Productivity Management in an Organization

Measurement and Analysis

KONGKITI PHUSAVAT

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Foreword

As a professor of Industrial Engineering and Management, I'm delighted to see that this book or dossier has been written. Productivity and quality have been the two major driving forces behind the Industrial Engineering discipline through past decades and those will be the main issues in the coming decades as well. The book/dossier covers in well thought form major issues of performance and productivity measurement and analysis. The presented ideas and examples are applicable equally in industrial companies as they are in public sector organizations like universities. This book/dossier gives certainly the reader new ideas how to use various methods to improve performance and productivity in organisations both private and public. What I particularly like about the book/dossier is that the examples aren't trivial ones designed to illustrate a simple point, but are potentially useful in their own right. The way that different approaches are considered will reward the reader who wants to develop a deeper understanding of how address the challenge of performance measurement and analysis.

This book/dossier is resulted from collaboration between academic professionals around the world. Dr. Kongkiti Phusavat has been the centre point in this work and I have been very fortunate to have the opportunity to be part of his network. This collaboration will not end by the publishing this book but will get extra energy from this publication. The ideas from this book/dossier will be utilized in various forms in Finland when looking for improvements in performance and productivity. The most obvious customers will be the teachers, researchers and students of Industrial Engineering and Management in the Finnish universities. The ideas give also a good boost to further academic research in the areas of covered in the book.

I would like to use this opportunity to thank and congratulate my dear friend Kongkiti for his extra efforts to put this publication together and at the same time all those who have contributed in the various research projects and articles that part of this book/dossier.

Dr. Pekka Kess

Department of Industrial Engineering and Management
Faculty of Engineering, University of Oulu, Finland

Kongkiti Phusavat's text/dossier on productivity management is highly useful material for any manager working within service and operations. This set of re-printed articles, published in international academic journals, introduces the concept of productivity from both analysis and measurement point of view. Practical tools and case studies are presented with illustrative numerical examples. Dr. Phusavat shows how the productivity concept can unleash hidden performance in different organizations, from local SME's to large multinationals, from manufacturing and outsourced operations to service business, R&D organizations, and public services. The dossier is a continuum in advances of productivity management, and clearly pushes the frontier in this important field of industrial engineering.

For scholars or researchers, this dossier can assist their academic teaching and research interests in the areas of performance/productivity measurement and analysis. Dr. Phusavat's text is great material used in advanced level executive education, and based on my past experiences it is very useful for consultants when developing a management system—especially performance/productivity measurement and analysis—to an organization. This text will make it easier for practitioners to apply performance/productivity measurement and analysis. From my viewpoint, the dossier deals with a topic issue, and come up at the time when the knowledge on performance/productivity measurement and analysis is needed.

Dr. Petri Helo

Logistics Systems Program, Department of Production
Faculty of Technology, University of Vaasa, Finland

The Management Systems Engineering balances and blends the human and technical elements of the organization applies tools and skills to work processes, and transforms data into information for its users. A well-designed management system allows managers and other users to navigate and control complex organizations and their processes, from manufacturing to knowledge-based enterprises. As part of the management systems framework, performance measurement is a key element providing input on the performance of the workforce.

In their early days, industrial engineers were known for time-motion studies. The field of industrial engineering has moved far beyond the mere observation of human motion in the workplace. In today's service and knowledge-based economy, measuring performance of the human, white collar workforce is an inherently difficult challenge.

The following work will provide an overview and discusses recent developments in management systems theory. Dr. Kongkiti Phusavat has advanced the theory and practice of management systems engineering in general and performance measurement in particular. His academic papers document his contribution to the academic world. Numerous organizations in Thailand and beyond have benefited from his work. Good theories find their way into practice.

Dr. Christian Wernz

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Preface

As one of the four traditional engineering disciplines (in addition to Civil, Mechanical, and Electrical Engineering), Industrial Engineering or IE has gradually evolved since the introduction of Scientific Management by Frederick Taylor, and Frank and Lillian Gilbreths in late 1800s and early 1900s. At the beginning, the focus was on how to improve productivity at the individual level, especially those who were refereed to as blue-collar. At that time, they made up the majority of the workforce. Given the continuous growth in global population in the early 1900s, industrial engineers constantly involved with the task of increasing productivity. This was accomplished mostly by better designs on motion, movement, and supporting tools and instruments in assembly or production lines.

During World War II, industrial engineers were called to extend their knowledge from the individual to operational levels (i.e., assembly line, plants, production, etc.). Applied mathematics and statistics to optimize production and to minimize resource consumption were one of many highlights of IE as the US was fighting the war in two fronts—Europe and Asia. Standardization efforts were extended from individual work into system design and development. After World War II, industrial engineers began to focus more efforts on the areas of manufacturing and production as economic growth and prosperity helped contribute to the higher international demands. Research into new materials for industrial and consumer products, and applied technology in manufacturing systems represented some of the primary tasks undertaken by industrial engineers then. Included were the design issues relating to assembly lines, production systems, scheduling, forecasting, inventory, layouts, and workflows.

In 1970s, the service sector began to increase its share in economic wealth and employment. As a result, industrial engineers were required to adapt their backgrounds for this new challenge. Systematic thinking became the norm of industrial engineers as they had to deal with complex situations. Furthermore, the concerns relating to productivity losses and poor quality attracted a lot of attention among scholars and researchers in the field of IE. At the same time, more calls were made to ensure that productivity at the functional and organizational levels continued to improve. This was highlighted by the establishment of American Productivity Center in late 1970s and its initiatives in developing several productivity-measurement techniques. These initiatives had led to several ongoing practices such as benchmarking and best practices. To reflect that high performance was attributed to productivity and quality, the center is now known as American Productivity and Quality Center.

Since 1980s, industrial engineers have been a champion in promoting effective process management in two areas, operation and management. The emerging importance of knowledge-intensive business units, widely used in Finland and Scandinavian countries, has highlighted the need of excellent management processes with timely performance information, decisions, and improvement interventions. As a result, several well-known universities such as Virginia Tech's Department of Industrial and Systems Engineering generally have four major areas for academic teaching and research focus. They are human factors, operation research, manufacturing, and management systems.

A management process has become more important due to some of the following reasons. In the past, personal experiences may overshadow the importance of performance information when making decisions or taking actions. Given the comprehensive integration of knowledge management in an organization, the use of information for managerial decisions and actions has become more prominent. Furthermore, due to the improvement in information and communication technology, databases have become more flexible and robust. Information generated from these databases has become more user-friendly. Moreover, the pressure on good governance and accountability has resulted in the increasing use of performance measurement—continuously generating information based on decisions made and actions taken to improve operational and organizational performance.

A management process helps describe the foremost responsibility for all managers. It illustrates that a manager should be accountable for his/her decisions and actions as their impacts need to be continuously measured. More importantly, a management process helps drive organizational missions, policies, and objectives. In addition, a management process strengthens organizational capability to overcome current competition and to better prepare for future endeavors in the globalization era. Therefore, an effective management process should benefit any organization operating under financial limitations, demographic changes, changing expectations of customers and/or citizens.

Finally, thanks to the three famous statements ("you cannot manage what you cannot measure, you cannot measure what you cannot define, and you cannot define what you do not understand") made by Deming (1986), people have recognized the roles and contributions of IE for this aspect. It is nevertheless important to recognize that the management system areas are still emerging and developing as an organizational system continues to be more complex. Other research subjects in the management system consist of system design and development, new product development, quality management, applied decision theories, process reengineering, and ownership and life-cycle management, self-managed and autonomous work teams, knowledge management, others.

Opening Remarks to Students

The book aims to build the foundation and understanding of productivity management which has remained critical for an organization's long-term competitiveness. It has several components, including historical development, contemporary management issues, research, tools and techniques, and case demonstrations. The textbook should help the students visualize several pertinent issues such as what to measure, where to measure, how to measure, and when to measure performance/productivity.

This textbook is based on a series of research completed by doctoral and master-degree students over the years with strong collaboration from private firms, state enterprises, and relevant public agencies, in particular Thailand's Ministry of Industry and Office of the Public Sector Development Commission. In addition, the case demonstrations are derived from the academic articles that have been published in the journals which employ vigorous double-blind reviews. These publications had taken place during 2006–2013.

The textbook is designed for the fourth-year undergraduate and the graduate students. It has been used at Thailand's Kasetsart University, especially 206447 (Productivity Measurement and Management) and 206557 (Productivity Management), and Engineering Management's 222531 (Performance Measurement, Assessment, and Analysis). In addition, most subjects in the text have been part of the lectures taught at Finland's Vaasa University and Oulu University, India's Institute of Management Technology—Ghaziabad, Poland's Maria Curie-Skłodowska University, Slovenia's International School of Social and Business Studies, Taiwan's National Chung Hsing University, USA's Virginia Polytechnic Institute and State University or Virginia Tech.

Chapter One

Productivity Overview

Introduction

The chapter deals with the historical development and current business practices. From its inception in late 1800s, as a result of the global industrial revolution, the term productivity has been recognized for its contribution to operational, organizational, industrial, and national competitiveness. It implies how well the resources are utilized for goods and service generation (and, from the national perspective, the wealth generation). The use of productivity as a strategic objective in a business is illustrated through the growing importance of low-cost carriers. The chapter continues to focus on productivity measurement. The overview on current practices relating to productivity measurement is described. The illustrations on how productivity is measured are provided. The following section focused on the term value added which has been recently popular for productivity measurement, especially at the organizational level. The definitions are clearly described. Finally, the last discussion section describes the emerging trends relating to an organization's productivity management within the emerging business environment. Specifically, the roles of knowledge work in contributing to organizational productivity are discussed.

The term productivity measurement has examined in various fields of study including Economics, Accounting, Management, Psychology, Human Resource Management, and Industrial Engineering. When focusing on the industrial, national, and international levels, the term productivity is used to indicate the level of industrial competitiveness and the ability to maintain low inflation without extensive governmental support. In fact, in the US, Bureau of Labor Statistics monthly releases an overall productivity level which is regarded as one of the most closely watched information. The accountants, human resource managers, and executives alike are always concerned about the organizational productiveness as it indicates the ability raise the salary and wages without a great deal of effects on the selling price.

The higher productivity level implies the lower operating cost. In other words, being productive is equivalent to being competitive. Industrial engineers have always been associated with productivity since its key founding members invented this term back in the late 1800s. From the individual and system level, industrial engineers are expected to look for a better way to reduce the use of resources while increasing the outputs that one generates. For individual workforce, the motion and efforts need to be used wisely while, at the system level, the wastes (of time and others) should be minimized.

Productivity measurement and analysis have gained more recognition from researchers and higher acceptance from practitioners over the past three decades. It has evolved from merely linking individual and accounting-related to more comprehensive information that contains both financial and non-financial information. "You cannot manage what you cannot measure," by Deming (1986), have been continuously repeated over the past three decades by the shakers and movers in the field of engineering and management. This is due to the general belief that the selection of productivity (as well as other performance aspects) measures is one of the greatest single determiners of an organization's effectiveness as a system.

The need to improve productivity measurement is apparent in both manufacturing and service industries. For examples, the Master Plan for Thai Automotive Industry for 2006–2010 by Thailand Automotive Institute in cooperation with the Federation of Thai Industries (published on February 28th, 2006) highlighted the continuous productivity improvement through comprehensive measurement and analysis. Many organizations have used productivity measurement as a primary tool for communicating future directions, establishing functional and project accountability, defining the roles and responsibilities, allocating the limited resources, monitoring and evaluating the activities, linking among key organizational processes, establishing the targets and benchmarks, and initiating necessary changes to ensure continuous improvement.

Historical Development and Current Business Practices

Productivity is defined as outputs divided by inputs (Taylor, 1911; and Barnes, 1980). It has always been recognized this way since the term was first mentioned in the late 1800s. The outputs represent products and goods (and later services) generated while the inputs include key resources used for this generation, especially in the immediate factors such as labors, materials, and machines. Productivity indicates the ability of all related activity to produce. Instead of independently and separately focusing on the input and output sides, productivity represented a major philosophical shift in how a work system (including a workstation, an assembly line, a process, and a plant) would be analyzed for continuous improvement.

When dividing the outputs by the inputs, the implications show how well the inputs (which can be described as the resources) are utilized in order to generate the outputs. These implications help shape the analysis from the improvement perspective. Simply put, improving the use of the resources must show the impacts on the outputs. It is important to note that if the definition is reserved (i.e., indicating how much resources needed in order to generate one output unit), the analysis could be looked at from the control viewpoint—to control the use of resources during the production.

Initially, productivity measurement and analysis focused on the individual level, especially at the assembly and production lines (Takala, Suwansaranyu, & Phusavat, 2006). The pressure to increase the product volumes while lowering and/or maintaining the production cost helped underline the importance of productivity and the linkage with business planning. Individualistic viewpoint (in reference to craft or skill production—uniqueness) needed to be transformed into what is known today as mass production—uniformity. After the improvement in medical treatments in the early 1800s, the world population had increased rapidly. This increase resulted in the higher demands for the basic goods, fueling the growth in the textile, tobacco, and ship building industries.

Coupled with the Industrial Revolution, the advancement and applications in machinery for production and transport resulted in the increase of large-scale or mass production lines which could be categorized as labor intensive. Often, the colonization period in Africa, Asia, and South America represented an example which highlights the attempt to secure natural resources, raw materials, and labors in order to assure the ability to produce the goods in a massive scale with little cost. These large-scale production lines, which consisted of labors and machines, underlined two important needs. The first need dealt with the product uniformity for consumers across the countries and continents. This uniformity requirement, under the mass production scheme, led to the need to have work standards to be followed and practiced by all workers alike. Standardization was associated with this attempt.

Because of more international trades and economic liberalization in the early 1900s, the competition forced the companies to constantly focus on the ability to maintain and/or lower their production cost. At the same time, due to past exploitation and suppression (e.g., poor and unsafe working conditions, and unfair labor wages and practices), labor unions were formed to counterbalance the owner side. Relying primarily on cost control (e.g., labor wages) has greatly contributed to production stoppages, labor strikes and unrests. As a result, new regulatory requirements were passed to protect the workers' rights. By then, a new philosophy begins to emerge.

The new philosophy was based on the premise that the labor wage could be substantially increased without the increase in the product price—which meant that a firm could still retain and/or increase its market share. To achieve the higher production rate did not necessarily suggest that more labors and machinery will be needed. The good design based on the scientific study (i.e., the use of human motions and the understanding of human capability and limitations) can lead to higher production's outputs. This eventually became the essential part of motion and time study which has later been used along with the term Scientific Management.

The term productivity became a permanent footprint in an organization during the World War II in which there was a need to increase the volume of war-fighting machines produced (e.g., aircrafts, tanks, and ships) under limited resources (as a result of enlisting the fighting workforce). Productivity was widely used as the feedback to determine how well and effective the limited resources (e.g., labors, materials, machineries, and facilities) had been utilized to produce the outputs to help fight the wars in the Atlantic and Pacific theatres simultaneously.

Key terms and tasks relating to productivity such as work manuals, standardization, interchangability, workspace, production stoppages, machines' set up, inventory, inbound and outbound, and quantitative analysis emerged. This productivity improvement has continued after the war as the Marshall Plan requires massive reconstruction to ensure peaceful transition in the western part of Europe and Japan. The US industries used productivity as a yardstick to monitor the progress in their production and operational systems (i.e., by reporting the yield and inventory turnover information as well as machine downtime and system availability). The efforts on eliminating the wastes such as waiting time, rejects, returns, rework, and work-in-process constantly linked to productivity improvement. From the past to the present, the business practices have often focused on productivity as one of the key strategic objectives. Cost competitiveness in the globalization era has contributed to long term business success. Boeing (www.boeing.com) has been able to sustain its business success and global footprint through various strategies, and mergers and acquisitions (e.g., McDonnell Douglas's take over in 1997). Throughout the years, productivity has been an integral part of its business strategy.

Specifically, for new product development, the focus is on the lifecycle design which considers commonality and interchangeability. These two consideration factors have helped ensure: (1) less design time due to familiarity of parts, (2) less production set up, (3) larger order quantities from suppliers and contractors resulting, (4) less time for users to learn and operate new aircraft, (5) more availability of spares in the marketplace, etc. It is part of the win-win strategies for Boeing and its customers and suppliers/contractors. Boeing's assembly plants have become more productive while the aircrafts are productively used by the airlines. Many of the support aircrafts for military operations have also adapted this practice (Blanchard, 208).

For examples, new Boeing 737s have over 60% common parts to each other which results in less cost for Boeing and the airlines, improved productivity at Boeing's assembly line and the airlines' aircraft utilization, less time for production for Boeing, and airport turnaround time for the airlines. The same design practice has been applied for Boeing 777 and 787. In addition, Boeing's military versions of the Boeing 767 model have served prominently in many applications. The Boeing KC-767 is a military aerial refueling and strategic transport aircraft which was earlier developed from the Boeing 767-200 Extended Range or ER. The Boeing E-767 is an Airborne Early Warning and Control aircraft. It was specifically designed in response to the Japan Air Self-Defense Force's requirements. This aircraft is essentially based on a Boeing 767-200 platform.

The term productivity has been frequently used to highlight the breakthrough into the aviation industry. The low cost carriers or LCCs started with the overall aim to ensure the productive use of two critical assets, namely aircrafts and employees. For aircraft acquisition, LCCs have largely employed a single model strategy. It means that they only acquire one aircraft model for the entire fleet. This decision has helped logistics footprint (e.g., spares, technician services, training for pilots and technicians, databases and software, handling, test and support, etc.) and subsequently lower operating and maintenance costs. In addition, because of the high level of familiarity, the time from acquisition to utilization becomes less. In addition, the aircraft turnaround time when landing and departure has been greatly reduced. This has resulted in higher productivity which results in the ability to lower ticket price for passengers.

It is important to note that Boeing 737-series (of classic such as Boeing 737-300, 400, and 500, and new generations such as Boeing 737-700, 800, 900, and MAX) as well as Airbus 319- and 320-family are the models commonly selected for LCCs. Southwest Airlines (US), Lion Air (Asia), Ryan Air (Europe), and Norwegian Air Shuttle (Europe) demonstrate the examples of LCCs which have selected Boeing 737. On the other hand, Air Asia Group (Asia), IndiGo (Asia), and easy Jet (Europe) represent the LCCs which have acquired Airbus 319 or 320 for their operations. Each of the aforementioned airlines has its fleet size of more than 100 aircrafts with large orders placed for future expansion of routes.

Particularly in Thailand (based on the report published by Bangkok Post on May 13, 2013), there are two major LCCs; i.e., Thai Air Asia (which is currently using Airbus 320-family) and Nok Air (which has selected Boeing 737-800 as its workhorse). By 2014, Nok Air expects to have Boeing 737-800 in its fleet in order to accommodate with the growing demands for domestic travelers. Due to the ability of consumers to afford local air travels (thanks largely to the productivity focus and open competition), the number of passengers flying domestic routes have doubled from 2005–2012. Out of 17 millions domestic passengers, LCCs makes up of more than 53.5%. In fact, approximately 53% of airline seats available in Southeast Asia belong to LCCs. Given the upcoming Association of Southeast Asian Nations or ASEAN Economic Community in 2015, the competition among LCCs (e.g., Cebu Pacific, Tigers Air, Lion Air, etc.) in the region is expected to intensify. The airline which exhibits the high level of productiveness will have a competitive advantage.

Note that there are four strategies deployed by the world's first LCC—Southwest Airlines. They are: (1) a single aircraft model for acquisition to reduce operating and maintenance cost, (2) utilization of secondary airport to help reduce landing fees and save time for passengers—since secondary airports (more efficient and less costly as no delay on taxiway and during an approach) tend to be located near the city center

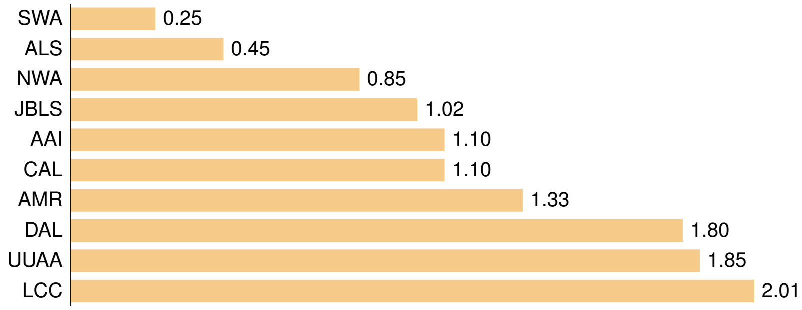

FIGURE 1.1 Customer Satisfaction of LCCs (Southwest Airlines)

such as Dallas Love Field and Chicago Midway instead of Dallas—Fort Worth International Airport and Chicago O'Hare, and (3) limited flying time to 2–3 hours since hot meals are not served. The Southwest Airlines fleet consists of more than 550 aircrafts (www.southwest.com). The airline operates more Boeing 737s in its fleet than any other airline in the world.

Specifically, in terms of aircraft productivity, the full-service or legacy carriers have attempted to catch up with the LCCs. For domestic operations, the full-service airlines tried to employ the productivity strategies of LCCs by flying directly (i.e., point-to-point) instead of a hub stop as well as streamlining aircraft acquisition into a few models for short- and long-haul flights. Nevertheless, the full-service carriers are not able to match the utilization rates (block hours per day of aircraft operation) that LCCs have been achieving. Interestingly, LCCs have also achieved the high satisfactory level from passengers. It indicates that productivity improvement which delivers both cost-effective operations (e.g., operation and maintenance, landing fees, etc.), and time-saving transport (e.g., traveling time from home to a secondary airport, check in time, waiting time, delay time, turnaround time, etc.) for passengers. Simply put, LCCs have enjoyed higher aircraft productivity, known as Utilization Rate- Block Hours per Aircraft per Day (see web.mit.edu/airlines/analysis/analysis_airline_industry.html). In addition, for labor productivity which is assessed in terms of Available Seat Miles or ASMs per Employees), LCCs have performed better.

Not only through acquisition and new investment, productivity improvement in several service organizations is through the focus on quality of work life. Getting back to Southwest Airlines, which is now the largest airline in the United States in accordance to the volume of domestic passengers, it has always attempted to maintain the work and life balance, positive feeling and attitude at the workplace, sense of belongingness and ownership, continuous gathering of front-line staffs' feedback, and corporate support on strong community involvement. As a result, Southwest Airlines has enjoyed higher labor productivity and, more importantly, higher customer satisfaction than legacy or full-service carriers (see http://www.jdpower.com/content/press-release/aOGunkG/2012-north-america-airline-satisfaction-study.htm).

Overview on Measuring Productivity

Attempts to measure profitability have come from various disciplines. There have been many recognized approaches designed and developed by the field of economics such as the Total Factor Productivity (also known as TFP) technique. At the organizational and functional levels, there are several productivity measurement approaches developed such as Multi-factor Productivity Measurement Model. Included are also financial indicators; namely Return on Assets and Return on Investment. At the group and individual levels, there are diverse concepts and methods, ranging from motivational approach (by industrial psychologists) and appraisals for salary structure/job assignments/workload analysis (by human resource specialists), to piece-rate and standard times (by industrial engineers) which deals with productivity measurement and assessment (Zigon, 1998).

To highlight the importance of productivity measurement, the discussion underlines the roles of Bureau of Labor Statistics (www.bls.gov/bls/productivity.htm). This bureau is part of the US's Department of Labor. Its main task is the collect the data for the US government in the areas of economics, an industrial and labor-related statistics. The information from measuring the broad productivity levels as well as relevant cost measures have been used for economic analysis, and public- and private-sector policy planning and initiatives. This information is also used to assess the current and potential changes in the production's unit cost, selling prices, labor wages, and impacts from technology investment. One of the bureau's objectives is to promote productivity improvement. This improvement means the ability to produce more with the same or less input which results an increase in an overall national income. For the past three decades, the US economy in general has been able to produce more goods and services with less consumed resources. It does not call for proportional increased of labor

TABLE 1.1 Demonstration of Productivity Information from US Bureau of Labor Statistics

Category	1987 2011	1987 1990	1990 1995	1995 2000	2000 2007	2007 2011	2010 2011
Multifactor Productivity	0.9	0.5	0.5	1.3	1.4	0.4	1.0
Output per hour of all persons	2.2	1.4	1.6	2.7	2.6	1.9	0.7
Output per unit of capital service	−0.7	−0.4	−0.4	−1.0	−0.5	−1.2	1.9

NOTES Multi-factor productivity information: Compound annual growth rates for productivity, output, and inputs in the private nonfarm business and private business sectors for selected periods from 1987–2011 (%).

time which subsequently causes a unit labor cost to decline and thus maintain the competitiveness (Table 1.1).

The bureau primarily measures productivity in two ways:

1. Labor productivity measures output per hour of labor. The productivity information is available for the non-farm and the manufacturing sectors, including mining, utilities, wholesale and retail trade, and services. Note that Bureau of Labor Statistics conducts extensive international comparisons in regard to the output per hour and unit labor costs in key manufacturing sectors between the US and important trading partners.
2. Multifactor productivity measures output per unit of combined inputs, which consist of labor and capital, and, in some cases, intermediate inputs such as fuel. The productivity information is available for 18 groups of manufacturing industries, 86 detailed manufacturing industries, line-haul railroads and air transportation

The bureau establishes the Division of Productivity Research and Program Development to help conducts research in order to ensure new knowledge in existing productivity measurement concepts and techniques as well as how to better analyze productivity information. Newsletters, technical notes, and reports on productivity analysis and possible future implications for American businesses are regularly published. These documents have also provided a comprehensive coverage into four regions: northeast, south, midwest, and west. For examples, the implications include the changes in the managerial skills, the changes in the production and operations, the changes in the resource allocation, and the direct and indirect impacts from research and development and investments in new technology. Bureau of Labor

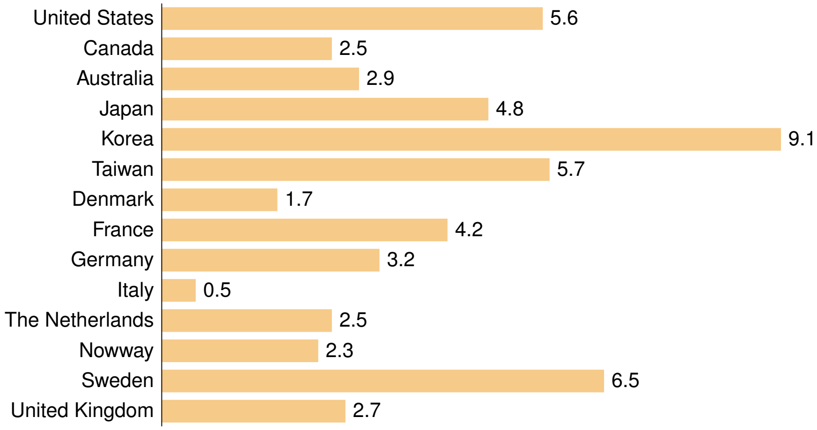

FIGURE 1.2 Labor Productivity's International Comparison by Bureau of Labor Statistics

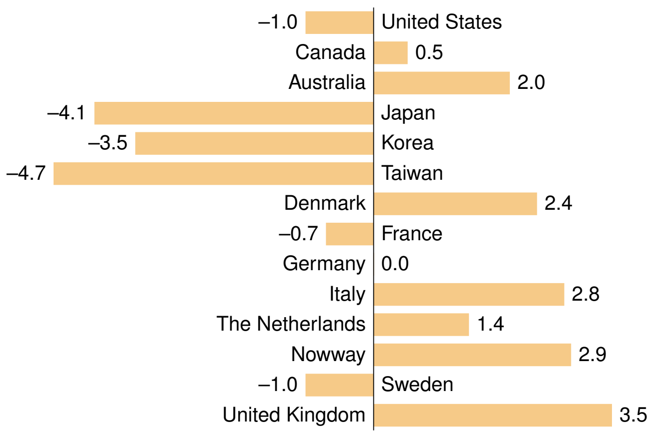

FIGURE 1.3 Impacts from Productivity Improvement on Unit Cost by Bureau of Labor Statistics

Statistics has continued to release the information from productivity measurement based on national and international studies (especially among key trading partners around the world; see Figures 1.2 and 1.3).

For the organizational level, measuring productivity deals with both financial and non-financial aspects. There have been several international well-known institutions dedicated the research and study in advancing productivity measurement and analysis. Namely, they are American Productivity and Quality Center which was originally called American Productivity Center (www.apqc.org), Michigan Manufacturing Technology Center (www.mmtc.org), National Center for Public Performance which was formally called National Center for Public Productivity (www.spaa.newark.rutgers.edu), Asian Productivity Organization (www.apo-tokyo.org), and Singapore' SPRING (www.spring.gov.sg).

Traditionally, productivity management includes an attempt to capture and collect the output data focuses on physical quantity (e.g., units, pieces, and m^2) and financial value. Specifically, for the physical quantity, when the products generated and/or services provided are generally identical, the outputs can be measured in physical units. It is important to note that, for this circumstance, these physical units are largely independent from price fluctuations—part of the push-production system. On the other hand, when the outputs are not homogeneous, many firms choose to measure them in terms of the monetary aspect such as sales and/or output value (sales subtracted by inventory on-hand for finished products).

For the input side, it by and large includes the resources used to generate the outputs. The most common inputs measured are labor, capital, materials, and others categorized as the intermediate factors. In regard to the labor input, the data includes headcount (i.e., persons), cost which includes wages and all fringe benefits, and time which is typically collected in terms of hours. For the capital input, it includes all related physical or tangible assets used to generate the outputs; e.g., machinery and equipment/instrument, and land and buildings. It is commonly measured in ether the physical quantity (e.g. number of machines, equipment hours, and facility space) or the financial value (e.g., depreciation value to production equipments).

For the material inputs, it is normally collected the data in either the physical unit (e.g., pieces, m^2, and m^3) or the financial value (e.g., purchased cost). Finally, the intermediate input factors are energy, and related business and technical services (e.g., inspection, calibration, and certification) required for generating the outputs. These inputs can be captured in terms of the physical units (e.g. kilowatts and m^3) or the financial value (e.g. cost of energy and testing service purchased for product release).

Generally, financial measures reflecting productivity have included inventory turnover, Return on Investment, Return on Assets, etc. At the same time, for technical or non-financial aspect, the measures include production yield, labor productivity, capital productivity, equipment utilization, machine downtime, and plant availability. During the past two decades, productivity measurement tends to incorporate the term downtime—including active maintenance, logistics delays, and administrative delays. Higher downtime indicates the lower level of productiveness on equipments due to a lack of utilization or usage. Availability is also often interpreted as the proportion between operating time and total time. For some, this term links with Mean Time between Failures and Mean Time between Maintenance as they relate to operational time of a machine, an assembly line, and/or a plant.

The measures, examining the waste (which is considered as the undesirable outputs and unwanted use of the inputs, the terms replacements, returns, reworks, and rejects) are part of productivity. For examples, when a rework has to be performed, it means that a company has one output unit while having to consume the inputs or resources at least twice. It shows productivity decline. The similar argument can be made for replacements, returns, and rejects. Manufacturing firms likely pay lots of attention to these measures as they indicate the productiveness (as well as quality). In addition to the "R" terms, the wastes sometimes include the inventory as a result of overproduction, the delay and waiting time, and the unnecessary motions of staffs and employees (Helo, Takala, & Phusavat, 2009).

Because of waste consideration, current practices in measuring organizational (as well as plant) productivity have included quality. Both terms are widely recognized today for their interrelationships. If quality is lower (more rejects, rework, returns, and recalls), it consequently indicates the lower level of productivity and higher unit cost of products. This recognition is underlined by the name change from American Productivity Center (1977–1988) to American Productivity and Quality Center (1988–present). In fact, the Malcolm Balrige National Quality Award was developed in 1985 under the supervision of then American Productivity Center.

Being productive shows that an organization is able to compete based cost. In other words, productivity increase means a decline in a unit cost. This decline should help strengthen a market share which will have positive effects on future investment in labors (through training and skill development), capital (through upgrade and scheduled upkeep), materials (through quality improvement and long-term partnership with suppliers), and intermediate factors (through more efforts on reducing utility usage). Specifically, productivity deals simultane-

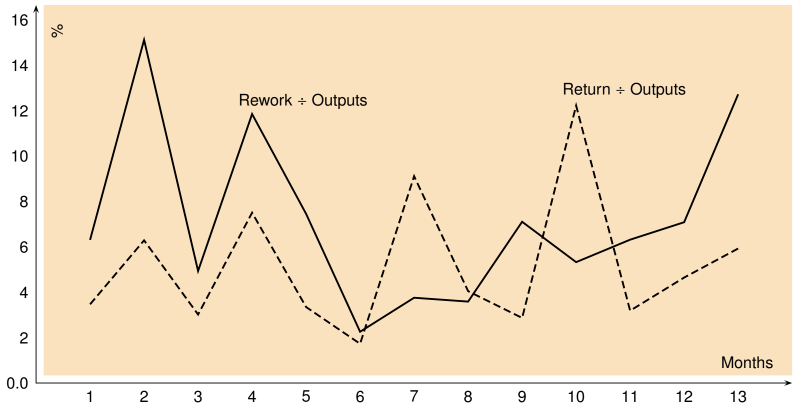

FIGURE 1.4 Indicators Reflecting a Plant's Productivity Level with the Percentage of Rework and of Return

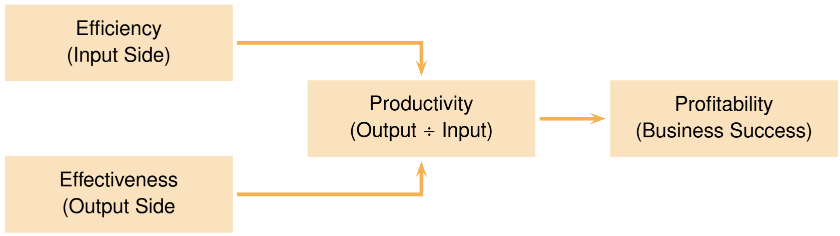

FIGURE 1.5 Interrelationships between Productivity and Other Performance Areas

ously with the output and input sides. When an organization is able to use its resources in a way that it results in less consumption than planned, it is referred to as being efficient. On the other hand, when an organization is able to achieve or exceed its output target, it is referred to as being effective. As a result, efficiency and effectiveness are often used within the context of productivity. As previously mentioned, productivity improvement contributes positively to an organization's profitability. This places productivity as an essential component of an organization's performance (Phusavat, 2007).

In the past, short-sighted view of management advocated the need to control salaries, wages, and fringe benefits while only investing in new machineries when needed. Profit appeared to be rise at the beginning but began to deteriorate. Lowering labor's financial benefits to fuel the profits can result in the labor conflicts which likely lead to more rejects and rework, and subsequently frequent work stoppages. Lasting confrontation and mutual distrust between labor and management should not take place. A lack of capital investment needed for upgrade and upkeep contributed to production slowdowns, longer downtimes, and higher costs in operation and maintenance. This negative effect will ensure production inefficiency (from consuming more resources than needed) and will eventually result in a lower profit level. The only sustainable way to raise profits on the continuous basis is through higher productivity. As a firm continues to share the financial gain with staffs and employees, to constantly invest in new technology and machinery, and to explore new ways to reduce waste; productivity will, without any doubt, improve. In other words, productivity plays the key role to sustaining the profit level in the long run (Sink, 1985).

The initial productivity study was on the blue-collar workers. In the early 1900s, work study attempted to combine the time study (advocated by Taylor, 1911) and the motion study (promoted by Frank and Lillian Gilbreth). In other words, the motion study searched for the best way to perform an assigned task-reducing unnecessary motions and better design of a workstation. An overall aim of the motion study was to help maximize the outputs while inserting the least amount of efforts and time by better methods. For the time study, the focus was on establishing a standard time as a result of motion improvement. This standard time could be used to provide the feedback on the effectiveness of motion improvements, to set production targets for a workplace, and to determine an appropriate level of incentives for a worker. Nowadays, both are the integral part of the term scientific management.

Today, the concept is being applied to manufacturing as well as service firms, including banks, hotels, hospitals, and airlines. For examples, the standard times are for cleaning a guest or a patient room, and for loading and unloading passenger's belongings to help achieve an aircraft turnaround time between landing and taking off. Hotels and other businesses (especially sports) have also employed the motion and time study in order to reduce time and fatigue.

The impact from the motion study is on matching a worker with his/her workstation and related instruments. Matching implies a balance among a worker's characteristics (e.g., age, height, weight, and past injuries), the efforts inserted to complete a task, and the locations of required instruments/equipments. The balance indicates the least possible fatigue level and the minimized ideal time for both a worker and related machines. The time study ensures that there is a benchmark for people who perform a similar task. This benchmark can be used to illustrate continuous improvement as the less time taken by a worker(s) to complete a task, the more productive a workplace has become.

Recently, measuring workforce productivity has shifted towards a new group called white-collar and knowledge work. Their work nature is quite different from that of the shop floor (known as blue-collar) since late 1970s (Phusavat, Anussornnitisarn, Helo, & Dwight, 2009). Knowledge work describes the activities that can help generate knowledge throughout one organization for the purposes of serving external customers and of addressing the needs of internal customers. This change has led to several new studies and research to ensure that the continuity in workforce productivity measurement. One of the initial broad-based studies was conducted in 1981 by then American Productivity Center which called a drastic change in how productivity would be measured. This call was based on several characteristics not exhibited by blue-collar workforce. The study also underlined the need to look at work impacts from white-collar and knowledge workers such as perceived benefits and quality more than assembly-line workers.

Given some significant changes in the workforce, improving workers' productivity level has focused more on use of information technology, motivation, teamwork, freedom and flexibility, self-managed, and continuous skill development through life-long learning programs. Despite the fact that most workers in the more advanced economy are classified as white-collar and knowledge work, measuring their productivity directly appear to be in the black box. The underlying difficulty stems from the premise that the task becomes less repetitive and more creative. For examples, measuring quantitatively the tasks completed by a researcher is more complicated than that of a shop floor worker. Some of the work can be described as follows:

- Perplexity and uncertainty
- Requirements of general skills such as communication and teamwork
- Mainly semi-structured to unstructured decisions with integrating creativity and innovation
- No specific time assigned for each task

Based on the above description, measuring white-collar and knowl-

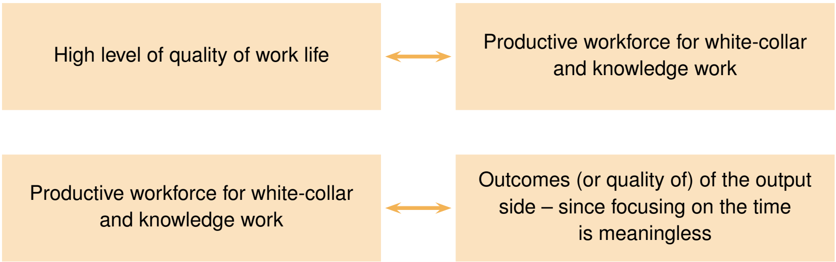

FIGURE 1.6 Surrogate of Productivity Measurement for White-Collar and Knowledge Work

edge workers' productivity has to rely more on the outcomes and due to the difficulty to quantify the outputs. Typically, knowledge workers are researchers, instructors, financial analysts, managers and executives, etc. The outcomes can be the impacts, contributions, and consequences. For examples, a researcher's output cannot be measured in terms of one idea unit but should be captured differently; e.g., perceived potential benefits from a research idea given the 1–5 scale, and satisfactory level given the 1–5 scale. On the other hand, it is difficult to quantify a specific amount of time taken to come up with one idea since it is subject to experiences, creativity, educational background, and others.

Given the nature of white-collar and knowledge work, several attempts have been made in the past to look for the productivity's appropriate surrogate or proxy. For instance, it is probably to substitute productivity measurement with quality of work life. It is based on a presumption that if knowledge workers have positive feeling (e.g., motivation, energy, freedom, and happiness) about their workplace, they become inevitably more productive. Due to its high proportion of the entire workforce as well as growing numbers of knowledge-intensive businesses or knowledge enterprises (e.g., software development, market survey, testing and certification, business advisory, and engineering design, research, etc.), possible applications of a surrogate for productivity measurement is deemed more prominent. Indeed, the focus on measuring white-collar or knowledge workforce productivity has been about quality and/or the output side—on-time submission with satisfactory of the outcomes. The argument for this premise is that, due to the uncertainty and challenge of work as well as more flexible and autonomous working hours, focusing primarily on the input side may not be meaningful.

