



Web enabled performance measurement systems

Web enabled
measurement
systems

Management implications

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1273

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Abstract *In order to respond proactively to the new emerging challenges, management requires up-to-date and accurate information on performance. Such performance measurement systems are still not common because there is not sufficient research focused on management implications of IT enabled performance measurement systems. This paper presents an empirical case study where a fully integrated IT enabled performance measurement system was implemented and its management implications studied. The paper concludes, based on a single case study, that if properly implemented, such systems would promote a proactive management style and greater confidence in management decisions.*

Introduction

The manufacturing industries are facing tough challenges to succeed in a globally competitive market. Markets are becoming increasingly sophisticated and dynamic. Customer demand is changing rapidly in terms of sophistication of the products and services they require. As a result, companies need to become more responsive to customer and market needs with greater numbers of customer-specific products, more flexible processes, suppliers and resources co-ordinated through a number of factories and warehouses, while reducing costs.

In order to respond proactively to these challenges, management requires up-to-date and accurate information on its:

- markets and customers;
- competitive position;
- financial performance;
- customer service performance;
- operational performance;
- suppliers' performance, and so on.

Furthermore, this performance information needs to be integrated, dynamic, accurate, accessible and visible to aid fast decision making to promote a proactive management style leading to agility and responsiveness.

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Recent years have seen the development of a number of frameworks and models for performance measurement. Some companies are now attempting to make use of information technology to provide the required information online.

However, despite this amount of research and development, performance measurement systems that are properly integrated, dynamic, accurate, accessible and visible to facilitate responsive manufacturing, are still not common (Bititci and Carrie, 1998). This is because the technical, technological and people issues concerning dynamics of performance measurement systems are not completely understood.

The objective of the research presented in this paper was to study the management issues concerning dynamics of performance measurement by embedding performance measurement systems using IT and Web technology, implementing these in collaborating companies and studying its impact on performance, people and decision making.

Background

The background of this paper extends back to the mid-1980s when the need for better integrated performance measurement systems was identified (Johnson and Kaplan, 1987; McNair and Masconi, 1987; Kaplan, 1990; Druker, 1990; Russell, 1992). Since then, there have been numerous publications emphasising the need for more relevant, integrated, balanced, strategic and improvement-oriented performance measurement systems.

In terms of frameworks and models, the SMART model (Cross and Lynch, 1988-1989) and the performance measurement questionnaire (Dixon *et al.*, 1990) were developed in the late 1980s. In the 1990s the balanced scorecard (Kaplan and Norton, 1996) made a significant impact by creating a simple, but effective, framework for performance measurement. During the 1990s the European Business Excellence Model (EFQM, 1998) also made a significant impact on what measures companies used and what they did with these measures. The EPSRC-funded research on integrated performance measurement systems tested the feasibility of developing an auditable reference model from three different viewpoints – structures (Bititci and Carrie, 1998), information (Kehoe and Little, 1998) and people behaviour (Burns and Backhouse, 1998). This work built on the balanced scorecard and EFQM models using the viable systems structure (Beer, 1985) and resulted in the development of the integrated performance measurement systems reference model.

Other research programmes, and to a certain extent consultancy organisations, also developed approaches, procedures and guidelines for developing and designing effective performance measurement systems (Doumeingts *et al.*, 1995; Krause, 1999). The Performance Measurement Workbook developed at Cambridge by Neely *et al.* (1996) is now widely known, and the performance PRISM (Neely and Adams, 2001) is emerging as the most contemporary framework for performance measurement.

There have been several other initiatives for developing and defining performance measures for various business areas and processes, including

performance measures for production planning and control (Kochhar *et al.*, 1996), performance measures for the product development process (Oliver, 1996) performance measures for planning and control (Oliver Wight, 1993).

Bititci and Carrie (1998) used the IPMS reference model to audit the performance measurement systems of over 30 UK and European-based manufacturing and service companies. This work identified the main reasons behind the absence of performance measurement systems that would facilitate responsiveness and agility as:

- Today most performance measurement systems are historical and static. That is, they are not dynamic and sensitive to changes in the internal and external environment of the firm. As a result, the information presented is not relevant, up-to-date or accurate. This creates a vicious circle because it has a negative effect on the perceived value and usefulness of the performance measurement system, resulting in lack of commitment and ownership, which, in turn, discourages proper maintenance and updating of the system.
- Few performance measurement systems have an integrated IT infrastructure. This results in cumbersome and time-consuming data collection, sorting, maintenance and reporting. As a result, companies cannot justify further investment of already stretched resources in data collection, sorting, maintenance and reporting type activities, which have low perceived values.

