555	(20,694)	(14,379)	0	2,617	(2,389)	(12,195)	(470)
Labor	0	225,718	50,872	141,636	70,769	0	(29,354)	30,408	(94,372)	(39,845)	0	196,364	81,279	47,264	30,925
Electricity	0	60,275	17,903	6,650	(8,329)	0	(7,150)	4,273	(20,704)	(13,027)	0	53,125	22,176	(14,053)	(21,355)
Capital	0	120,771	96,073	68,296	56,965	0	(29,793)	(114,259)	(132,860)	(123,675)	0	90,978	(18,186)	(64,564)	(66,710)
Miscellaneous	0	4,465	28,917	(48)	6,109	0	(41,023)	(28,445)	(9,743)	(1,761)	0	(36,558)	472	(9,791)	4,347
Total	0	420,673	189,821	225,033	139,424	0	(114,147)	(106,468)	(278,373)	(192,687)	0	306,526	83,353	(53,340)	(53,264)

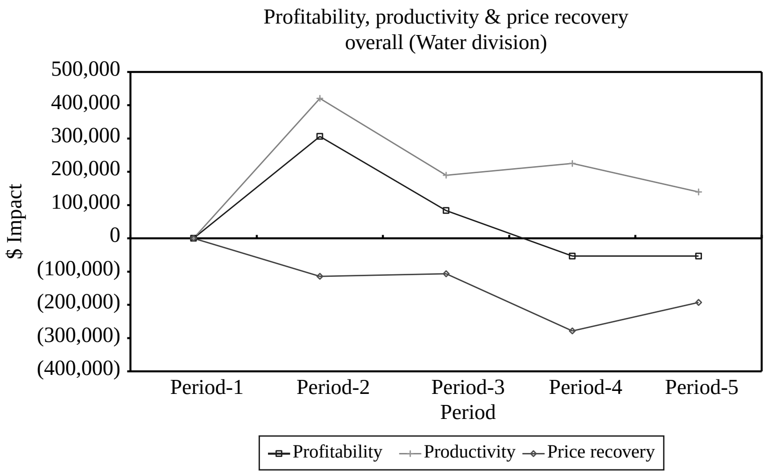

Figure 1.
Overall profitability, productivity, and price recovery

Management can also look at the performance results at the category level. Figures 2 and 3, for instance, show the performance trends of material and labor. One could draw graphs for other categories such as capital, energy and miscellaneous as well as for every element in each category. These graphs will provide a better perspective than the performance results of just one single period. It will be useful to focus on only areas, i.e. categories or elements, which affect the bottom line more significantly.

As an example, labor performance is analyzed next. Figure 3 shows trends in the contributions of labor to productivity, price recovery, and profitability. Although still positive, the profitability contribution of labor is steadily declining requiring management's attention in finding the causes in order to take corrective actions. Price recovery contributions reveal a slight decreasing trend and remain negative in most of the periods. In general, price recovery and productivity show opposite contribution patterns through the periods with respect to labor contributions. The decreasing trend

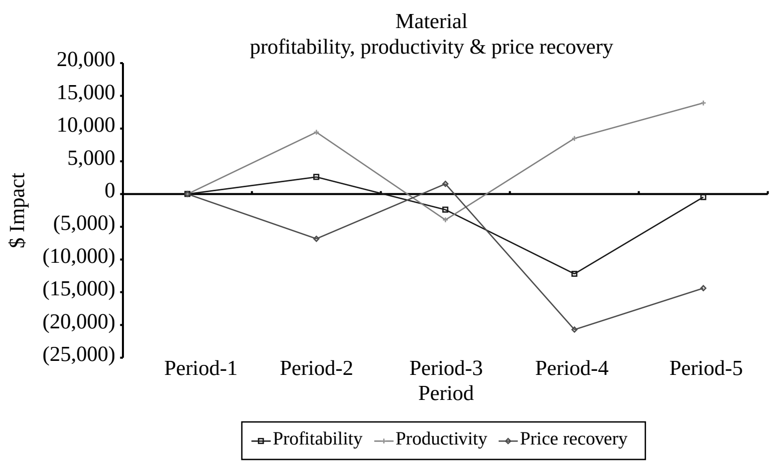

Figure 2.
Material profitability, productivity, and price recovery

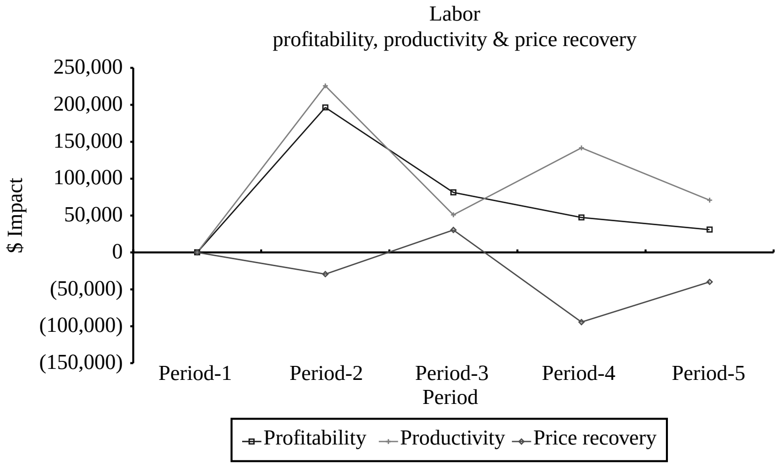

Figure 3.
Labor profitability, productivity, and price recovery

in labor productivity is because man-hours for some key labor components (e.g. system engineer, foreman, and equipment operators) have increased whereas the water output remained the same. When analyzing these results, one should go back and look at the quantity and price data in Table I to gain more insight. Further, one could look at the history of management actions that led to the Table I outcome and troubleshoot the cause of the performance results in question.