TABLE 1.2 Summary of Productivity Measurement

Level	Productivity Measurement Approach	Sources
Industry/Nation	(1) Use of Gross Domestic Products or GDP. (2) Integration of labor and capital as the key inputs.	Duke and Torres (2005) Meyer and Harper (2005)
Organization and function	(1) Multi-factor productivity with the focus on labor, capital, materials, and intermediate inputs. (2) Proxy or surrogate (e.g., quality and quality of work life).	Sink and Tuttle (1989) Dixon, Nanni, and Vollman, (1990) Sumanth (1998)
Individual (for all workforce types)	(1) Motion and Time (Work) Study with direct capture of outputs and inputs. (2) Proxy or surrogate (e.g., quality of work life, innovation, work outcomes, output quality, customer satisfaction, etc.).	Hodgetts (1998) Zigon (1998)

In summary, productivity is commonly defined as a quantitative ratio of outputs generated to input consumed. While there is no disagreement on this general premise, measuring productivity at different levels of domain (e.g., national, industrial, organizational, and individual) requires in-depth understanding of how productivity information should be analyzed and the measurement limitations (i.e., dealing with definitions, data collection, and analysis frequency). For examples, when focusing on the raw materials as the inputs, one may encounter about a suitable measurement dimension—unit cost (i.e., $) or a physical unit (i.e., pieces or m^2). In addition, if a unit cost dimension is chosen, which period should this raw material be considered—when it was purchased or it is about to be used. In addition, for the labor input, a company has to clarify whether only full-time workers are to be considered or an inclusion should be made to contracted and/or temporary workers. Therefore, measuring productivity needs various approaches since there is no single productivity measure that can comprehensively provide the entire information. The summary of productivity measurement is presented in Table 1.2.

Value-Added and Productivity Measurement

Productivity measurement generally deals with three perspectives with the primary focus on the input side. The first one is called total factor in which an organization's outputs is divided by a total input. Partial or multi factor productivity measurement involves the relationships between total output and two or more input factors. The last perspective is called single factor productivity measurement—indicating a total output divided by a single input factor. Each perspective represents different challenges for a measurement effort (Phusavat, Fankham-ai, Haapasalo, & Lin, 2011).

For instance, when using the raw material, the debate earlier focused on whether the unit cost incurred when they were purchased or the present unit cost when they are used should be used to reflect their use. When a company begins to contract out certain tasks such as packaging, how this circumstance should be considered for productivity measurement (since the direct headcounts become less). More importantly, the issues relating to time-lag effects (e.g., when investing in a new technology, a firm has to deal with the learning curve before the expected outputs can be realized. If a traditional approach for productivity measurement is used, a firm may be resistant to productivity improvement through future investment upgrade. Then, dealing with the unit dimension difference (e.g., hours, $, etc.) can be difficult when attempting to merge the data for a report to management.

Emerging trends (e.g., human capital brand value and global sourcing) have contributed greatly to several significant changes in productivity measurement. New product development time becomes shorter. Constant changes in output requirements due to the regulations and the pressure from consumer protection groups have resulted in the need to come up with new products and services. Specifically, the question on how to capture the output side more accurately is more prominent since a firm no longer produces the same products or offers the similar product portfolios over the years. The competition has accelerated new product developments and shortened a product's useful life. In addition, recent mergers and acquisitions have been repeatedly used as a strategy for market expansions. As a result of rapid changes in product portfolios, the attention has shifted more on the output side.

Given the trends in the more significant roles from the intangible assets, the attention has turned to how much value a firm is able to generate (instead of merely the products and/or services). Based on the statistics of S&P 500 Market Value (in reference to www.OceanTomo.com), the intangible assets represent approximately 80% of a firm's value. The intangible assets such as human capital and intellectual properties have replaced the tangible assets when assessing and evaluating a firm's market value and brand. The term value added is used to reflect how well a firm is able to utilize both tangible and intangible assets which represent its input factors. This is because an output should not only represent what a firm produces but also reflects the value-added into the products and/or services to be used by customers—indicating the importance of knowledge and innovation. Currently, the key challenge is to ensure that a company's intangible assets are productively utilized.

The contemporary view, derived from Asian Productivity Organization (see www.apo-tokyo.org/productivity/pmtt_015.htm), states the following in regard to the value-added. The value added represents the value which a firm is able to add to the materials in order to create its sale revenue or value of output turnover. It reflects the ability for a firm to generate the value that meets customer requirements and needs. Perceived value shows that customers are satisfied with the products and services received, given the amount of money paid. Because of the importance of intangible assets (e.g., knowledge, human capital, etc.), measuring the value added has been widely practiced to reflect an organization's outputs. This is the case for most small and medium enterprises that have prioritized the innovation and creativity for their operations, including new product development and process improvement. In addition, due to the constant changes in a company's operations such as shifting from a "push" to "pull" approach, use of information and communication technology, constant changes in product portfolio, capital, and more intense business competition; measuring a company's value added appears inevitable.

The value added can be measured in several ways. It is generally defined as how well a firm is able to transform the raw materials into the products that are needed by customers. As a result, the value added represents by the difference between the value of outputs (e.g., expected sale price multiplied by number of products) and the combination of purchased value of raw materials, services needed for production (e.g., external inspections or certifications), and utilities (e.g., electricity and water). This difference represents the value added in which a typical company aims to increase continuously. Based on this definition, the ability to learn and understand customer needs and blend them into new product and service development (including product functionality, life time service support, new product generation, etc.) is essential. The ability to minimize utility usages for production and operations is also critical. Understanding the markets so that a firm is able to acquire needed raw materials at the right cost is important.

Many leading manufacturers and even service providers have begun to consider the value-added as their outputs (instead of an actual output in the physical unit or financial term). Then, the value-added is to be divided by key inputs such as labor, and equipment and machinery. They are known as value-added labor and machinery productivity respectively. Specifically, value-added labor productivity reflects how well a person (or one hour or one Baht used by labor) is able to generate value added (which is measured in terms of Baht). The information from this indicator shows whether a firm is able to utilize its workforce in several areas such as production and other operational processes (e.g., customer relations, new production development, inspection, etc.). Simply put, the substitute of value added for a company's outputs has been widely adapted and is commonly used presently.

In summary, the term value added represents an overall wealth created through a firm's operational process and/or provision of services (e.g., certification and calibration). This wealth is generated by the combined efforts of those who work in the firm (employees) and those who provide needed capital and investments (e.g., managers, executives, and investors). The consideration into outsourced services during output generation needs to be included. A firm's long-term business depends on its ability to create what is known as utility value (i.e., fitness of use, functionality, value for money.)

Value added can be quantitatively computed as follows. It is popularly referred to as the subtract method. The value added can be computed by using data from a company's financial statements (i.e., profit and loss statement, balance sheet). The analysis of value-added information focuses on how well a firm is able to increase the sales by better integrating customer requirements into product functionality and service delivery—adding the value into the raw materials). It also helps a firm focus on listening to the voice of its customers, building core competency, and search for ways to purchase the raw materials at the optimal price. Creativity and innovation in translating customer needs into product and service development become critical.

Value added = Net Sales (or Output Value) – Cost of Outside Purchases.*

* E.g., materials, energy, and outsourced services such as calibration and certification for output generation.

The term value added has also been measured in different ways. For

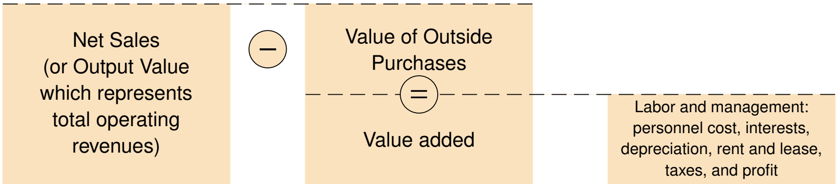

FIGURE 1.7 Computation of Value Added (adapted from www.apo-tokyo.org/productivity/pmtt_015.htm)

some, the value-added is the revenue subtracted by the cost of goods sold and depreciation:

Value added = Sales – (Cost of Goods Sold + Depreciation).

Another popular usage is known as Economic Value Added or EVA. The EVA indicates the financial value derived from a firm's economic profit—a profit earned by the firm after taxes and also subtracted by less the cost of financing the firm's capital. The management has to ensure that the return on the firm's economic capital employed is greater than the cost of that capital.

EVA = Net Operating Profit after Taxes – Capital Charge

Other definitions are illustrated in Table 1.3.

Productivity Measurement in Emerging Business Environment

Interestingly, based on the report published by the US-based National Association of Manufacturers (www.nam.org), the significance of productivity and value-added can be summarized as follows. Worker productivity is considered as a key variable in attracting more interests and investments from foreign manufacturers. Despite the increase in labor

TABLE 1.3 Value Added Definitions

Source	Formula
Bank of Japan	Value added = Ordinary income + Personal costs + Financial costs + Rent + Taxes and Public imposts + Depreciation costs
Mitsubishi Research Institute Japan	Value added = Personal costs + Rent + Depreciation costs + Financing cost + Taxes and public imports
Small and Medium Enterprise Institute	Value added = Production value – (Direct material costs + Cost of parts purchased + Payments to subcontractors + Indirect material costs)

cost, US workers have been among the world's most productive workforce. The use of the value-added concept helps indicate both productivity and quality which are suitable to today changing business environments.

Both productivity and quality are an integral part of the term performance. Furthermore, the US has the most value added per worker than any other of the top ten economies in the world. This high level of value-added labor productivity helps the manufacturing sector remain competitive against low-wage nations. The most recent numbers published in 2009 by the Bureau of Labor Statistics indicate that the value added per worker in the United States was over $118,000, slightly $25,000 more Japan.

The benefit of shifting to the value added productivity measurement contributes to another important development in the recent years. This trend is known as near-sourcing. The essential belief is based on the need to decrease the distance between the source of supplies and the markets will be critical for future competition. Because of continuous increases in value-added productivity (especially labor and capital in the US), coupled with higher labor and other business costs in traditionally low-wage or developing countries, it will eventually become necessary to produce the products near a firm's largest customer bases or markets. According to Michigan Manufacturing Technology Center (www.mmtc.org), there are several indicators being adapted today in the US and other countries with respect to productivity measurement:

- Value-added ($) per full-time employees (persons)
- Value-added ($) per machinery value ($)
- Value-added ($) per capital and labor expenses ($)
- Value-added ($) per production floor space (ft^2)

The need for integrating human capital, knowledge, and other intellectual capital for productivity management continues. Knowledge-based organizations or enterprises have recently enjoyed more prominent roles in the society. Today the financial performance of many companies depends heavily on their ability to introduce new products and/or services, and make applications from new technologies. The time dimension has been recognized as the foundation for long-term business success and it indicates the productive use of resources by eliminating the wastes. The importance of this has been perceived in particular by telecommunication and electronics industries where the product life cycles have shortened to only a few months. As a result, many companies attempt to obtain high performance from their knowledge-work unit or function, such as R&D teams, sales engineering and other activities related to product development. This development has also taken place in other traditional industries such as automobiles and textiles as time management becomes essential for manufacturers, customers, and suppliers.

When performing knowledge-intensive work, one of the most difficult tasks for measurement is to define, estimate, quantify, and collect the data relating the value of inputs and outputs. In addition, an organization's value has depended on intangible assets than tangible assets. Generally, there are two types of a company's asset. The first one is classified as tangible: tangible assets represent the assets that can depreciate and are easily estimated as part of a company's accounting system. They have both book and market values. They are, for example, building, vehicles, equipment, machines, etc. On the other hand, intangible assets represent the knowledge used for work and project completion. This asset type cannot be depreciated by employing traditional accounting methods (e.g., straight-line, etc.).

The intangible assets deal with knowledge (e.g., data and information, expertise and skills, and experience), intellectual properties (e.g., copyrights, trademarks, trade secrets, and patents), brand recognition, customer loyalty, etc. In general, it is not possible to assign the book value. The value of the intangible assets cannot be depreciated by applying traditional methods. Moreover, knowledge work accomplishment and success depend largely on human capital. If using a traditional productivity approach, there is a danger of only capturing human resources in terms of $, time spent on work, and/or headcounts which are not entirely applicable in today workforce. Mostly, knowledge-work outputs, e.g. R&D and customer services, are considered as labor-intensive in the contemporary sense. Financial advisory team does not depend on large buildings. They can work from home or from anywhere. Since a financial deal is not identical, the ability to learn from past mistakes and experiences is critical for becoming a productive work unit. The level of productiveness is perceived as how well it is able to respond to customer needs, requests, and requirements in a timely fashion while achieving the satisfaction—also known as the responsiveness.

Nowadays, productivity is no longer a standalone term. It has been used in association with many contemporary terms. For examples, productivity is often described as a prerequisite for becoming resilient in today economy and competition. Productivity also contributes to the term sustainability. The ability for an organization to utilize the limited resources and to minimize (or even to reuse) the wastes from its operations represents the sustainability's foundation. Productivity is usually discussed when focusing on building a robust organization. A robust organization reflects the ability to adapt to continuous changes in business environment. Time management is essential in this ability.

In conclusion, productivity has evolved over the past century and is now a permanent fixture when focusing on an organization of the future. Becoming productive is part of achieving excellent performance. At the organizational level, productivity has been an integral part of business success and strategies. Both financial and non-financial data has been adapted to help measure and manage productivity. Recently, the use of value-added is advocated in conjunction with the increasing importance of the intangible assets. On the other hand, the use of proxy or surrogate measures reflects the impacts on performance from productivity such as the outcomes or the cause on productivity such as quality of work life.

Exercises

1.1 In your own words, describe the development and movement in regard to productivity measurement and management in accordance to the American Productivity and Quality Center's history (see www.apqc.org/history).

1.2 Examine the roles of Thailand Productivity Institute (or a productivity organization in your country) and identify the past key activities and/or initiatives to help increase public awareness on the importance of productivity.

1.3 It is quite common for an organization not being able to measure R&D productivity directly (using outputs divided by inputs due to the time-lag). Suggest two alternatives that may present the possibility to achieve this task.

1.4 For some, there are at least two key goals for a successful organization such as better product/service quality with lower cost, and higher market share. Discuss what you have learned from LCCs in integrating productivity into these goals. Provide some specific examples.

1.5 According to the recent United Nations report, the average US worker produces $63,885 of wealth per year, more than their counterparts in all other countries, the International Labor Organization said in its report. Ireland comes in second at $55,986, followed by Luxembourg at $55,641, Belgium at $55,235 and France at $54,609. The productivity figure is found by dividing the country's gross domestic product by the number of people employed. The UN report is based on the 2006 figures for many countries, or the most recent available. Review the reports, technical notes, and newsletters published by Bureau of Labor Statistics, and summarize the level of importance on the term productivity in the US from your opinion.

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Chapter Two

Creating a Management System

The chapter deals with the subjects relating to performance measurement and its roles in a management process. There are a total of five sections in the chapter. The first section focuses on building a management system. The description of a management process which links different components within a management system is discussed. The second section demonstrates with the roles of productivity and performance measurement within the context of a management system—ensuring its effectiveness. Included is a case demonstration which highlights productivity measurement in a small firm. The third section summarizes how performance measurement (in which productivity is part of) contributes to a strong management process. The remaining sections are the exercises and the references

As a graduate level at Virginia Polytechnic Institute and State University's or Virginia Tech's Department of Industrial and Systems Engineering, one can choose to enroll in one of the four available options is called the Management Systems. The Management System option is expected to address ongoing problems relating to complex and dynamic organizational systems. Thanks largely to Professors Benjamin Blanchard, D. Scott Sink, Harold Kurstedt, Paul Torgersen, C. Patrick Koelling, and Paul Rossler; the term Management Systems Engineering or MSE is clearly defined. They should be regarded as pioneers in MSE.

There are two ways to interpret what MSE implies. The first one is to engineer a management system. To engineer a management system means to design, develop, and deploy. It has been proven that an effective management system is critical for a high-performance organization. A strong management system can drive organizational policies and achieve stated objectives. Secondly, it is to use an engineering approach to assess a management system. As an industrial engineer, it is often brought up that all system (regardless whether it is primarily a hardware, software, or humanware) consists of the terms "in" and "out." In addition to input and output, an industrial engineer often encounters the terms cash inflow and outflow when dealing with the Discounted Cash Flow Analysis for Engineering Economy. The terms inbound and outbound involve with the flows of finished goods and raw materials during logistic support planning. This essentially represents the fundamental viewpoint for building and analyzing a management system.

Dealing with the terms business processes and process management has often been on operational and technical aspects such as production, services and delivery. Not until in 1990s, researchers and scholars have begun to recognize the importance of a management process. To help highlight its roles for continuous performance improvement in an organization, the American Productivity and Quality Center or the APQC has suggested and classified business processes into operating and management/support categories. This initiative later resulted in the concept known as Process Classification Framework. Within this framework, operating processes include some of the following—design and develop products/services, market and sell products/services, deliver products/services, and manager customer services. On the other hand, the management and support processes deal with managing knowledge, improvement, and change; developing and managing human capital; and managing information technology. Measuring performance and analyzing performance information are an integral part embedded in the management and support processes (Phusavat, Fankham-ai, Haapasalo, & Lin, 2011).

The need to measure performance is underlined by the popularity of a quality management system. In fact, not only performance measurement; analyzing, learning from performance information, and continuous improving the performance level represent a critical process for an organization's management (Deming, 1986). ISO 9001: 2008 specifically mentions measurement, analysis, and improvement as one of its requirements to ensure an effective quality management system.

Commonly, the Malcolm Baldrige National Quality Award or the MBNQA in the US highlights the linkages among performance measurement, information analysis, and knowledge management for sustaining quality excellence. For the MBNQA, clear emphasis is made on the primary responsibility of a firm's management. In addition to a traditional description of planning, coordination, and execution; the focal point is the need to measure the results relating to customer, workforce, and process management. Measuring how well relevant key processes have performed over a specific period such as daily, weekly, monthly, and quarterly. (Please examine the APQC's Process Classification Framework for further usages.) As a result, productivity is often singled out as a crucial aspect of the term performance. More importantly, merely measuring the performance levels is no longer enough (Dixon, Nanni, & Vollman, 1990).

An effective MBNQA cannot be sustained without continuous performance improvement. As a result, the description relating to performance measurement includes information analysis and use of knowledge from past poor performance for continuous improvement in all key processes mentioned earlier (Neely, 1998). Therefore, applications of information technology, statistical analysis, quality tools (such as Cause-and-Effect Diagram, Process Flow Diagram, Bar Chart, Check Sheet, Scattering Plot, and Paretro Diagram), and brainstorming and other team building are important for this linkage. Even successful benchmarking efforts depend on having common performance indicators for process analysis and improvement (Phusavat, Anussornnitisarn, Helo, & Dwight, 2009). Often, this is a foundation for business process reengineering.

Some of contemporary management tools such as the Capability Maturity Model or CMM openly recognize the need for performance measurement and analysis in order to reflect a company's long-term survivability. CMM illustrates a step-by-step framework that reflects the evolution of process improvement. CMM was proposed after the examination of the data collected from primary contractors of US Department of Defense. Due to the long useful life of many aerospace and defense systems, contractor risk (e.g., ability to provide life-time service support, ability to redesign and upgrade a system, etc.) was deemed critical for sustaining war readiness. Therefore, the terms capability and maturity indicate the degree of standardization, formality, and optimization of all key processes. It is important to note that CMM is a registered service mark of Carnegie Mellon University.

Specifically, the CMM Level 4 indicates all processes have to be quantitatively measured and controlled while its Level 5 highlights the need to use this information to help redesign existing processes or develop new processes. This is essential for continuous performance improvement (Neely, 2002). In other words, the process is quantitatively managed in accordance with agreed set of performance indicators (also referred to as metrics, ratios, indexes, etc.). By adapting performance measurement with quantitative data, a firm's management can assess

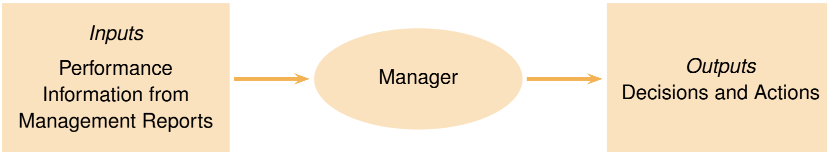

FIGURE 2.1 Input and Output Viewpoints from a Manager

process capability, and also monitor whether this capability is stable and predictable. This ensures that a decision or an action to intervene deals with common causes in order to achieve continuous process improvement.

Building a Management System

The vital component of any management system is always a manager (Kurstedt, 1992). Generally, a manager can be anybody regardless of his or her levels of managerial responsibility in an organization. In other words, a manager can be a managing director, a plant manager, an operation manager, a project manager, and a team leader. Based on the in-out framework (known as the system approach), the primary input for performing managerial tasks is performance information from a management report. Then, the major output from a manager can be described as managerial decisions and/or actions, sometimes referred to as improvement interventions (Figure 2.1).

Extending the system approach further, the output from a manager becomes an input into his or her domain of responsibility. According to the good governance concept which emphasizes accounting and transparency, he or she is obligated to measure the performance of his or her domain responsibility and the impacts from improvement interventions. It is part of follow-up responsibilities and of learning from the mistakes and/or successes. Typically, productivity constitutes the performance to be measured. The key component from measuring the performance levels is the data as it is derived directly from a set of performance indicators identified earlier (Figure 2.2).

By stretching the system approach further by looking at the Performance Measurement and Data on Performance Results as the input, the next component to receive this input is an organization's information and communication technology or ICT. This ICT plays a critical role in translating and converting the data on a set of performance indicators into management information and report. Therefore, this man-

FIGURE 2.2 Input and Output Viewpoints from Domain of Responsibility

FIGURE 2.3 Input and Output Viewpoints from Organization's ICT

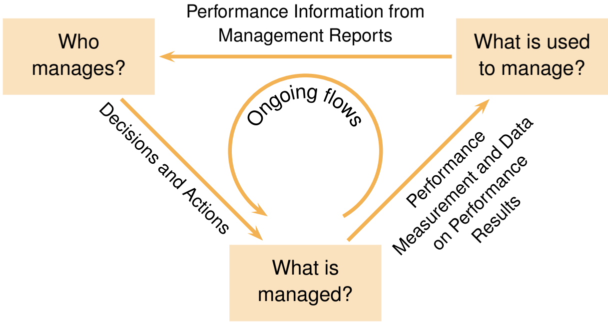

FIGURE 2.4 Illustration of a Management System

agement information can be considered as an output from an organization's ICT (Figure 2.3).

Afterwards, the closed loop can be established. In other words, creating a management system is accomplished by linking all previous inputs and outputs from the three components. To simplify the references used for the three components, the terms "who manages" for a manager, "what is managed" for domain of responsibility, and "what is used to manage" for an organization's ICT. Essentially, a management system consists of three components and three interfaces or linkages (Figure 2.4).

From the viewpoint of a process, a management process consists of performance measurement (i.e., a set of performance indicators and data corresponding to the indicators), performance analysis (i.e., performance information, management report, and evaluation on a report's information), and performance improvement (i.e., making decisions, taking actions, and learning from past performance interventions). As a result, regardless of the type of a management (e.g., quality and safety), these three key tasks always appear as its integral part.

Building a management system helps highlight the need to have better understanding on how to measure and analyze performance, what to measure, and where to improve (Phusavat, 2007). Other extended studies relating to a management system have included decision science (e.g., cognitive engineering, decision quality and methods, etc.), knowledge management, and benchmarking and business process reengineering through best-practice cases.

To ensure that a management system becomes open and dynamics, there is a need to consider and integrate with potential external linkages. As a result, the integration of external knowledge can provide a manager with a complete view of the current situation and future business circumstances. Competitions from existing and unforeseeable competitors (see the airlines and electronics industries) and regulations highlight the need of a manager to be proactive and engaged with external environment. This indicates the long-term ability to deal with various stakeholder groups (e.g., customers, suppliers, contractors, regulators, and consumer advocacy groups). Thereby, a more open management system is developed.

Building an effective management system is needed for both private firms and public agencies (Phusavat, 2008). The effectiveness depends on how well a management process (in accordance to a management system) fits into strategic management of an organization. For examples, a strategic objective of a LCC is to maintain low operating and maintenance cost of an aircraft fleet. Thus, measuring aircraft productivity such as utilization, turnaround time, delays, downtime, available seat miles (or kilometers), and actual passenger miles (or kilometers) flown is critical; in addition to typical financial statements. The productivity analysis needs to link with relevant processes such as training and skill development, acquisition, contract management with suppliers so that suitable improvement interventions can be made.

For the public sector, the need to build an effective management system has been brought up repeatedly since 1980s. There have been a series of requirements and regulations to ensure public accountability among public agencies in various countries. Being accountable im-

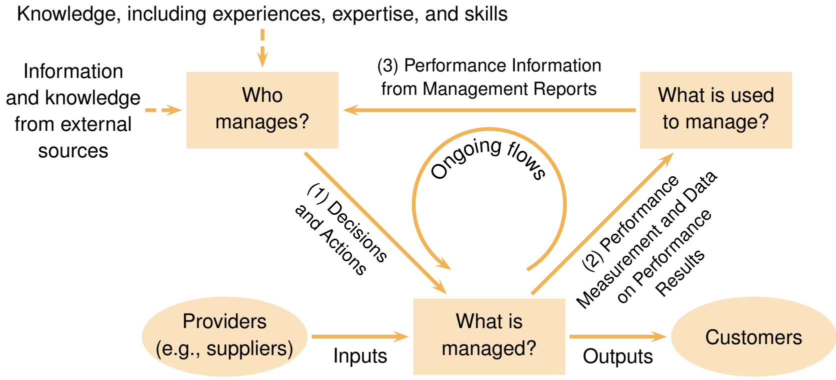

FIGURE 2.5 MSM with Consideration into External Environment

plies performance measurement as a means to demonstrate value-for-money of services provided by public agencies. For examples, there are two major regulations passed in early 1990s as part of the global public-sector reform movement in the US; i.e., Government Performance and Results Act of 1993 and Government Management Reform Act of 1994. Under these acts, all federal agencies are required to measure their performance which primarily includes productivity and quality and to report their performance levels to the general public. Performance agreement is also used to reaffirm commitment, responsibility, and accountability.

By using the system approach in building a management system, it is now possible to assess whether it functions effectively. Simply, by following the flows, the ability to visualize a management system is created. Key questions can be raised. What are the measurement areas that reflect a manager's decisions and actions? How often does a manager receive performance information? Does a manager receive required information that corresponds to his or her domain of responsibility? What is the knowledge learned from a management report? Despite an improving trend, have we improved fast enough relatively to our competitors?

To learn more about the applications of a management system, a case demonstration is to be discussed. Extensive interviews have been made with a managing director of a company during an attempt to help visualize and evaluate the effectiveness of a management system. Founded in 1987, the company under study is part of a large industrial group—an important food producer group in Thailand. The company has exported 70% of its products to international markets such as Japan, Taiwan and Hong Kong. These key products include ready mixed flour, corn starch, rice flour, rice starch, glutinous rice flour, tapioca starch, and modified starch. In 1997, the company became the first operator in Southeast Asia to be certified with both HACCP and ISO 9001: 1994. The company has more than 500 employees and is now expanding into the areas of food warehouses and distributions.

The company's managing director is familiarized with current management tools, business processes, business competitiveness, and market competitors. First of all, the company is constantly striving for international awards and recognition so the issues relating to a management process are of the managing director's interests. From the interviews, there were several subjects that had received a lot of attention. They were as follows:

- An ongoing flow issues such as the contents, continuality, speed, and frequency
- How well information and knowledge from external sources flow into an organization
- How effective the lessons learned are accumulated and shared throughout an organization

Generally, the above subjects deal with the roles of a management process in sustaining high performance and business successes. For specific feedback, a company that relies on exports, it has to be prepared constantly for customer audits and on-site visits. More or less, an on-site customer audit has focused more on process management than product quality. Client representatives typically pay a lot of attention on information awareness and communication across an organization and the level of control within key processes such as production, storage, warehouses, delivery, sales, purchasing, and human resource development. The managing director believes that an effective management process represents one of the critical prerequisites for this achievement. Moreover, a good performance measurement system with vigorous managerial reviews creates more positive impression for the company's customers (Phusavat, Manaves, & Takala, 2007).

Visualizing a management system helps identify key problems or challenges facing the company's managing director. First of all, the MSM underlines the need to have appropriate performance information for individual departments within BIF. Production manager

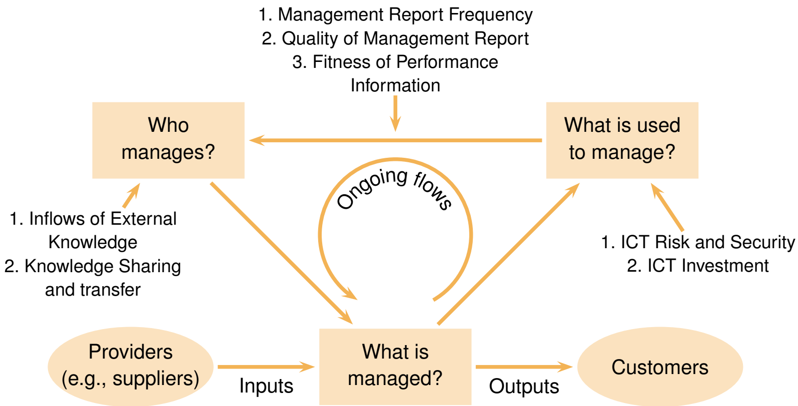

FIGURE 2.6 Key Factors for an Effective MSM

should be provided relevant information relating to plant's operations. Furthermore, procurement, human resource, marketing, local sales, international sales, information technology managers should have performance information on their respective departments. Only production manager appears to have needed information; i.e., technical and financial information. This is probably due to its location which is separated from the company's headquarters. The additional concerns expressed by the managing director include: (1) quality of management report as it probably influences decision quality by managers, (2) database capability as the company is faced with the risk issues such as security and backup, and (3) channels that allow external information to enter individual managers, especially customer and competitor information.

Learning from Integrating Productivity/Performance Measurement in a Management System

In this section, a case application of the MSM is described and discussed. The company under study is classified as a small-medium enterprise or SME. The case illustrates the attempt to apply the MSM and to develop suitable performance measures for analysis and improvement at the production level. The sentiment among the owners was the need to have a separate set of performance measures for a plant manager who would not be familiar with accounting information. In other words, the study's focus was on the issues relating to the company's management processes and its business competitiveness. Furthermore, it was agreed that, in the beginning, the company's management system needed to be assessed and evaluated prior to the development of performance measures.

The company under study was founded in 1995 and is located near Bangkok. During its first year of operation, the company mainly manufactured parts such as Punch and Die Insert for electronic industries. Given a strong financial opportunity in the automotive industry, the company shifted its aim to further provide tooling and spare parts, jig and fixture, and mold for stamping parts for both electronic and automotive industries. In the early 2000s, the number of its entire staffs stood at 60 persons. The company's overall policy was to continuously develop, enhance, and improve our knowledge, skills, expertise, technology, and innovation throughout the organization in order to achieve the advancement of and to satisfy the needs from the employees, customers, and surrounding communities.

After a few extensive reviews, there was one serious weaknesses identified within the company's management system. It was the interfaces of Performance Measurement and Data on Performance Results. This weakness was on the lack of performance measurement that provided comprehensive and insightful information. Apparently, a current accounting system was not suitable in giving information that helped tackle ongoing problems such as customer complaints and rising operational cost. In addition, the managing director and production manager also relied heavily on their judgment and experiences which might not be appropriate, given the fact that the company was expanding and attracting new customers.

Then, the study attempted design and develop productivity, quality, and quality of work life for the company. It was hopeful that this effort would lead to a better flow among the three components of the MSM and more suitable performance information for a plant manager (instead of sharing the same financial report which is weekly reviewed by the company's owners). By ensuring the flow exists and continues, an effective MSM can be established. Due to the company's inability to capture its outputs in a physical unit (e.g., piece or batch), it was decided to use the output value (i.e., piece or batch multiplied by unit prices).

As a result, there were three productivity measures, two quality measures, and two measures for quality of work life proposed for a plant manager. In this study, due to a relative short inventory turnover time

TABLE 2.1 Measuring Productivity, Quality, and Quality of Work Life

Performance criteria	Measures
Productivity*	Output value ÷ Labor cost Output value ÷ Materials Output value ÷ Utility
Quality	Rework ÷ Outputs in % Return ÷ Outputs in %
Quality of Work Life	Unplanned absent period ÷ Working period in % Work stoppage period ÷ Working period in %

NOTES * Due to the data limitation, the term revenue would be used to reflect the value of organizational outputs.

for finished products, the term revenue would be used for the output value (Table 2.1).

The next step in the study would involve data collection and the development of a management report. This exercise aimed to assist the redesign of data collection and reporting processes. Both tabular and graphical portrayals of performance information were included during the study. It was agreed that the data for these proposed measures would later be collected on the monthly basis. Previous data was reorganized for the demonstration of a month report. Performance information relating to productivity, quality, and quality of work life is illustrated in Tables 2.2, 2.3, and 2.4 (p. 61), and in Figures 2.7, 2.8, and 2.9 (p. 60).

Note that the company under study produced several products while using the same machines and equipment, and workers. As a result, one problem emerged when using the physical unit such as pieces to measure the output side. The reason was that not all outputs had an equal weight. For examples, a company which produces one motorcycle and one truck cannot simply add the two products together to become two pieces. Despite that both motorcycle and truck can be measured in terms of the physical unit, the consideration of the weight difference (as a result of different selling prices). The same reason can be implied when focusing on the input side. Instead of focusing on the number of aircrafts available, the airlines adapt the seat available (or the availability of seat-miles). This is due to different aircraft sizes.

In the study, a further task involved performance analysis. For the analysis, two examples can be discussed. The first analysis example deals with examining individual measures and understanding their corresponding trends. The immediate task for the company's manage-

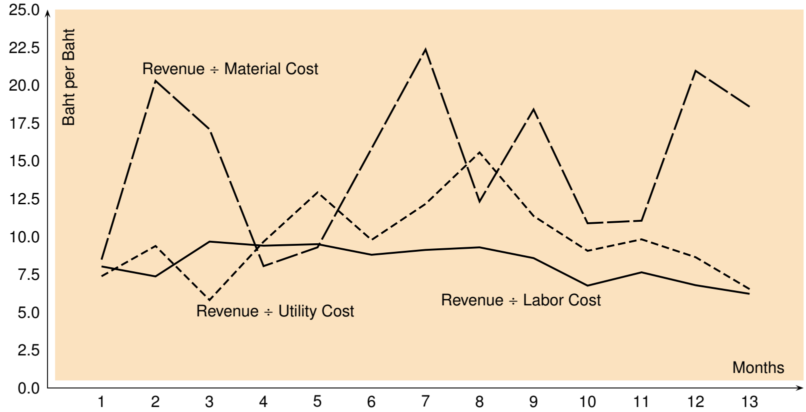

FIGURE 2.7 Productivity Information in the Graphical Format

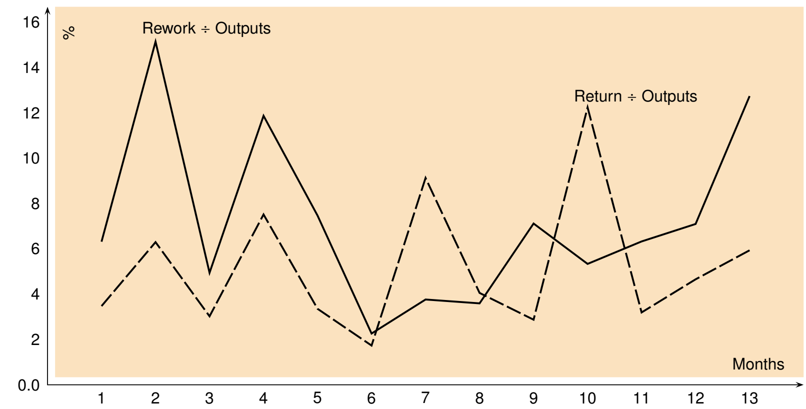

FIGURE 2.8 Quality Information in the Graphical Format

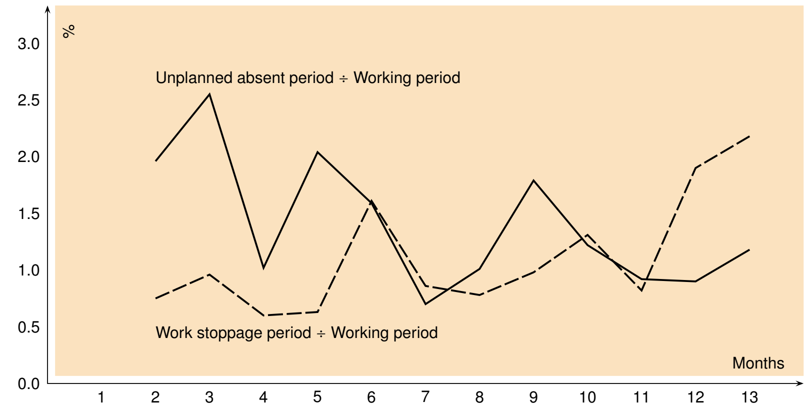

FIGURE 2.9 Quality of Work Life Information in the Graphical Format

TABLE 2.2 Productivity Information in the Tabular Format

Item	Month												
	1	2	3	4	5	6	7	8	9	10	11	12	13
(1)	8.03	7.37	9.67	9.40	9.50	8.80	9.12	9.29	8.58	6.76	7.64	6.79	6.22
(2)	8.48	20.29	17.09	8.05	9.29	15.82	22.36	12.32	18.40	10.88	11.05	20.95	18.58
(3)	7.38	9.38	5.81	9.66	12.92	9.78	12.16	15.56	11.36	9.06	9.82	8.64	6.53

NOTES Row headings are as follows: (1) Revenue ÷ Labor Cost, (2) Revenue ÷ Material Cost, (3) Revenue ÷ Utility Cost. The term revenue is used as a proxy for the output value.

TABLE 2.3 Quality Information in the Tabular Format

Item	Month												
	1	2	3	4	5	6	7	8	9	10	11	12	13
(1)	6.31	15.13	4.94	11.86	7.46	2.26	3.76	3.59	7.11	5.33	6.32	7.09	12.73
(2)	3.47	6.29	3.02	7.51	3.35	1.73	9.12	4.05	2.87	12.23	3.19	4.65	5.93

NOTES Row headings are as follows: (1) Rework ÷ Outputs (%), (2) Return ÷ Outputs (%). Data is based on the financial value of Baht.

TABLE 2.4 Quality of Work Life Information in the Tabular Format

Item	Month												
	1	2	3	4	5	6	7	8	9	10	11	12	13
(1)	—	1.96	2.55	1.02	2.04	1.59	0.70	1.01	1.79	1.22	0.92	0.90	1.18
(2)	—	0.75	0.96	0.60	0.63	1.61	0.86	0.78	0.98	1.31	0.82	1.90	2.18

NOTES Row headings are as follows: (1) Unplanned absent period ÷ Working period (%), (2) Work stoppage period ÷ Working period (%).

ment, including the plant manager, would be to determine the targets for the annual, quarterly, and monthly basis. It was clear that having the indicators alone was not sufficient. More efforts would be needed, especially in the areas of management report, target setting, and staff communication. For the first example, it appeared to be quite simple initially but failed to provide an integrated picture. Analyzing individual indicators pointed to a specific improvement or decline. For examples, the revenue-to-labor cost indicator illustrated a declining trend which would require immediate attention from the management. On the other hand, the unplanned absent period-to-working period (in %) showed an improvement sign.