Bourne and Neely (2000) independently monitored reasons behind the success and failure of performance measurement systems implementations and concluded that the design, implementation and maintenance of performance measurement systems are seen to be time-consuming activities, and that the benefits of these activities could not be clearly justified.

Similarly, Hudson *et al.* (1999) summarised the reasons for failure of performance measurement systems initiatives in SMEs as:

- historical measures with out-of-date and irrelevant information;
- the time consuming nature of PMS development and maintenance;
- lack of commitment and enthusiasm from senior management.

It seems that three independent research projects (Bititci, 2000; Bourne and Neely, 2000; Hudson *et al.*, 1999) all identified one of the barriers affecting the successful implementation of performance measurement systems as the time consuming and cumbersome nature of data maintenance associated with manual or partially IT-supported performance measurement systems. These researchers also found that this manifested as performance measures with out-of-date and irrelevant information leading to lack of commitment and enthusiasm at all levels.

Some IT vendors and consultants have also developed software tools for designing, implementing and managing performance measurement systems,

such as: IPM, pbViews, iThink Analyst and PerformancePlus (Coleman, 1998). In fact some ERP vendors, such as Oracle, are at present in advanced stages of developing performance measurement modules to integrate with and support their ERP modules.

Further research done by Begemann and Bititci (1999) established that use of IT platforms make outputs from performance measurement more accessible and visible, as well as making updating and maintenance of performance measures easier.

However, there is little empirical research that supports the proposition that a fully integrated IT-supported performance measurement system would promote a more proactive and agile management style by providing dynamic, accurate and readily accessible information to aid decision making.

The research

The objective of the research presented in this paper was to study the management implications of Web-enabled performance measurement systems. This was achieved by:

- Working with Alcan Packaging, Foil Rolling and Technical Products (AFE), UK, to develop a fully integrated Web-enabled, intranet-based, performance measurement system based on the integrated performance measurement systems (IPMS) reference model (Bititci and Carrie, 1998).
- Creating a structured data collection tool to assess the management implications before, during and after implementation of the Web-enabled performance measurement system.

Architecture of the Web-enabled performance measurement system (WePMS)
Alcan Packaging, Foil Rolling and Technical Products (AFE), is a profit centre of Alcan. The site specialises in the manufacture of thin aluminium foil (such as those used for cooking, food and confectionery packaging) and laminated aluminium foil (such as those used in the cigarette packaging). The main processes within the factory are rolling and laminating.

The IPMS reference model (Bititci and Carrie, 1998) was used to guide the management team to identify and structure the key performance measures. The details of the structure of the performance measurement system has been the subject of previous papers, thus it has not been included in this paper.

At the heart of the WePMS implemented at AFE is the Quality Analyst software product, which is essentially a software platform designed specifically for supporting statistical process control applications. It provides a good combination of flexibility, and ease of use. It easily integrates into manufacturing data systems. It produces all standard SQC charts, plus many special-purpose charts. It allows the user to dig into the information by “drilling down” into the charts.

With the Open Data Base Connectivity (ODBC), Quality Analyst can pull down data from different sources into its own database. In this case, it is being

used as a tool to collect and convert numerical data into graphical Shewhart charts (more commonly known as SPC charts). In AFE the numerical data is available from a number of sources including:

- MRPII system;
- spreadsheet applications, i.e. MS Excel;
- database applications, i.e. MS Access;
- machine controllers, i.e. the process controllers of various equipment, such as mills;
- data loggers.

Figure 1 illustrates this structure where Quality Analyst provides the main interface between the Web pages and the numerical data. This architecture enables the following:

- Creation of data either automatically (through the MRPII system, machine controllers and the data loggers) or manually (through spreadsheets and databases).
- Annotation of data either manually (e.g. by providing a comment field within the database or spreadsheet) or automatically (through reason codes that may be available within the existing systems).
- Viewing information through AFE's intranet pages.

In AFE the WePMS is known as the management team reporting (MTR) system. Figure 2 illustrates a sample of the performance reports available through the MTR system.

The Web page in Figure 2a illustrates the main menu page providing access to performance reports for various parts of the business.