Analysis of the measurement results

The measurement system allows management to keep track of changes in productivity and price recovery and their impact on profitability from period to period. Based on the results, several conclusions about the company's performance in terms of productivity, price recovery, and profitability are drawn. The conclusions drawn serve to direct management's attention to factors that require investigation; thus, improving productivity and profitability.

For instance, the results indicate that productivity contributions to profitability are much greater than the losses due to price changes, especially in the labor and capital costs. Overall labor and capital contribution to profitability would have been much worse had there not been solid productivity improvement. It seems that the cost of labor and capital has increased much more than that of the price of water. This may raise questions such as:

> Can we increase the price of water to offset cost increases without losing sales? If so, how much do we have to raise water prices so that there is no loss of $53,264 in period-5 profitability or no loss of $192,687 in period-5 price recovery?

Similarly, one can conclude that the productivity of electricity is causing profit deterioration. Is electricity being wasted? Alternatively, is it due to a change in the process? Is it possible to cut down the electricity consumption without affecting the output? If so, what should the electricity consumption be for it not to affect profitability negatively? The answers to some of these questions can be determined by using the "Goal Seek" and "Solver" features of Excel.

Answers using goal seek

The "Goal Seek" and "Solver" features are found in the Tools menu of Microsoft Excel (Figure 4). Goal Seek is the opposite of what-if analysis. Using Goal Seek, we begin with the target value in a dependent cell and determine the corresponding value in the independent cell upon which the target cell is dependent. What follows is a guide to answering some of the preceding questions.

- What should the electricity consumption be for it not to affect profitability negatively?

  The business lost $21,355 (Table V) because it used 3,979,592 kWh (Table I) of electricity in period 5. To determine electric consumption for zero loss in profitability, we go to the Tools menu, choose "Goal Seek," and set cell BN45 (profitability of total energy) to zero and "By changing cell" to F44 (quantity of electricity) as shown in the dialog box below. After clicking on the "OK" button, the answer in cell F44 is 3,369,446 kWh. Therefore, consumption can be cut by roughly 600,000 kWh without negatively affecting company profitability.

- What should the price of water be increased to in order to offset the current overall loss of $53,264 in period 5?

  Following the same procedure as above using "Goal Seek," we set cell BN50 (profitability, currently – $53,264) to zero and "By changing cell" to K6 (price of water). Clicking the "OK" button increases the value of cell K6 from $0.001190 to $0.001248.

- What should be the increased price of water be in order to offset the current overall price recovery of – $192,687 in period 5?

  Again following the same procedure as above using "Goal Seek," we set cell BI50 (profitability, currently – $192,687) to zero and "By changing cell" to K6 (price of water). Clicking the "OK" button increases the value of cell K6 from $0.001190 to $0.001399. The resulting price recovery would be zero and profitability would be $139,424.

Managerial implications

Good performance management requires a system that managers will use easily and frequently. Microsoft Excel is very popular with business executives, especially for accounting and financial applications. Moreover, performance trends over multiple periods provide better perspective to managers than a single-period performance. Therefore, financially oriented business managers find the APC model and its multi-period implementation in spreadsheet software presented here easy to

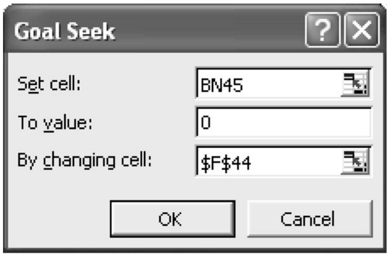

Figure 4.
Goal seek

understand and use, thus encouraging more widespread use and thorough attention to performance results. Such results can lead managers to diagnose problem areas and take corrective actions in a timely manner.

The APC model is in existence for over 25 years now. It seems to be easy to use. There is no reported flaw in the model. But why can't we find any published article describing its applications? This may be because the model requires sensitive operational data such as prices and quantities of inputs and outputs that business managers do not want to share with the competition. Because Harlingen Waterworks, as an enterprise under a municipal government, cannot claim confidentiality we were able to collect data and describe its application in this paper. Business executives can develop their own applications based on the example presented in this paper.

In this paper, we went beyond the basic use of Excel. We have described how one can use Goal Seek and Solver features of Excel in order to gain further insights. These examples should be very useful to those that rarely use these features.

This application is viable for any revenue generating organization. The APC model is also expandable by incorporating the PPP model or other models. In the APC model, since the first period is the initial standard against which the performance of all other periods is measured, the first period could be actual data or an optimal data that is generated based on engineering or other studies (Rao, 1993). In fact, one could also project what the performance should be for each period, then compare the actual versus this projection, and analyze the variances. That provides an additional perspective on performance.

Moreover, the results can be accessed from other software, such as expert systems. Expert systems can interpret results, determine causes, and recommend solutions (Rao and Miller, 2004; Rao *et al.*, 2005). Because spreadsheet software is popular and economical, business managers will be eager to develop this application and use it effectively.

Conclusion

With increasing customer expectations and intensifying pressure to cut costs and reduce prices simultaneously, municipal waterworks and other government agencies have to utilize tools that will help measure, monitor, and improve performance. As shown in this paper, the spreadsheet-based application using the APC model has provided a better understanding of problem areas at Harlingen Waterworks. The executive actions were expected to be based on not only the results of this system, but also other politically viable factors. The APC model is based on financial data. It is not a comprehensive model like the balanced scorecard is. The model could be used independently. It could also be used in conjunction with the scorecard because financial perspective is one of the four perspectives used by the scorecard. We hope that the application presented here would motivate many applications in the private and public organizations, and lead to further research in this area.

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