For the second analysis example, the focus was on examining multiple indicators simultaneously. For productivity, to the surprise of the company's management, labor productivity had declined despite a stable sign from the material side. Training and retraining might not have been as useful as once thought. This simultaneous examination showed the need for more in-depth waste analysis during production. Aging machinery and a lack of conservation on energy and water usages could be cited as two primary contributors to poor utility productivity as well as possible work stoppages which was part of the assessment of quality of work life. For quality, the concern was on the inspection process in which the reasons contributing to both rework and return had to be identified. The rework and return problems should not have taken placed at the same time. The general feeling was as follows. If there was any rework, no return would have been necessary.

Finally, the study highlighted the effort to strengthen the company's management system and to rely more on quantitative information for decision-making—integration of performance measurement. By becoming more familiar with performance measurement, several benefits could be expected. At the time of the study, the company was preparing for the ISO 9001: 2000—certification process, especially when the Requirement 8 explicitly addresses the issues of measurement, analysis, and improvement. This certificate would be necessary for SMEs in competitive industries such as food, furniture, electronic, and automobile. It would help the company gradually move up the confident level of its customers. This will be beneficial when audited by major end-of-the-chain customers such as Toyota Motors. Other key lessons learned included the recognition of the database and the reliance on accounting information when analyzing the performance levels. At the plant level, given the limited availability of data, combining performance information with experiences underscored the roles of a manager. Communication and maintaining visibility when initiating performance measurement were highly critical as some misunderstandings had taken place at the company. The plant workers were concerned about the reduction of overtime pay and the revision on a previous pay-for-performance agreement.

Performance Measurement and Management Process

Performance measurement provides feedback to the following three questions. How well an organization is performing? Is the organization achieving its objectives? How much has the organization improved from a last period? Performance measurement helps create feedback

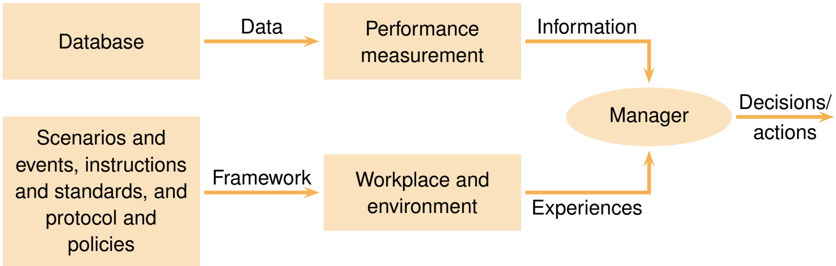

FIGURE 2.10 Performance Measurement and Management's Roles

to managers on the effectiveness of improvement interventions as part of learning and development Performance measurement, coupled with experiences and knowledge learned from past decisions and actions, provides an excellent management tool.

Recently, performance measurement reflects the attempt to become accountable to stakeholders who are mainly interested in a company's impacts. Shareholders pay strong attention to financial performance and returns of a company. Furthermore, performance measurement has begun to play more influential roles in process management within a company as the database has been upgraded with the advancement in information and communication technology. Performance measurement can also be used to reveal how well a company's operations are managed. It gives a sign of management awareness and responsibility which is now highly valued during customer audit.

Performance measurement requires the extensive use of both quantitative and qualitative data with clear definitions and specific frequency for managerial reviews. This is quite helpful for data collection and reporting efforts. For the clear definition, different managers may interpret the term revenue differently. For some, revenue implies cash plus account receivables. For others, revenue indicates cash and future receivable amounts subtracted returns of goods sold to customers. In addition, the dimensional units must also be stated. The term labor has at least 3 dimensions, i.e., time (hours), headcounts (persons), and financial value (dollars). The term maintenance may be collected in various dimensional units such as frequency (times), cost (dollars), and headcounts (persons), and time (hours). The specific frequency of review (daily, weekly, monthly, quarterly, and so on) is helpful for reporting.

The study was earlier conducted in Thailand to identify future roles of performance measurement within an organization. Six leading private firms and six well-recognized public agencies participated in this study. The discussions focused on their viewpoints, and past and current policies, objectives, and initiatives relating to performance measurement. Their comments are recorded and later categorized into key groups or codes—in accordance to the Grounded Theory. Based on their responses, the following terms represent the descriptions of performance measurement: (1) management responsibility, (2) management tool, (3) a component for a quality management system, and (4) a foundation for a knowledge-based organization. This code represents repeated assertions during the interviews.

For the private sector, the interview involved the senior level in an organization. The official title of the interviewees included managing directors, accounting managers, and production/operation managers. The company's backgrounds were as follows.

1. Service provider: software solutions for accounting and financial systems with 80 staffs
2. Service provider: transportation services (raw materials) with 60 staffs
3. Service provider: warehouse and distribution services (finished products) with 90 staffs
4. Manufacturer: food (cooking starch) products with 450 staffs
5. Manufacturer: automotive parts with 200 staffs
6. Manufacturer: high voltage equipment for a distribution system with 250 staffs

All six participating companies were certified with ISO 9001:2000 and/or 2008 and had previously applied the Thailand Quality Award (which resembles the MBNQA). These companies were members of the Federation of Thai Industries and were recognized as a leading company in their respectively industries. They had also operated in their businesses for more than 15 years. This selection criterion was important so that performance measurement had been deployed for quite some time.

For the public sector, the official title of the interviewees included deputy director generals, deputy commissioners, and senior advisors. The agency's backgrounds were as follows.

1. Agency in charge of research policies and funding. This agency belongs to Office of the Prime Minister.

2. Agency in charge of the entire public sector's budget preparation and allocation. This agency belongs to Office of the Prime Minister.
3. Agency in charge of updating and revising the regulations for accounting practices and financial management among public agencies. It belongs to Ministry of Finance.
4. Agency in charge of research on science and mathematics teaching and learning for primary and secondary students as well as training and skill development of teachers. This agency belongs to Ministry of Education.
5. Agency in charge of improving social welfares among citizens (e.g., a lack of affordable homes, poverty, and healthcare). This agency belongs to Ministry of Interior.
6. Agency in charge of inspection of industrial factories to ensure health and safety of their workforce as well as pollution control. This agency belongs to Ministry of Industry.

All six participating agencies were considered to be leading candidates for the upcoming event for the Public Sector Quality Management Award (adapted from Thailand Quality Award for public agencies). They had also received a high satisfactory mark from their stakeholders and have maintained good reputations and images among their peers. For the opinions expressed by participants from the private sector, performance measurement was a necessary tool for successful management. They perceived this term as a representation of a new managerial style in the workplace. Performance measurement underlined the change towards management by information and knowledge instead of primarily relying on experiences and judgment. It signified one of the desirable outcomes from recent investment in information and communication technology. Performance measurement was strongly related to knowledge management as Learning from past mistakes is made possible with performance measurement.

For the public sector, performance measurement was mandated as part of a performance agreement between an agency's head and his/her superior. This requirement was part of an effort to integrate a 4-year strategic plan with annual performance goals and targets into a management process within individual agencies. Performance measurement helped bring new terms and concepts such as efficiency, productivity, and quality into day-to-day operations. In addition, both the

TABLE 2.5 Past and Present Viewpoints on Performance Measurement

Examples of the comments on performance measurement from the interviews	Past-to present categories
Highlighting the requirements and responsibility of management. Representing a milestone of effective management—implying a serious management failure without performance measurement.	Reflecting management responsibility
Being considered as an information provider. Representing a more systematic mechanism for feedback and information. Reflecting a more systematic decision-making process. Being utilized with accounting information for better insights into a company's operations. Providing feedback for planning and strategic decisions—how productive an agency is, how well an agency provides the services to citizens. Linking database with managerial decisions. Benchmarking efforts in an organization.	Representing a management tool (e.g., a decision-making process that is based on performance information)
Increasing more acceptances from staffs when making policy initiatives and decisions. Improving communications between management and workforce with greater visibility. Being required by ISO 9001: 2000 as well as the 2008 version as a means to help make better and timely decisions.	Indicating a strength of a quality management system (for both ISO 9001: 2000 and 2008, and Thailand Quality Award).
Representing a foundation of knowledge management as required by Thailand Quality Award. Enhancing a learning capability of an organization as there is more visibility for everyone. Being part of how information should be made available and accessible to staffs.	Supporting an effort on becoming a Learning or knowledge-based organization.

Budget Bureau and Ministry of Finance had encouraged public agencies to develop performance measurement that is unique in order to monitor and evaluate the progress of an organization. The summary of the viewpoints on past and present descriptions in regard to performance measurement is presented in Table 2.5.

It should be noted that, based on the first part of the interviews, the level of complexity on the roles of performance measurement from the past to the present appeared to increase gradually. Performance measurement-related tasks such as identifying an appropriate set of

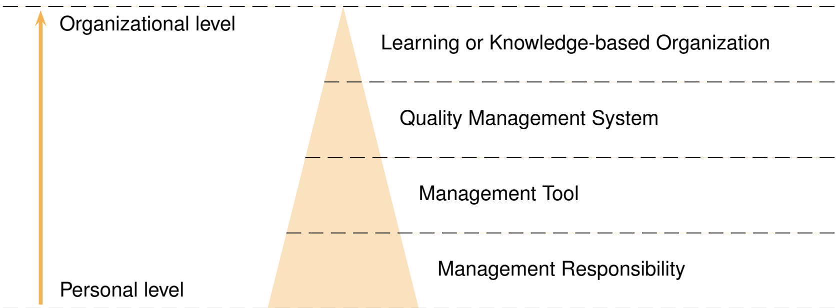

FIGURE 2.11 Increasing Levels of Complexity from Performance Measurement

key performance indicators, revising and modifying this set at least on the annual basis, and setting and communicating the target levels based on these indicators represented the fundamental responsibilities of top management. It was also regarded as an important management tool to help direct an organization and/or an operation. Progressively, it became an integral part of a quality management system. Finally, it was considered as a foundation for a learning organization. Based on the interviews, performance measurement had become broader and complex with stronger relationships to management responsibility.

The next stage of the interview was more challenging. It involved future viewpoints on the roles of performance management. This represented the attempt to capture what the interviewees perceived as the future trends in performance measurement in the workplace and an organization. The interviews, with the same group of top management, revealed many remarkable thoughts on the emerging importance and future roles of performance measurement. Despite the fact that some comments might be conceptual and abstract in nature, they were helpful in visualizing the future shape and form of performance measurement. In fact, for the interviews with senior executives from the public sector, this study represented an initial step in gaining more knowledge on the concept of Government 2.0 (Eggers, 2005). Interestingly, their viewpoints were not as diverse as anticipated. It appeared that participants center their opinions, based on past experiences and familiarity with international practices.

It is important to note that participants generally agreed that performance measurement would become more important and would imply how well an organization or a functional unit was managed—high

TABLE 2.6 Future Viewpoints on Performance Measurement

Examples of the comments on performance measurement from the interviews	Future categories
Symbolizing good governance in the era of globalization and social responsibility. Demonstrating management commitment towards continuous performance improvement. High performance public agency needs to include productivity, quality, and value-for-money from the viewpoint of taxpayers. Strengthening a company's execution capability on its strategies, policies, and objectives. Indicating a strong evidence for good control and supervision-oversight. Performance measurement, with two-way communication, will indicate transparency, participatory governance, and check-and-balance mechanism.	Reflecting good governance, transparency, and oversight.
Serving as a reminder of future responsibility for managerial decisions made today. Answering the call for more effective mechanism on monitoring and evaluation. Enhancing organizational flexibility and responsiveness as performance information becomes available faster.	Strengthening accountability.
Being foundation for a more complex audit on value for money or budget spent. Supporting the need to audit outputs and outcomes of a project or a program (instead of focusing on a budget and processes of spending money). Influencing the shift the viewpoint from compliance to soundness (impacts and desirable outcomes) of management in an organization.	Assisting in the enlargement of the audit scope to be performed by external parties (e.g., governmental agencies and/or citizens).
Representing groundwork for making operations in an organization more repeatable and predictable (as the focus is on variations—root causes of a problem instead of random attributes). Strengthening working environment that focuses improvement such as a use of benchmarking practices. Symbolizing competency of top management and capability of an organization.	Attaining desirable characteristics from external parties—competency and capability.

performance with openness to all stakeholders. Any future reforms to become more open and mobile government would need performance measurement. Performance measurement would become one of the focal points in an organization for external stakeholders (as part of audits—manufacturers and suppliers for contractual partnership, and citizen groups and agencies for public spending). Apparently, perfor-

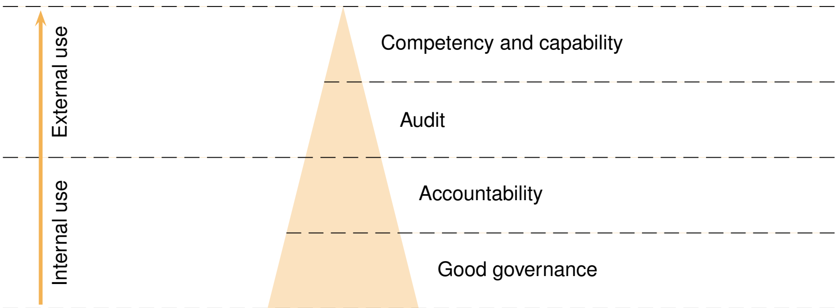

FIGURE 2.12 Shift towards External Use

mance measurement largely would reflect professionalism and competency of top management in the near future.

Given the opinions expressed by leading managers and administrators, a relatively consistent perspective on performance measurement began to emerge. Past and present points of view indicate that performance had gradually moved from merely a management tool to become an integral part of a quality management system. The perceived importance highlighted performance measurement as a prerequisite for attaining a learning behavior. This behavior became critical in the era of globalization and limited resources with more challenging goals and objectives for continuous performance improvement.

The participants' future anticipation on performance measurement appeared to be more complex as it symbolized ongoing and future trends on transparency, accountability, empowerment of staffs, and public participation in governmental affairs. It also represented as a surrogate or a proxy for desirable characteristics of organizational capability and competent management. It reflected a sought-after evidence of how an organization or a functional unit should be managed. More importantly, the participants agreed that the extensive use of information and communication technology would contribute greatly to an effective performance measurement.

Document reviews support the above findings on performance measurement. Probably, one of the clearest examples is the series of the regulations passed by the US government. They require all public agencies to establish performance measurement by focusing on several aspects such as productivity, quality, and value for money. These regulations are namely: (1) Government Performance Results Act of 1993 or GPRA, (2) Government Management Reform Act of 1994 or GMRA, (3) Information Technology Management Reform Act of 1996 or ITMRA, and (4) Executive Order 12862 on Setting Customer Service Standards. These regulations aim to: (1) inspire the confidence of citizens on the performance levels, especially quality, standards, and consistency of services that they receive, (2) to ensure that public agencies are responsive to citizens, and are operationally effective, efficient, and productive while maintaining fiscal responsibilities, and (3) to shift the focus from the operational processes and inputs to the outputs and outcomes of impacts from an agency.

To ensure that all public agencies would be accountable with good governance practices, the Office of Management and Budget of the US government earlier developed a performance measurement-related tool in the early 2000s. This initiative was called Program Assessment Rating Tool or PART. Information from performance measurement represented effective management practices. Moreover, performance measurement played a crucial role in implementing value-for-money or performance audits. There were several regions and countries that have performed value-for-money audits such as European Court of Auditors for European countries, Hong Kong, and Singapore. The aim was to ensure the public's confidence and trust in governmental spending. Simply put, performance measurement underlines management's responsibilities which include measuring, learning, and improving (Kess, Phusavat, Torkko, & Takala, 2008).

From 1980s until 2010s, there have been so many concepts developed relating to performance measurement (Kaplan and Norton, 2004). It has included several attempts to measure specific areas such as productivity, quality, innovation, and profitability. On the other hand, various comprehensive frameworks have been proposed so that the entire performance can be measured. Despite the fact that an organization's objective is different, many proposed performance measurement concepts allow individual organizations to adapt. Sink and Tuttle (1989) suggested that measuring performance would include seven criteria (i.e., profitability, productivity, quality, quality of work life, efficiency, effectiveness, and innovation).

For a public agency, the term budgetability was to be a substitute for profitability. Nowadays, the inclusion of stakeholders was the focus instead of the shareholders when adapting by a public agency. Based on the 1996 Guidelines for Performance Measurement published by Office of Policy, US Department of Energy and the 2001 OECD Manual on

TABLE 2.7 Performance Measurement Summary

Subject	Description
Research disciplines	(1) International/national/industrial levels: Economics (2) Organizational/functional levels: Business Administration (especially Accounting), Engineering (especially Industrial Engineering), Social Science (especially Industrial Psychology) (3) Group/individual levels: Business Administration (especially Human Resources Management), Engineering (especially Industrial Engineering), Social Science (especially Industrial Psychology)
Components	Many concepts and frameworks (which contain the term productivity): (1) Harper (1984): (i) productivity, (ii) unit cost, (iii) price, (iv) factor proportion, (v) cost proportion, (vi) product mix, and (vii) input allocation (2) Sink and Tuttle (1989): (i) profitability, (ii) productivity, (iii) innovation, (iv) quality of work life, (v) quality, (vi) effectiveness, and (vii) efficiency (3) Thor (1994): (i) profitability, (ii) productivity, (iii) external quality, (iv) internal quality, and (v) other quality (4) Kaplan and Norton (1996): (i) finance, (ii) customer, (iii) internal business process, and (vi) innovation and learning (5) Neely (2002): (i) customers, (ii) employees, (iii) suppliers, (iv) regulators and communities, and (v) investors

Measuring Productivity published by Organisation for Economic Cooperation and Development, the summary of performance measurement is presented in Table 2.7.

Performance measurement should reflect how much knowledge and understanding there is in all necessary areas, processes, and activities. Good performance measurement needs to include both outputs and inputs—indicating productivity. Effective performance measurement needs to incorporate the outcomes and processes. Imagine a person walks into a building in the late night without the lights. It is almost impossible not to stumble on anything. Turing one light on may be helpful on the spot. Having an entire floor brighten may be useful when walking around in that floor. Still, it is not possible to walk to all floors without any incident. This is an analogy of performance measurement. Too few performance measures may not provide a clear picture of how an organization has performed. Then, poor decisions (without proper information) can occur, just like a person walks without the lights in a dark building.

Finally, performance measurement is shown to be a critical part of a management system. Measuring performance provides feedback that a manager needs in order to properly make decisions or take actions. This step requires good database with a timely report for evaluation and analysis. This chapter help underscore the important remark made by Deming (1986) which has been widely used since "you cannot manage what you cannot measure."

Exercises

2.1 Review the quality management system (ISO 9000 series) from the 1987, 1994, 2000, and 2008 versions. In your own words, describe the roles of and the importance of performance measurement in assuring the effectiveness of the ISO 9001 certified company. You should try to look at the required quality records and others within the context of management reviews.

2.2 Review the MBNQA and the European Foundation for Quality Management Award. Identify what constitutes performance information. In other words, what areas should a company attempt to measure?

2.3 Examine any management system that you are used to. Look closely and determine whether there is a gap between performance measurement and the "what is managed" component. Hint: The gap includes financial performance for a manager at the assembly line level who may need more productivity and other technical information for evaluation and analysis.

2.4 Examine Standards, Productivity, and Innovation Board from Singapore (www.spring.gov.sg/Pages/homepage.aspx) and highlight how the term performance measurement has been promoted.

2.5 Compare and contrast Thailand Productivity Institute (www.ftpi.or.th) and Malaysia Productivity Corporation (www.mpc.gov.my/home/index.php) and describe the implementation of performance measurement among small and medium enterprises.

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Chapter Three

Creating Productivity Network through an Integrated Approach

An organizational system consumes several types of the resources for generating the intended outputs. Traditionally, due to the fact that manpower is the key organizational input, labor productivity is often used when measuring an overall productivity level. Given the complexity of and the reliance on other input factors as value-added activities for production, a single indicator does not apparently provide a complete picture of the productivity level within an organization. To a certain extent, an integrated approach that relates various productivity-related measures should be adopted. Dealing with customers to understand their needs prior to partnering with appropriate suppliers or contractors (just in case, services after sales as well as technical services for production and operations are needed) until providing such products and services to satisfy those needed require a comprehensive view on performance. This comprehensiveness also indicates cause-and-effect relationships among productivity-related measures. Relating labor to capital and materials as well as to products and value-added is important for a complete view of the performance levels. Acquiring productivity information, especially value-added productivity, requires a systematic approach which can integrate individual measures into a bigger picture (see *A Guide to Productivity Measurement,* 2011).

The chapter consists of five sections. The first one deals with the concept of productivity network. This network concept was first introduced by Harper (1984). Despite its inception in the early 1980s, the practices are still popular today (based on *A guide to productivity measurement,* 2011). An integrated approach by simultaneously considering various productivity-related indicators provides several benefits. They include the underlined interrelationships which allow a manager to better analyze the factors that contribute to the productivity level, an instantaneous viewpoint on productivity, and to enable an organization to organize the data for supporting productivity measurement efforts.

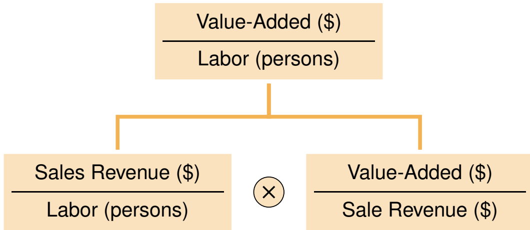

FIGURE 3.1 Use of a Ratio-format Indicator for a Network

The second section presents the case study. The extensive applications from the productivity network are illustrated. The third section discusses key consideration when adapting the network concept for productivity measurement. The last two sections deal with the exercises and the references.

Introduction to Productivity Network Concept

Harper (1984) developed a comprehensive productivity measurement framework that integrated productivity-related indicators into a network. Harper (1984) advocated the use of a ratio-format indicator. It should be noted that Harper (1984) recognized that the ratios had been used extensively, especially in the areas of financial management (e.g., liquidity, debt-equity, inventory turnover, profit margin, return on investment, return on assets, etc.). However, it was necessary to explore a way to explicitly connect and integrate these ratios together. With the use of a ratio as an indicator, it is possible to formulate a network. Once a network is established, it would also contribute to productivity analysis.

For the network in the Figure 3.1, a decline in value-added labor productivity could be attributed by lower sale revenue per a worker (from a new competitor) or a lower margin on sales (from higher product cost). The cause-and-effect analysis should help lead to a better decision. Harper (1984) further suggested that a system analysis would be needed in order to derive the ratios. The number of the ratios in a network would depend on the desirable development of network complexity (e.g., network layers) for productivity analysis, and data availability (Figure 3.2).

There are generally two rules when attempting to develop a network (Harper, 1984). The first one is known as the more-than-one-factor rule. In a production or operational system, more than one input fac-

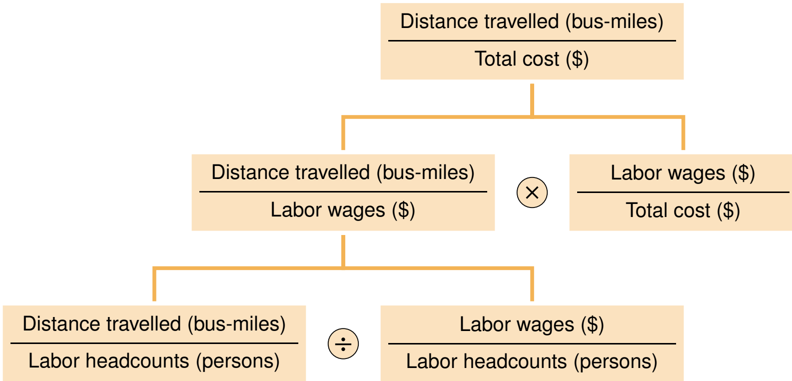

FIGURE 3.2 Illustration of Productivity Network for a Service Provider (Bus Company)

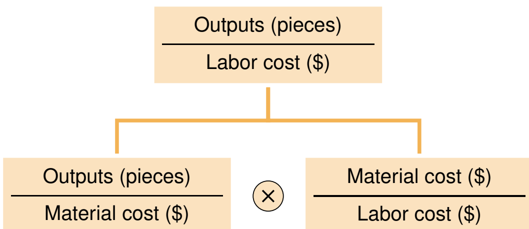

FIGURE 3.3 Illustration of the First Rule

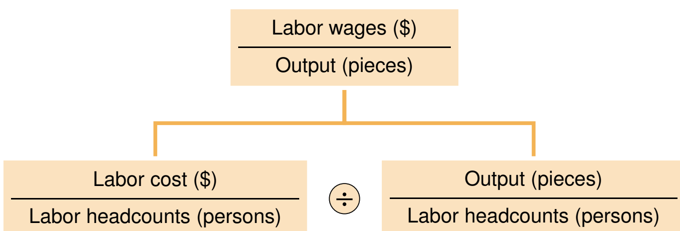

FIGURE 3.4 Illustration of the Second Rule

tor is needed. At least, three factors should be considered; i.e., labor, materials, and capital. The second one is referred to as the pay-and-productivity rule. The cost per unit is a function of productivity and how much a company pays for input consumption (Figures 3.3 and 3.4).

The ratios in the Harper's framework can be classified into seven groups. They are as follows.

1. *Productivity*

$$\text{Productivity} = \frac{\text{Output(s) (in physical quantity)}}{\text{Input(s) (in physical quantity)}}$$

$$\text{Example: } \frac{\text{Output (pieces)}}{\text{Labor Headcount (persons)}}$$

2. *Unit cost (indicating how much a firm has to pay in order to produce one output)*

$$\text{Unit Cost} = \frac{\text{Input(s) (in financial value)}}{\text{Output(s) (in physical quantity)}}$$

$$\text{Example: } \frac{\text{Labor Cost (\$)}}{\text{Output (pieces)}}$$

3. *Unit price (indicating how much a firm has to pay for a consumption of one input)*

$$\text{Unit Price} = \frac{\text{Input (in financial value)}}{\text{Input (in physical quantity of the same type)}}$$

$$\text{Example: } \frac{\text{Labor Cost (\$)}}{\text{Labor Headcount (persons)}}$$

4. *Factor Proportion*

$$\text{Factor Proportion} = \frac{\text{Input(s)}}{\text{Input(s)}}$$

Note: Physical quantity or financial value of one input over another type input.

$$\text{Example: } \frac{\text{Material Cost (\$)}}{\text{Labor Cost (\$)}}$$

5. *Cost Proportion*

$$\text{Cost Proportion} = \frac{\text{Input}}{\text{Total Inputs}}$$

Note: Financial value of one input over the total financial value of an entire input.

$$\text{Example: } \frac{\text{Labor Cost (\$)}}{\text{Total Cost (\$)}}$$

6. *Product Mix*

$$\text{Product Mix} = \frac{\text{Output}}{\text{Output}}$$

Note: Physical quantity or financial value of one output over another output (or in some cases, one output can be broken into smaller categories).

$$\text{Example: } \frac{\text{Value of Product A (\$)}}{\text{Value of Product B (\$)}}$$

7. *Input Allocation*

$$\text{Input Allocation} = \frac{\text{Input}}{\text{Input}}$$

Note: To be applied when one input can be broken into smaller categories for both physical quantity and financial value.

$$\text{Example: } \frac{\text{Workers Responsible for Quality Inspection (\$)}}{\text{Production Line Workers (\$)}}$$

It is strongly recommended that an input/output analysis should be applied to help identify both input and output factors of either an organizational or a functional system (Phusavat & Kingpadung, 2008). The next step is to categorize input and output factors into physical quantity (e.g., kilograms, meters, m^2, m^3, etc.) as well as financial values ($). It should be noted that Harper (1984) recognized that the ratios had been used extensively, especially in the areas of financial management (e.g., liquidity, debt-equity, inventory turnover, profit margin, return on investment, return on assets, etc.). However, it was necessary to explore a way to explicitly connect and integrate the combination of financial and non-financial ratios together. See Figure 3.5 on page 80.

Case Demonstration

The primary objective of the study was to improve current productivity measurement at the plant level by applying the Harper's performance network concept. The application was at one Thai Electronic Manufacturing Plant (to be referred to as STT). The study also explored the interrelationships among productivity and other performance areas as advocated by Harper (1984) such as factor proportion, cost proportion, etc. As stated in Harper (1984), the key productivity-related indicators need to be in the ratio format. They reflect both outputs and inputs of the processes with regard to production and other critical operations. In this study, the term productivity is defined as value-added divided by total cost. For this company, the term value-added is total revenue subtracted by material cost (Saengchote, Phusavat, & Takala, 2006).

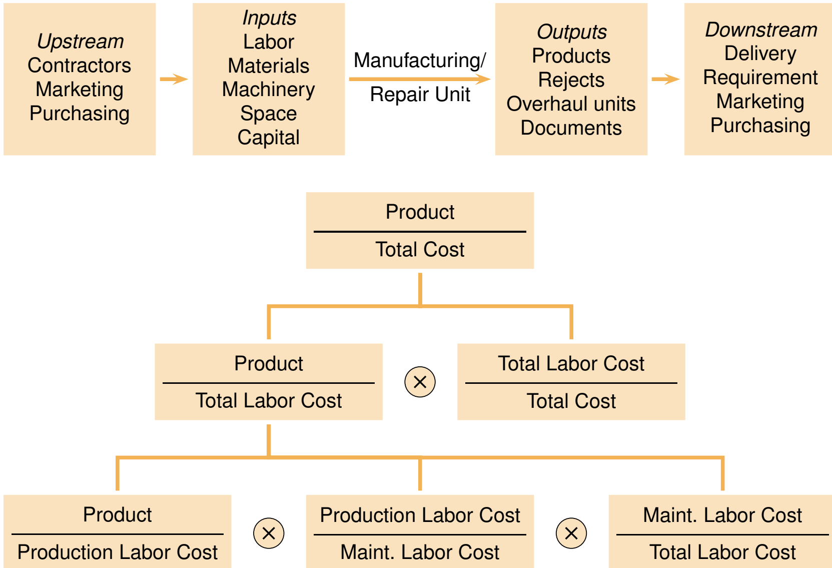

FIGURE 3.5 Demonstration of Input-Output Analysis and Productivity Networks

For this study, the data for each ratio in the networks was comprehensively collected during the 2000s. There were several problems facing the STT plant. Although it is generally accepted that productivity measurement is very important, there appeared to be a lack of a well-designed and comprehensive measurement for productivity at the plant level. The measurement mainly focused on scrap and rework. Secondly, there was a lack of applying measurement information to help analyze the root causes or evaluate an ongoing target-setting process.

The general feeling among STT executives was that the plan-do-check-act was not completed. Each component was performed separately and independently. Relevant staffs were not sharing data, information, and knowledge. This sharing was essential for continuous improvement. This was deemed necessary as the pressure on cost reduction and productivity increase continued to grow. In addition, many key decisions were made from scattered data (and not integrated and comprehensive information) and were dependent on experiences and stories passed along by operational staffs.

The first task was to identify the top ratio of a performance network. The outputs are described by the total value-dded and total production volume. The inputs primarily consist of labor, materials, and capital. In this study, the focus is on measuring productivity. As a result, for this study, the ratio reflecting productivity is defined as total value-added/total cost. To be consistent with the term used in the company under study, total value-added is referred to as sale turnover or revenue subtracted by material cost. Then, the two rules (Harper, 1984) to help further identify were applied. Some of the results from the network development are as follows.

(1) $$\frac{\text{Total value-added}}{\text{Total cost}} = \frac{\text{Operation cost}}{\text{Total cost}} \times \frac{\text{Total value-added}}{\text{Operation cost}}$$

(1.1) $$\frac{\text{Total value-added}}{\text{Operation cost}} = \frac{\text{Variable cost}}{\text{Operation cost}} \times \frac{\text{Total value-added}}{\text{Variable cost}}$$

(1.1.1) $$\frac{\text{Total value-added}}{\text{Variable cost}} = \frac{\text{Direct labor wage}}{\text{Variable cost}} \times \frac{\text{Total value-added}}{\text{Direct labor wage}}$$

(1.1.1.1) $$\frac{\text{Direct labor wage}}{\text{Variable cost}} = \frac{\text{Direct labor wage}}{\text{Production volume}} \times \frac{\text{Production volume}}{\text{Variable cost}}$$

(2) $$\frac{\text{Total value-added}}{\text{Total cost}} = \frac{\text{Total value-added}}{\text{Direct material cost}} \times \frac{\text{Direct material cost}}{\text{Total cost}}$$

(2.1) $$\frac{\text{Total value-added}}{\text{Direct material cost}} \times \frac{\text{Total value-added}}{\text{Material overhead}} \times \frac{\text{Material overhead}}{\text{Direct material cost}}$$

(2.1.1) $$\frac{\text{Total value-added}}{\text{Material overhead}} = \frac{\text{Total value-added}}{\text{Operation cost}} \times \frac{\text{Operation cost}}{\text{Material overhead}}$$

(2.1.1.1) $$\frac{\text{Total value-added}}{\text{Operation cost}} = \frac{\text{Total value-added}}{\text{Other production cost}} \times \frac{\text{Other production cost}}{\text{Operation cost}}$$

There were altogether five productivity networks established. These networks had been made possible by breaking down the term productivity into key aspects. As advocated by Harper (1984), all indicators are in a ratio format. The first network (Figure 3.6 on page 82) focused on the material-cost aspect. The second network (Figure 3.7 on page 83) concentrated on the variable-cost aspect. The direct-labor cost was the key consideration of the third network (Figure 3.8 on page 84). The indirect-labor cost was explored and integrated for the fourth network (Figure 3.9 on page 85). The fifth network attempted to understand the impacts from productivity from the production-related cost (Figure 3.10 on page 86).

The multiple regression method was applied to identify the interrelationships for each productivity network. The variance inflation factor (VIF) was also utilized to help further refine the following five equations. This task was important so that the ratios, at the lower level of the