In Figure 2b, the top chart illustrates a Shewhart chart for monitoring variations in the porosity during the rolling process. This is a critical technical measure captured by the data loggers on a continuous basis and the daily averages are reported automatically by the MTR system at the end of each day. The figure also illustrates that the tolerances were tightened in July 1999. Annotations communicate that the targets are not achieved, indicating the

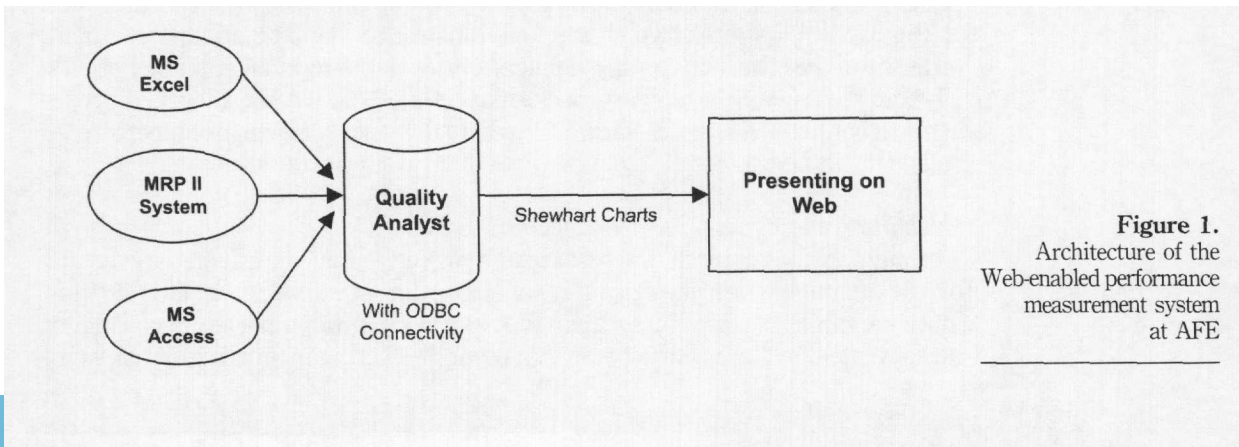


Figure 1.
Architecture of the
Web-enabled performance
measurement system
at AFE

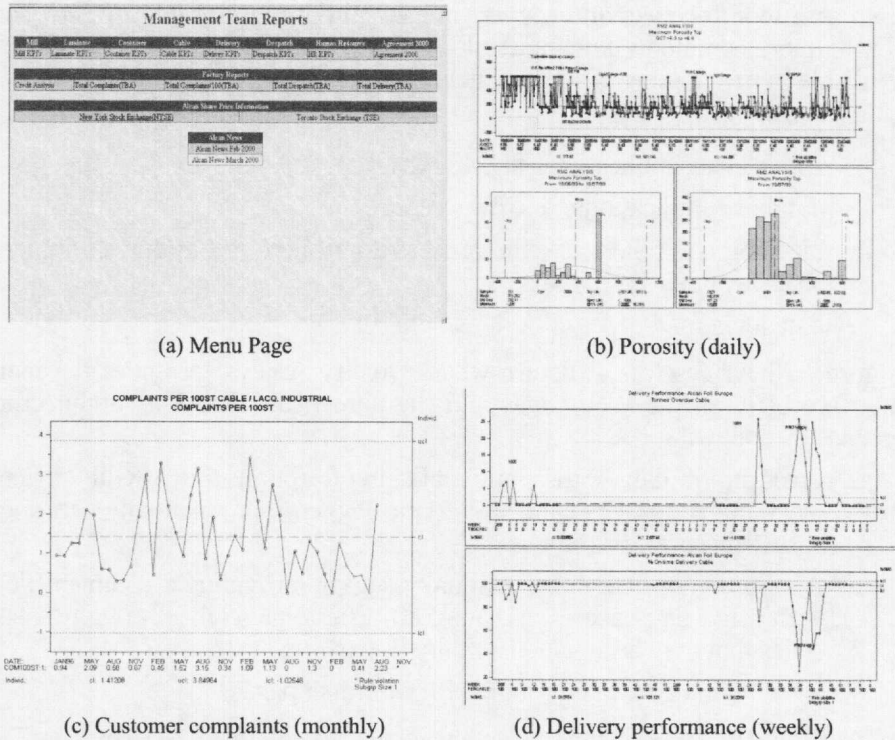


Figure 2.
Sample pages from the
AFE's MTR system
(WePMS)

reasons such as paper change, roll change, etc. The bottom charts illustrate the process capability histograms, one before tightening the tolerances and the other after tightening the tolerances.