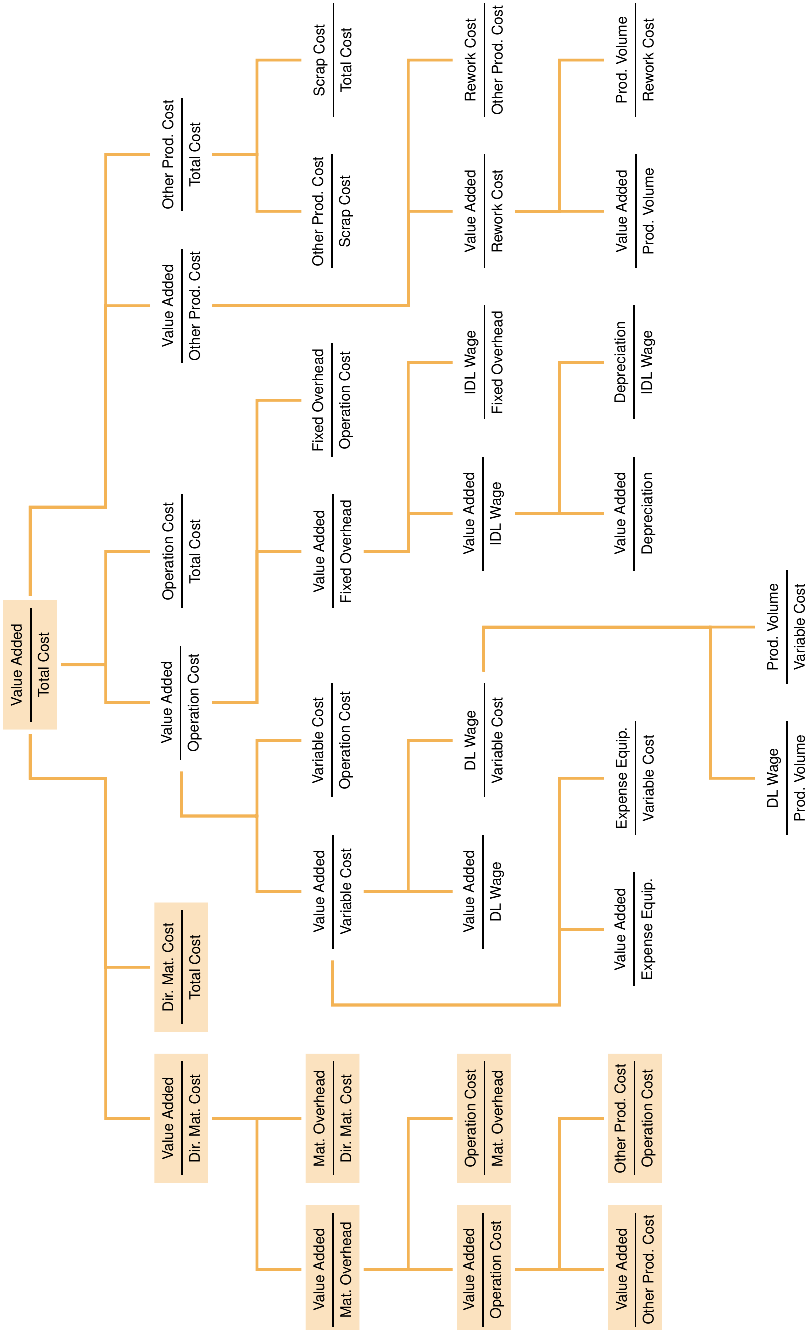

FIGURE 3.6 Illustration of Productivity Network #1

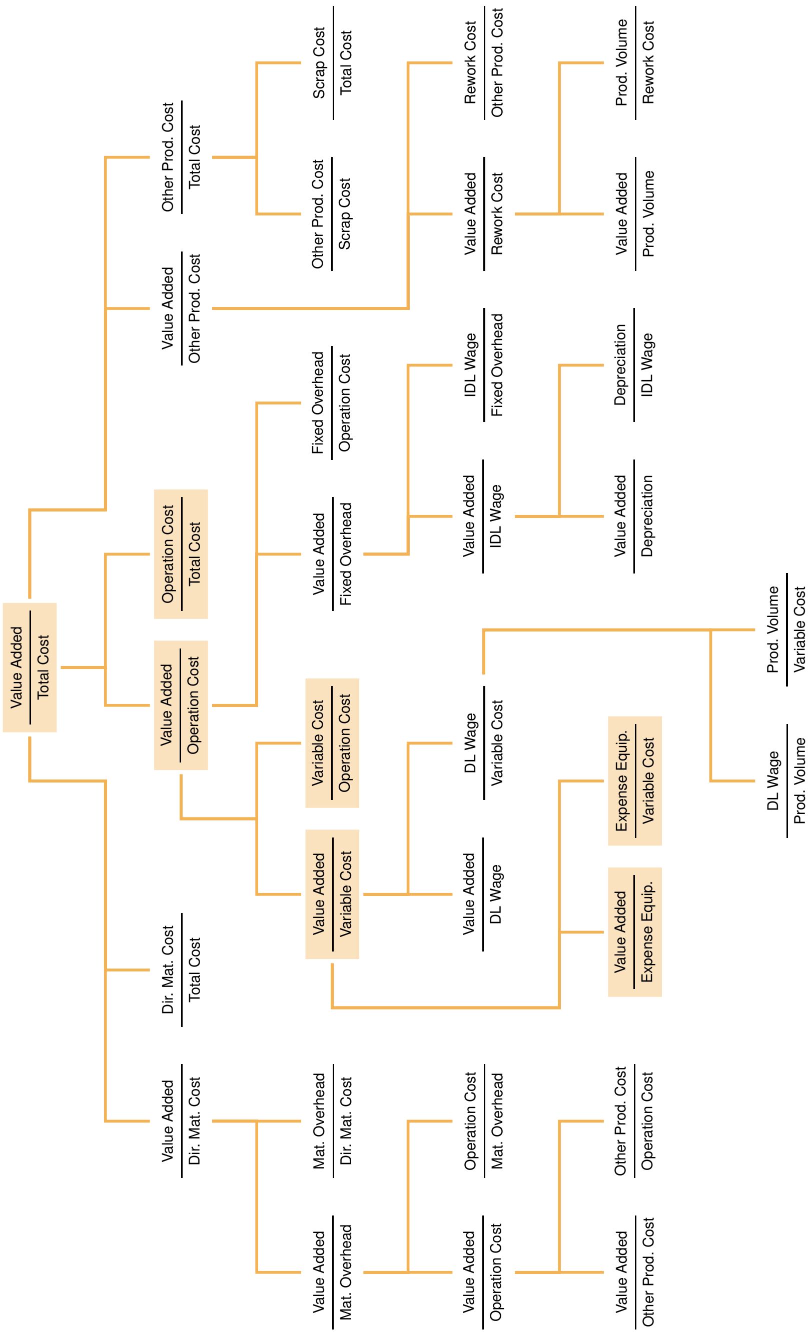

FIGURE 3·7 Illustration of Productivity Network #2

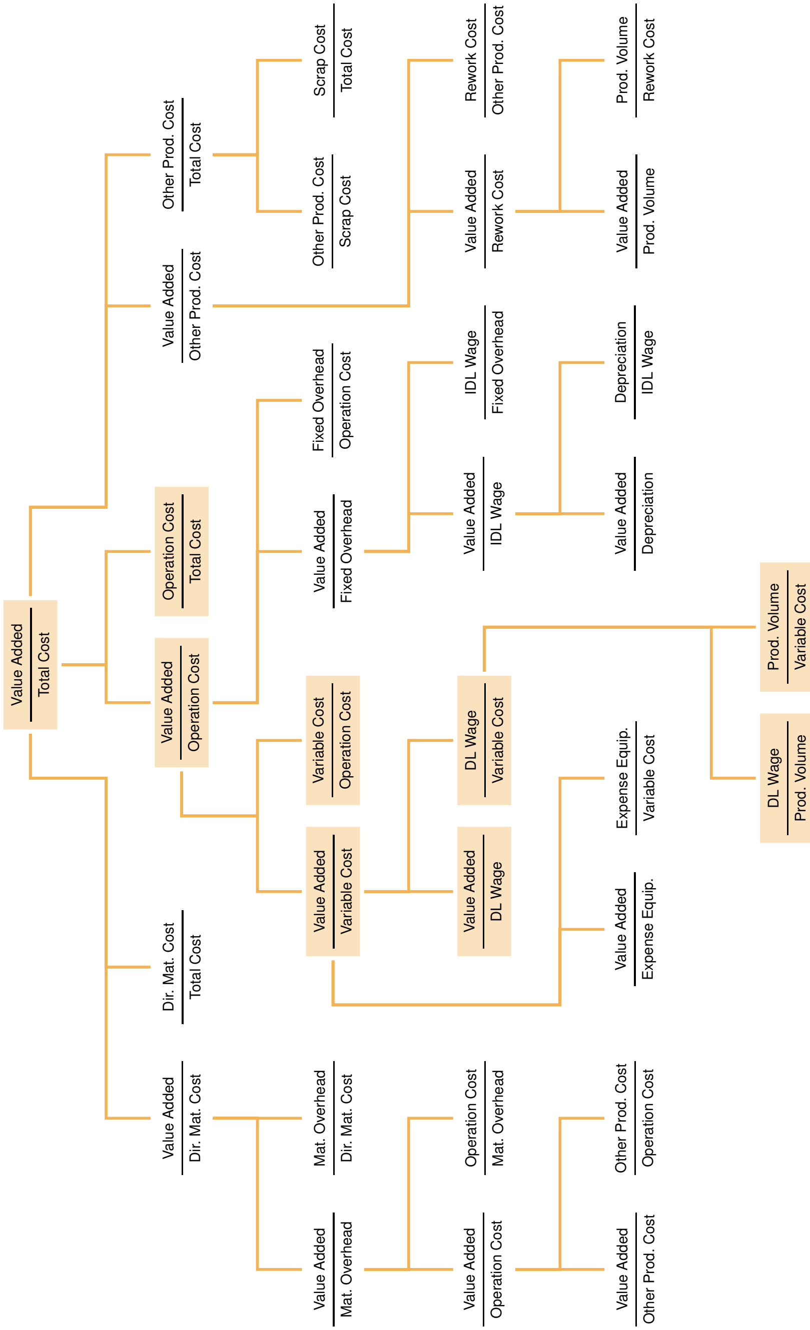

FIGURE 3.8 Illustration of Productivity Network #3

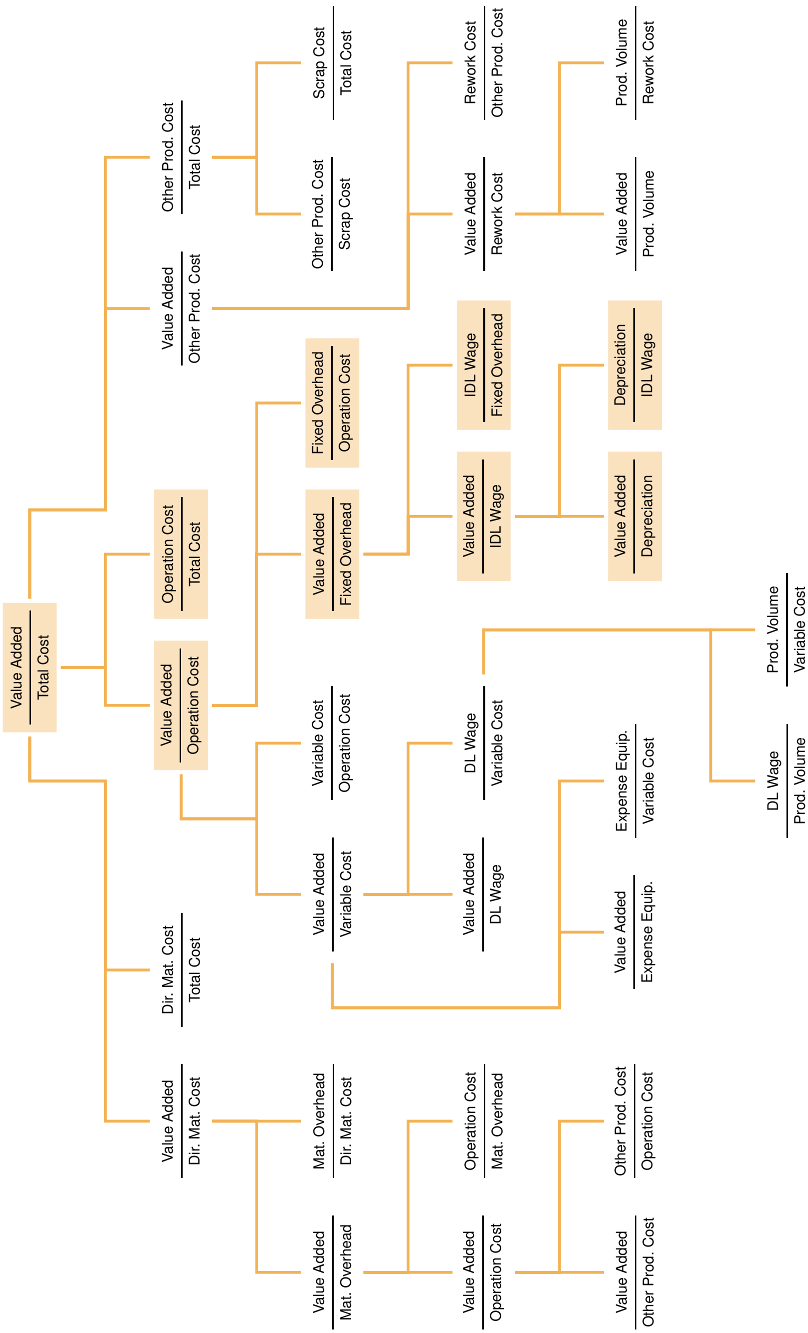

FIGURE 3.9 Illustration of Productivity Network #4

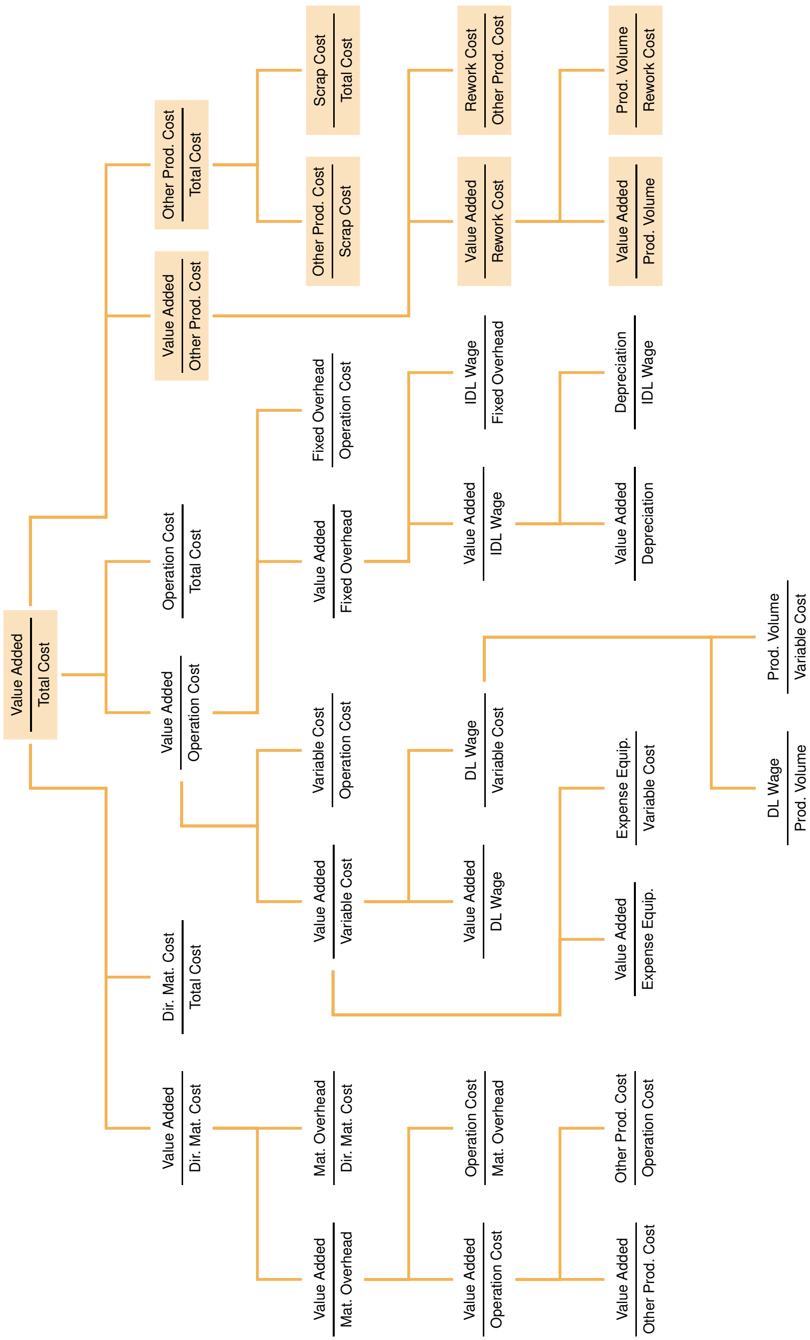

FIGURE 3.10 Illustration of Productivity Network #5

TABLE 3.1 Illustration of Initial Network's Statistical Analysis

Predictor	Coefficient	SE coeff.	t	p	VIF
Constant	−0.2806	0.2000	−1.40	0.184	
VA/EXP EQ	0.014612	0.006686	2.19	0.048	36.4
EXP EQ/VAR C	0.5954	0.2258	2.64	0.021	21.5
VAR C/OPC	0.1410	0.1683	0.84	0.417	9.0
OPC/TTL C	0.92435	0.04626	19.98	0.000	1.2

NOTES $S = 0.00908823$, $R^2 = 97.6\%$, R^2 (adj.) = 96.8%.

Analysis of variance

Source	DF	SS	MS	f	p
Regression	4	0.042813	0.010703	129.59	0.000
Residual error	13	0.001074	0.000083		
Total	17	0.043887			
VA/EXP EQ	1	0.001025			
EXP EQ/VAR C	1	0.007168			
VAR C/OPC	1	0.001641			
OPC/TTL C	1	0.032980			

network, were verified without their duplicative effects at the higher level. For this study, if the VIF value is greater than 5, then the ratios were removed under the condition of correlation coefficient greater than 0.80 by using the pair-wise method. To illustrate how the equation is developed and refined, the focus is on Productivity Network #2. For the initial Productivity Network #2, the regression equation is:

$$VA/TTL\ C = -0.281 + 0.0146\ VA/EXP\ EQ + 0.595\ EXP\ EQ/VAR\ C + 0.141\ VAR\ C/OPC + 0.924\ OPC/TTL\ C.$$

In the above initial productivity network #2, the VIFs that are greater than the value of 5 are 36.4 and 21.5. Therefore, a multi-collinearity problem exists. In order to reduce the multi-collinearity, the variables $VA/EXP\ EQ$ (x_1) and $EXP\ EQ/VAR\ C$ (x_2) are removed. Notes: $VA/EXP\ EQ$ (x_1), $VIF_1 = 36.4$; $EXP\ EQ/VAR\ C$ (x_2), $VIF_2 = 21.5$; $VAR\ C/OPC$ (x_3), $VIF_3 = 9.0$; $OPC/TTL\ C$ (x_4), $VIF_4 = 1.2$.

The new simpler equation is established. The revised performance network #2 shows that Ra^2 is 95.1%. This implies that 95.1 percent of the value of $VA/TTL\ C$ (y) had been determined when the two regressor variables $VAR\ C/OPC$ (x_1) and $OPC/TTL\ C$ (x_2) were involved. Given that $VIF_1 = VIF_2 = 1.1$, this indicates that the ratios of $VAR\ C/OPC$ (x_1)

TABLE 3.2 Illustration of Revised Network's Statistical Analysis

Predictor	Coefficient	*SE* coeff.	*t*	*p*	*VIF*
Constant	0.14364	0.05790	2.48	0.025	
VAR C/OPC	−0.15531	0.07348	−2.11	0.052	1.1
OPC/TTL C	0.92138	0.05615	16.41	0.000	1.1

NOTES $S = 0.0112016$, $R^2 = 95.7\%$, R^2 (adj) = 95.1%.

Analysis of variance

Source	*DF*	*SS*	*MS*	*f*	*p*
Regression	2	0.042005	0.021003	167.38	0.000
Residual error	15	0.001882	0.000125		
Total	17	0.043887			
VAR C/OPC	1	0.008218			
OPC/TTL C	1	0.033787			

and *OPC/TTL C* (x_2) are not highly correlated between themselves. Therefore, the removal of the ratios of *VA/EXP EQ* and *EXP EQ/VAR C* appeared to reduce the multi-collinearity problem and improve the regression model or equation.

For the revised productivity network #2, the regression equation is:

$$VA/TTL\ C = 0.144 - 0.155 VAR\ C/OPC + 0.921 OPC/TTL\ C.$$

The final results of the regression questions from the five productivity network are presented in Table 3.3.

To further verify the usefulness of the networks and their information, a discussion session was held with STT executives and plant managers. The aim was to gather their feedback and comments within the context of the usefulness of new productivity information. The suitable networks for this plant should at the minimum contain the ratios of variable cost-to-operation cost, and operation cost-to-total cost. Other ratios that are partially helpful include the ratios of material cost-to-total cost, material overhead cost-to-material cost, etc. In particular, the following discussion provides key observations as a result from the meeting.

- All five networks were apparently suitable for STT productivity measurement. Specifically, Productivity Networks #2, #3, and #4 with the predictability (adjusted R^2) at 95.1%, 95.1% and 95.0% had received more attention from the executive and plant manager relatively Productivity Networks #1 and #5.

TABLE 3.3 Final Regression Equations derived from STT's Productivity Network

(1)	(2)	(3)	(4)
1	*VA/OTH C* *OTH C/OPC* *OPC/MATOH* *MATOH/MAT* *−MAT/TTL C*	*VA/TTL C* = 0.414 + 0.123 *VA/OTH C*	90.1%
2	*VA/EXP EQ* *EXP EQ/VAR C* *VAR C/OPC* *OPC/TTL C*	*VA/TTL C* = 0.144 − 0.155 *VAR C/OPC* + 0.921 *OPC/TTL C*	95.1%
3	*VA/OTH C* *VA/DLW* *DLW/VOL* *VOL/VAR C* *VAR C/OPC* *OPC/TTL C*	*VA/TTL C* = 0.144 − 0.155 *VAR C/OPC* + 0.921 *OPC/TTL C*	95.1%
4	*VA/OTH C* *VA/DEP* *DEP/IDL W* *IDL W/FIX* *FIX/OPC* *OPC/TTL C*	*VA/TTL C* = 0.0087 + 0.141 *FIX/OPC* + 0.913 *OPC/TTL* C_2	95.0%
5	*VA/OTH C* *VA/VOL* *VOL/RWK* *RWK/OTH C* *OTH C/SCRAP* *SCRAP/TTL C*	*VA/TTL C* = 0.414 + 0.123 *VA/OTH* C_3	90.1%

NOTES Column headings are as follows: (1) productivity network #, (2) variables (ratios), (3) regression equations, (4) adjusted R^2.

- There were four most relevant ratios out of the 32 original ones, after the removal of some of these ratios with high duplicative effects (high VIF). The four ratios were as follows. They are: (1) Variable cost-to-Operation cost (*VAR C/OPC*), (2) Operation Cost-to-Total cost (*OPC/TTL*), (3) Total Value-Added-to-Other cost (*VA/OTH C*) and (4) Fix Cost-to-Operation cost (*FIX/OPC*). Based on Harper's definition, it is reasonable to conclude that, for STT, its productivity is strongly related to both the factor proportion and the cost proportion areas.

For other comments, STT plant manager expressed the following feedback and observations. For the network concept, the top-level ra-

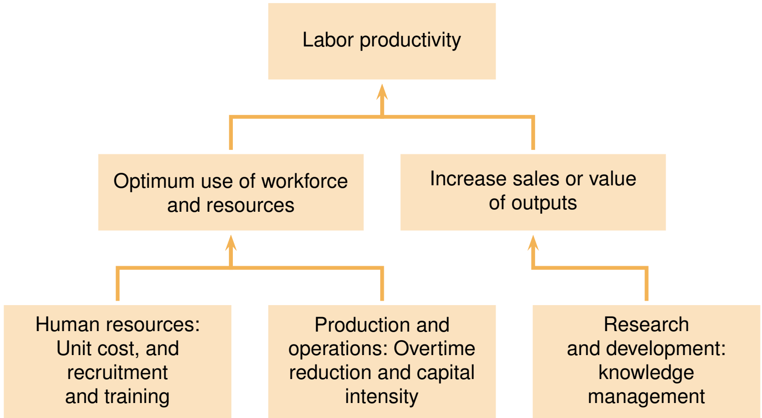

FIGURE 3.11 Driving Factors for Labor Productivity

tio was clearly supported by other lower level ratios. The measurement attempt appeared to become more systematic. It would be appropriate to allocate the responsibility for achieving their targets to different groups. Therefore, the accountability issue could be resolved. In addition, the clarity of roles and responsibility would also be addressed. Given the fact that the results from each ratio would be reported at the same time, the effectiveness of a business meeting could also be achieved. Nevertheless, it is important to note that as more data was continuously collected, more revisions would be expected. As a result, some ratios could emerge into or be deleted from the productivity network. This would depend on the coefficient values. The responsibility assigned to a group for a particular measure might be changed as well.

From their perspective, the concept on a productivity network provided valuable information on how an organization is performing, where it performed well and where its weakness lied. Productivity measures would only be useful if they related to an organization's goals and objectives and brought actions for continuous improvement of an organization. Productivity needed to be part of an overall strategy of an organization. This required strong commitment from senior management and needed teamwork and support from all employees. Then, a new framework was emerged from the meeting in regard to labor productivity which was still important in STT's operations. The labor cost contributed to 25% of the entire cost.

Finally, for the STT, the plant manager and the company executive expressed a great deal of concern on the readiness of the organization if the concept were to be fully implemented. In particular, the investment on upgrading and linking the databases from other functional units for real time and reliable data would be necessary as a prerequisite to productivity measurement. This was due to the same frequency of data to be collected for the ratios developed (Saengchote et al., 2006). The culture of "show me" instead of "trust or believe me" was still prevailing. By relying heavily on the quantitative feature, the impacts on working culture would have to be considered. Simply put, it appears there were two issues to be addressed prior to the deployment the productivity network concept at the STT; i.e., the database readiness and the staff preparation.

Key Application Consideration for Productivity Network

The productivity concept's application is illustrated. It provides useful productivity information which is based on cause-and-effect relationships among key ratios. To support its use in an organization, the summary on what an organization needs to consider when adapting the network concept for productivity measurement can be described briefly as follows (Phusavat, 2003).

- *Unit dimension:* There are many dimensions for measuring ratio such as person, unit, \$, m^2, m^3, and mile. The determination of measuring an output or an input side in terms of a physical or a financial value needs to be initially clarified.
- *Level of network complexity:* There is no specific requirement on the network level. It depends on an organization whether the network provides sufficient information on an overall productivity and performance level.
- *Data availability:* The definition of terms and the preparation for data collection need to be first thought out. The data frequency (e.g., daily, weekly, monthly, and quarterly) within a network needs to be the same. The definition clarity is needed to ensure the consistency of the data to be collected.
- *Process stability and product portfolio:* An organization planning to adapt the Harper (1984) network concept should have standardized operations which indicate resource consumption for each output unit generated. In addition, the products/services offered should be stable over time so that a comparison and information analysis can be made.

- *Inflation:* A primary assumption for the Harper (1984) network concept is low inflation which does not create a great deal impact on either unit cost or price during purchases and sales respectively. For a company with a long lead time during a purchase and a usage of the materials, when faced with high inflation, would have some difficulty in choosing which price to be used in a network.

The use of the productivity-network concept is still popular today, especially with an organization that is classified as labor intensive, and has stable product portfolios over the years with standardized operational processes (Bouckaert, 1990; Mondal, Maiti, & Ray, 2010). Despite a lot of flexibility in identifying productivity-related ratios, Harper (1984), including the 2011 SPRING's *A guide to productivity measurement,* strongly suggested a network needs to contain some of the following indicators.

- Return on capital: Profit ÷ Capital employed
- Capital turnover: Sales ÷ Capital employed
- Share of profit in value-added: Profit ÷ Value added
- Profit margin: Profit ÷ Sales
- Efficient use of purchased materials and services: Value-added ÷ Sales
- Value-added labor productivity: Value-added ÷ Labor
- Value-added capital productivity: Value-added ÷ Capital employed
- Capital intensity: Capital employed ÷ Labor
- Labor contributions: Sales ÷ Labor
- Unit labor cost: Labor cost ÷ Labor headcounts

In conclusion, the applications of the Harper (1984) network allow an organization to focus on the significant factor(s) that impact on the performance levels. Key attributes to productivity should be measured such as capital and materials in an integrated way (Stainer, 1997). The network concept also concentrates on information usefulness which contributes directly to decisions and actions by an organization's management. The top level ratio should reflect the policy objectives of an organization. When properly developed, a network should help explain interrelationships among its ratios' information, and related trends

TABLE 3.4 Data for Developing a Productivity Network (Exercise 3.4)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	1.4100	18.6713	1.5904	0.0755	2.4270	0.0832
2	1.2691	12.8669	1.0374	0.0986	2.7700	0.0755
3	1.3842	17.9452	1.5667	0.0771	2.3666	0.0804
4	1.6357	20.8282	2.4507	0.0785	2.2391	0.0845
5	1.3815	17.3014	1.7629	0.0798	2.6596	0.0879
6	1.4309	17.9953	1.4290	0.0795	2.3444	0.0782
7	1.4186	18.6279	1.4801	0.0762	2.3490	0.0721
8	1.3795	24.1876	2.0785	0.0570	2.4719	0.0891
9	1.2381	17.4569	1.3779	0.0709	2.0925	0.0806

NOTES Column headings are as follows: (1) Ratio/Period, (2) Revenue/Total Cost, (3) Revenue/Labor Cost, (4) Revenue/Material Cost, (5) Labor Cost/Total Cost, (6) Product/Utility, (7) Product/Material.

and patterns. Several recommended ratios above are part of an industry's standards so possible further comparisons exist. Monitoring industrial standards represents a foundation for long-term continuous improvement in productivity and performance.

Exercises

3.1 Conduct the Input-output Analysis of a company of your choice. Develop a productivity network.

3.2 Based on the case discussion in the third section, examine and provide your comments whether the non-linear relationships should be established. Why and why not.

3.3 Analyze the case demonstration (Figure 3.12 on page 94). Examine a firm operating in an agricultural business and provide your feedback.

3.4 Develop a productivity network based on Table 3.4. Apply the Scattering Plot to analyze the interrelationships among different ratios. Hint: You may develop more than one network.

References and Further Reading

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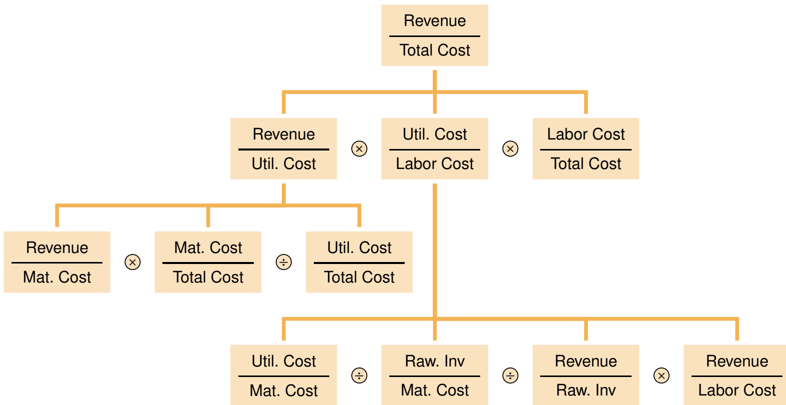

Productivity Network Application at One Private Firm Operating in the Agricultural Business

Target y: Revenue-to-Total Cost ratio	x_5: Revenue-to-Material Cost ratio
x_1: Revenue-to-Material Cost ratio	x_6: Revenue-to-Raw Material Inventory ratio
x_2: Material Cost-to-Total Cost ratio	x_7: Revenue-to-Labor Cost ratio
x_3: Utility Cost-to-Total Cost ratio	x_8: Labor Cost-to-Total Cost ratio
x_4: Utility Cost-to-Material Cost ratio	t: Number of months

$$
\begin{aligned}
y = & -0.310 - 0.0002(t) + 0.576(x_1) - 0.291(x_2) + 14.145(x_3) \\
& - 10.166(x_4) + 0.004(x_5) + 0.024(x_6) + 0.010(x_7) + 1.826(x_8)
\end{aligned}
$$

ANOVA	*df*	*SS*	*MS*	*F*	Sig. *F*
Regression	9	0.577163054	0.064129228	48.44460516	$4.87847e^{-12}$
Residual	21	0.027799046	0.001323764		
Total	30	0.604962100			

Coefficients		*Regression Statistics*	
Intercept	−0.310834904	R^2	0.954048285
Time	0.000256815	Standard Error	0.036383569
1	0.576443391	Observations	31
2	0.291028871		
3	14.145944700		
4	−10.166119990		
7	0.010423175		
5	0.004389066		
6	0.024166094		
8	1.826286500		

FIGURE 3.12 Performance Network of the Company (Exercise 3.3)

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Chapter Four

Multi-Factor Productivity Measurement Model

The importance and popularity of performance (especially productivity) measurement had continuously increased during 1990s. According to Neely (1998), there had been new reports and articles on this topic appearing at a rate of one for every five hours of every working day since 1994. In 1996 alone, one new book on this subject appeared every two weeks. For the same year, the survey found that 64% of American businesses were actively experimenting with new ways of measuring and utilizing non-financial data. Even in the United Kingdom, the government issued the statement calling for more vigorous research in finding better ways to capture the performance of an organization regardless whether it operates as a private firm or a public agency.

The chapter focuses on one of the most important techniques for productivity measurement. Measuring productivity represents a systematic attempt to understand both inputs and outputs of an organization and/or a production system. The Multi-factor Productivity Measurement Model or MFPMM was developed in the 1970s during the APQC's initial efforts in promoting productivity measurement at an organizational and/or plant level. Since then, the MFPMM has long been implemented for assessment of profitability for several well-known corporations such as Phillips Petroleum, General Foods, and so on (Phusavat, Anussornnitisarn, Sujitwanit, & Kess, 2009). The chapter aims to describe the MFPMM's computational and information analysis frameworks. One specific case is to be illustrated with the advantages, disadvantages, and consideration factors the model's applications.

The essential premise for the MFPMM is that the increase in profitability is based on the improvement of two specifically areas: productivity and price-recovery. The MFPMM is widely regarded because it portrays a comprehensive picture with forward-looking information. The MFPMM represents one of the earlier efforts in explicitly linking productivity and performance measurement with information analysis (Phusavat, 2010). The model contains a combination of financial

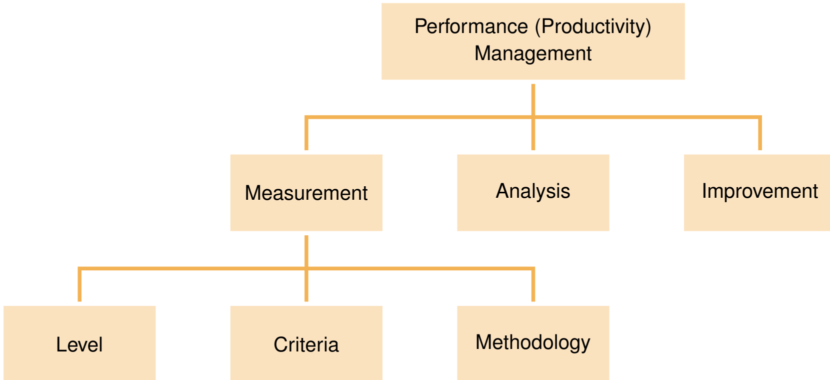

FIGURE 4.1 Scope of the MFPMM in a Management Process

and non-financial information which is helpful when communicating with technical staffs at a plant level as well as management staffs and executives. The MFPMM is applicable at both an organization and a plant level with three main criteria; i.e., profitability, productivity, and price recovery. The methodology is regarded as quantitative. The MFPMM uses primarily accounting data with the unit cost standards (Figure 4.1).

Introduction

The MFPMM was developed by the APQC in 1977 for measuring productivity and price recovery, and for explicitly relating these results with profitability at the organizational/functional levels (Sink, Tuttle, & DeVries, 1984). The MFPMM's primary focus is on a manufacturing/production unit with tangible outputs and inputs. It is suitable for a process that is stable which implies that there are not-so-often changes in products being offered (Sink & Tuttle, 1989). The MFPMM can easily adapt the data from a typical accounting system. The MFPMM is also known as the "Profitability = Productivity + Price Recovery" or PPP model in some literatures (Rao & Miller, 2004). The MFPMM was initiated under the urgency of integrating productivity information into all levels within an organization. In the late 1970s, many businesses in the US were faced with the gradual decline in productivity which had caused negative impacts on profitability.

Instead of having individual indicators reflecting pieces of performance information, some forms of aggregate measurement should be promoted (Sink, 1985). The MFPMM attempts to expand routine accounting information by incorporating several ideas and concepts such as productivity, price recovery, opportunity gain/loss, and forward-looking information. Profit depends on the revenue generated and the cost to be paid by an organization. The level of revenue is derived from the amount of products produced and the unit price that an organization is able to charge. The similar description can be explained for the cost level.

The MFPMM is regarded as a dynamic and comprehensive approach to track the performance in the areas of profitability, productivity, and price-recovery (Phusavat, Jaiwong, Sujitwanit, & Kanchana, 2008). Its focus is on changes in the inputs with respect to the outputs from the system under study. This focus includes the aspects of quantity, price and cost per unit, and the values of revenues and costs. The model's application is designed to be at the organizational level. The essential premise of the model is that profitability is a function of productivity and price-recovery (Sumanth, 1998).

The data requirement for the MFPMM can be found from traditional accounting and standard-costing systems. The set of required data needs to be periodic for all outputs and inputs, such as annually, semi-annually, quarterly, monthly, and so on. The fundamental concept for the analysis is the comparison of data from one period (known as the base period) with data from the next period (the current period). Different ratios in the model communicate a set of information about the system under investigation.

Specifically, the term productivity is defined as the relationship of the input-quantity used with respect to the output-quantity generated from the system. In other words, when dealing with the changes in the quantities of products generated and the resources consumed (i.e., outputs and inputs), it corresponds to the term productivity (Kaydos, 1991).

The price-recovery indicates the relationship between the unit price of outputs and the unit cost of inputs. The term, price-recovery, can be perceived as the extent to which the increases in unit of inputs are passed on to the customers in terms of the higher unit price of outputs. Simply out, the ability for an organization to raise its unit price as a result of an increase in a unit cost of resources consumed for production is referred to as price recovery.

If the organization has been productive and has performed well on its price-recovery, it should be profitable. The term, profitability, im-

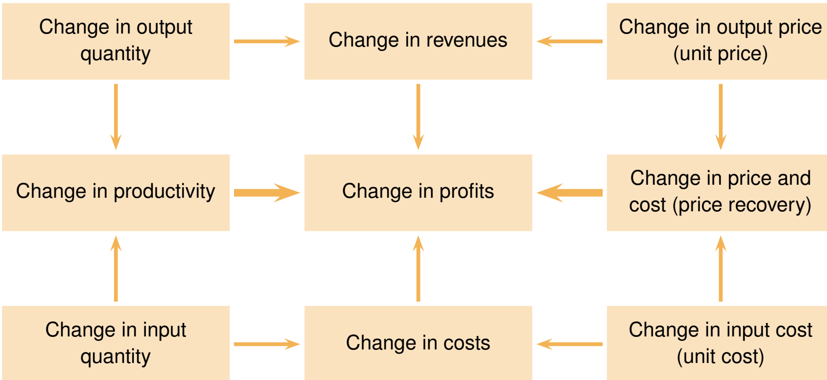

FIGURE 4.2 Background of the MFPMM Development (adapted from Sink, 1985)

plies the relationship between the two rates of change- revenue generated and cost incurred. The firm is profitable when its revenue has increased at a faster rate than that of its cost. As a result, there are four ways that can directly influence an organization's profit level. They are: revenue, cost, productivity, and price-recovery (Figure 4.2).

One of the key contributors to the MFPMM's popularity is the forward-looking integration by blending with the opportunity concept. In addition, there are two viewpoints on productivity; i.e., static and dynamic. See the following demonstration.

Year	2011	2012
Output Value Generated ($)	5,000,000	6,000,000
Input Value Consumed ($)	1,000,000	1,500,000

Based on the above example, the following implications can be summarized.

1. Surplus from the difference between the output and input values:
   - Year 2011: $4,000,000
   - Year 2012: $4,500,000
2. Productivity level, from the static viewpoint, implying the output value divided by the input value:
   - Year 2011: 5.0
   - Year 2012: 4.0

3. Productivity level from the dynamic perspective is as follows:
    - The rate of change in output values is 1.20 (from 6,000,000 ÷ 5,000,000) or the output value has gone up by 20%.
    - Rate of change in input values is 1.50 (from 1,500,000 ÷ 1,000,000) or the output value has gone up by 50%.
    - Therefore, the rate of change in productivity is only 0.80 due to the fact that the rate of input consumption has increased faster than the rate of output generation (from 1.20 ÷ 1.50). If this trend continues, the profit level will gradually decline.

From the opportunity viewpoint, to quantify this loss, the model's calculation is based on two scenarios—cost or profit center. For the cost center's viewpoint, the opportunity loss is derived from the following rationale. This viewpoint is suitable for plant or production managers. A company generates the output of $5,000,000 with the consumption of $1,000,000 worth of the inputs. If a company is able to generate up to $6,000,000 of the output, the input consumption should have been only $1,200,000 (from (6,000,000 × 1,000,000) ÷ 5,000,000). It means that this company has consumed the input more than it should have consumed by $300,000. This represents the opportunity loss (not a financial loss) of $300,000.

For the profit center's point of view, a company consumes the inputs worth of $1,000,000 to generate the output value of $5,000,000. This point of view is suitable for managing director or chief executive officer. If a company actually consumes $1,500,000 of the input, the output value that should have been generated is $7,500,000 (from (5,000,000 × 1,500,000) ÷ 1,000,000). It means that this company has generated the output less than it should have generated by $1,500,000. This represents the opportunity loss of $1,500,000.

Typically, the information on the opportunity gain/loss is not made available. However, this information is very useful because it provides a future warning sign to an organization. Given the integration of the opportunity concept (for forward-looking information) and the two productivity viewpoints, the MFPMM is shown in Table 4.1.

MFPMM Formulations and Case Study

This section demonstrates the case application of the MFPMM at the GPO (Phusavat and Photaranon, 2006). The critical problem at the

TABLE 4.1 Demonstration of Key Features in the MFPMM

Category	2011	2012	Note
Output Value ($)	5,000,000	6,000,000	
Input Value ($)	1,000,000	1,500,000	
Surplus	4,000,000	4,500,000	
Productivity in a static format	5.0	4.0	
Productivity in a dynamic format	(6,000,000 ÷ 5,000,000) ÷ (1,500,000 ÷ 1,000,000) = 1.2 ÷ 1.5 = 0.80		Rate of change in output value vs. rate of change in input value
Opportunity Loss in $ (from a profit-center point of view)—typically opportunity gain/loss not included in the performance or accounting report	−1,500,000		If maintaining the ratio 5.0 from year 2011, the system should have generated the output value of $7,500,000 in 2012. Therefore, the system has earned less than it should have by $1,500,000 (based on 7,500,000 – 6,000,000). However, this number does not represent a financial loss as shown by the accounting system.
Opportunity Loss in $ (from a cost-center point of view)—to be used in this project computation	−300,000		If maintaining the ratio 5.0 from year 2011, the system should have consumed $1,200,000 in 2012. Therefore, the system consumed more than it should have by $300,000 (based on 1,500,000 – 1,200,000).

GPO's production department was a lack of a comprehensive productivity and performance measurement at the production level. Performance information is primarily at an organizational level. During the time of the study, the accounting department had been mostly responsible for collecting production-related data, and for reporting performance information. The production department had merely been informed of its performance while the staffs from the accounting department routinely conducted performance analysis and recommended possible improvement actions.

Before deploying the MFPMM, a discussion session was held with the production department's management team. This session focused on a selection of a suitable measurement technique Such as ROA. Even, the term Economic Value-Added (EVA) was brought up. Eventually, the

MFPMM was selected due to the need to capture an overall productivity level as well as to relate this information with financial implications. Further, the information on opportunity gain/loss attracted a lot of attention. Since it would be unwise to launch the MFPMM throughout the production department, one production unit was selected and tested—the tablet-production unit (the third section) was chosen. Simply, the objectives of this project were to test whether the MFPMM was a suitable tool to help initiate productivity/performance measurement for the GPO's production department, and to assess and evaluate its performance-analysis capability.

It is important to note that the third section unit did not experience low performance levels. It was selected because it represented a typical production unit. Further, the GPO was not in any immediate business danger. It is a state enterprise under the Ministry of Public Health. The GPO has produced over 200 basic drugs in a complete range of dosage forms (tablets, capsules, creams, ointments, liquids, syrups, dry syrups, powders, and injections) for household consumption. Its overall goal has always been to produce pharmaceutical products that support the public-health policy on the availability (implying large volumes) and the accessibility (implying low prices) of basic medicines for the poor and the general public.

There were several steps that had been taken for project completion. Some of the key tasks included the determination of the periods to be tested, the unit dimensions of the required data, and the actual computation. The data of each period, for the third section, was separated into two major groups, namely outputs and inputs. It should be noted that not all input factors could be captured or included in the MFPMM. Top production administrators were explained that the focus needed to be on the input factors that directly resulted in the outputs under study.

The outputs to be examined were 3 package sizes of Paracetamol or "Para" tablet (10's, 100's and 1000's). The listed price (not considering retailers' discounts) represented the unit price to be charged. For the input side, the unit cost, based on the purchasing contracts, was used. For its quantity, the inputs were divided into 5 categories as follows.

- Labor was divided into 4 groups; i.e., manager, pharmacist, officers, and casual workers. Each group was broken down into regular- and over-time.
- Materials included raw materials and packing materials.