The Web page in Figure 2c illustrates AFE's performance with respect to customer complaints received each month. This information is captured manually. As customer complaints are received by the customer services department they are entered into a customer complaints log (MS Access Database), in accordance with the company's ISO9000 procedures. Quality Analyst picks this information from the database and presents it on the Web page. The chart in Figure 2c shows customer complaints received by AFE.

Figure 2d illustrates two charts, one illustrating backlog against customer orders and the other illustrating delivery performance against customer orders. The chart shows that delivery performance has been within target of 95 per cent except between weeks 36 and 41, where delivery performance has suffered considerably due to a problem with raw material supply (as annotated).

Evaluating the management implications of WePMS

Throughout the research, the researchers played a dual role. Crigeton was one of the managers within Alcan responsible for specifying, developing and implementing the fully integrated Web-enabled, intranet-based, performance measurement system. Turner was the researcher acting in an advisory capacity

assisting with the implementation of the IPMS-based performance measurement system. Bititci and Nudurupati were acting as external observers, who conducted the empirical research independently of the development and implementation process.

At the outset of the research, a number of interviews were held with the senior management and middle management teams, which led the research team to understand the before scenario at AFE. During the design, development and implementation of the new performance measurement system, Creighton and Turner were observing and recording the implementation process, which was reviewed by the senior management team and the research team on a quarterly basis, through project steering committee meetings. The after scenario was captured as a result of a set of structured interviews with the key users of the system. This involved all levels of management from the general manager to team leaders. The results presented in this paper are thus based on a population of 29 managers, which remained stable throughout the research with no changes (i.e. nobody leaving or joining the company).

In order to evaluate the business and management implications of the WePMS, a set of research questions were formulated at the outset, based on the background discussion provided earlier in the paper. These questions included:

- What is the cost of implementing and operating WePMS?
- What are the business benefits of implementing and operating WePMS?
- What is the impact of the WePMS on business performance and strategy?
- Are managers more confident in their decisions as a result of WePMS?
- Are the managers and decisions becoming more proactive as a result of using WePMS?
- How does the WePMS affect the management behaviour?
- How does the WePMS affect the dissemination of knowledge throughout the organisation?
- Does the WePMS impact on the visibility of information throughout the organisation?
- Does the WePMS highlight or pinpoint the weaknesses of the business?

The interviews for the before and after scenarios were structured to capture the management opinion with respect to the above questions through a simple but structured questionnaire. During the after interview each respondent was asked to rate the impact of the system, in the context of each question, on a five-point scale (significant improvement, some improvement, no improvement, some deterioration, significant deterioration). The respondents were also asked to justify their choice by explaining the key features of the change. The data was collected through face to face interviews with a cross-section of personnel in AFE.

Research results

In this section the feedback obtained from the questionnaire and personal interviews is summarised under separate headings corresponding to questions asked.

Cost and scope of implementation

The company has invested approximately £20,000 on buying and implementing the software, which includes the cost of the software products and training. It has invested £50,000 in hardware to support the software, which includes new PCs, data loggers, etc. The company has employed one full time employee and allocated, on average, approximately 10 per cent of the management time to this project. Most of the interviewees responded that it is very difficult to quantify the operating costs, as it has become a routine part of their business.

Business benefits of implementing and operating the MTR system

Even though few respondents indicate that there are some benefits, many respondents indicate that there are significant benefits. The MTR system has created visibility for promoting continuous improvement. It identified, strengths, weaknesses, opportunities and threats for the business:

(1) Before:

- Limited transparency of information at all levels.
- Duplication of data (often inaccurate).
- Measures with no clear targets and focus on what needs to be done.
- Many people are involved in collecting data.

(2) After:

- There is complete transparency and visibility of information.
- Data is now from a single source and accurate.
- Problems are clearer, which helps to focus and manage improvement.
- The cause and effect relationships between capital targets and operational activities are more visible, making monitoring against capital objectives easier and more visible.
- Everyone knows what needs to be done and problems are not hidden.

Impact on business performance and strategy

Even though some people responded that there is some improvement, many people responded that there is significant improvement. The consensus view was that the business performance would have stagnated if the system was not in place. They said that:

(1) Before:

- Managers found it difficult to focus on key areas of business improvement.