TABLE 4.2 Base and Current Periods for the MFPMM Implementation

(1)	(2)
July 2002	August 2002
August 2002	September 2002
September 2002	October 2002
October 2002	November 2002
November 2002	December 2002
December 2002	January 2003
January 2003	February 2003
February 2003	March 2003
March 2003	April 2003
April 2003	May 2003
May 2003	June 2003
June 2003	July 2003
July 2003	August 2003
August 2003	September 2003
September 2003	October 2003
October 2003	November 2003
November 2003	December 2003
December 2003	January 2004
January 2004	February 2004
February 2004	March 2004
March 2004	April 2004
April 2004	May 2004
May 2004	June 2004
June 2004	July 2004
July 2004	August 2004
August 2004	September 2004
September 2004	October 2004
October 2004	November 2004
November 2004	December 2004

NOTES Column headings are as follows: (1) base period (period 1), (2) current or comparing period (period 2).

- Energy was represented by water and electricity.
- Services were represented by the cost of maintenance and spare parts.
- Miscellaneous category included other costs such as welfare, office materials, etc.

The collected data, organized together with the GPO's production administrators is presented in Table 4.3.

There are a total of 19 columns within the MFPMM when simultaneously measuring productivity, price-recovery, and profitability which blend both the opportunity concept, and the static/dynamic viewpoints (Table 4.6, see p. 114). In addition, the MFPMM resolves the issues regarding to the unit dimensions and the weight problems in the input and output sides. The formulations for each column can be illustrated as follows. Based on Sink (1985), the formulas for the MFPMM can be shown as follows.

Column 1 Representing the quantities of outputs produced and/or sold and the quantities of input consumed in order to produce those outputs for period 1 (Q_{i1}). The term "i" indicates the different categories

TABLE 4.3 Dimensional Units for the MFPMM Application

Category	Quantity	Price	Value
Outputs			
Para 10's	Pack	Baht/pack	Baht
Para 100's	Bottle	Baht/bottle	Baht
Para 1,000's	Bottle	Baht/bottle	Baht
Inputs			
Labor			
Manager	Man-hr	Baht/man-hr	Baht
Pharmacist	Man-hr	Baht/man-hr	Baht
Officers	Man-hr	Baht/man-hr	Baht
Casual workers	Man-hr	Baht/man-hr	Baht
Raw material			
Paracetamol DC	Kg	Baht/kg	Baht
Packing materials			
Sticker 10's	Each	Baht/each	Baht
Carton No. 46	Each	Baht/each	Baht
Foil	Roll	Baht/roll	Baht
Box	Each	Baht/each	Baht
Sticker 100's	Each	Baht/each	Baht
Carton No. 49	Each	Baht/each	Baht
PE-100's	Bottle	Baht/bottle	Baht
Al Foil	Each	Baht/each	Baht
Spongy 100's	Each	Baht/each	Baht
Sticker 1000's	Kg	Baht/kg	Baht
Carton No. 23	Each	Baht/each	Baht
PE-1000's	Bottle	Baht/bottle	Baht
Spongy 1,000's	Kg	Baht/kg	Baht
Energy			
Water	Unit	Baht/unit	Baht
Electricity	Unit	Baht/unit	Baht
Services			
Maintenance and spare parts	Month	Baht/month	Baht
Miscellaneous	Month	Baht/month	Baht

for both the output and input. For instance, the input factor consists of labor, material, etc.

Column 2 Representing the outputs' unit prices & the inputs' unit cost in period 1 (P_{i1}).

Column 3 Reflecting the value (quantity unit price or unit cost) of period 1.

Column 3 = Column 1 × Column 2

Column 4 Representing the quantities of outputs produced and/or sold and the quantities of input consumed in order to produce those outputs for period 2 (Q_{i2}).

Column 5 Representing the outputs' unit prices & the inputs' unit cost in period 1 (P_{i2}).

Column 6 Reflecting the value (quantity unit price or unit cost) of period 2.

Column 6 = Column 4 × Column 5

Column 7 Price-weighted and base period price indexed changes—quantities (both unit price and cost remained constant at period 1).

$$\frac{\sum_{i=1}^{n} Q_{i2} P_{i1}}{\sum_{i=1}^{n} Q_{i1} P_{i1}}$$

Column 8 Quantity-weighted & current period indexed changes—unit prices and costs (both output and input quantities remained constant at period 2)

$$\frac{\sum_{i=1}^{n} Q_{i2} P_{i2}}{\sum_{i=1}^{n} Q_{i2} P_{i1}}$$

Column 9 Examining the impact of changes in price and quantity from period 1 to 2—quantity (for outputs and inputs) and unit price/cost not held constant.

$$\frac{\sum_{i=1}^{n} Q_{i2} P_{i2}}{\sum_{i=1}^{n} Q_{i1} P_{i1}}$$

Note that there is a need to separate the term "Q_i" or quantity into "O_i" reflecting specifically the outputs produced, and "I_i" representing only the inputs consumed. This is necessary since the computation for the remaining columns will focus on both the output and input sides simultaneously. In addition, it is often that the input side be further divided into different categories and sub-categories respectively. On the contrary, for the output side, it seldom contains at the sub-category level. For example, the labor input can have management, supervisors, and operation categories. The operational-labor category can be separated into assembly-line, warehouse, and quality inspection sub-categories. As a result, the term "I_i" is to be denoted as "I_{ij}." It should be noted that it is possible that each output category can have several corresponding sub-categories. However, the formulas, provided by Sink (1985), don't reflect this need for the output side.

Column 10 Examining the cost-to-revenue for period 1.

$$\frac{I_{ij1}}{\sum_{i=1}^{n} O_{i1}P_{i1}}$$

Column 11 Examining the cost-to-revenue for period 2.

$$\frac{I_{ij2}}{\sum_{i=1}^{n} O_{i2}P_{i2}}$$

Column 12 Examining the output-to-input ratios for period 1.

$$\frac{\sum_{i=1}^{n} O_{i1}P_{i1}}{I_{ij1}P_{ij1}}$$

Column 13 Examining the output-to-input ratios for period 2.

$$\frac{\sum_{i=1}^{n} O_{i2}P_{i1}}{I_{ij2}P_{ij1}}$$

Column 14 Reflecting price-weighted productivity indexes.

$$\frac{\left.\frac{\sum_{i=1}^{n} O_{i2}P_{i1}}{\sum_{i=1}^{n} O_{i1}P_{i1}}\right\}\text{Rate of Change on Output Quantity}}{\left.\frac{I_{ij2}P_{i1}}{I_{ij1}P_{i1}}\right\}\text{Rate of Change on Input Quantity}}$$

Column 15 Representing quantity-weighted price recovery indexes.

$$\frac{\left.\frac{\sum_{i=1}^{n} O_{i2}P_{i2}}{\sum_{i=1}^{n} O_{i2}P_{i1}}\right\}\text{Rate of Change on Output's Unit}}{\left.\frac{I_{ij2}P_{i2}}{I_{ij2}P_{i1}}\right\}\text{Rate of Change on Input's Unit Cost}}$$

Column 16 Depicting profitability indexes, reflecting the rates of change on both the quantity produced/consumed and unit price/cost.

$$\frac{\left.\frac{\sum_{i=1}^{n} O_{i2}P_{i2}}{\sum_{i=1}^{n} O_{i1}P_{i1}}\right\}\text{Rate of Change on Output}}{\left.\frac{I_{ij2}P_{i2}}{I_{ij1}P_{i1}}\right\}\text{Rate of Change on Input Value}}$$

Column 17 Indicating the impacts (opportunity gain/loss) from a productivity change.

$$I_{ij1}P_{i1}\left[\frac{\sum_{i=1}^{n} Q_{i2}P_{i1}}{\sum Q_{i1}P_{i1}} - \frac{I_{ij2}P_{i1}}{I_{ij1}P_{i1}}\right]$$

Column 18 Indicating the impact from a price recovery change.

Column 18 = Column 19 − Column 17

Column 19 Indicating the total impact on profits from productivity/price recovery.

$$I_{ij1}P_{i1}\left[\frac{\sum_{i=1}^{n} Q_{i2}P_{i2}}{\sum Q_{i1}P_{i1}} - \frac{I_{ij2}P_{i2}}{I_{ij1}P_{i1}}\right]$$

The results from Columns 14 to 19 are illustrated in Table 4.4.

From the departmental management team's perspective, it was important to understand the impacts from productivity and price-recovery on profitability. Essentially, the key concern was the required magnitude on the overall productivity improvement that needed to be achieved in order to make up for or offset the GPO inability to increase a unit price of its products. Given the use of Minitab, the regression equation, based on the columns 14, 15, and 16—representing the overall results on productivity, price-recovery, and profitability was computed and can be demonstrated as follows. Also see the graphical illustration (Figure 4.3 on page 110).

Profitability = −0.989 + 1.00 (Productivity) + 0.987 (Price Recovery)

The computation for the above equation is based on the following statistical analysis.

Column 16 = −0.989 + 1.00 Column 14 + 0.987 Column 15 or

Profitability = −0.989 + 1.00 (Productivity) + 0.987 (Price Recovery)

Some of the key lessons that were taken from this study can be summarized as follows. The first lesson stems from the results based on the third section unit. If the unit plans to maintain (not improving) the profitability level of 1.0, both the overall values of productivity and price recovery needed to be approximately 1.0. Given the circumstance facing the GPO, the overall value of productivity needed to continuously achieve a level higher than 1.0 in order to compensate for the negative

TABLE 4.4 Overall Results on Productivity, Price recovery, and Profitability

Period	Productivity		Price Recovery		Profitability	
	Value	Baht	Value	Baht	Value	Baht
07.02–08.02	0.9909	−7,6594.32	1.0020	16,414.37	0.9928	−60,179.95
08.02–09.02	1.0021	18,324.52	1.0100	83,422.66	1.0122	101,747.18
09.02–10.02	0.9689	−25,5510.91	1.0921	702,267.08	1.0581	446,756.17
10.02–11.02	1.0607	51,1374.19	1.0060	54,772.54	1.0671	566,146.72
11.02–12.02	0.9497	−317,140.50	0.9798	−125,113.13	0.9304	−442,253.62
12.02–01.03	1.0469	348,863.17	0.9891	−81,021.77	1.0354	267,841.40
01.03–02.03	1.0233	141,569.29	1.0094	56,527.99	1.0329	198,097.27
02.03–03.03	1.0072	42,550.77	0.9468	−323,855.84	0.9537	−281,305.07
03.03–04.03	1.0335	157,424.74	1.0082	39,057.81	1.0420	196,482.56
04.03–05.03	0.9475	−310,361.91	1.0234	133,882.42	0.9697	−176,479.48
05.03–06.03	0.9722	−200,184.11	1.0312	217,649.26	1.0025	17,465.15
06.03–07.03	1.0020	13,459.08	0.9530	−341,545.79	0.9548	−328,086.71
07.03–08.03	1.0548	377,551.22	1.0549	351,886.65	1.1127	729,437.87
08.03–09.03	0.9624	−187,776.53	0.9605	−199,998.34	0.9244	−387,774.87
09.03–10.03	0.9071	−374,743.29	1.0468	177,168.32	0.9496	−197,574.97
10.03–11.03	1.1634	1,040,355.42	0.9539	−321,070.29	1.1098	719,285.13
11.03–12.03	0.9052	−406,850.94	1.0856	337,892.78	0.9827	−68,958.15
12.03–01.04	1.0625	285,255.42	1.0185	76,974.67	1.0821	362,230.10
01.04–02.04	0.9519	−255,173.00	0.9785	−119,195.30	0.9315	−374,368.30
02.04–03.04	0.9842	−85,540.81	1.0021	10,703.79	0.9863	−74,837.01
03.04–04.04	1.0290	167,544.27	0.9962	−23,367.83	1.0251	144,176.44
04.04–05.04	1.0106	73,638.74	0.9528	−345,968.01	0.9630	−272,329.27
05.04–06.04	0.9893	−87,047.65	0.9918	−65,856.62	0.9813	−152,904.27
06.04–07.04	1.0136	105,254.80	1.0152	118,323.54	1.0290	223,578.33
07.04–08.04	0.9636	−201,995.54	0.9304	−414,418.58	0.8965	−616,414.12
08.04–09.04	0.9410	−297,669.54	1.0984	451,439.08	1.0336	153,769.54
09.04–10.04	1.0035	19,818.15	1.0110	62,454.46	1.0145	82,272.61
10.04–11.04	1.0235	107,189.68	1.0349	156,166.46	1.0592	263,356.14
11.04–12.04	1.0082	26,826.10	0.8173	−718,744.06	0.8240	−691,917.96

constant value of 0.989. This was again due to the GPO's inflexibility and restriction on price-recovery.

The second issue is the consideration into the impacts from the recent governmental policy for universal-health coverage. This policy placed the primary responsibility of producing affordable and basic medicines under the GPO. Therefore, productivity improvement probably would represent the only viable alternative to achieve a profitable status. It should be noted that a profitable operation for a state enterprise's perspective does not represent the for-profit goal but reflects the ability to rely on oneself without financial assistance from the cen-

TABLE 4.5 Demonstration of Statistical Analysis

Predictor	Coefficient	*SE* Coefficient	*t*	*p*
Constant	−0.98946	0.01520	−65.08	0.000
Column 14	1.00203	0.00978	102.45	0.000
Column 15	0.986690	0.00930	106.07	0.000

NOTES S = 0.002607, R^2 = 99.8%, R^2 (adjusted) = 99.8%.

Analysis of Variance

Source	*DF*	*SS*	*MS*	*f*	*p*
Regression	2	0.116547	0.058273	8572.15	0.000
Residual Error	26	0.000177	0.000007		
Total	28	0.116724			
Column 14	1	0.040064			
Column 15	1	0.076483			

Unusual Observations

Obs.	Col. 14	Col. 16	Fit	*SE* Fit	Residual	St. Res.
16	1.16	1.1098	1.11750	0.00162	−0.00770	-3.77^{rx}
17	0.91	0.9827	0.98873	0.00115	−0.00603	-2.57^{r}
29	1.01	0.8240	0.82720	0.00175	−0.00320	-1.66^{x}

NOTES ^{r}An observation with a large standardized residual. ^{x}An observation whose *x* value gives it large influence.

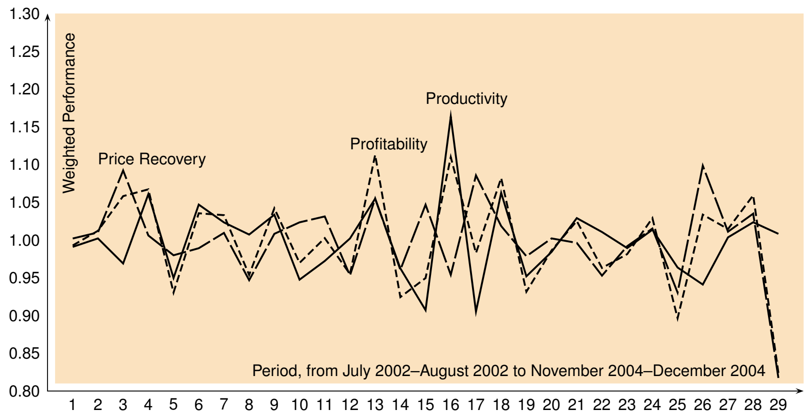

FIGURE 4.3 Graphical Presentation on Productivity, Price-Recovery and Profitability (adapted from Phusavat & Photaranon, 2006)

tral government (while fulfilling its missions and goals). The third issue deals with the opportunity loss. This information created a lot of concern. The opportunity losses (not necessary implying actual financial losses) surprised most senior managers at the production department, especially from the productivity side (where most of improvement interventions from the organization were intended to focus). The GPO had earlier attempted to improve its operations through inventory, delivery, and maintenance.

The fourth issue relates to the material inputs. The materials represented the most important input component. Therefore, the tasks relating to price forecasting, contracting, production planning, inventory control, and exchange rate estimation would have to be examined more carefully. A plan was also being considered on experimenting with an e-procurement system. This could possibly result in a lower purchasing cost. Further, a task for seasonal demand and its impacts on material management and production was discussed.

The follow-up review sessions took place after the review of the MFPMM information. Generally, the use of MFPMM was perceived to be useful and provided helpful information for policy- and decision-making. It helped stimulate the discussion on potential improvement interventions and process improvement (as previously described in the third and fourth implications respectively). Simply put, the MFPMM by and large fulfilled the requirement set forth by the GPO and production department's management on measuring productivity and financially quantifying its impacts on the profit/loss.

Based on these review sessions with the management team and line supervisors, the challenges that the GPO would need to overcome in order to integrate the MFPMM can be summarized as follows. The MFPMM practicality was the central issue of the debate. It was agreed that its sustainability and acceptance would depend on the ability of the management team to analyze performance information. However, the confidence on information interpretations, analysis skills, and knowledge on analysis tools (e.g., use of the Pareto Diagram to help portray the results from Columns 10 and 11, the regression analysis to show the different interrelationships among productivity, price-recovery, and profitability in terms of the time-lag effects, etc.) was not high, especially among line supervisors.

The next critical aspect was the database readiness for a future use of the MFPMM or other productivity/performance measurement techniques. Since the relevant data had been recorded and stored at two locations (i.e., the accounting and production departments), it was necessary that a change would have to be made. It was important that the data needed to be standardized in terms of output and input classifications, and to be uniformly maintained. Otherwise, the measurement effort would only represent merely a monitoring effort (or lagging effort) without much usefulness for analysis and improvement (implying forward-looking or leading effort). It should be noted that, for this experiment, a special effort had to be made in order to obtain necessary data for the MFPMM. The reason was that there was a time overlap between the two departments' data collection frequencies. Some data was collected on the daily basis while others were recorded on the weekly, monthly, and quarterly basis.

For the possibility of a departmental or organizational-wide implementing the MFPMM, it would require additional preparations from the GPO. Based on the lessons learned and the limitations from this experiment, the future preparations need to be made in two aspects. The first one is on technical preparations. Some of the key consideration factors for the MFPMM implementation are as follows.

1. Clarity on inputs to be captured
2. Standardization of data to be collected—outputs and inputs
3. Verification of data accuracy
4. Assignment of a responsible team for these collection and verification tasks,
5. Identification of information-review frequency
6. Developing a management report for analysis and decisions/actions,
7. Recording such decisions for further follow-ups.
8. Readiness assessment of the staffs to be assigned a task of conducting performance analysis such as knowledge and experience on quality tools (e.g., Pareto and Cause-and-Effect Diagrams)

Assurance on skills and expertise of a management team on selecting appropriate productivity/ performance improvement techniques. In addition, a clearer policy is likely needed on a lag-time effect from improvement interventions. Unrealistic expectation of immediate improvement may discourage the continuous use of the MFPMM and other possible future performance measurement techniques.

Finally, these difficulties confronting an effort on performance measurement at the GPO's production department are typical and usual for any organization—not a discouraging sign for the participating management team. Furthermore, the ability to continuously manage the performance, with the focus on linking with analysis and improvement, is essential for sustaining and ensuring the success of performance measurement. Otherwise, it is possible that performance measurement subsequently becomes another stand-alone management tool. As a result, sustaining the use of performance measurement requires a great deal of attention on both technical and managerial aspects.

MFPMM Illustration

For the MFPMM illustration, the following example is discussed in Sink (1985). The purpose of this section is to show how each formula is applied. The interpretations are also provided. In other words, the details on the formulas' applications are described. There are three key issues to be considered.

1. The MFPMM focuses on primary inputs (but not all). That's the reason why it is called multi and not total factors.
2. There are the different unit dimensions when considering multiple inputs and outputs. For instance, the labor input can be measured in persons while the material input can be assessed in pieces. Note that the two inputs can be combined when collecting the data in different unit dimensions.
3. Despite sharing the same unit dimension, the weight difference still imposes a great deal of the difficult for multi factor measurement. For instance, when a manufacturer produces a truck, a container, a car, and a motorcycle, the weight difference should be recognized as a selling price is not the same.

The MFPMM applies the unit cost (when using the inputs for output generation and the unit price (when selling a product) as a key mechanism in adjusting the weight and unit dimension differences. It is important to note that dealing with productivity only focuses on the changes in the quantity of both inputs and outputs. Dealing with price recovery only looks at the unit cost and unit price. On the other hand, for profitability, the formulation include the changes in the quantity (of inputs and outputs), and the unit cost and unit price (of inputs and outputs respectively).

In general, the first step in using the MFPMM involves the identification of the inputs and outputs of a system to be examined. It can be

TABLE 4.6 GPO's MFPMM Demonstration

	11/2004			12/2004		
OUTPUT(S)	1	2	3	4	5	6
Para 10's	1,273,752	2.00	2,547,504.00	1,701,864	1.96	3,335,653.44
Para 100's	21,286	20.62	438,917.32	10,800	20.62	222,696.00
Para 1000's	21,107	112.72	2,379,181.04	3,117	112.35	350,194.95
Total			5,365,602.36			3,908,544.39
INPUT(S)						
Labor						
Managing (man-hr)						
Regular	140	282.14	39,499.60	140	282.14	39,499.60
OT	98	207.00	20,286.00	86	251.53	21,631.58
Pharmacist (man-hr)						
Regular	140	11.07	15,549.80	140	111.07	15,549.80
OT	75	165.00	12,375.00	73	165.00	12,045.00
Officer (man-hr)						
Regular	1960	60.24	118,070.40	1960	60.24	118,070.40
OT	407	92.98	37,842.86	1980.07	73.55	145,634.15
Causal Working (man-hr)						
Regular	980	25.00	24,500.00	980	25.00	24,500.00
OT	1319	48.28	63,681.32	597.25	41.21	24,612.67
Total			331,804.98			40,543.20
Material						
Raw material Para DC (kg)	20400	144.00	2,937,600.00	12000	195.00	2,340,000.00
Sticker—10's (ca)	4440	0.32	1,412.81	5920	0.46	2,743.33
Carton No. 46 (ca)	2160	12.25	26,460.00	2880	12.25	35,280.00
Foil (roll)	264	1,280.00	337,920.00	352	1,280.00	450,560.00
Box (ca)	25920	2.45	63,504.00	34560	2.45	84,672.00
Sticker—100's (ca)	23800	0.15	3,570.00	11900	0.15	1,785.00
Carton No.49 (ca)	1080	3.50	3,780.00	540	3.50	1,890.00
PE—100	21600	3.17	68,443.92	10800	2.46	26,578.80
Aluminium Foil (ca)	20000	0.25	5,000.00	10000	0.25	2,500.00
Spongy—100 (kg)	11	450.00	4,950.00	5.5	450.00	2,475.00
Sticker—1000	23600	0.37	8,729.64	3540	0.36	1,263.78
Carton No.23	1060	13.20	13,992.00	159	13.20	2,098.80
PE—1000	21600	7.63	164,874.96	3240	6.72	21,786.08
Aluminium Foil—1000 (ca)	20000	0.45	9,000.00	3000	0.45	1,350.00
Spongy—1000 (kg)	40	450.00	18,000.00	6	450.00	2,700.00
Total			3,667,237.33			2,977,682.79
Energy						
Water (Unit)	95	16.08	1,527.60	101	16.08	1,624.08
Electricity (Unit)	12256.93	3.04	37,261.07	14196.83	2.93	41,596.71
Total				38,788.67		43,220.79
Services						
Maintenance	1	1,929.02	1,929.02	1	1,850.00	1,850.00
Total						1,850.00
Etc.						
Miscellaneous	1	407,725.59	407.725.59	1	507,368.30	507,368.30
Total			407,725.59			507,368.30
Total Input			4,447,485.59			3,931,665.08
Difference			918,116.77			−23,120.69

NOTES Column headings are as follows: (1) quantity, (2) price, (3) value, (4) quantity, (5) price, (6) value.

TABLE 4.6 *Continued from the previous page*

	Weighted Change Ratios			Cost/Revenue Ratio		Productivity Ratios	
OUTPUT(S)	7	8	9	10	11	12	13
Para 10's	1.3361	0.9800	1.3094				
Para 100's	0.5074	1.0000	0.5074				
Para 1000's	0.1477	0.9967	0.1472				
Total	0.7413	0.9826	0.7284				
INPUT(S)							
Labor							
Managing (man-hr)							
Regular	1.000	1.000	1.000	0.0074	0.0101	135.8394	100.7041
OT	0.8776	1.2151	1.0663	0.0038	0.0055	264.4978	223.4452
Pharmacist (man-hr)							
Regular	1.0000	1.0000	1.0000	0.0029	0.0040	345.0593	255.8086
OT	0.9733	1.0000	0.9733	0.0023	0.0023	433.5840	330.2426
Officer (man-hr)							
Regular	1.0000	1.0000	1.0000	0.0220	0.0302	45.4441	33.6898
OT	4.8650	0.7910	3.8484	0.0071	0.0373	141.7864	21.6058
Causal Working (man-hr)							
Regular	1.0000	1.0000	1.0000	0.0046	0.0063	219.0042	162.3581
OT	0.4528	0.8536	0.3865	0.0119	0.0063	84.2571	137.9483
Total	1.3273	0.9118	1.2102	0.0618	0.1027	16.1710	9.0320
Material							
Raw material Para DC (kg)	0.5882	1.3542	0.7966	0.5475	0.5987	1.8265	2.3020
Sticker—10's (ca)	1.3333	1.4563	1.9418	0.0003	0.0007	3797.8284	2111.6310
Carton No. 46 (ca)	1.3333	1.0000	1.3333	0.0049	0.0090	202.7816	
Foil (roll)	1.3333	1.0000	1.3333	0.0630	0.1153	15.8783	112.7486
Box (ca)	1.3333	1.0000	1.3333	0.0118	0.0217	84.4924	8.8285
Sticker—100's (ca)	0.5000	1.0000	0.5000	0.0007	0.0005	1502.9698	46.9786
Carton No. 49 (ca)	0.5000	1.0000	0.5000	0.0007	0.0005	1419.4715	2228.4438
PE—100	0.5000	0.7767	0.3883	0.0128	0.0068	78.3941	2104.6414
Aluminium Foil (ca)	0.5000	1.0000	0.5000	0.0009	0.0006	1073.1205	116.2345
Spongy—100 (kg)	0.1500	1.0000	0.5000	0.0009	0.0006	1083.9601	1591.1089
Sticker—1000	0.1500	0.9651	0.1448	0.0016	0.0003	614.6419	1607.1807
Carton No. 23	0.1500	1.0000	0.1500	0.0026	0.0005	383.4764	3037.7520
PE—1000	0.1500	0.8809	0.1321	0.0307	0.0056	32.5435	1895.2603
Aluminium Foil—1000 (ca)	0.1500	1.0000	0.1500	0.0017	0.0003	596.1780	160.8400
Spongy—1000 (kg)	0.1500	1.0000	0.1500	0.0034	0.0007	298.0890	2946.4980
Total	0.6478	1.2535	0.8120	0.6835	0.7618	1.4631	1473.2490
Energy							
Water (Unit)	1.0632	1.0000	1.0632	0.0003	0.0004	3512.4394	2449.2465
Electricity (Unit)	1.1583	0.9638	1.1164	0.0069	0.0106	144.0002	92.1669
Total	1.1545	0.9651	1.1143	0.0072	0.0111	138.3291	88.8244
Services							
Maintenance	1.0000	0.9590	0.9590	0.0004	0.0005	2781.5172	2062.0689
Total	1.0000	0.9590	0.9590	0.0004	0.0005	2781.5172	2062.0689
Etc.							
Miscellaneous	1.0000	1.2444	1.2444	0.0760	0.1298	13.1598	9.7560
Total	1.0000	1.2444	1.2444	0.0760	0.1298	13.1598	9.7560
Total Input	0.7353	1.2022	0.8840	0.8289	1.0059	1.2064	1.2163
Difference							

NOTES Column headings are as follows: (12) period 1, (13) period 2.

Continued on the next page

TABLE 4.6 *Continued from the previous page*

	Weighted Performance Indexes			Bath Effects On Profits		
OUTPUT(S)	14	15	16	17	18	19
Para 10's						
Para 100's						
Para 1000's						
Total						
INPUT(S)						
Labor						
Managing (man-hr)						
Regular	0.7413	0.9826	0.7284	(10,216.70)	(509.63)	(10,726.33)
OT	0.8448	0.8086	0.6831	(2,763.04)	(4,091.31)	(6,854.35)
Pharmacist (man-hr)						
Regular	0.7413	0.9826	0.7284	(4,022.01)	(200.63)	(4,222.63)
OT	0.7617	0.9826	0.7484	(2,870.83)	(159.66)	(3,030.50)
Officer (man-hr)						
Regular	0.7413	0.9826	0.7284	(30,539.28)	(1,523.36)	(32,062.65)
OT	0.1524	1.2422	0.1893	(156,052.00)	37,984.51	(118,067.72)
Causal Working (man-hr)						
Regular	0.7413	0.9826	0.7284	(6,337.00)	(316.10)	(6,653.11)
OT	1.6372	1.1512	1.8847	18,374.71	3,400.93	21,775.65
Total	0.5585	1.0777	0.6019	(194,426.37)	34,584.74	(159,841.63)
Material						
Raw material Para DC (kg)	1.2603	0.7256	0.9145	449,780.41	(649,901.38)	(200,120.97)
Sticker—10's (ca)	0.5560	0.6747	0.3751	(877.81)	(877.81)	(1,714.18)
Carton No. 46 (ca)	0.5560	0.9826	0.5463	(341.39)	(341.39)	(16,005.35)
Foil (roll)	0.5560	0.9826	0.5463	(4,359.90)	(4,359.90)	(204,403.98)
Box (ca)	0.5560	0.9826	0.5463	(819.34)	(819.34)	(38,412.85)
Sticker—100's (ca)	1.4827	0.9826	1.4569	(46.06)	(46.06)	815.55
Carton No. 49 (ca)	1.4827	0.9826	1.4569	(48.77)	(48.77)	863.52
PE—100	1.4827	1.2652	1.8758	6,760.09	6,760.09	23,278.81
Aluminium Foil (ca)	1.4827	0.9826	1.4569	(64.51)	(64.51)	1,142.22
Spongy—100 (kg)	1.4827	0.9826	1.4569	(63.87)	(63.87)	1,130.80
Sticker—1000	4.9423	1.0181	5.0318	(66.97)	(66.97)	5,095.28
Carton No. 23	4.9423	0.9826	4.8563	(180.53)	(180.53)	8,093.60
PE—1000	4.9423	1.1154	5.5128	817.92	817.92	98,316.20
Aluminium Foil—1000 (ca)	4.9423	0.9826	4.8563	(116.12)	(116.12)	5,206.00
Spongy—1000 (kg)	4.9423	0.9826	4.8563	(232.24)	(232.24)	10,412.00
Total	1.1445	0.7839	0.8971	(649,540.87)	(649,540.87)	(306,303.34)
Energy						
Water (Unit)	0.6973	0.9826	0.6852	(491.60)	(19.71)	(511.31)
Electricity (Unit)	0.6400	1.0195	0.6525	(15,534.99)	1,080.90	(14,454.09)
Total	0.6421	1.0181	0.6537	(16,026.59)	1,061.19	(14,965.39)
Services						
Maintenance	0.7413	1.0246	0.7596	(498.95)	54.13	(444.82)
Total	0.7413	1.0246	0.7596	(498.95)	54.13	(444.82)
Etc.						
Miscellaneous	0.7413	0.7896	0.5854	(105,459.52)	(140,903.25)	(210,362.77)
Total	0.7413	0.7896	0.5854	(105,459.52)	(140,903.25)	(210,362.77)
Total Input	1.0082	0.8173	0.8240	26,826.10	(718,744.06)	(691,917.96)
Difference						

NOTES Column headings are as follows: (14) change in productivity, (15) change in price recovery, (16) change in profitability, (17) change in productivity, (18) change in price recovery, (19) change in profitability.

FIGURE 4.4 Identification of the Inputs and Outputs for Boat Production

shown as followed. The MFPMM focuses on the inputs that immediately result in the outputs. These inputs typically include labor, materials, and utilities. For this illustration, there are two types of the plant's outputs. They are Boats A and B. The plant utilizes various inputs which contribute directly to the boat production. They include labor, materials, and utilities. For labor, there are three groups; i.e., assembly, fiberglass, and plant management. For materials, there are two key categories; i.e., woods and fiberglass. Finally, for utilities, the usage focuses on natural gas and electricity. Finally, when applying the MFPMM, the computation and analysis need to at least cover two periods. The first period can be considered as a base while the second period is a comparison (Figure 4.4).

Columns 1–6 For the case illustration, the first six columns represent basic data which involves the quantity, the unit price and unit cost, and the value (Table 4.7). The value (or the financial value), in $US, is computed by multiplying the quantity with the unit price (or the unit cost).

Column 7 The details for the Column 7 computations are as follows. Notice that the unit price and cost remains constant at Period 1 since the focus is on the quantity change. Also note that the weight adjustment and unit dimension conversion are made.

Output quantities (Boats A and B): 27.27% more outputs from the period 1 to 2 with the unit price/cost remains constant at period 1 to reflect the true changes in the quantity.

$$\frac{70 \times 5{,}000 + 35 \times 10{,}000}{50 \times 5{,}000 + 30 \times 10{,}000} = 1.2727$$

Input quantities: 5% less total labor consumed from the period 1 to 2 with the unit price/cost remains constant at period 1 to reflect the true changes in the quantity:

$$\frac{304 \times 20 + 760 \times 8 + 1{,}064 \times 6}{320 \times 20 + 800 \times 8 + 1{,}120 \times 6} = 0.95$$

TABLE 4.7 Initial MFPMM with Quantity, Unit Price and Cost, and Financial Value

Category	Period 1			Period 2		
	(1)	(2)	(3)	(4)	(5)	(6)
Boat A	50	5,000	250,000	70	5,500	385,000
Boat B	30	10,000	300,000	35	12,000	420,000
Outputs			550,000			805,000
Mgt.	320	20	6,400	304	22	6,688
Glass	800	8	6,400	760	9	6,840
Assembly	1,120	6	6,720	1,064	7	7,448
Labor			19,520			20,976
Fiberglass	2,200	50	110,000	3,000	85	255,000
Wood	750	3	2,250	1,000	3	3,000
Materials			112,250			258,000
Electricity	8000	0.10	800	8,200	0.10	820
Natural gas	100	4	400	90	4	260
Energy			1,200			1,180
Inputs			132,970			280,156

NOTES Column headings are as follows: (1) quantity, (2) price/cost, (3) value, (4) quantity (5) price/cost, (6) value.

Input quantities: 36.3% more total materials consumed from the period 1 to 2 with the unit price/cost remains constant at period 1 to reflect the true changes in the quantity:

$$\frac{3{,}000 \times 50 + 1{,}000 \times 3}{2{,}200 \times 50 + 750 \times 3} = 1.363$$

Input quantities: 29.9% more total inputs consumed from the period 1 to 2 with price/cost remains constant at period 1 to reflect true changes in quantity:

$$\frac{304 \times 20 + 760 \times 8 + 1{,}064 \times 6 + 3{,}000 \times 50 + 1{,}000 \times 3 + 8{,}200 \times 0.1 + 90 \times 4}{320 \times 20 + 800 \times 8 + 1{,}120 \times 6 + 2{,}200 \times 50 + 750 \times 3 + 8{,}000 \times 0.1 + 100 \times 4} = 1.299$$

Column 8 The details for the Column 8 computations are as follows. Notice that the quantity used or produced is held constant at Period 2 since the focus is on the change in the unit price and cost.

Also note that the weight adjustment and unit dimension conversion are made.

Output prices (Boats A and B): 15% higher price per unit of outputs from the period 1 to 2 with the quantity remains constant at period 2 to reflect the true changes in the unit price/cost:

TABLE 4.8 MFPMM's Applications—Weight Change and Cost-to-Revenue Ratios

Category	Weighted Change Ratios			Period 2	
	(7)	(8)	(9)	(10)	(11)
Boat A	1.4000	1.1000	1.540		
Boat B	1.1667	1.2000	1.400		
Outputs	1.2727	1.1500	1.464		
Mgt.	0.9500	1.1000	1.045	0.0116	0.0083
Glass	0.9500	1.1225	1.069	0.0116	0.0085
Assembly	0.9500	1.1667	1.108	0.0122	0.0093
Labor	0.9500	1.3110	1.075	0.0355	0.0261
Fiberglass	1.3636	1.7000	2.318	0.2000	0.3168
Wood	1.3330	1.0000	1.330	0.0041	0.0037
Materials	1.3630	1.6863	2.298	0.2041	0.3205
Electricity	1.0250	1.0000	1.025	0.0015	0.0010
Natural gas	0.9000	1.0000	0.900	0.0007	0.0004
Energy	0.9833	1.0000	0.983	0.0022	0.0015
Inputs	1.2990	1.622	2.107	0.2418	0.3480

NOTES Column headings are as follows: (7) quantity, (8) price/cost, (9) value, (10) period 1, (11) period 2.

$$\frac{70 \times 5{,}500 + 35 \times 12{,}000}{70 \times 5{,}500 + 35 \times 10{,}000} = 1.15$$

Input costs: 13.11% higher cost per unit of the overall labor from the period 1 to 2 with quantity remains constant at period 2 to the reflect the true changes in the unit price/cost:

$$\frac{304 \times 22 + 760 \times 9 + 1{,}064 \times 7}{304 \times 20 + 760 \times 8 + 1{,}064 \times 6} = 1.1311$$

Input costs: 68.63% higher cost per unit of the overall materials from the period 1 to 2 with quantity remains constant at period 2 to reflect the true changes in the unit price/cost:

$$\frac{3{,}000 \times 85 + 1{,}000 \times 3}{3{,}000 \times 50 + 1{,}000 \times 3} = 1.6863$$

Input costs: 62.20% higher cost per unit of the inputs from the period 1 to 2 with quantity remains constant at period 2 to reflect the true changes in the price/cost:

$$\frac{304 \times 22 + 760 \times 9 + 1{,}064 \times 7 + 3{,}000 \times 85 + 1{,}000 \times 3 + 8{,}200 \times 0.1 + 90 \times 4}{304 \times 20 + 760 \times 8 + 1{,}064 \times 6 + 3{,}000 \times 50 + 1{,}000 \times 3 + 8{,}200 \times 0.1 + 90 \times 4} = 1.622$$

Column 9 The details for the Column 9 computations are as follows. Notice that, since this column deals with the financial value, there is no need to hold the quantity, and the unit cost and price constant. Also note that the weight adjustment and unit dimension conversion are made.

Output value or revenues (Boats A and B): 46.36% higher financial value from Boats A and B from the period 1 to 2:

$$\frac{70 \times 5{,}500 + 35 \times 12{,}000}{50 \times 5{,}000 + 30 \times 10{,}000} = 1.4636$$

Input value or costs: 7.46% higher cost of the overall labor from the period 1 to 2:

$$\frac{304 \times 22 + 760 \times 9 + 1{,}064 \times 7}{320 \times 20 + 800 \times 8 + 1{,}120 \times 6} = 1.0746$$

Input value or costs: 129.8% higher cost of the overall materials from the period 1 to 2:

$$\frac{3{,}000 \times 85 + 1{,}000 \times 3}{2{,}200 \times 50 + 750 \times 3} = 2.298$$

Input value or costs: 110.7% higher cost of the inputs from the period 1 to 2:

$$\frac{304 \times 22 + 760 \times 9 + 1{,}064 \times 7 + 3{,}000 \times 85 + 1{,}000 \times 3 + 8{,}200 \times 0.1 + 90 \times 4}{320 \times 20 + 800 \times 8 + 1{,}120 \times 6 + 2{,}200 \times 50 + 750 \times 3 + 8{,}000 \times 0.1 + 100 \times 4} = 2.107$$

For Columns 10 and 11, the details can be described as follows.

Column 10 The computation for Column 10 is simple as it uses the data from the first period. Note that the Pareto Diagram should be used to reflect the proportion of the inputs.

- Total labor cost represents 3.55% of the total output value (from 19,520 ÷ 550,000).
- Total material cost represents 20.41% of the total output value (from 112,250 ÷ 550,000).
- Total cost represents 24.18% of the total output value (from, 132,970 ÷ 550,000).

Column 11 For Column 11, the computation is the same as of the 10th column. This computation is based on the data from Column 6. Note that the Pareto Diagram should again be used and analyzed in conjunction with the results from the 10th column. Which cost factor(s) consistently appear in the highest contributors' group should receive the attention from a plant or a company management.

TABLE 4.9 MFPMM's Applications—Productivity Change and Dynamic Ratios

Category	Productivity Ratios		Weighted Performance		
	(12)	(13)	(14)	(15)	(16)
Boat A					
Boat B					
Outputs					
Mgt.	85.94	115.13	1.340	1.045	1.401
Glass	85.94	115.13	1.340	1.022	1.369
Assembly	81.85	109.65	1.340	0.986	1.321
Labor	28.18	37.75	1.340	1.017	1.362
Fiberglass	5.00	4.67	0.933	0.676	0.631
Wood	244.44	233.33	0.955	1.150	1.098
Materials	4.90	4.58	0.934	0.682	0.637
Electricity	687.50	835.66	1.242	1.150	1.428
Natural gas	1375.00	1944.44	1.414	1.150	1.626
Energy	458.33	593.22	1.294	1.150	1.488
Inputs	4.14	4.05	0.980	0.709	0.695

NOTES Column headings are as follows: (12) period 1, (13) period 2, (14) productivity, (15) price-recovery, (16) profitability.

- Total labor cost represents 2.61% of the output value (from 20,976 ÷ 805,000). When comparing with the 10th column, the burden on the labor cost has come down.
- Total material cost represents 32.05% of the output value (from 258,000 ÷ 805,000). When comparing with the 10th column, the burden on the material cost has gone down.
- Total cost represents 34.8% of the output value (from 280,156 ÷ 805,000). When comparing with the 10th column, the burden on the total cost has gone up.

For the next five columns, the computations will become more difficult as the MFPMM attempts to focus on the change in productivity and to introduce the dynamic features into the ratios involving productivity, price recovery, and profitability.

Column 12 For Column 12, it is important to revisit the term productivity used in the MFPMM. Productivity deals with the change in quantity of the outputs produced relatively to the change in the quantity of the inputs consumed when producing the outputs. As a result, when computing the productivity change, the practice on holding the unit price and cost constant is still applied. This computation is based on the first period (or the base period).

For the total labor productivity, the result based on the data from the third column is as follows.

$$\frac{50 \times 5{,}000 + 30 \times 10{,}000}{320 \times 20 + 800 \times 8 + 1{,}120 \times 6} = \frac{550{,}000}{19{,}520} = 28.18$$

For the total material productivity, the result based on the data from the third column is as follows.

$$\frac{50 \times 5{,}000 + 30 \times 10{,}000}{2{,}200 \times 50 + 750 \times 3} = \frac{550{,}000}{112{,}250} = 4.90$$

For the overall productivity in the first period, the result based on the data from the third column as follows.

$$\frac{50 \times 5{,}000 + 30 \times 10{,}000}{320 \times 20 + 800 \times 8 + 1{,}120 \times 6 + 2{,}200 \times 50 + 750 \times 3 + 8{,}000 \times 0.1 + 100 \times 4} = 4.14$$

Column 13 For Column 13, in order to reflect the true in productivity, the unit price and cost needs to be held as a constant value at the first period so that the focus on the quantity change can be made.

For the total labor productivity, the result is as follows.

$$\frac{70 \times 5{,}000 + 35 \times 10{,}000}{304 \times 20 + 760 \times 8 + 1{,}064 \times 6} = \frac{700{,}000}{189{,}544} = 37.75$$

For the total material productivity, the result is as follows.

$$\frac{70 \times 5{,}000 + 35 \times 10{,}000}{3{,}000 \times 50 + 1{,}000 \times 3} = \frac{700{,}000}{153{,}00} = 4.58$$

For the overall productivity, the result is as follows.

$$\frac{70 \times 5{,}000 + 35 \times 10{,}000}{304 \times 20 + 760 \times 8 + 1{,}064 \times 6 + 3{,}000 \times 50 + 1{,}000 \times 3 + 8{,}200 \times 0.1 + 90 \times 4} = 4.05$$

The overall change shows a small decline in productivity. It indicates that the use of the input quantity is more than an increase in the outputs generated.

For Columns 14–17, the computation becomes more complex as the MFPMM introduces the dynamic ratios. In general, the dynamic ratio represents the comparison of two ratios. In this case, the focus is on comparing the ratios relating to the outputs with the input-related ratios.

Column 14 Specifically for Column 14, the dynamic measures on productivity imply the comparison between a rate of change in the output quantity produced and a rate of change in the input quantity used.

The overall labor productivity level is computed as follows. When the value is greater than 1.0, it implies that the rate of the output quantity generated is faster than the rate of the input quantity consumed from the first to second period.

$$\frac{\dfrac{70\times 5{,}000+35\times 10{,}000}{50\times 5{,}000+30\times 10{,}000}}{\dfrac{304\times 20+760\times 8+1{,}064\times 6}{320\times 20+800\times 8+1{,}120\times 6}}=\frac{1.2727}{0.95}=1.34$$

The overall material productivity level is computed as follows. When the value is less than 1.0, it implies that the rate of the output quantity generated is slower than the rate of the input quantity consumed from the first to second period.

$$\frac{\dfrac{70\times 5{,}000+35\times 10{,}000}{50\times 5{,}000+30\times 10{,}000}}{\dfrac{3{,}000\times 50+1{,}000\times 3}{2{,}200\times 50+750\times 3}}=\frac{1.2727}{1.363}=0.933$$

The overall productivity level is computed as follows.

$$\frac{\dfrac{70\times 5{,}000+35\times 10{,}000}{50\times 5{,}000+30\times 10{,}000}}{\dfrac{304\times 20+760\times 8+1{,}064\times 6+3{,}000\times 50+1{,}000\times 3+8{,}200\times 0.1+90\times 4}{320\times 20+800\times 8+1{,}120\times 6+2{,}200\times 50+750\times 3+8{,}000\times 0.1+100\times 4}}=\frac{1.2727}{1.299}=0.98$$

Column 15 Specifically for Column 15, the dynamic measures on price recovery imply the comparison between a rate of change in the unit price and a rate of change in the unit cost. A firm is able recover well if it can raise its unit price as fast as an increase in a unit cost.

The overall price recovery for the labor factor is as follows. When the value is greater than 1.0, it implies that the rate of the unit price change is higher than the change in the unit cost of the input factors.

$$\frac{\dfrac{70\times 5{,}500+35\times 12{,}000}{70\times 5{,}000+35\times 10{,}000}}{\dfrac{304\times 22+760\times 9+1{,}064\times 7}{304\times 20+760\times 8+1{,}064\times 6}}=\frac{1.15}{1.10}=1.045$$

The overall price recovery for the material factor is as follows. When the value is less than 1.0, it implies that the rate of the unit price change is lower than the change in the unit cost of the input factors.

$$\frac{\dfrac{70\times 5{,}500+35\times 12{,}000}{70\times 5{,}000+35\times 10{,}000}}{\dfrac{3{,}000\times 85+1{,}000\times 3}{3{,}000\times 50+1{,}000\times 3}}=\frac{1.15}{1.6863}=0.682$$

The overall price recovery can be computed as follows.

$$\frac{\frac{70\times5{,}500+35\times12{,}000}{70\times5{,}000+35\times10{,}000}}{\frac{304\times22+760\times9+1{,}064\times7+3{,}000\times85+1{,}000\times3+8{,}200\times0.1+90\times4}{320\times20+760\times8+1{,}064\times6+3{,}000\times50+1{,}000\times3+8{,}200\times0.1+90\times4}}=\frac{1.15}{1.622}=0.709$$

Column 16 Specifically for Column 16, the dynamic measures on profitability imply the comparison between a rate of change in the output value and a rate of change in the input value.

The profitability on the labor factor indicates that, while the labor cost has gone up by 7.46% from the first to second period, the output value has increased at the faster rate (or at 46.36%).

$$\frac{\frac{70\times5{,}500+35\times12{,}000}{50\times5{,}000+30\times10{,}000}}{\frac{304\times22+760\times9+1{,}064\times7}{320\times20+800\times8+1{,}120\times6}}=\frac{1.4636}{1.0746}=1.362$$

The profitability on the material factor indicates that, while the output value has gone up by 46.36%, the material cost from the usage during the first to second period has increased at a much faster rate which should raise the level of concern among a plant or a company management.

$$\frac{\frac{70\times5{,}500+35\times12{,}000}{50\times5{,}000+30\times10{,}000}}{\frac{3{,}000\times85+1{,}000\times3}{2{,}200\times50+750\times3}}=\frac{1.4636}{2.298}=0.637$$

The overall profitability for the production of Boats A and B has decreased. It can be shown as follows.

$$\frac{\frac{70\times5{,}500+35\times12{,}000}{50\times5{,}000+30\times10{,}000}}{\frac{304\times22+760\times9+1{,}064\times7+3{,}000\times85+1{,}000\times3+8{,}200\times0.1+90\times4}{320\times20+800\times8+1{,}120\times6+2{,}200\times50+750\times3+8{,}000\times0.1+100\times4}}=\frac{1.4636}{2.107}=0.695$$

For the remaining two columns in the MFPMM, the focus is on the financial implications in terms of the opportunity gains and losses due to the increase and decrease in the productivity, price-recovery, and profitability areas. As stated earlier, the simple explanation of the opportunity concept is through the extrapolation's application. This application is only relevant to the productivity and profitability. As a result, the financial impact for the price-recovery is computed by subtracting the results from Column 19 (on profitability) with Column 17 (on productivity).

Column 17 The description of Column 17 is as follows. A single factor can be used and summarized for the total input factor. By revisiting

TABLE 4.10 Opportunity Concept in the MFPMM

Category	Monetary impacts (opportunity)		
	(17)	(18)	(19)
Boat A			
Boat B			
Outputs			
Mgt.	2,065.45	613.82	2,679.27
Glass	2,065.45	461.82	2,527.27
Assembly	2,165.73	218.91	2,387.64
Labor	6,299.64	1,294.54	7,594.18
Fiberglass	−10,000.00	−84,000.00	−94,000.00
Wood	−136.36	429.55	293.18
Materials	−11,136.36	−83,570.44	−93,706.81
Electricity	198.18	152.73	350.91
Natural gas	149.09	76.36	225.45
Energy	347.27	229.09	579.36
Inputs	−3,489.45	−82,046.81	−85,536.27

NOTES Column headings are as follows: (17) change in productivity, (18) change in price-recovery, (19) change in profitability.

productivity, the computation is based on holding a unit price and cost constant at the first period. This allows the focus to be on the quantity change.

Specifically for the labor assembly, the output of Boats A and B are as follows (based on the unit price in the period 1):

- 50 × 5,000 + 30 × 10,000 = 550,000 for period 1
- 70 × 5,000 + 35 × 10,000 = 700,000 for period 2

Labor assembly cost (based on the unit cost in the period 1): (1,120 × 6) = 6,720 for the first period.

Given: with the value of 550,000, the consumption is at \$6,720 in the first period. With 700,000, the use of labor assembly should have been at (700,000 × 6,720) ÷ 550,000 or \$8,552.73.

The result indicates the quantity of labor assembly that should have been consumed in the second period is (8,552.73 ÷ 6) or 1,425.46. However, the actual consumption in the second period is only 1,064. In other words, a plant has used the labor assembly less than it should have by 361.46. In the financial term, it is \$2,168.73 (361.46 × 6).

For the fiberglass, the output of Boats A and B are as follows (based on the unit price in the period 1):

- 50 × 5,000 + 30 × 10,000 = 550,000 for period 1
- 70 × 5,000 + 35 × 10,000 = 700,000 for period 2

Fiberglass cost (based on the unit cost in the period 1): (2,200 × 50) = 110,000 for the first period.

Given: with the value of 550,000, the consumption is at $110,000 in the first period. With 700,000, the use of labor assembly should have been at (700,000 × 110,000) ÷ 550,000 or $140,000.

The result indicates the quantity of fiberglass that should have been consumed in the second period is (140,000 ÷ 50) or 2,800. However, the actual consumption in the second period is 3,000. In other words, a plant has used the fiberglass more than it should have by 200. In the financial term, it is $10,000 (200 × 50).

Column 18 The data for Column 18 is derived from the subtraction between Columns 19 and 17.

Column 19 For Column 19, the computation on the labor assembly factor from the opportunity concept is as follows. Note that when dealing with the term profitability, there is no need to hold either the quantity or the unit price and cost constant.

The output value from the first period is 550,000 with the use of labor assembly of during the same period is 6,720.

Given the actual output from period 2 of 805,000, the financial value of labor assembly input should have been during the second period at 9,835.64. This is derived from: 805,000 × 6,720 ÷ 550,000.

However, the actual consumption value is 7,448. As a result, a plant has consumed $2,387.64 (i.e., 9,835.64 – 7,448) less the labor assembly value than it should have.

Specifically for the fiberglass, the output value from the first period is 550,000 with the consumption value of fiberglass of 110,000. Given the actual output from the second period of 805,000, the value of fiberglass input that should have been consumed is 161,000. This is derived from: 805,000 × 110,000 ÷ 550,000 = 161,000.

However, the actual consumption value is 255,000. As a result, a plant has used $94,000 (i.e., 255,000 – 161,000) more fiberglass value than it should have.

Finally, for the total input, the output value from the first period is 550,000 with the value consumption of the total inputs is 132,970. Given the actual output from the second period of 805,000, the value of total inputs should have been 194,619.7. This is derived from: 805,000

× 132,970 ÷ 550,000 = 194,619.7. Since the actual consumption value is 280,156; a plant has consumed $85,536.3 (i.e., 280,156,000 − 194,619) more the input value than it should have.

Exercises

4.1 From the MFPMM model, what are the roles of productivity in contributing to profitability?

4.2 From the case application below, provide your own insights on performance analysis and recommend the future improvement interventions of the company under study. Hint: You need to examine a furniture-making firm.

Case Description: The MFPMM has been applied at one furniture-making company, known as VCH. The company is currently producing wood-related products such as chairs, office furniture, office floor, and so on. The observation and careful examination were made in regard to the level of impacts from productivity and price-recovery on the term profitability. To accomplish this task, the multiple regression method was employed. In this examination, the set of data for the MFPMM was collected from the company's accounting system during 2004 to 2009. Specifically for this paper, the period 1 will be designated as a base period while the period 2 will be referred to as a current period as illustrated in Table 4.11.

For the VCH, there are eight output categories. They are: (1) parquet flooring, (2) mosaic flooring, (3) timber flooring, (4) wood skirt, (5) lumber, (6) installation, (7) door, window, frame, and stair, and (8) sandpaper, sawdust, glue, and other materials. On the other hand, this study focuses on four types of input (based on data availability and its weight on the total company's cost). They are (1) labor, (2) materials, (3) energy, and (4) miscellaneous.

The statistical technique to be used for finding the interrelationship among productivity, price-recovery and profitability is the regression model. It should be noted that due to the fact that there are one dependent variable and two independent variables, a multiple regression model is to be applied for this study. For this case study, only three values in regard to productivity, price-recovery, and profitability are utilized. The results from the multiple-linear regression model in which the impacts from productivity and price-recovery are integrated into the profitability equation illustrated in Table 4.13.

By using the multiple-linear regression model, the interrelationships among profitability, productivity, and price-recovery can be demonstrated as follows: Profitability = −0.97568 + 1.14011 (Productivity) + 0.83116 (Price-Recovery).

TABLE 4.11 Base Period and Current Period for the MFPMM

Base Period	2004	2005	2006	2007	2008
Current Period	2005	2006	2007	2008	2009

TABLE 4.12 Units of Measurement for the MFPMM Application

Outputs/inputs	Quantity	Unit Price	Value
Outputs			
1. Parquet flooring	Square Meter	Baht/m^2	Baht
2. Mosaic flooring	Square Meter	Baht/m^2	Baht
3. Timber flooring	Cubic Foot	Baht/ft^3	Baht
4. Skirt	Meter	Baht/m	Baht
5. Lumber	Cubic Foot	Baht/ft^3	Baht
6. Installation	Square Meter	Baht/m^2	Baht
7. Door, window, frame, and stair	Year	Baht/year	Baht
8. Sandpaper, sawdust, glue, etc.	Year	Baht/year	Baht
Inputs			
1. Labor			Baht
1.1. Management	Day	Baht/day	Baht
1.2. Controller	Day	Baht/day	Baht
1.3. Workers	Day	Baht/day	Baht
1.4. Installation Workers	Square Meter	Baht/m^2	Baht
2. Materials			Baht
2.1. Wood	Year	Baht/year	Baht
2.2. Glue, Rope, Sandpaper, and Paint	Year	Baht/year	Baht
3. Energy			Baht
3.1. Electricity	Year	Baht/year	Baht
3.2. Water	Year	Baht/year	Baht
4. Miscellaneous			Baht
4.1. Transportation	Year	Baht/year	Baht
4.2. Gas	Year	Baht/year	Baht
4.3. Maintenance/spares	Year	Baht/year	Baht
4.4. Miscellaneous	Year	Baht/year	Baht

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TABLE 4.13 Productivity, Price-Recovery and Profitability Values from 2004–2009

Period	Productivity	Price Recovery	Profitability
2004–2005	0.6609	1.4163	0.9361
2005–2006	0.8798	1.1327	0.9965
2006–2007	0.7861	1.1426	1.3698
2007–2008	05639	1.2199	0.6880
2008–2009	0.9980	0.8737	0.8716

TABLE 4.14 Summary of the Outputs in terms of ANOVA Table

Regression Statistics	
Multiple R	0.99712
R^2	0.99426
Adj. R^2	0.98851
Std. Error	0.02684
Observations	5

ANOVA	*Df*	*SS*	*MS*	*F*	Sig. *F*
Regression	2	0.24941	0.12470	173.06734	0.00574
Residual	2	0.00144	0.00072		
Total	4	0.25085			

	Coeff.	Std. Err.	*t*	*p*	Lower 95%	Upper 95%	Lower 90.0%	Upper 90.0%
(1)	−0.97568	0.11025	-8.85007	0.01253	−1.45003	−0.50133	−1.29760	−0.65377
(2)	1.14011	0.08807	12.94557	0.00591	0.76118	1.51904	0.88295	1.39727
(3)	0.83116	0.04659	17.84163	0.00313	0.63072	1.03161	0.69514	

NOTES Row headings are as follows: (1) intercept, (2) productivity, (3) price recovery.

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Chapter Five

Multi-Criteria Performance Measurement/Analysis Technique

The Multi-Criteria Performance Measurement/Analysis Technique or MCPMT represents an attempt to measure and analyze key performance areas, especially productivity. The MCPMT helps link between measurement and analysis (Sink & Tuttle, 1989). This technique can assist during an attempt to identify the overall performance level (by converting into a non-dimensional scale information). This technique is based on the concept of the multi-attribute decisions (Phusavat & Kingpadung, 2005).

Strengthening an organization's management process has increasingly become more important since it is part of continuous performance improvement efforts (Anussornnitisarn, Phusavat, Jaiwong, Pennanen, & Helo, 2009). Given constant changes and complexity of business environments (due to globalization and information technology's applications in the workplace), the urgency to improve a management process is even more demanding. An improved management process can result in better decisions' quality and timeliness. This gives a company's management a more strategic focus by incorporating all necessary information with respect to financial and non-financial information, competitor-centered and customer-focused.

A typical management process has five important activities: (1) measurement, (2) evaluation and analysis, (3) improvement interventions, (4) deployment and monitoring, and (5) sharing lessons, experiences, and knowledge to ensure constant learning and development. In general, without a strong management process, it would be difficult to plan and deploy organizational policies and objectives, and to monitor and evaluate performance levels (Sink & Tuttle, 1989). Improvement interventions stems from better information visibility, management by facts, staffs' acceptance of changes, shifts in organizational paradigm or problem perception, and likelihood to achieve stable work and operatonal processes.

It is important to note that performance measurement and analysis are different. They require different skills for successful implementation and applications (Sink, 1985). Performance measurement should derive from business needs and strategy, and provides critical information on key processes, outputs, and results. On the other hand, performance analysis focuses on extracting larger meaning from existing information to support evaluation and improvement. This analysis needs to rely on using quantitative data in order to anticipate future trends and to understand causes and effects that may not otherwise be evident.

Performance analysis deals with two issues simultaneously: (1) current performance levels or "as is" from performance measurement, and (2) expected performance levels and their interrelationships or "should be." The performance analysis should link the as-is and should-be components.

In reference to the MSM, a managing director's domain was an organization while a plant manager's domain would be a factory. The MSM's flow revealed many crucial behaviors which are important for effective performance measurement and analysis. They were as follows.

- Decisions/actions from a management team needed to be primarily based on a management report. These decisions/actions needed to focus on current and/or potential problems facing the domain of responsibility. Knowing an overall performance level is critical. The MCPMT helps resolve this aspect.
- There was the need to have a specific set of measures representing the feedback on decisions/actions. These measures needed to consider a database capability such as data availability, accuracy, and timeliness (i.e., frequency of management review).
- The information contained in a report needed to be user-friendly.

Introduction and Illustration

The MCPMT has been widely adapted and used for performance measurement at the functional and organizational levels. This technique can assist during an attempt to identify the overall performance level or the overall level of each of the seven performance criteria (given that each criterion is measured by several ratios). This technique is based on the concept of the multi-attribute decisions. The primary mechanism for this technique involves the use of the performance scale and the preference curve. In other words, the MCPMT can be implemented in the following sequence (Phusavat & Kingpadung, 2005).

TABLE 5.1 Productivity Ratios for the MCPMT Applications

Output Value ÷ Indirect Labor (denoted as ILAB) in Baht per Hour
Output Value ÷ Direct Labor (denoted as DLAB) in Baht per Hour
Output Value ÷ Material (denoted as MAT) in Baht per Piece
Output Value ÷ Utility (denoted as UTI) in Baht per Baht

1. Identification of performance measures, especially in a ratio format
2. Collection of data
3. Selection of a performance scale to be used by all ratios, e.g., the 0–1.00, 0–10.00, or 0–100.00 scale
4. Analysis of data for better understanding on what represents high and poor performance from each ratio
5. Development of a preference curve for each ratio—each ratio can have a different preference curve
6. Collection of the latest data and integration it to individual ratios' preference curve
7. Retrieval of an actual performance level from the preference curve
8. Assign the weights for each ratio
9. Identification of an overall performance level

A case demonstration is shown in Table 5.1. There are four productivity ratios. Note that, since the company under study has a quick turnaround time for its products, it is acceptable to use the term revenue for the output value. Then, the data for each productivity ratio was collected over the period of 12 months.

For the application of the MCP/MT, the performance scale of 0 to 100 is to be used for all productivity ratios. The best result over the one-year duration from each ratio is to receive the score of 100 while the worst number is to be assigned the score of 0. The score of 50 is for the average value. Then, other results in each month can be assigned the numerical scores between the score 0 to 100 (since the three points, namely the maximum, minimum, and average values, form the so-called preference curve) by the interpolation (Table 5.2).

The scores shown on Table 5.2 are derived from the interpolation which is based on the preference curves for the output value-to-indirect labor ratio. When initially attempting to apply the MCPMT, at least

TABLE 5.2 Demonstration of the Values from the Scale of 0 to 100

1	15.66	72.00
2	14.83	62.48
3	18.10	100.00
4	14.91	63.40
5	16.22	78.43
6	14.80	62.14
7	14.85	62.71
8	15.34	68.33
9	15.63	71.66
10	10.27	31.40
11	4.41	0.00
12	12.97	45.86
13	10.66	33.49
(4)	13.74	50.00

NOTES Column headings are as follows: (1) month, (2) outputs value ÷ ILAB, (3) score from the 0–100 scale, (4) average.

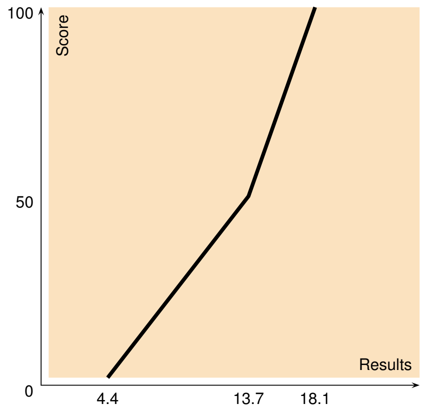

FIGURE 5.1 Illustration of Preference Curve for the Output Value-to-Indirect Labor Ratio

three points are recommended. The highest performance should match with the best point from the 0–100 scale; i.e., the score of 100. The lowest performance should correspond to the worst point from the 0–100 scale; i.e., the score of 0. For the score of 50, there are several possibilities. In this example, the average performance over the duration of one year is chosen. On the other hand, an industrial average, a benchmark, or a competitor's performance level can also be selected (Figure 5.1).

Given the scores for all four productivity ratios, the next task is to assign the weight. For this illustration, an equal weight is used to compute an overall level of productivity for each month (Table 5.3).

MCPMT Application

The section provides the use of the MCPMT when attempting to gain better understanding on innovation by one company. As previously stated, there are several areas which reflect the term performance; in addition to, productivity. They include quality, quality of work life, and innovation (Phusavat & Jaiwong, 2008a). Some has previously been mentioned as a productivity surrogate which reflects a contributor to

TABLE 5.3 Determination of Overall Productivity Levels from the 0–100 Scale

(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	72.00	35.22	3.16	19.44	0.25	32.46
2	62.48	5.85	86.18	44.22	0.25	49.68
3	100.00	66.65	64.71	0.00	0.25	57.84
4	63.40	100.00	0.00	47.64	0.25	52.76
5	78.48	82.90	9.04	76.89	0.25	61.82
6	62.14	66.14	56.21	49.12	0.25	58.40
7	62.71	83.93	100.00	70.17	0.25	79.20
8	68.33	85.29	31.24	100.00	0.25	71.22
9	71.66	64.43	73.48	63.24	0.25	68.20
10	31.40	30.09	20.71	40.22	0.25	30.66
11	0.00	34.37	21.94	49.57	0.25	26.47
12	45.86	28.24	90.60	35.02	0.25	49.93
13	33.49	0.00	74.69	8.90	0.25	29.27

NOTES Column headings are as follows: (1) month, (2) outputs value ÷ ILAB, (3) outputs value ÷ DLAB, (4) outputs value ÷ MAT, (5) outputs value ÷ UTI, (6) weight for each ratio, (7) overall productivity level.

or the impacts from being productive. In this case application, there was a request to look at and assess an overall level of an organization's innovativeness. The top management for the company under study felt strongly that the innovation is an indication of the level of productiveness. In other words, if an organization is productive, the level of innovativeness should also be high. As a result, several ratios were proposed. The following example describes the case.

Based on the discussion with the company's top management, the term innovation needed to reflect the ability to adapt to changing business environment and competition. Altogether, there were a total of seven ratios which were deemed suitable for measuring the innovation and learning of an organization. The data was collected on the monthly basis (Table 5.4). They were:

- IL1: R&D expense per total expenses (%)
- IL2: Competence development expenses per employee (Baht per person)
- IL3: Satisfied-employee index (%)
- IL4: Marketing expense per customer (Baht per person)
- IL5: Information coverage ratio (%)

TABLE 5.4 Illustration of the Results from Individual Innovation Ratios

Period	IL1	IL2	IL3	IL4	IL5	IL6	IL7
1	2.11	45.28	79.00	566.04	80.00	71.43	0.00
2	4.29	43.17	79.00	539.57	80.00	71.43	0.95
3	4.93	42.11	79.00	526.32	80.00	71.43	0.48
4	4.47	40.68	82.00	593.22	80.00	68.81	0.00
5	2.00	39.34	82.00	573.77	80.00	68.81	0.46
6	1.97	38.09	82.00	555.57	80.00	114.68	0.00
7	1.92	38.71	82.00	580.66	87.00	114.68	0.00
8	3.80	36.92	82.00	1,461.59	87.00	114.68	0.00
9	1.95	36.47	82.00	547.11	87.00	109.65	0.00
10	2.00	35.82	85.00	537.31	87.00	65.79	0.00
11	1.92	35.82	85.00	1,432.84	87.00	65.79	0.00
12	2.17	35.82	85.00	1,492.54	87.00	65.79	0.00
13	1.92	45.46	85.00	576.37	90.00	90.91	0.87
14	3.79	45.46	85.00	1,424.51	90.00	90.91	0.00
15	1.95	45.46	85.00	418.99	90.00	75.76	0.00
16	2.01	45.46	90.00	417.83	90.00	75.76	0.00
17	1.92	45.46	90.00	831.02	90.00	75.76	0.00
18	2.17	45.46	90.00	1,388.89	90.00	75.76	0.00

- IL6: Investment in new product support and training per total employees (Baht per person)
- IL7: Staff turnover (%)

The performance scale of 0 to 100 was selected for all ratios. Furthermore, there were three points that would form a preference curve like the previous example. For a ratio with a desirable increasing trend, the highest result over the 18-period duration received the score of 100 while the lowest result was assigned the value of 0. On the other hand, for a ratio with a desirable decreasing trend (such as rejection and rework rates), the highest result received the score of 0 while the lowest result was assigned the value of 100. The score of 50 was for the average result over the 18-period duration. Then, the next task was to convert the results from each ratio into a common 0–100 scale. Afterward, the following task was to derive an overall performance result on an organization's innovation by assigning an equal weight to individual ratios. This overall result would later be computed by multiplying individual results from the interpolations of the 0–100 scale with the assigned weight (Figure 5.2).

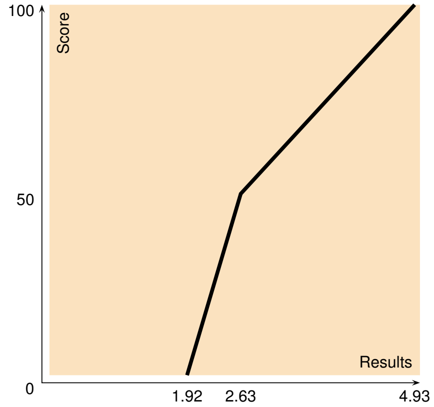

FIGURE 5.2 Illustration of Preference Curve for IL1

TABLE 5.5 Preference Curve Formulation

Period	IL1	IL2	IL3	IL4	IL5	IL6	IL7
1	2.11	45.28	79.00[w]	566.04	80.00[w]	71.43	0.00[b]
2	4.29	43.17	79.00	539.57	80.00	71.43	0.95[w]
3	4.93[b]	42.11	79.00	526.32	80.00	71.43	0.48
4	4.47	40.68	82.00	593.22	80.00	68.81	0.00
5	2.00	39.34	82.00	573.77	80.00	68.81	0.46
6	1.97	38.09	82.00	555.57	80.00	114.68[b]	0.00
7	1.92[w]	38.71	82.00	580.66	87.00	114.68	0.00
8	3.80	36.92	82.00	1,461.59	87.00	114.68	0.00
9	1.95	36.47	82.00	547.11	87.00	109.65	0.00
10	2.00	35.82[w]	85.00	537.31	87.00	65.79[w]	0.00
11	1.92	35.82	85.00	1,432.84	87.00	65.79	0.00
12	2.17	35.82	85.00	1,492.54[w]	87.00	65.79	0.00
13	1.92	45.46[b]	85.00	576.37	90.00[b]	90.91	0.87
14	3.79	45.46	85.00	1,424.51	90.00	90.91	0.00
15	1.95	45.46	85.00	418.99	90.00	75.76	0.00
16	2.01	45.46	90.00[b]	417.83[b]	90.00	75.76	0.00
17	1.92	45.46	90.00	831.02	90.00	75.76	0.00
18	2.17	45.46	90.00	1,388.89	90.00	75.76	0.00
Average	2.63	41.17	83.83	803.56	85.67	82.66	0.15

NOTES [b] Best performance level. [w] Worst level of performance.

Use of MCPMT to Interpret Productivity

The section illustrates one case study that earlier employed the MCPMT. This case is based on the attempt to gain better understanding on cause-and-effect relationships between productivity and quality of

TABLE 5.6 Conversion to a Common Performance Scale of 0–100

Period	IL1	IL2	IL3	IL4	IL5	IL6	IL7
1	13.24	98.00	0.00	80.79	0.00	16.72	100.00
2	86.05	73.32	0.00	84.22	0.00	16.72	0.00
3	100.00	60.96	0.00	85.94	0.00	16.72	29.79
4	90.13	45.44	31.03	77.26	0.00	8.95	100.00
5	5.46	32.97	31.03	79.79	0.00	8.95	30.88
6	3.59	21.28	31.03	82.15	0.00	100.00	100.00
7	0.00	27.03	31.03	78.89	65.38	100.00	100.00
8	75.43	10.31	31.03	2.25	65.38	100.00	100.00
9	1.77	6.11	31.03	83.24	65.38	92.15	100.00
10	5.46	0.00	59.46	84.51	65.38	0.00	100.00
11	0.00	0.00	59.46	4.33	65.38	0.00	100.00
12	17.80	0.00	59.46	0.00	65.38	0.00	100.00
13	0.00	100.00	59.46	79.45	100.00	62.89	5.18
14	75.43	100.00	59.46	4.94	100.00	62.89	100.00
15	1.77	100.00	59.46	99.85	100.00	29.55	100.00
16	5.46	100.00	100.00	100.00	100.00	29.55	100.00
17	0.00	100.00	100.00	48.01	100.00	29.55	100.00
18	17.80	100.00	100.00	7.52	100.00	29.55	100.00

TABLE 5.7 Overall Level of Innovation

(1)	(2)	(1)	(2)	(1)	(2)
1	44.11	7	57.48	13	58.14
2	37.19	8	54.92	14	71.82
3	41.92	9	54.24	15	70.09
4	50.40	10	44.97	16	76.43
5	27.01	11	32.74	17	68.22
6	48.29	12	34.66	18	64.98

NOTES Column headings are as follows: (1) period, (2) overall score from the 0–100 scale.

work life. As previously mentioned on an emerging importance of the intangible assets, the roles of human capital are expected to become a factor for sustaining the high productivity level in an organization (Phusavat & Jaiwong, 2008a). Investing in new machinery and technology alone is no longer sufficient. The study is derived from the interrelationships among seven performance criteria proposed by Sink and Tuttle (1989). They even suggested that continuous improvement in the productivity level depends on quality of work life or QWL. This term

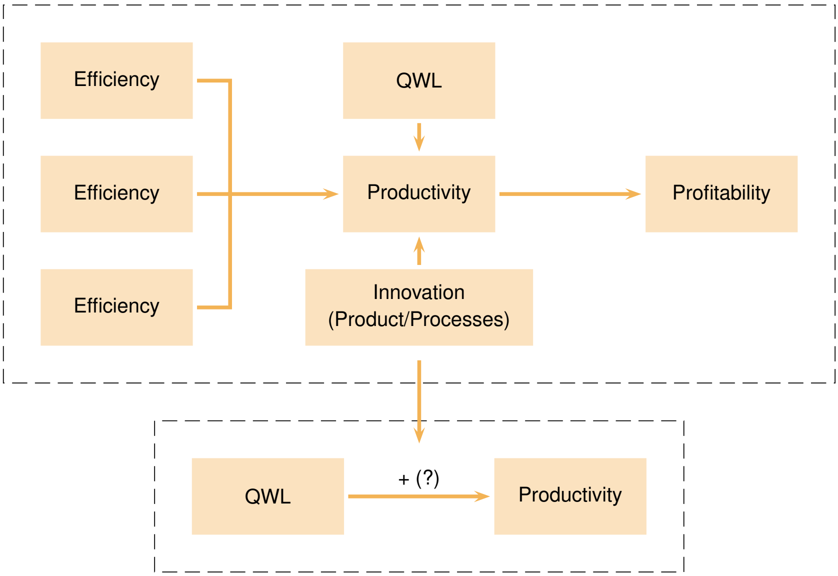

FIGURE 5.3 Scope of the Case on Productivity Analysis

represents general feeling and attitude towards a workplace by staffs which may include working environment, safety, peer relationships, career development, etc (Phusavat & Jaiwong, 2008b). The premise for the study is that high level of QWL should contribute positively to productivity. The MCPMT is employed for the analysis (Figure 5.3).

There were many ratios identified for both productivity and QWL. Altogether, there were seven ratios for productivity and four ratios used for measuring QWL.

The data collection was made for the 12-month period. To apply the MCPMT, the performance scale of 0 to 100 was to be used for all eleven ratios. The maximum result over this duration from each ratio would receive the score of 100 while the minimum outcome would be assigned the score of 0. The score of 50 was assigned for the average value. The other results could be assigned the numerical scores (within the 0–100 scale) since the three points (the maximum, minimum, and average) formed the so-called preference curve. Therefore, in this research, the preference curves were in the linear shape (Tables 5.9 and 5.10 and Figure 5.4 on page 141).

Then, all ratios (i.e., seven ratios for an overall productivity level and four ratios for an overall QWL level) were assigned the scores. The equal

TABLE 5.8 Productivity and QWL Ratios

Productivity	QWL
1. Product ÷ Labor (Kilograms per person in one month)	1. Training ÷ Labor (Hours per person in one month)
2. Product ÷ Total labor cost (Kilograms per Baht in one month)	2. Job turnover (Person per person in one month)
3. Product ÷ Total production labor cost (Kilograms per Baht in one month)	3. Compensation cost ÷ Labor (Baht per person in one month)
4. Product ÷ Total cost for utility in production (Kilograms per Baht in one month)	4. Total benefits for labor ÷ Labor (Baht per person in one month)
5. Product ÷ Total utility cost (Kilograms per Baht in one month)	
6. Product ÷ Total material cost (Kilograms per Baht in one month)	
7. Product ÷ Total production cost (Kilograms per Baht in one month)	

TABLE 5.9 Partial Demonstration of the Performance Scale and the Value from the Preference Curve for a Productivity Ratio

NOTES Column headings are as follows: (1) month, (2) product quantity (kilogram), (3) production cost (Baht), (4) result (kg/Baht), (5) score from the scale of 0–100.

(1)	(2)	(3)	(4)	(5)
1	3,759,330	60,617,398	0.0620	53.57
2	4,789176	81,363690	0.0588	40.62
3	3,580,156	58,267,128	0.0614	50.01
4	2,960,450	45,050,045	0.0657	76.51
5	3,955,924	57,157,662	0.0692	98.21
6	3,463,664	56,128,735	0.0617	51.66
7	3,173,232	56,220,960	0.0564	31.84
8	4,096,096	58,987,297	0.0695	100.00
9	2,438,338	41,025,687	0.0594	42.71
10	2,999,212	47,471,134	0.0632	60.78
11	4,142,824	61,555,639	0.0673	86.37
12	3,554,552	63,186,932	0.0562	31.15
13	2,451,552	51,418,508	0.0477	0.00
Average			0.0614	50.00

weight was assigned for each ratio within productivity and QWL (Tables 5.11 and 5.12 on page 142).

After the statistical tests, the following findings were discovered. Given the integration of the time factor into the examination, the interrelationships became much more robust and explicit. These findings explained that gradually over time, the QWL would impact the level of productivity. The higher level of QWL would result in the increasing level of productivity. The opposite relationships could also be stated.

TABLE 5.10
Partial Demonstration of the Performance Scale and the Value from the Preference Curve for a QWL Ratio

NOTES Column headings are as follows: (1) month, (2) employees who resign from work, (3) current employees, (4) results, (5) score from the scale of 0–100.