- “Flavour of the month” approach to improvement.
 - Unstructured approach to performance planning.
- (2) After:
- Now completely focused on areas needing improvement.
 - There is a systematic approach to improvement.
 - The capabilities of business and manufacturing processes are better understood.
 - Achieved state of excellence on certain quality characteristics, which allowed adoption of higher technical specifications resulting in improved margins.
 - Improved partnership with major customers who can view the MTR system during audits and see that the issues concerning business problems are being addressed.

In one particular case, a customer was ready to take its business elsewhere. Having seen how AFE was planning to tackle the problem, they got involved in the process. As a team they improved the performance of the product using the MTR system to such an extent that the customer was delighted with the results. They have now formalised a partnership agreement for AFE to supply other products.

Confidence in management decisions

Most of the respondents have reported that they are now more confident in their management decisions. They said that:

- (1) Before:
- Decision making was based on inaccurate and historical data.
 - It took several hours to collect and analyse data, this usually meant that in most cases it was not done at all or not done properly.
 - Arguments about the validity of data caused friction between individuals.
 - More often the organisation reacted to external stimuli, such as customer complaints, rather than internal stimuli due to the lack of confidence in the information available.
- (2) After:
- Decisions can now be made quickly with confidence as the information is available in real-time or near real-time and the trends are visual on “active” SPC charts throughout the business.
 - Information is accurate and reliable – because it is from a single source. This also eliminated animosity and friction between

individuals caused as a result of arguments over the validity of data – “we are managing by fact, using a single set of data”.

- It is easier to conduct root cause analysis to resolve problems and improve operations.

Impact on management style

Most of the respondents have indicated that management decisions have become more proactive by selecting the “some improvement” option. They said that:

- (1) Before. Managers were reactive and unfocused because of duplicated information and low levels of confidence in the information.
- (2) After implementing MTR:
 - Common view of transparent information, which allows managers to discuss and plan work to improve performance and then act on it.
 - When things go wrong everybody knows the reason – it is annotated on the charts. Visibility like this makes us get on with our jobs rather than arguing about the data.

Effect on management attitude and behaviour

Many people responded that the MTR system has a significant positive effect in many cases. In isolated cases some negative effects were mentioned, mainly related to manual data collection and sorting. They said that:

- (1) Before:
 - Easy not to be a “team player” and hide behind the poor data and so use a political approach to each situation.
 - Most decisions were based on instinct and not on facts.
 - There was a lot of pressure and wasted time before weekly management meetings, analysing data, understanding what went wrong and justifying why – “we used to try to justify the past”.
- (2) After:
 - Managing director used the MTR system to change the management style from reactive to proactive by insisting on all analysis to be based on statistical approach.
 - Now there are no places to hide. This was difficult to get to grips with to start with. A lot of people felt very exposed. But the open management style helped a lot to overcome the fears.
 - If you are not a “team player” it becomes very obvious very quickly.
 - Now managers just turn up to the weekly management meetings and discuss what they are going to do rather than trying to explain what went wrong and why – “we are now managing the future”.

Effect on dissemination of knowledge throughout the organisation

Almost everybody responded that there is a significant positive effect. Previously, only a few people knew what was happening in the company, but now everybody knows what's happening. They said that:

(1) Before:

- Knowledge was only disseminated through management briefings.
- Consequently, some of the information and knowledge were retained at top levels without reaching operational levels.
- Each function collected its own data independent from each other.

(2) After:

- All critical information and knowledge is completely accessible by all members of the organisation.
- Support and operational staff (e.g. line operators, manufacturing engineers, quality engineers, etc.) use the information because they need to resolve problems. Management use the information because they need to make decisions, drive improvement and create focus.

Business weaknesses highlighted by MTR system

Half of the people responded that it highlighted some weaknesses. The other half responded that it highlighted many weaknesses. Here the main message was that before, people did not understand the effect of operational problems on business performance. Improvements were mainly driven by reactions to customer complaints. Now the cause and effect relationship is better understood and more visible, improvements are internally driven rather than being reactions to feedback from customers.

Discussion

The objective of this paper is to identify the management implications of IT supported performance measurement systems, because the current literature in performance measurement suggests that with IT support, performance measurement can be made less cumbersome, more dynamic and responsive, thus leading to a more proactive management style.