(1)	(2)	(3)	(4)	(5)
1	44	482	0.091	26.87
2	48	520	0.092	26.12
3	60	470	0.128	0.00
4	26	462	0.056	55.19
5	14	446	0.031	90.06
6	12	494	0.024	100.00
7	18	492	0.037	82.78
8	18	518	0.035	85.35
9	32	518	0.062	48.68
10	34	536	0.063	47.45
11	20	550	0.036	83.09
12	40	526	0.076	38.13
13	26	546	0.048	67.32

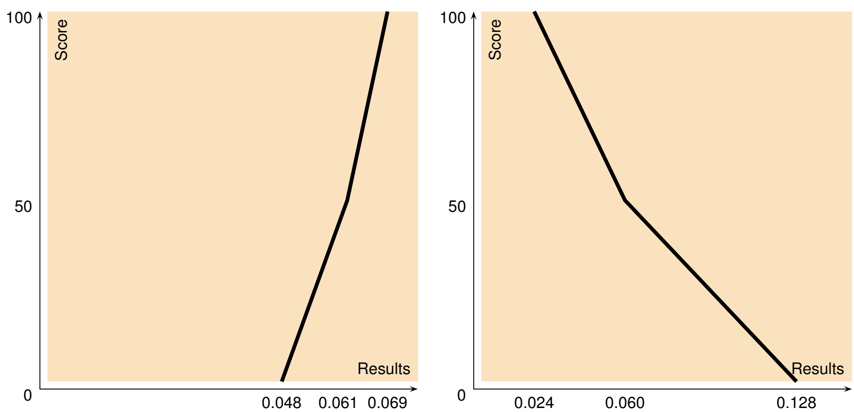

FIGURE 5.4 Preference for the Productivity and QWL Ratios

Further examinations also showed that if the level of QWL were to be constant, the level of productivity would without doubt decline. This was due to time-lag effects. The interrelationships from the statistical analyses can be illustrated as follows. The interrelationships between the overall levels of the two criteria ($y = a + bx + ct$, where y and x are the overall levels of productivity and QWL respectively, and the term t represents the number of months to be incorporated.)

$$y = 0.945(x) - 4.220(t)$$

The interrelationships are depicted in Figure 5.6 on page 143.

Finally, the key lessons learned from this study can be summarized

TABLE 5.11 Weighted Average Scores for Productivity (Scale 0–100)

(1)	P1	P2	P3	P4	P5	P6	P7	(2)	(3)
1	68.79	82.79	86.62	52.38	75.07	46.89	53.57	1/7	66.59
2	100.00	91.66	100.00	94.84	100.00	34.56	40.62	1/7	80.24
3	64.76	60.77	71.93	44.48	13.56	53.20	50.01	1/7	51.25
4	38.97	49.86	49.43	27.42	32.97	76.44	76.51	1/7	50.23
5	92.47	100.00	99.57	81.18	74.87	97.29	98.21	1/7	91.94
6	51.35	45.22	49.23	41.51	39.76	49.54	51.66	1/7	46.90
7	39.82	49.62	0.00	42.13	60.43	31.50	31.84	1/7	36.48
8	71.18	62.52	71.93	57.93	60.43	100.00	100.00	1/7	74.86
9	4.41	0.00	6.48	7.78	31.80	69.11	42.71	1/7	23.18
10	22.47	24.23	31.40	29.83	1.73	69.11	60.78	1/7	34.22
11	62.88	75.22	84.27	100.00	99.37	79.49	86.37	1/7	83.94
12	46.08	35.15	41.72	58.68	48.88	29.34	31.15	1/7	41.57
13	0.00	8.77	16.94	0.00	0.00	0.00	0.00	1/7	3.67

NOTES Column headings are as follows: (1) month, (2) weight, (3) weighted score.

TABLE 5.12 Weighted Average Scores for QWL (Scale 0–100)

NOTES Column headings are as follows: (1) month, (2) weight, (3) weighted score.

(1)	QWL1	QWL2	QWL3	QWL4	(2)	(3)
1	0.00	26.87	98.64	48.15	0.25	43.42
2	5.97	26.12	64.34	100.00	0.25	49.11
3	6.61	0.00	0.00	70.74	0.25	19.34
4	33.61	55.19	92.72	28.96	0.25	52.62
5	93.87	90.06	44.99	72.99	0.25	75.48
6	100.00	100.00	47.64	65.75	0.25	78.35
7	0.00	82.78	90.50	31.13	0.25	51.10
8	67.77	85.35	78.80	82.69	0.25	78.65
9	15.99	48.68	95.45	28.59	0.25	47.18
10	42.49	47.45	100.00	31.90	0.25	55.46
11	98.12	83.09	64.34	46.24	0.25	72.95
12	75.71	38.13	83.74	73.26	0.25	67.71
13	45.50	67.32	99.27	0.00	0.25	53.02

as follows. The development of the ratios should also be comprehensive. Initially, there were some of the proposed ratios planned to be utilized such as: (1) Lateral transfer rate, (2) Unplanned absent hours working hours, (3) Work Stoppage hours due to injuries and occupational safety issues working hours, and (4) % of new recruits resigned within 6-month period after admission due to work-related reasons. Due to the lack of data, they were omitted which would affect the com-

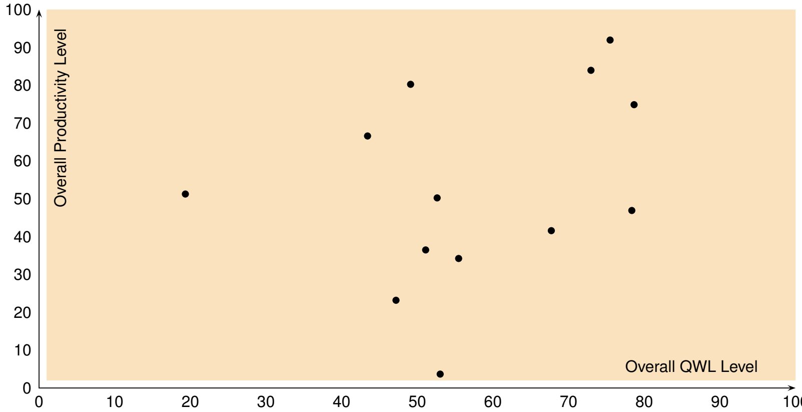

FIGURE 5.5 Scattering Plot for Productivity—QWL Relationships

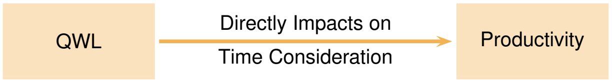

FIGURE 5.6 Impacts from QWL on Productivity with the MCPMT Application

prehensiveness of QWL. Simply put, the data availability plays an important role in the MCPMT success.

The development of a preference curve is also critical for the MCPMT applications. The preference curve developments are based on a closed-system approach in which the best and worst performance levels are selected from the past data. The preference curve is unique from one ratio to the next (unlike the performance scale). The values on this curve should be controllable as well as challenging and measurable (numerical figures). The weight assignment should also reflect an organization's policies and objectives.

Exercises

5.1 Based on the following case company which operates as a part maker in an automotive industry, develop at least five ratios and apply the MCPMT to provide an overall performance level. Hint: You may adapt the ratio development from the network concept by Harper (1984) earlier discussed. The company's top management aims to further reduce the subcontractor expenses as forecasting and production planning should gradually be improved. All data is in Baht (Thai currency; see Table 5.13).

TABLE 5.13 Data for Applying the MCPMT

(1)	(2)	(3)	(4)	(5)	(6)	(7)
January	78,762,000	24,547,000	7,963,000	98,000	1,583,000	874,000
February	60,134,000	23,334,000	6,227,000	112,000	2,127,000	912,000
March	82,277,000	23,870,000	6,455,000	85,000	1,855,000	989,000
April	47,556,000	10,619,000	4,852,000	78,000	846,000	652,000
May	31,467,000	12,055,000	4,047,000	51,000	997,000	545,000
June	20,425,000	11,457,000	3,398,000	54,000	785,000	516,000
July	28,064,000	12,141,000	3,352,000	65,000	1,005,000	576,000
August	24,974,000	12,379,000	3,751,000	45,000	998,000	544,000
September	33,449,000	14,327,000	4,274,000	49,000	776,000	512,000
October	51,325,000	18,177,000	4,912,000	56,000	1,056,000	743,000

NOTES Column headings are as follows: (1) month, (2) output value, (3) raw materials, (4) direct labor, (5) injury/compensation, (6) subcontractors, (7) utility.

References and Further Reading

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Chapter Six

Ratio Development as Productivity Surrogates

The ratio development is important when attempting to measure productivity. The primary reason stems from the need to have the surrogates in order to gain better insights into the level of productivity. There are several steps and key consideration factors when identifying meaningful ratios. The ability to come up with new ratios and/or to revise an existing set of the ratios is critical for sustaining the effectiveness of productivity (as well as performance) measurement. This is because a poorly designed measurement system likely will have several problems during use. They are as follows.

1. Failure to use information from productivity measurement for improvement interventions
2. Failure to obtain necessary data for the given ratios
3. Failure to continuously measure the productivity and other productivity-related areas
4. Failure to revise, adjust, delete, or add the ratios when necessary

In general, during the attempt to derive the ratios as productivity surrogates, the consideration be given the ability to collect, store, and retrieve. Otherwise these ratios will have no value to decision-makers. In other words, for productivity surrogates to be effective and utilized, data consideration must be simultaneously included. The data availability includes whether data is generated at the frequency required. If a productivity surrogates is to be used on the monthly basis, its corresponding data must be generated every month.

The unit dimensions (e.g., hours, persons, m^2, m^3, \$, and so on) must be clarified during the design. This issue can be a challenge as a team in charge of data collection has to be included with a management team who determines the ratios and analyze this information. For example, a facility space can be measured in *s* or m^2. The unit dimensions for delivery service can include distance (in kilometers), cost (in \$), and quantity (in tons).

Clear description on what to be measured is also important. For example, the term labor must be clarified whether it includes all classifications of the workforce or one specific level such as direct and indirect staffs. When focusing on maintenance cost, a company needs to clarify whether it focuses on only in-house maintenance or a combination of in-house and contracted-out maintenance services. Even the term revenue when using it for the output value can be defined in many ways within an organization. The term can indicate only a combination of cash and account receivable, or this combination subtracted with returns from customers.

The ratio development helps ensure the ability to gain better knowledge and insights into the productivity (as well as performance) levels within an organization. The ratio implies quantifiable measurement—meaning that a ratio can be calculated and compared over time. The ratio format is necessary for future benchmarking which is critical for adapting external knowledge to help improve the productivity levels. This is referred to as the need to normalize productivity information. In addition, the use of a ratio which needs to use verified data can lead to less confrontational and obstructive by staffs. In addition, when developing the ratios, there are many consideration factors which can be described as follows (Muhos, Kess, Phusavat, & Sanpanich, 2010).

The data-processing capability also involves the issues in regard to sorting, dissemination, and retrieval. This capability which reflects the flexibility and robustness of the organization's information system must be considered. The term robustness addresses the speed in which the conversion of the unit dimensions and of the report format for the system's user is made. The dimension of labor should be easily adjusted from persons to person-hours or person-$. In addition, the team, formed for the task on productivity measurement, should have in-depth knowledge on the type and the level of accuracy of data, the capability for dimension conversion, and the programming of the report formats for the system's user.

It is also important that a user be considered at the ratio identification stage. The user of the system must be clearly identified. His/her background with respect to cognitive style and preference on information portrayal and perception must be determined. This also includes past experience and educational background. In other words, the personal preference on the specific characteristic of information (e.g., tabular, descriptive, and/or graphical format) must be known. Furthermore, the need for training on interpreting the information from productivity surrogates must be identified. Otherwise, the user may not accept or use the system.

The consideration must also be given to the objectives and policies of the organization. Without these two elements, an attempt to measure productivity will become meaningless. The reason is that they cannot provide feedback in regard to the accomplishment of organizational objectives, or the determination of the area of weaknesses. The useability consideration should also include those who could be impacted by decisions/actions made after having implemented productivity measurement. Involving them at the design stage is important. The sense of ownership to the productivity measurement system should encompass its users and people whom may be impacted by its presence.

It is important that the proposed productivity surrogates be tested before their implementation (Phusavat, Nilmaneenava, Kanchana, Wernz, & Helo, 2012). Testing can be arranged to make it similar to past situations and/or can be completed through simulated circumstances. This testing is to ensure that the readiness of the information system. Furthermore, the effort to design and develop productivity measurement incurs cost. As a result, understanding of and knowledge with respect to cost resulted from this effort is critical. Such cost categories are, for example, data collection, documentation, reporting, and so on. Although top managers tend to accept it as a necessary decision-making tool, high cost for data collection and information reporting cannot be overlooked.

Finally, the issues relating to how to revise or adjust the proposed ratios when needed should be considered (Phusavat & Chansa-ngavej, 2007). The need to schedule a review on these ratios should be made. In other words, the user must review the suitability of the ratios as they still reflect the productivity level. Furthermore, there are changes in business strategies, technologies employed in the organization, an incentive system, the user must review whether these surrogates are still applicable or suitable.

Applications of Input/Output Analysis

The Input/Output Analysis has been widely used to help identify the set of ratios needed to reflect the productivity level, and to assess and indicate the performance level of an organization. This analysis is based on a systematic viewpoint. It stresses that an active system needs to

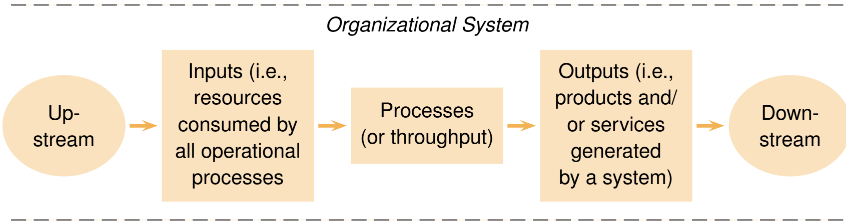

FIGURE 6.1 Extended Input/Output Analysis

generate outputs and to consume inputs or resources. Traditionally, the inputs include labor, materials, capital, machinery, utility, facility space, and information. It is important to recognize that one of the on-going issues relating to the input side is how to incorporate outsourced work (or the tasks that need to be contracted out to other firms) into consideration. As a result, On the other hand, for the output side, it reflects all products and/or services generated by a system to serve customers and users such as finished products. It is critical to note that even undesirable outputs such as wastes, and rejects should be considered when measuring productivity (Phusavat, Anussornnitisarn, Rassameethes, Helo, & Kess, 2009).

The contemporary perspective today highlights the need to extend the input-process-output chain with upstream prior to the input and with downstream after the output (Lee et al., 2011). The term upstream deals with the providers of the inputs which typically include suppliers, contractors, and regulators. On the other hand, the term downstream focuses on the impacts from the outputs in many areas. They are: financial impacts such as profit from selling the product, customer impacts such as satisfactory level as a result of product usage, and other impacts such as higher income for trainees who take part in in-house training provided to surrounding communities (as part of a company's corporate social responsibility policy). In addition to upstream, various terms have also been referred to such as the outcomes, the impacts, etc.

Productivity Surrogates

Often, measuring productivity directly is not entirely possible. Past research has advocated the use of surrogates which can be used to substitute a key component in the term productivity and to reflect the productivity level (Phusavat, Anussornnitisarn, Rassameethes, & Kess, 2009). As previously mentioned, it is common to replace the out-

TABLE 6.1 Quality Measurement as a Productivity Surrogate for a Service Delivery Firm Description

Description (negative features to be avoided)	(1)	(2)	(3)
Late delivery (more than 2 hours after an agreed time)	1		
Missing proof of service delivery to customers	1		
Invoice amendment requested by a customer	1		
Complaint(s) reopened by the same customer	5		
No reply from a customer's phone call	5		
Damaged goods during delivery (resulting in a reclaim)	10		
Lost goods during delivery (resulting in a comp. of an insured item)	10		

NOTES Column headings are as follows: (1) weight (level of seriousness), (2) frequency (occurrence in one month), (3) points (weight × frequency).

put value with revenue, especially under the circumstance of a short turnaround time from finished products to sold goods to customers. Nevertheless, if there is a mechanism in place in which the value of holding cost is known (so that the revenue subtracted by the holding cost becoming the output value), then it is quite flexible to quantify the output side of productivity.

The use of quality measurement to reflect productivity is also common. The reason is that when measuring quality, it is normal to focus on rejects, returns, and reworks. As a result, many ratios such as rework-to-materials and rejects-to-labor have often been used to simultaneously evaluate the performance level on productivity and quality. It is nothing out of the ordinary to assume that high rejects, returns, replacements, and reworks indicate poor quality as well as low productivity. In some cases, the surrogate concept is further adapted when it is difficult to measure positive outcomes from work. For instance, when a delivery company is productive, the use of financial performance alone does not provide accurate productivity information. As a result, there is an attempt to gain better understanding on negative outcomes under the following presumption. If the negative outcome does not take place, it indicates high service quality and use of resources productively. See Table 6.1 for an example in a Thailand.

Recently, the use of quality of work life and innovation as the surrogate for productivity has become more popular. Probably, this is due to the growing importance of white-collar and knowledge workers as well as the emphasis more towards service providers. Their definitions are as follows.

Innovation Ability to change over time within processes or operations, and products/services offered in the market. The term innovation focuses on the ability to understand customers' needs and want by offering new products and services on the continuous basis. At the same time, when focusing on operational processes, the innovativeness reflects how simple and how fast an improvement (i.e., change and modification) can take place.

QWL Reflecting on how people feel toward their workplace. Feeling in driven by factors such as pay, compensation, recognition, safety, culture, relationships with co-workers and supervisors, flexibility, autonomy, etc. The negative feeling likely impacts on quality and subsequently productivity. In addition, financial performance is expected to suffer if poor QWL continues.

In general, measuring innovation incorporates new products and services recently offering to the markets and how well they have been received or greeted by customers. On the other hand, for process innovation, the focus has been the suggestions made by staffs and customers, and whether these suggestions have been considered and determined their suitability. It is based on the presumption that if a firm is able to utilize available time from its staffs and resources productively, then it should also be innovative.

For QWL, the feeling of a staff to a workplace is critical. Negative feeling probably will result in poorer quality at the beginning. If this negative feeling persists, work stoppage likely follows. In some cases, this can lead to workplace thief and sabotage. As a result, the attention on occupational safety and health is important, especially continuous feedback from staffs and assessments on a workplace. Sink (1985) used the cockpit analogy to highlight the importance of performance dashboard analogy, and also to underline the interrelationships between productivity and innovation as well as QWL. These interrelationships allow both to reflect the productivity level.

To identify the ratios, there is a need to again observe the results from the Input/Output Analysis. The first step is to depict a box which represents all key processes. Then, an agreement needs to be made on what constitutes the output side (i.e., what comes out from the box). Afterwards, a focus on what resources to be consumed by the box should be undertaken. The next step is to describe the outputs' expected impacts. Finally, what constitutes the upstream can be identified. It is important

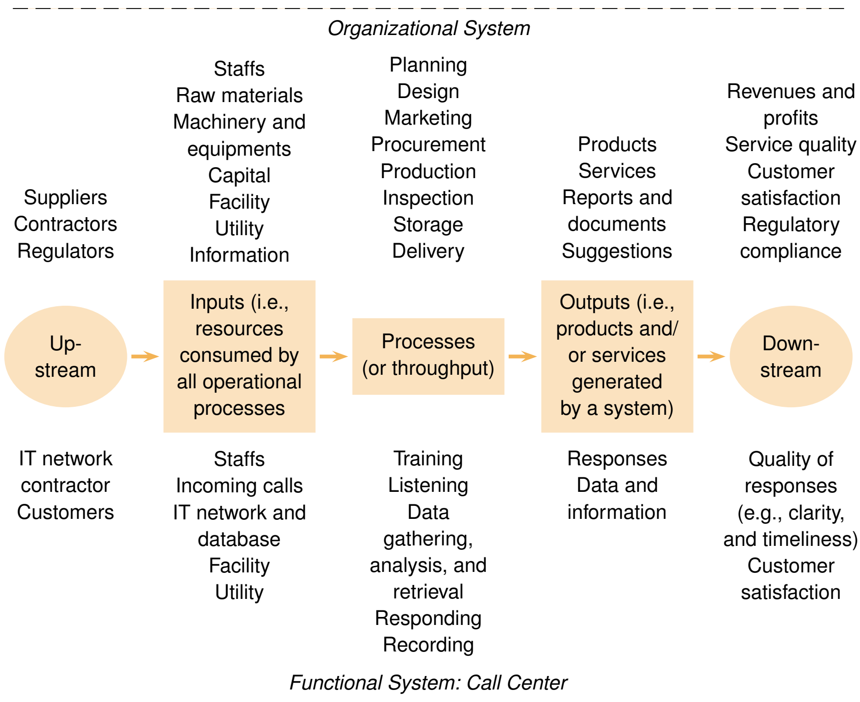

FIGURE 6.2 Details of the Extended Input/Output Analysis at Various Levels

to note that this analysis can be applicable at any organizational level. See the call center from one firm operating in Thailand (Figure 6.2).

After a completion of the Input/Output Analysis, a ratio can be easily identified. For both innovation and QWL, some of the ratios reflecting the productiveness in an organization are as follows.

Innovation The ability to generate the revenue from new products and services displays an organization's productiveness in utilizing available resources and exercising effective time management.

1. Product innovation:
    - Revenue from new products and services ÷ Total revenue
    - Revenue from new products and services ÷ Staffs
    - Revenue from new products and services ÷ Total value of equipment and machinery
2. Process innovation:
    - Suggestions proposed ÷ Staffs
    - Suggestions implemented ÷ Suggestions proposed

QWL Positive feeling towards the workplace ultimately results in productive workforce and subsequently cohesive units which will positively contribute to an organization's productivity.

- Accidents ÷ Staffs
- Training cost ÷ Staffs
- Compensation cost due to injuries from occupational safety and health ÷ Staffs
- Lateral transfers requested ÷ Staffs
- Terminated staffs ÷ Staffs
- Unplanned absent hours ÷ Staffs
- Work stoppage hours ÷ Staffs
- Financial losses due to stolen and damaged properties ÷ Staffs

For a company's call center, the focus narrows on the quality of a staff's reply to an inquiry and a complaint made by a customer. In this case, it is the presumption that the reply quality and customer satisfaction represent the sign of a call center's productivity. The reason is that if the customer satisfaction level is high, there is no need to add unnecessary staffs and other resources. The ratios used for this case are as follows.

- Incoming calls from the same phone number within a 2-hour period ÷ Incoming calls
- Incoming calls going through an operator within one minute ÷ Incoming calls

Note: The same phone number which calls within two hours may not entirely reflect a reply's quality (i.e., clarity of a response) since other subject matters may prompt a call. Nevertheless, the company's management still preferred to measure this aspect.

Then, there are three issues to be considered. The first one deals with the data for the set of ratios. This consideration include: (1) unit dimensions, (2) frequency, (3) data accuracy and reliability, and (4) definition for data collection. For the first issue, there are three possible unit dimensions for the staffs; i.e., headcounts, bath (Thai currency), and working hours. For the frequency, a decision needs to be made whether the data will be collected on the weekly, monthly, quarterly, or annual basis. It is important to work with a team in charge of data collection to ensure the accuracy and timeliness of the data for a management report.

For the definition of the staffs, it is important to clarify whether a company focuses only on full-time workers, full- and part-time workers, or full-time and contracted-out workers, etc. Without this clarity, the staff headcounts are not accurate. The second issue relates to the information usefulness for future decisions and actions. Understanding of a ratio's trend is important to avoid overreaction on uncontrollable events. The last issue is to ensure that the selected ratios have strong linkage with organizational policies and objectives. It is important that a ratio is consistent with an organization's business goals and supports its long-term competitiveness.

Finally, there are two guidelines to follow when developing a ratio. The first guideline is referred to as an absolute rule. This rule implies an attempt to quantify a number and later compare it with a target. For instance, to ensure a productive operation for a repair service, a company may choose to measure the following ratio—an average waiting time for a customer which is computed by having a total waiting time divided by a number of customers.

The second guideline is called a frequency rule. This second rule is based on the premise that a target has already been established. Therefore, a company attempts to gain better understanding on how well it achieves this target. For example, if the same company has determined the target for a repair service to be no more than 90 minutes for one customer, a ratio can be % repair services completed less than 90 minutes. This is computed by a total repair services completed less than 90 minutes divided by a total repair services completed, and then multiplied the result by 100. Both guidelines are helpful when applying the ratios for information analysis.

It should be noted that other ratios for profitability, effectiveness, and efficiency can be identified. In general, the term profitability can be represented by having the downstream divided by the inputs (also known as a cross ratio) such as the revenue-to-cost and profit-to-cost ratios. On the other hand, it has been widely practiced to evaluate the profitability level with having the downstream divided by the downstream as a self ratio. Some of the profitability ratios include the profit-to-revenue and revenue from rework-to-revenue ratios.

For the term effectiveness, any ratio should relate to the output side such as the actual product produced-to-planned products to be produced, and the unplanned products produced-to-actual products produced ratios. The reason is that the effectiveness indicates the degree to which a system achieves the right thing.

For the efficiency, any ratio should focus on the input side since this term implies a system which utilizes its resources in the right way. Typical ratios relating to efficiency include planned materials consumed-to-actual use of materials, and planned labor headcounts-to-actual labor headcounts hired ratios.

Audit to Verify and Improve Proposed Ratios

The audit task is critical before data collection, staff communication, and information reporting processes can be undertaken. The audit is typically used to ensure the quality of a set of ratios to be used by a company's management (Phusavat, Manaves, & Takala, 2007). It is important that an overall framework is created and shared with relevant groups dealing with measurement and analysis efforts. This framework is illustrated in Table 6.2.

The vigorous audit on the set of identified ratios should be conducted in a constructive way as it is likely that some ratios may be discarded. As a result, a new set of ratios may have to be developed to ensure that the awareness on the productivity level can be made. See the audit table example. The answer of either yes or no is expected. In the past, when a ratio receives a no answer, a decision needs to be made on whether it should be discarded. For instance, if the suggestions implemented-to-suggestions proposed corresponds to an organization's attempt to engage more with staffs but is not accepted by most staffs, it should not be deployed until further communication can be made. In this case, staffs feel that the suggestions could be used as a criterion for dismissal from a workplace. In addition, a lack of training (especially on problem-shooting skills) would hinder the quality of suggestions. Despite, the ratio is perceived to be useful and has available data for information analysis, imposing it onto the staffs is not recommended until the concerns from staffs are addressed (Table 6.3).

Exercises

6.1 Based on the Input/Output Analysis of one public university in Thailand, develop productivity, innovation, and QWL ratios. Examine the policies and objectives of this university (of your choice) and conduct the audit to verify the identified ratios (based on what you will have reviewed). Hint: You are not expected to have data availability in one

TABLE 6.2 Overall Framework when Identifying the Ratios

Organizational system analysis	
1.1	Specific business (products and services) the organization that it is operating
1.2	Description of overall organizational strategy, policies, and objectives
1.3	Primary and secondary customers and their needs
1.4	Primary and secondary suppliers and what the organization needs from them
1.5	Key or critical processes for providing the above outputs
1.6	Current and desirable behavior of organizational personnel
1.7	Shared values and cultures embedded in the organization
1.8	Organizational staffing and structure
1.9	Threats from external environment
Information suitability	
2.1	Types of data currently collected and location where data is stored
2.2	Dimensions which this set of data is kept
2.3	Capability for the information system to convert to different data dimensions
2.4	Frequency of performance report for management review
2.5	Widely used and applied by benchmarking partners or being referred to as industrial average
Analysis on Measurement Acceptance	
3.1	Current awareness on productivity measurement
3.2	Sharing of productivity information at the organizational and divisional levels
3.3	Setting of productivity targets at the organizational and divisional levels
3.4	Who would analyze and make improvement interventions?

TABLE 6.3 Demonstration of Audit to Ratio Verification and Improvement

Ratio/Audit Items	(1)	(2)	(3)	(4)	(5)
Ratio 1: Suggestions proposed ÷ Staffs	Yes	Yes	Yes	Yes	No
Ratio 2: Suggestions implemented ÷ Suggestions proposed	Yes	Yes	Yes	No	No

NOTES Column headings are as follows: (1) alignment with policies and objectives, (2) information usefulness, (3) data availability and timeliness, (4) use as an industrial average or by partners, (5) acceptance by relevant groups.

of your audit items. Be sure to include the frequency, definitions, and unit dimensions when completing your set of proposed ratios.
The overall future environment facing this public university can be summarized as follows (see Table 6.4 and Figure 6.3).

- Need to strengthen quality of university education for better qualified workforce for an emerging economy—creative and knowledge-based.

TABLE 6.4 Ranking Comparisons of 5th Pillar, 12th Pillar, and Overall Global Competitiveness Index or GCI during 2009-2010

Country	(1)	(2)		(3)		(4)	
	Rank	Rank	Score	Rank	Score	Rank	Score
Switzerland	2	1	5.60	6	5.60	2	5.56
United States	1	2	5.59	7	5.57	1	5.77
Singapore	5	3	5.55	5	5.62	8	5.09
Sweden	4	4	5.51	3	5.76	5	5.39
Denmark	3	5	5.46	2	5.90	10	5.04
Finland	6	6	5.43	1	5.97	3	5.53
Germany	7	7	5.37	22	5.07	7	5.11
Japan	9	8	5.37	23	5.06	4	5.51
Canada	10	9	5.33	9	5.50	12	4.80
Netherlands	8	10	5.32	10	5.49	13	4.79

NOTES Column headings are as follows: (1) Overall GCI 2008–2009, (2) Overall GCI 2009–2010, (3) 5th pillar Higher Education and Training Index 2009–2010, (4) 12th pillar Innovation Index 2009–2010.

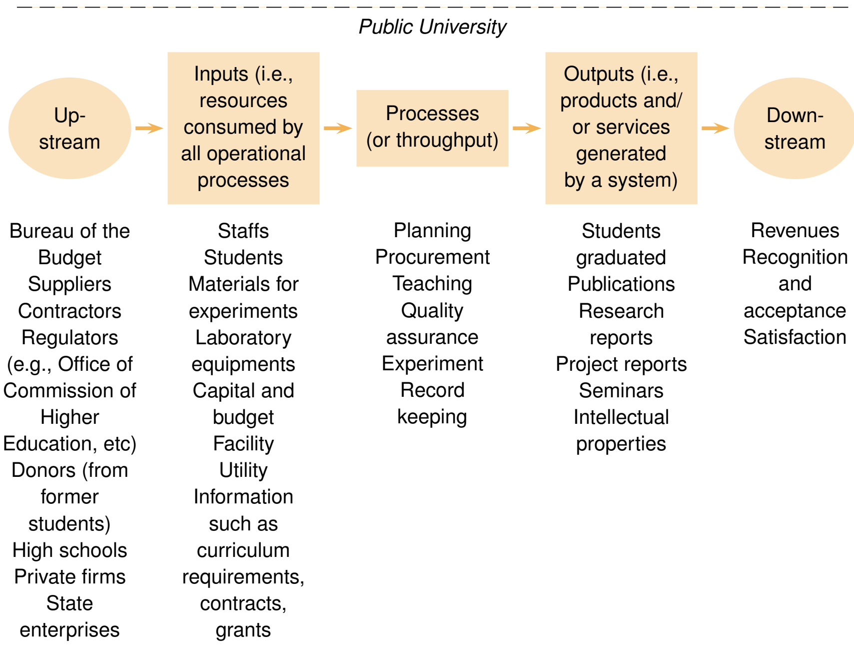

FIGURE 6.3 Details of the Extended Input/Output Analysis for a Public University

- Need to work together with international partners for better peer recognition and higher global ranking position.
- Need to focus on research, innovation, and intellectual properties for strengthening the global country's competitiveness.
- Need to focus on better financial management to ensure the long-term capability to survive a fiscal constraint to be expected in the near future.
- Need to focus on the aging population trend in which there will be less incoming 1t-year students.

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Chapter Seven

Productivity Analysis through Case Demonstrations

The chapter focuses on extending productivity measurement into information analysis, business strategies, and process improvement. Traditionally, there are three common questions under examination when analyzing productivity (and even performance) information. Is our productivity level improving? Is our productivity level good enough? How does productivity interact with and impact on others? The first one needs to be addressed by applying statistical analysis and to evaluate a possible trend as a result of productivity information. This is sometimes referred to as internal information analysis. It deals with process variation and capability. Understanding the implications of common and special causes is important for effective decisions and actions. This Understanding contributes to a shift in an average value is important for this first approach. The second questions needs to compare productivity information with a result from benchmarking partners and an industrial average value. In the past decade, APQC has extended its benchmarking initiative to incorporate performance improvement though learning and adapting from best-practice cases. This second approach is often mentioned as external information analysis. Any improvement that stems from internal and external information analyses is referred to as business process reengineering. The third approach deals with extending productivity information by linking it with strategy map, and business planning on strategy and process improvement.

The sections in this chapter highlight the importance of productivity analysis within the context of business decisions and planning. In the first section, the focus is on productivity analysis by understanding the trends. The second section deals with the application of benchmarking. In the third sectin, the discussion highlights the development of a strategy map which shows the interrelationships between productivity and other strategic objectives. A strategy map is a critical feature of management analysis on the productivity and performance levels of an organization. The last section demonstrates how understanding of productivity has played a role in service improvement even for a public agency. This section shows the service improvement based on blending productivity and quality. This case is recognized as one of the most outstanding service improvement efforts undertaken by the Royal Thai Government.

Productivity Analysis with Trends

Effective productivity measurement benefits internal and external information analyses (Phusavat, 2008). Internal analysis focuses on a trend with closer attention on root-cause analysis when detecting a shift in an average value (Phusavat, Ketsarapong, Ranjan, & Lin, 2011). It is important that common and special causes are identified. The reason is that better understanding on what constitutes controllable and uncontrollable factors needs to be established. Otherwise, a decision may lead to a more destabilized operational process. For instance, a natural disaster may cause a delay in in-house technical services for a plant's machinery. If a plant's management team decides to outsource maintenance tasks, it may not lead to an expected reduction of delay time. Typically, internal performance analysis involves the application of statistics for understanding the trends and process variations. It primarily focuses on whether a productivity level has improved.

Given the above description, when developing a set of ratios for productivity and performance measurement, it is important that a desirable trend has to be determined.

1. Productivity indicator: Value-added labor productivity
   Formula: Value added ÷ Labor.
   Unit dimensions: $ per person.
   Definition:
   - Value-added is defined as sales subtracted by cost of purchased goods and services.
     - Sales indicate the revenue earned from products sold and/or services delivered by the firm. This revenue for the term value added needs to exclude non-operating incomes.
     - Note that, in a manufacturing firm, not all goods or products sold are produced in the same period. The change in inventory level should be subtracted from sales for a better reflection of the value of output produced during that period.

    - Purchased goods and services traditionally include raw materials, supplies, and utilities and services (e.g. insurance, security, professional services) bought from external suppliers.
- Labor is defined as full-time workers.

Frequency: Monthly.
Desirable trend: Increasing.
Implications when increasing:

- Optimum use of labor for skills, knowledge, and intellectual capital during the transformation of raw materials to finished products

2. Productivity indicator: Value-added capital productivity
Formula: Value added ÷ Fixed assets
Unit dimensions: $ per $
Definition:

- Value-added is defined as sales subtracted by cost of purchased goods and services.
- Fixed assets indicates a net book value

Frequency: Monthly
Desirable trend: Increasing
Implications when increasing:

- Optimum use of machinery and equipment in a firm for the transformation of raw materials to finished products. Be aware of the proportion of the leased tools, equipments, instruments, and machines relatively to the book value of fixed assets during productivity analysis.

The use of two trends to simultaneously analyze productivity information can also be applied in an approach called a cross-examination trend (Helo, Takala, & Phusavat, 2009)). For instance, there are three ratios under study. They are: (1) output value-to-labor, (2) work stoppage time-to-labor, and (3) training cost-to-labor. For these ratios, a desirable trend is clearly defined and understood. The output value-to-labor ratio's trend should continuously increase. The similar trend (but with a more stable direction) is also expected for the training cost-to-labor ratio. However, the declining trend should be for the second ratio since the work stoppage should be avoided.

For a cross-examination trend, the three trends should be scrutinized simultaneously. A desirable trend for each of the three ratios as well as expected caused-and-effect relationships should be first described. If the training cost-to-labor is gradually upward, the work stoppage time-to-labor should decrease while the output value-to-labor is expected to increase. If this condition does not take place, then more in-depth analysis through the use of root-cause analysis tools (e.g., fishbone diagram, 5-why, scattering plot, process flow diagram, etc.). The cross-examination approach is quite helpful when there is a need to concurrently consider several ratios for information analysis instead of analyzing individual ratios (Phusavat, Ketsarapong, et al., 2011).

Productivity Analysis with Benchmarking

External productivity analysis generally includes benchmarking and involves the adaptation from best-practice cases. In the previous discussion, it is important that the ratios being used by the industry or benchmarked partners should be considered when measuring productivity and performance. Tracking information based on the ratios currently being used by other organizations and/or an industry helps facilitate productivity analysis. As a result, it is important for a manager to realize whether the performance levels of a firm, a functional unit, or a process is improving and is good enough. Comparing the information from productivity measurement, learning from partners, and improving operational process (i.e., reengineering) have been practiced over the past two decades. This is primarily due to the more active roles of the APQC as a benchmarking clearinghouse and a promoter of best practices.

Benchmarking can be performed in many ways. Several leading firms have consistently applied benchmarking for internal comparison of similar operations or functions. Aerospace and defense, automotive, and electronic firms as well as service providers have used benchmarking to strive for continuous improvement in productivity and other performance areas. This is often referred to as process benchmarking. Benchmarking can be performed by comparing the results with the industrial competitors. This practice is known as competitive benchmarking. Recently, benchmarking is performed as a way for an organization to learn from world-class or best-practice companies. The APQC has been the leader in creating a clearinghouse where the use of generic benchmarking can be applied. In other words, for the private sector, the application of benchmarking has led to the establishment of a clearinghouse where best-practice reports are written and publicized.

Productivity (as well as performance) measurement is a foundation for benchmarking which stresses the importance of the ratio-format indicators. The ratio is applied so that the baseline for performance comparison and analysis can be properly made. Benchmarking has become a popular approach in ensuring that measuring, analyzing, learning, and improving can be systematically organized. Presently, benchmarking has been promoted within the private and public sectors.[1] According to Office of Economic Cooperation Development,[2] benchmarking should be constantly encouraged as a platform for promoting knowledge sharing from successful or excellent practices from different countries, especially in the areas of health care services, education, public participation, budgeting, and performance audits.

To deploy benchmarking for productivity analysis effectively, several factors need to be considered. A benchmarking project was conducted for a large manufacturing firm. Three most important suppliers of raw materials and parts had participated in this study. They were referred to as Suppliers 1, 2, and 3 respectively. The first supplier produced construction and chemical materials with approximately 150 employees. The second supplier provided plastics and paper packages with the employment of over 200 staffs. The third supplier's primary outputs were liquid materials with approximately 200 employees. It has roughly about 25% market share in 2006. For all three suppliers under study, their managing directors were also the owners. Five productivity ratios were proposed in the study, so called internal productivity or IP. They were as follows.

- IP1—On-time delivery (%)
- IP2—Lead time from order to delivery (day)
- IP3—Inventory turnover (Baht/Baht)
- IP4—Mean Time to Repair or MTTR (hour)
- IP5—percentage of new product development projects completed on time (%)

1. See www.globalbenchmarking.org and www.oecd.org

2. See www.oecd.org/std/stestimelinessframeworkuseofbenchmarkingtechniques.htm

TABLE 7.1 Benchmarking Parameters for Supplier Improvement (IP1: On-time delivery, %)

Month	SME #1	SME #2	SME #3
1	94.72	94.69	94.30
2	96.91	97.39	89.89
3	94.78	97.27	93.43
4	96.10	89.83	97.82
5	98.05	98.40	91.88
6	98.25	96.30	97.91
7	97.10	98.54	97.95
8	98.00	97.12	95.65
9	97.26	98.53	97.57
10	97.16	97.84	97.01
11	98.50	98.12	98.85
12	98.53	98.98	98.29
13	91.11	96.48	95.45
14	86.53	95.17	90.62
15	96.32	96.60	94.71
16	92.70	96.62	91.87
17	89.05	96.15	91.62
18	90.28	98.04	96.34
Average	95.08	96.78	95.06

The definitions for each of the five productivity ratios were clarified for data collection. The total period of 18 months was used for this study as it was deemed long enough to observe seasonal demands by the manufacturer on its three suppliers. After the information analysis, it was determined that Supplier 2 had consistently exhibited higher productivity. The reason is that Supplier 2 was able to maintain its price while achieving superior on-time delivery relatively to Suppliers 1 and 3. This indicated a productive use of resources such as planning, routing, communication, vehicle availability, driver competency, etc.