One of the first questions asked related to the cost-benefit of such systems. At the conclusion of this research this was a question the researchers felt unsatisfied with because: Although it was fairly easy to establish the implementation costs, it proved difficult to establish the operational costs or saving of such systems (i.e. the marginal cost or saving of operating maintaining, updating and using such a system). As the MTR system became an inextricable part of the company's processes and structures, it became increasingly difficult to separate the impact of the MTR system from other assets and activities (Willcocks and Lester, 1999). Another related question is, how are the benefits achieved in this company correlated with the total investment of implementing the MTR system? Even though the paper

demonstrated that there are overall benefits of the MTR system, it failed to address whether the benefits are worth the MTR system investment. However, the management team’s opinion was that the business benefits enjoyed were largely attributable to the MTR system and that it far outweighed its costs.

Figure 3 summarises the results of the feedback received from the selected cross-section of employees within AFE, providing qualitative answers to the rest of the questions posed earlier in the paper.

The results of this research may be summarised as follows. The Web-enabled performance measurement system, locally known as the MTR system, implemented in AFE plant resulted in significant benefits by:

- making performance information more transparent and visible;
- improving accuracy, reliability and credibility of performance information;
- creating awareness of issues and focus on critical problems;
- creating an understanding of the cause and effect relationship between the business measures and operational measures.

Consequently, managers are:

- more confident with their decisions;
- more proactive in their management style;
- working more as a team than individuals;
- more efficient as a team.

As a result, AFE demonstrated improvements in its bottom-line performance, which is measured through economic value added (EVA).

No.	Question	Significant Deterioration	Some Deterioration	No Improvement	Some Improvement	Significant Improvement
1.	The business benefits of the MTR System				●	
2.	The impact of MTR System on business performance				●	
3.	Confidence in manager’s decisions					●
4.	Management style - proactive				●	
5.	Effect on the behaviour of management					●
6.	Effect on the behaviour of operational staff				●	
7.	Effect on the team behaviour - management				●	
8.	Effect on the team behaviour - operational staff				●	
9.	Effect on dissemination of knowledge					●
10.	Effect on visibility of information					●

Figure 3.
Summary of structured interviews

The researcher's opinion is that the majority of the benefits gained are attributable not only to WePMS but also to other factors, which played a significant role in its success. These are:

- Adoption of a framework (in this case IPMS Reference Model) to structure the performance measurement system. It is evident that creating a set of performance measures and publishing these on the Web would not have created the depth and breath of understanding evident in this case.
- Adoption of Shewhart charts as a standard method of documenting performance information. In a process plant where SPC techniques are widely understood, this approach gained considerable support mainly due to familiarity and also due to visual and graphical nature of the charts.
- Senior management commitment, was by far one of the key influences that led to the success of the MTR system. The managing director insists that all personnel, when they are talking to him on performance related issues, use the MTR system. He said: "I look at several charts several times every day, I ask questions to my managers and team leaders about them, I expect them to communicate to me using these charts". In our opinion it is his commitment that resulted in adoption of the MTR system as an everyday management tool.
- Open and non-threatening management style from the very top of the organisation. One of the difficulties with the implementation of this system was that with the previous systems it was easy for managers to hide behind inaccurate and historical data. The difficulty was that as soon as the managers found out about the project they felt threatened and vulnerable. This feeling continued until the system was operational and they could see that the general manager was using the system to improve the business, and not to point fingers and apportion blame. The general manager's continuous assurance and his sensitive approach throughout the development and implementation was a key factor for the success of this system.
- Data collection and analysis was integrated into the business as part of one's everyday job. Where possible, data collection was automated. In certain areas data collection and recording methods were changed, e.g. customer complaints are logged into a database instead of a book, allowing the MTR system to collect data directly from the database.

These conclusions are consistent with Sauer (1993) who stated that every successful IT project has a new work practice supporting it. The discussion above makes it clear that providing just the hardware and software would not have resulted in these benefits. Other major influencing factors include changes in working practices, general managers' commitment and an open and non-threatening management style.

Conclusions

This paper provides empirical evidence that appropriately designed performance measurement systems, if supported through appropriate IT platforms, appropriately implemented will improve visibility, communications, teamwork, decision making and will lead to a more proactive management style. However, this conclusion is based on a single case study. The authors are confident that the benefits enjoyed by AFE are replicable in other organisations provided that the environmental conditions are similar. For example, it would be interesting to see what happens to the MTR system in AFE if another general manager with different management style and values was to take over the business. Therefore, more research is required to provide answers to the following questions:

- How valid and generalisable are these results?
- What is the impact of different business environments on the performance of the WePMS?
- How does WePMS perform under different cultural environments?

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