Then, the following tasks included process analysis by adapting process flow diagram and evaluating key success factors and activities undertaken by Supplier 2. The use of this process flow diagram for all three suppliers helped visualize work flows relating to the delivery process and allowed more in-depth evaluation on documentations, training, and use of a transportation program in predetermining a delivery route for the manufacturing firm. The description of key operational processes (i.e., process classification) is important for a successful benchmarking. Knowledge sharing on excellent practices from Suppliers 2 was made with Suppliers 1 and 3. It is important to note that this manufacturing firm sponsored this project.

Finally, this benchmarking study generally involved several key steps such as planning, partner selection, identification of productivity ratios, process identification and analysis, and recommendation of process improvement (Kess, Phusavat, & Jaiwong, 2009)). Based on this study, there were many lessons learned from the study. Benchmarking

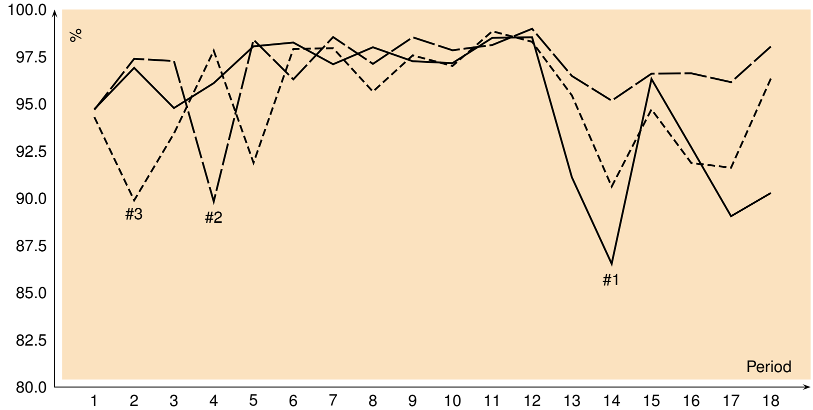

FIGURE 7.1 Benchmarking Parameters for Supplier Improvement (IP1: On-time delivery, %)

was part of productivity analysis and was perceived to be a mechanism for continuous productivity (as well as performance) improvement in an organization. Benchmarking helped build knowledge on improvement. Benchmarking represented an effort to become a learning or knowledge-based organization. It enhanced innovation within an organization since the changes in key processes such as new product development, customer complaint handlings, and supplier development are inevitable. In other words, benchmarking could be applied in conjunction with ISO 9001: 2008, the MBNQA, and the EFQM.

Bundled with the APQC's Process Classification Framework (PCF), productivity analysis through benchmarking can strengthen continuous improvement in an organization. The PCF highlights the importance of process management and stresses continuous improvement through benchmarking.[3] In addition to operations (e.g., production, manufacturing, delivery, new product/service development, marketing and sale of products/services, etc.), the PCF also focuses on the term management process. Some of the key activities in the PCF's management process include managing knowledge, improvement, and changes (Phusavat, Songnisai, Rassameethes, & Kekale, 2008).

There are many reasons for benchmarking and the PCF's emerging importance (Phusavat, 2010). First of all, ISO 9001:2000 drastically changed its structure from the 1987 and 1994 versions with the focus

3. See www.apqc.org/pcf

more on an effective management process. The specific requirement dealing directly with this issue was established and was referred to as Measurement, Analysis, and Improvement in its 2000 version. It is important to point out that the most recent version of 2008 maintains this requirement as part of management responsibility.[4] Even in the public sector, benchmarking had constantly been encouraged. For the UK, the Public Sector Benchmarking Service, launched in November 2000, aimed to promote effective benchmarking and to help share good practices across the public sector.[5] It enabled organizations to share knowledge and learn from the best (Phusavat et al., 2008).

Productivity Analysis within the Context of Strategy Map

Productivity analysis generally involves the use of a strategy map to highlight what affect productivity and how productivity contributes to an overall higher performance level of an organization (Phusavat & Jaiwong, 2008b). A strategy map typically associates with two features: (1) current productivity and performance levels or "as is," and (2) expected productivity and performance levels and their interrelationships or "to-be." A strategy map should help link both as-is and to-be features. It reflects the hypothetical interrelationships among strategic objectives of an organization (Kaplan and Norton, 1996; 2004). In most literatures, the term strategy map is closely related to the use of Balanced Scorecard (BSC) which highlights the interrelationships among four performance perspectives; i.e., customers (how do customers see us?), finance (how do we look to shareholders?), internal business (what must we excel at?), and innovation and learning (can we continue to improve and create value?). Productivity is part of the internal business perspective (Phusavat & Jaiwong, 2008a).

The following study was an extension from the initial benchmarking study (in reference to the second section). The manufacturing firm's management team decided to extend the study by developing a strategy map in which three key suppliers exhibited. These three suppliers were considered as the firm's first tier and top performer. The strategy map represented an attempt for this manufacturing firm to work with its important suppliers. This attempt was part of the firm's program on improving its supply chain management. From the firm's top management, the strategy map reflected a road map to achieve excel-

4. See www.iso.org/iso/management_standards.htm
5. See www.archive.cabinetoffice.gov.uk/servicefirst/.../benchmarkingservice.htm

lent performance. If a supplier could excel, it would benefit the firm in two ways: (1) less inspection cost and staffs, and (2) higher capability to maintain competitive price for materials and parts to be purchased. This strategy map could also provide a firm with a general framework of what needs to be focused first if it decided to send an engineering team for management and technical support in other suppliers.

The BSC was chosen to ensure the level of familiarity among the three suppliers' team members. As a result, the subject of internal productivity was modified to internal business process perspective (but the firm's management team opted to maintain the term IP). In this study, the first step involves the identification of ratios relating to each of the four perspectives within the BSC. The firm's management team and the three suppliers were working together on the definition and common ratio that they would agree on. The results are presented in Table 7.2. It should be pointed out that the financial and internal-processes perspectives have received most of their attention during this step.

Then, the MCPMT was then applied for the BSC verification and the development, based on the results of the three suppliers over the 18-month period. See the results from the first supplier (Table 7.3).

The performance scale of 0 to 100 was selected for all ratios. Furthermore, there were three points that formed a preference curve for individual ratios. For a ratio with a desirable increasing trend, the highest result over the 18-period duration would receive the score of 100 while the lowest result was assigned the value of 0. On the other hand, for a ratio with a desirable decreasing trend, the highest result would receive the score of 0 while the lowest result was assigned the value of 100. The score of 50 would be for the average result over the 18-period duration. Then, the next task was to convert the results from each ratio into a common 0–100 scale. Afterward, the following task was to derive an overall result from one perspective by assigning an equal weight to related ratios. This overall result could be computed by multiplying the individual results from each KPI by the assigned weight. In this demonstration, each KPI was assigned a weight of 1/7.

Then, for each supplier, the interrelationships were computed on the following: (1) finance and customer perspectives, (2) finance and internal business process perspectives, (3) finance and innovation/learning perspectives, (4) customer and internal business process perspectives, (5) customer and innovation/learning perspectives, and (6) internal business process and innovation/learning perspectives. The use of the

TABLE 7.2 Common Ratios for Strategy Map Development

F1. Current rate (Baht/Baht)	C1. New customers per total customers (%)	IP1. On-time delivery (%)	IL1. R&D expense per total expenses (%)
F2. Interest expense per sales (Baht/Baht)	C2. Customer lost (%)	IP2. Average lead time (day)	IL2. Competence development expenses per employee (Baht/employee)
F3. Revenues per total assets (%)	C3. Satisfied-customer index (%)	IP3. Lead time, from order to delivery (day)	IL3. Satisfied-employee index (%)
F4. Revenues per employee (Baht/employee)	C4. Customer-loyalty index (%)	IP4. Lead time, production (day)	IL4. Marketing expense per customer (Baht/customer)
F5. Profits per employee (Baht/employee)	C5. Number of customer complaints (record)	IP5. Average time for decision-making (day)	IL5. Information coverage ratio (%)
F6. Market value (Baht)	C6. Customer payment on-time (%)	IP6. Inventory turnover (Baht/Baht)	IL6. Investment in new product support and training per total employees (Baht/employee)
F7. Return on capital employed (%)	C7. Average direct communications to customers (time/customer)	IP7. Maintenance cost per revenue (%)	IL7. Staff turnover (%)
F8. Profit margin (%)		IP8. Supplier on-time delivery (%)	
F9. Cash flow (Baht)		IP9. Mean Time between Failure or MTBF (hour)	

Continued on the next page

regression analysis was applied in conjunction with the MCPMT. The partial demonstration of the regression analysis from Supplier 1 is as follows. The applications *F* the MCPMT and regression equations were applied to all three suppliers.

- Finance vs. Internal Business Process: $F = 22.1 + 0.5(IP)$ at the p-value at 0.006.
- Innovation and Learning vs. Finance: $IL = 21.9 + 0.6(F)$ at the p-value at 0.005.

TABLE 7.2 *Continued from the previous page*

F10. Return on investment (%)	IP10. Mean Time to Repair or MTTR (hour)
F11. Earnings Before Interest, Taxes, Depreciation, Amortization, and Restructuring or Rent Costs or EBITDAR (Baht)	IP11. % of new product development projects completed on time (%)
F12. Revenues from new product per total revenue (%)	IP12. Total supply chain delivery performance to end customer (%)
F13. Revenues per cost of goods sold (Baht)	
F14. Revenues per marketing expense (Baht)	
F15. Revenues per raw material cost (baht)	
F16. Revenues per energy cost (Baht)	
F17. Market share (%)	
F18. Profit per customer (Baht/customer)	
F19. Revenue per service expense (Baht/Baht)	

In general, all three suppliers exhibited the expected interrelationships as shown in the BSC (Figure 7.2).

The next task is to classify the common ratios into different strategic objectives, to be referred to as the focus areas. For the three suppliers, there were ten common focus areas. They represent strategic objectives of the three SMEs, as agreed by participating executives. Their general descriptions are as follows.

1. *Liquidity:* The ability to sustain operations financially on the continuous basis.
2. *Profitability:* The ability to generate revenue and profit under the effective and efficient use of resources.

TABLE 7.3 Demonstration of the Results from Supplier 1's Innovation and Learning Perspective

Month	IL1	IL2	IL3	IL4	IL5	IL6	IL7
1	2.11	45.28	79.00	566.04	80.00	71.43	0.00
2	4.29	43.17	79.00	539.57	80.00	71.43	0.95
3	4.93	42.11	79.00	526.32	80.00	71.43	0.48
4	4.47	40.68	82.00	593.22	80.00	68.81	0.00
5	2.00	39.34	82.00	573.77	80.00	68.81	0.46
6	1.97	38.09	82.00	555.57	80.00	114.68	0.00
7	1.92	38.71	82.00	580.66	87.00	114.68	0.00
8	3.80	36.92	82.00	1,461.59	87.00	114.68	0.00
9	1.95	36.47	82.00	547.11	87.00	109.65	0.00
10	2.00	35.82	85.00	537.31	87.00	65.79	0.00
11	1.92	35.82	85.00	1,432.84	87.00	65.79	0.00
12	2.17	35.82	85.00	1,492.54	87.00	65.79	0.00
13	1.92	45.46	85.00	576.37	90.00	90.91	0.87
14	3.79	45.46	85.00	1,424.51	90.00	90.91	0.00
15	1.95	45.46	85.00	418.99	90.00	75.76	0.00
16	2.01	45.46	90.00	417.83	90.00	75.76	0.00
17	1.92	45.46	90.00	831.02	90.00	75.76	0.00
18	2.17	45.46	90.00	1,388.89	90.00	75.76	0.00

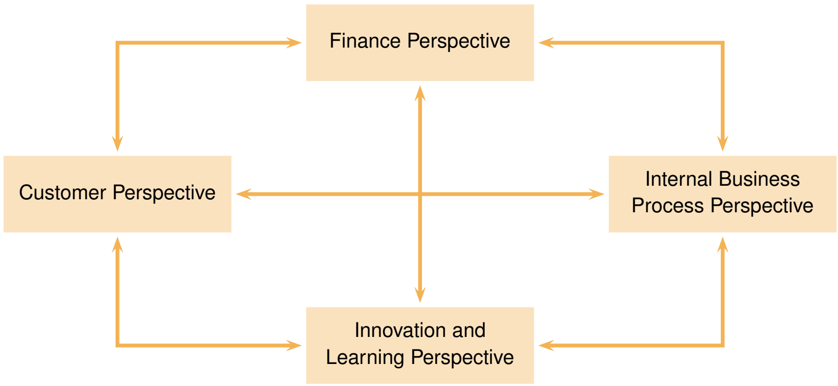

FIGURE 7.2 Interrelationships among BSC's Perspectives

3. *Corporate Competency:* The embedded ability of a company to overcome competition and changes in its business environment.
4. *Service Quality:* The ability to respond to and possibly exceed the expectation of a company's customers.

TABLE 7.4 Preference Curve Formulation for Supplier 1's Innovation and Learning Perspective

Month	IL1	IL2	IL3	IL4	IL5	IL6	IL7
1	2.11	45.28	79.00[w]	566.04	80.00[w]	71.43	0.00[b]
2	4.29	43.17	79.00	539.57	80.00	71.43	0.95[w]
3	4.93[b]	42.11	79.00	526.32	80.00	71.43	0.48
4	4.47	40.68	82.00	593.22	80.00	68.81	0.00
5	2.00	39.34	82.00	573.77	80.00	68.81	0.46
6	1.97	38.09	82.00	555.57	80.00	114.68[b]	0.00
7	1.92[w]	38.71	82.00	580.66	87.00	114.68	0.00
8	3.80	36.92	82.00	1,461.59	87.00	114.68	0.00
9	1.95	36.47	82.00	547.11	87.00	109.65	0.00
10	2.00	35.82[w]	85.00	537.31	87.00	65.79[w]	0.00
11	1.92	35.82	85.00	1,432.84	87.00	65.79	0.00
12	2.17	35.82	85.00	1,492.54[w]	87.00	65.79	0.00
13	1.92	45.46[b]	85.00	576.37	90.00[b]	90.91	0.87
14	3.79	45.46	85.00	1,424.51	90.00	90.91	0.00
15	1.95	45.46	85.00	418.99	90.00	75.76	0.00
16	2.01	45.46	90.00[b]	417.83[b]	90.00	75.76	0.00
17	1.92	45.46	90.00	831.02	90.00	75.76	0.00
18	2.17	45.46	90.00	1,388.89	90.00	75.76	0.00
Average	2.63	41.17	83.83	803.56	85.67	82.66	0.15

NOTES [b] was noted the best performance level; [w] reflected the worst level of performance.

5. *Customer Relation:* The attempt by a company to communicate and understand its customers for future growth.
6. *Productivity and Process Efficiency:* The relationship between a company's outputs and inputs with the ability to utilize resources and time in the manner in which a company can achieve its policies and objectives.
7. *Partnership:* The ability to work with suppliers for operational excellence.
8. *Operational and Technical Quality:* The ability to achieve operational excellence and produce quality products.
9. *Product Innovation:* The ability of a company to change according to time by being able to anticipate future needs or want from its customers.
10. *QWL:* The feelings of workers, staffs, and employees on many fac-

TABLE 7.5 Demonstration of Common Performance Scale of 0–100

Month	IL1	IL2	IL3	IL4	IL5	IL6	IL7	Overall
1	13.24	98.00	0.00	80.79	0.00	16.72	100.00	44.11
2	86.05	73.32	0.00	84.22	0.00	16.72	0.00	37.19
3	100.00	60.96	0.00	85.94	0.00	16.72	29.79	41.92
4	90.13	45.44	31.03	77.26	0.00	8.95	100.00	50.40
5	5.46	32.97	31.03	79.79	0.00	8.95	30.88	27.01
6	3.59	21.28	31.03	82.15	0.00	100.00	100.00	48.29
7	0.00	27.03	31.03	78.89	65.38	100.00	100.00	57.48
8	75.43	10.31	31.03	2.25	65.38	100.00	100.00	54.92
9	1.77	6.11	31.03	83.24	65.38	92.15	100.00	54.24
10	5.46	0.00	59.46	84.51	65.38	0.00	100.00	44.97
11	0.00	0.00	59.46	4.33	65.38	0.00	100.00	32.74
12	17.80	0.00	59.46	0.00	65.38	0.00	100.00	34.66
13	0.00	100.00	59.46	79.45	100.00	62.89	5.18	58.14
14	75.43	100.00	59.46	4.94	100.00	62.89	100.00	71.82
15	1.77	100.00	59.46	99.85	100.00	29.55	100.00	70.09
16	5.46	100.00	100.00	100.00	100.00	29.55	100.00	76.43
17	0.00	100.00	100.00	48.01	100.00	29.55	100.00	68.22
18	17.80	100.00	100.00	7.52	100.00	29.55	100.00	64.98

NOTES The interpolation was used for this conversion. At the same time, each ratio's monthly result was multiplied by 1/7 to help determine an overall performance level at that month.

tors within a company such as autonomy, flexibility, culture, supervisor relation, and etc.

In order to formulate a strategy map, the MCPMT was again applied. The results from each ratio within individual focus areas were converted into a common non-dimensional scale of 0–100 with an equal weight. The impacts from one focus area to the others were tested by the regression analysis. The results highlighted the importance of productivity to achieving high performance of the three suppliers. Specifically for information analysis based on the strategy map below, productivity from a manufacturing firm' supplier was influenced by QWL, product innovation, and partnership with second-tier suppliers (since the three suppliers were regarded as first-tier). The results underlined, for the future, the manufacturing firm would be required to provide the knowledge on the management of QWL, innovation, and supplier partnership with other first-tier suppliers. The productivity level also

TABLE 7.6 Classifying Common Ratios into Ten Focus Areas

Perspective	Focus Areas or Strategic Objectives	Ratios	
Financial	Liquidity	F1	Current rate
		F7	Return on capital employed
		F9	Cash flow
		F10	Return on investment
	Profitability	F2	Interest expense per sales
		F3	Revenues per total assets
		F4	Revenues per Employee
		F5	Profits per employee
		F6	Market value
		F8	Profit margin
		F11	EBITDAR
		F12	Revenues from new product per total revenue
		F13	Revenues per cost of goods sold
		F14	Revenues per marketing expense
		F15	Revenues per raw material cost
		F16	Revenues per energy cost
	Corporate Competency	F17	Market share
		F18	Profit per customer
		F19	Revenue per service expense
Customer	Service Quality	C3	Satisfied-customer index
		C4	Customer-loyalty index
		C5	Number of customer complaints
		C6	Customer payment on-time
	Customer Relation	C1	New customers per total customers
		C2	Customer lost
		C7	Average direct communications to customers

Continued on the next page

impacted directly on service quality and customer relation (Figure 7.3).

Finally, the strategy map helped explain the need to focus on multiple areas and the anticipated outcomes when working with other first-tier supplies. In other words, the results from product innovation and QWL should be consistent with productivity and process efficiency. If product innovation and/or QWL begin to experience poorer results, more attention needs to be made on productivity and process

TABLE 7.6 *Continued from the previous page*

Perspective	Focus Areas or Strategic Objectives	Ratios
Internal Business Process	Productivity and Process Efficiency	IP2 Average lead time
		IP3 Lead time, from order to delivery
		IP4 Lead time, production
		IP5 Average time for decision-making
		IP6 Inventory turnover
		IP9 MTBF
		IP10 MTTR
		IP11 Percentage of new product development projects completed on time
	Partnership	IP8 Supplier on-time delivery
		IP12 Total supply chain delivery performance to end customer
	Operational and Technical Quality	IP1 On-time delivery
		IP7 Maintenance cost per revenue
Innovation and Learning	Product Innovation	IL1 R&D expense per total expenses
		IL4 Marketing expense per customer
		IL5 Information coverage ratio
	QWL	IL2 Competence development expenses per employee
		IL3 Satisfied-employee index
		IL6 Investment in new product support and training per total employees
		IP7 Staff turnover

efficiency of a supplier. Furthermore, positive productivity contributes directly to service quality and customer relation. If the level of service quality and/or customer relation begins to decline, an in-depth examination into productivity needs to be made.

Business Process Reengineering: Illustration of the One-Stop Services

Productivity analysis should always include the viewpoints of a manufacturer and service provider, and a customer. The ratio of output divided by input provides an overall framework of how improvement should be made. As a manufacturer and a service provider, the ability to use less resource while continuing to generate higher output value should be its overall goal. From this viewpoint, when applied to a cus-

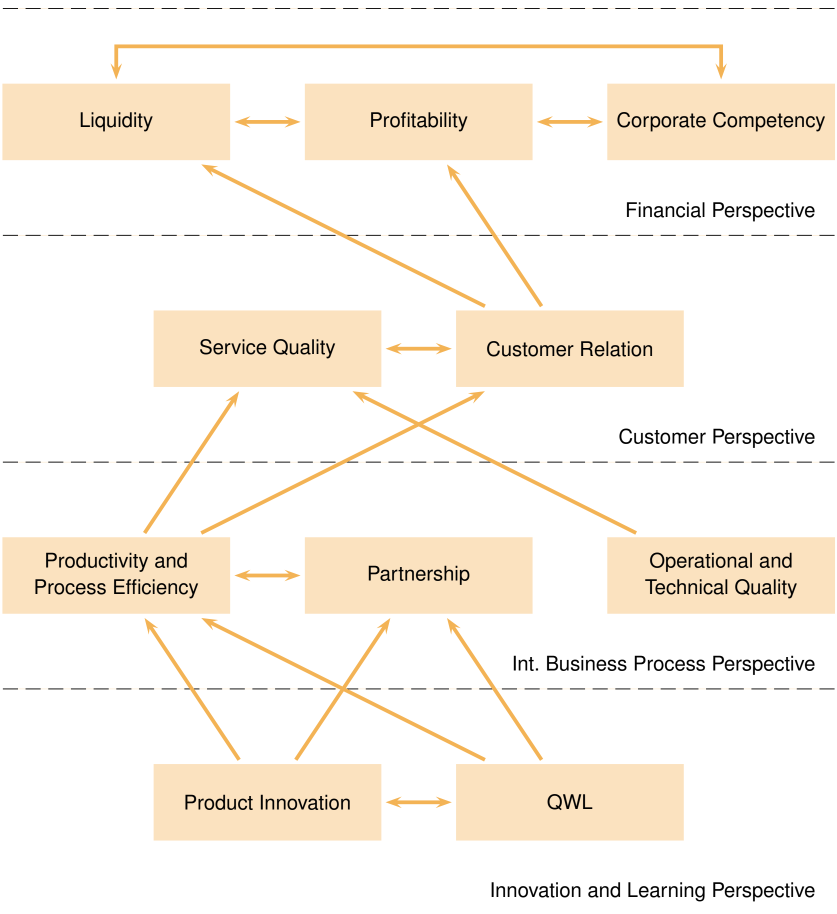

FIGURE 7.3 Productivity and Strategy Map Development for Three Suppliers

tomer, the productivity application indicates the ability for a manufacturer and/or a service provider to save time and cost for its customers. For instance, the design of Boeing 737 (in reference to the first chapter) which underlines the commonality and interoperability helps improve the productivity at the assembly line while benefiting an airline in terms of reduced training time and cost, minimizing inventory, and lowering other logistics footprint. It is so called a win-win situation. The case demonstration below shows how the analysis and application of productivity to achieve this situation. This is the case of one public agency in Thailand where productivity was clearly integrated into service design and delivery. The impacts from this productivity improvement cover both governmental officers, citizens and the general public.

The citizen-centered approach represents a monumental shift in the latest public-sector reform efforts, especially in Thailand (Phusavat, Anussornnitisarn, Comepa, Kess, & Lin, 2010). The 1997 economic crisis in Asia accelerated the need to reform governmental operations. Internal-related reforms focused on the improvement of accounting (e.g., internal control) and human resource management (e.g., fast-track career). In addition, the use of information and communication technology became more integrated to daily tasks. Furthermore, service improvement through process analysis was part of the quality and value-for-money movements. Several regulatory requirements were passed to ensure accountability (e.g., performance agreement) and fiscal responsibility (e.g., public and private partnership) in the public sector. The use of international comparisons such as United Nations' e-Government Readiness and Transparency International's Corruption Perception has been widely integrated into planning and budget allocations (Phusavat, Anussornnitisarn, Rassameethes, & Janssens, 2011).

This shift underlines the importance of performance and value created to the citizens by public agencies. The Office of the Public Sector Development Commission (OPDC), as a host agency to promote public-sector reforms in Thailand, aims to assist public agencies in this transformation. Nowadays, the public sector is faced with new challenges such as financial constraints, demographic changes, technological innovations, productive operations, and citizens' demands and expectations of quality and value-for-money services. Furthermore, a public agency is required to provide better services while maintaining or reducing cost (Phusavat, Kruaithong, Ranjan, & Lin, 2012). For instance, when people can pay their credit card invoices on-line, they also expect a similar service when paying public fees, fines, and taxes electronically. Due to free flows of information under the internet economy and a political trend towards globalization, they reinforce the need for public agencies to change and become more innovative.

Service improvement in the public sector in Thailand has been accelerated from the external influences. The context analysis, conducted by the OPDC, shows that the changes have occurred and will continue to take place in many areas such as geography (e.g., declining and aging populations), social (e.g., migrations and life styles), economic (e.g., industrial growth and income distributions), and political (e.g., decentralization and public-private partnership). Life styles and declining populations in the country have inevitably results in changes in how public services are delivered to citizens. The service satisfaction of city dwellers is likely based on speed and convenience with more extensive applications of information and communication technology or ICT. In Thailand, some of already-adapted examples that have been widely practiced in private firms include on-line tax payments (i.e., 24-hour services) and home-delivery services for passports.

The OPDC was established in 2000 to help promote public-sector reforms in Thailand. It has worked closely with Organization for Economic Co-operation and Development or OECD Asian Centre for Public Governance and the World Bank in the recent years in order to ensure continuous improvements in the Thai public sector. The OPDC has introduced contemporary concepts, tools, techniques, and practices to all public agencies. The goals for this improvement focus on productivity, quality, and value-for-money. For the enterprise development's efforts within the public sector, in 2005, the OPDC promoted two important initiatives. They are known as: (1) Service Link or SL, and (2) Governmental Counter Service or GCS. They were intended to increase convenience and comfort for citizens as well as to improve how individual agencies could work together. Productive operations mean that delay and waiting times for both governmental staffs and citizens should be reduced. Service quality will subsequently achieved.

Essentially, the SL aimed to ensure citizens were no longer required to stop at various public agencies for information and documents, and for submitting their requests. Many agencies assigned their staffs to ensure the realization of this one-stop concept. On the other hand, the GCS aimed to increase service satisfaction by relocating public agencies closer to citizens such as shopping complexes and elevated train/subway stations. Ministry of Commerce was the pioneer and tried to experiment with the SL. This is due to its roles in granting licenses and permits to private firms. Several agencies relating to operating licenses such as Departments of Export Promotion and of International Trades had stationed their staffs in one location. This was expected to help reduce the number of service stops that a private firm had to make.

The case demonstration deals with the Nakhon Prathom City District Office or NPCDO. There are several basic services being provided by the NPCDO: (1) identification cards, (2) copies of household certificates, (3) updating household members—births, deaths, move-in, (4) married certificates, (5) sale licenses of fired arm and alcohols, (6) handgun license, (7) temporary gambling license, and (8) building permits. Nakhon Prathom province is regarded as an important industrial area where workers have usually migrated from other regions and neighboring countries. Given its proximity to Bangkok, many factories have been built for foods and agricultural-related products. Due to economic development and urbanizations, the NPCDO has had to serve a large number of migrants and illegal immigrants while its registered city resident had continued to grow. Previous complaints and dissatisfaction were a lack of facility space, long waiting time, unfriendly atmosphere, and inconvenient operating hours.

It is important to further recognize that public demands for governmental services are generally not stable and can be unpredictable from time to time. In fact, for some, managing the demands is probably more difficult than many private firms since a public agency cannot turn down a citizen's request. For examples, the demands for identification cards can be high during election cycles at the local and national levels as well as during long public holidays. Furthermore, the need for copies of household certificates appears to be high on Monday and Friday. Adding to the problems on the quality of services, an increase in budget from the Bureau of Budget has not been possible as the country's infrastructure, education, and healthcare are more critical.

During the interview with Mr. Chokchai Dejamorntan, a former Chief of Nakhon Prathom City District, Ministry of Interior, he mentioned that paradigm shift on how the public services needed to be made in order for public agencies to become more citizen-centered. This paradigm shift resulted in the following mindsets and changes.

1. Focus on time when citizens have to spend inside and outside an office (e.g., parking, waiting before and after a submission of documents, collecting all document and photos for a submission of an identification card request, etc.) represents an improvement in enterprise development within a public agency. This is essential since public agencies cannot reduce fees for citizens.
2. Learning from private firms such as banks, restaurants, and hotels represents an organizational development from public agencies. This is to ensure more proactive to ongoing changes and expectation such as city life styles.

3. Working together with a private firm(s) for service improvement is critical under the financial and resource restrictions. It will be shown later that, in all three cases, these public agencies opened and have operated their branch offices the shopping malls and the private hospital without office rental fees.

Here is the summary of some of the key service improvements relating to productivity that were made during the tenure of Mr. Dejamornthan at the NPCDO.

- Reservation service for people who needed the public services on Tuesday, Wednesday, and Thursday. This initiative aimed to balance the demands which were usually high on Monday and Friday. People could call and made an appointment. They could go to the counter directly at the appointed time. The productivity benefits have included the better use of the district's resources (i.e., avoiding hiring additional staffs to handle high demands on Monday and Friday while less work is expected on Tuesday, Wednesday, and Thursday), and the time reduction for the general public.
- Home delivery service for people who needed to be back at work. This initiative aimed to help people who took the lunch break off for governmental services. Typically, they would submit the documents and waited to ensure that the submitted document were correct. Then, they had to wait for the officers to process their requests. It was difficult for them to wait until their requests were completed. As a result, the home delivery service was initiated to reduce waiting time. The productivity improvement centers on better resource allocation during lunch hours in the office while reducing the waiting time for the general public.
- Branch office at the Big C hypermarket. This initiative aimed to provide more convenience and to reduce the time for looking a parking space. The branch office opened seven days in accordance to the operating hours of the hypermarket. By partnering with a private operator, the district becomes more productive in using existing space (instead of a budget request for a new office building) to provide more convenient services. In addition, the district strengthens the ability serve more people by not having to invest a new construction.

FIGURE 7.4 Entry to the Branch Office at the Big C Hypermarket

Finally, by becoming more productive operations, one of the most important benefits for the general public is the reduction of service time. Mr. Dejamorntan agreed that a public agency could not reduce the fees but could help reduce the time that citizens had to wait for services. For examples, the time that citizens had to gather documents before a request submission had to be taken into consideration. At the city district office, there was a call center to help explain the documents needed for renewing a vehicle registration. The time that citizens looked for a parking was also important. Contacting the city district was not time-consuming as citizens did not have to search or wait for an available parking.

Exercises

7.1 Visit the APQC and summarize the roles of a benchmarking clearinghouse in productivity and performance analysis.

7.2 Examine the importance of a strategy map and explain how it would help strengthen productivity and performance analysis.

7.3 Study the US Government Performance and Results Act of 1993 and the Government Management Reform Act of 1994, and outline the requirements on performance measurement and analysis for public agencies in the US.

7.4 Study the Skytrax (www.airlinequality.com) and compare the results of the rating of airlines and airports. Suggest how an airline or an airport of your choice can learn from better practices.

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Chapter Eight

Research in Productivity Measurement

The chapter focuses on potential research areas relating to productivity management. Productivity subjects have always gathered a great deal of interests among several researchers. Productivity and business strategies have been advocated so that long-term business competitiveness can be achieved. Past research has concentrated on how productivity information could be used and analyzed to strengthen operational and organizational competitiveness. Previous research on productivity measurement has often dealt with new approaches and surrogates to ensure the accuracy and reliability of information (Phusavat, Anussornnitisorn, Sujitwanit, & Kess 2009). Exploring a new alternative for productivity measurement which is more cost effective and user friendly has been one of the primary objectives for the academic studies.

Despite the usefulness of current accounting ratios such as return on assets, the need for better information under changing business environment continues (Phusavat, Jaiwong, Sujitwanit, & Kanchana 2009). The trends such as outsourcing, near-sourcing, brand value, intellectual capital have highlighted more studies on how to better capture productivity information within an organization (Phusavat, Nilmaneenava, Kanchana, Wernz, & Helo 2012). Several surrogates have been tested within the context of productivity such as innovation, quality work life, and profitability.

Three research studies are presented in this chapter. The first one relates to the interrelationships between productivity and organizational strategies. In this research, the surveys are applied to help gather the opinions from the executives. These opinions relate suitable measurement areas with organizational strategies on operations and supplier selection. In other words, this study describes when to measure productivity. The second research shows the study on key consideration factor when attempting to identify productivity measures for an organization. The last research deals with the implications of value-added productivity measurement in an organization. The interpretations of information from value-added productivity are highlighted with the lessons learned in the sugar business.

In conclusion, the term productivity constantly receives a lot of attentions from researchers and practitioners alike due to its impacts on short-and long-term business competitiveness. From the national to individual level, productivity has been an integral part of an organization's policy and strategic objective. Cost-effective operations through productivity improvement continue to be a firm's business aspiration (Phusavat, 2010; Phusavat, Fankham-ai, Haapasalo, & Lin, 2011. Given the continuous increase in labor cost, fuel price, taxes, expenses relating to regulatory compliance, and fluctuation in a foreign exchange rate which influence a price of a raw material, becoming more productiveness is often used as a business objective for many organizations. The simple ratio of output divided by input which was introduced more than one hundred years old will continue to play an important role in important business decisions from new product development, location selection, expansion, partnership development, investment, human resource management, sequencing and scheduling, layout design, and service delivery.

Productivity Measurement and Business Strategies

The research aims to increase fundamental knowledge on productivity management. The objective is to increase the knowledge on when to measure productivity in addition to existing awareness on what-to-measure, where-to-measure, and how-to-measure (Phusavat, Rapee, & Lin, 2009). This is expected to improve an understanding on productivity measurement by linking it with organizational strategies. In addition, the key question representing the research's premise is whether there is a specific circumstance that productivity becomes more important than other business objectives. The primary expected benefit is to strengthen existing knowledge on productivity measurement—what, how, and where to measure.

Several steps were completed for this study which took place in 2007 (Figure 8.1). There were a survey development, survey distributions, analysis, and follow-up discussion on the findings. The development of a survey focused on three main areas. The first area represented six strategic objectives for manufacturing operations; i.e., quality, customer-focus, delivery, flexibility, know-how, and costs. The second area addressed the set of strategies perceived to be critical for

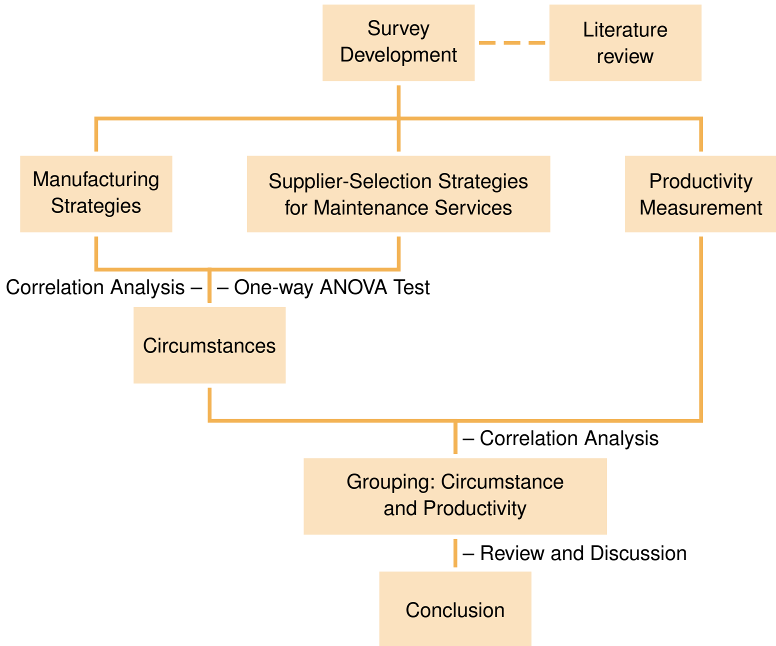

FIGURE 8.1 Research Methodology

successful supplier selection in the maintenance services. The reason was that these services directly impact the levels of operational performance. In other words, the strategies for supplier selection indicated the perceived high-impact areas which had contributed a success or failure of manufacturing strategies. There were a total of seven strategic criteria for this second part (i.e., quality, cost, delivery, responsiveness, management, technical services, and environment/safety). The third area concentrated on the perception of top executives on the importance of productivity when they deploy manufacturing and supplier-selection strategies. Productivity ratios included an average lead time, inventory turnover, mean time to repair, and mean time between maintenance.

The next step involved a survey distribution to companies. To complete the survey, top executives were asked to respectively rank the importance of strategic objectives for their manufacturing operations and supplier selection. In addition, they were asked to rate their opinions on productivity relatively to the level of criticality when deploying manufacturing and supplier-selection strategies. The survey was designed

TABLE 8.1 Survey Questions on Manufacturing Strategies

Strategies	Rating*				
Quality					
Low defect rate	5	4	3	2	1
Product performance	5	4	3	2	1
Reliability	5	4	3	2	1
Environmental aspect	5	4	3	2	1
Certification	5	4	3	2	1
Cost	5	4	3	2	1
Low costs	5	4	3	2	1
Value added costs	5	4	3	2	1
Quality costs	5	4	3	2	1
Activity based measurement	5	4	3	2	1
Continuous improvement	5	4	3	2	1
Delivery					
Fast delivery	5	4	3	2	1
On agreed time	5	4	3	2	1
Right quality	5	4	3	2	1
Right amount	5	4	3	2	1
Dependable promises	5	4	3	2	1
Flexibility	5	4	3	2	1
Design adjustments	5	4	3	2	1
Volume change	5	4	3	2	1
Mix changes	5	4	3	2	1
Broad product line	5	4	3	2	1
Customer-focus					
After-sales service	5	4	3	2	1
Product customization	5	4	3	2	1
Product support	5	4	3	2	1
Customer information	5	4	3	2	1
Measurement of satisfaction	5	4	3	2	1
Dependable promises	5	4	3	2	1

Continued on the next page

with a five-point scale from 1 (least importance) to 5 (extremely importance). The following step was to analyze the surveys' responses statistically with a correlation analysis. The correlation analysis is carried out to examine both manufacturing and supplier-selection strategies.

At this stage, possible circumstances between both strategies would

TABLE 8.1 *Continued from the previous page*

Strategies	Rating*				
Know-how					
Knowledge management	5	4	3	2	1
Creativity	5	4	3	2	1
Continuous learning	5	4	3	2	1
Problem solving skills	5	4	3	2	1
Training/education	5	4	3	2	1
R&D	5	4	3	2	1

NOTES * 5—high, 1—low.

emerge. For this study, the positive correlation implied that both strategies were complimentary—indicating that the perception by top executives that strategic criteria chosen for supplier selection would positively influence the ability to achieve strategic objectives for manufacturing operations. Afterwards, the correlation analysis was again applied to determine the relationship between the circumstances and productivity—the second stage. Then, the follow-up sessions with some of survey participants were conducted to help confirm the study's findings.

The surveys were distributed to 100 companies in early 2007. They operated within four major industrial clusters; i.e., automotive, electronics, food, and petro-chemical. Forty surveys were returned. Among them, 32.50 % of responses belonged to the automotive and auto parts industry, while 27.50%, 22.50%, and 17.50% were from food, electrical and electronics, and petrochemical industries respectively. 57.5% of respondents had more than 500 full-time employees. A majority of respondents were locally owned. 75% of participating executives had more than 25 years of business experiences. The titles of the respondents are General Manager (30.00%), Factory Manager (27.50%), Managing Director (20.00%), Purchasing Manager (12.50%), and Production Manager (10.00%).

For manufacturing strategies, the respondents were asked to rank the importance of six strategic objectives and their respective dimensions. The findings showed that the top three competitive priorities are: (1) delivery, (2) quality, and (3) customer-focus. They indicated that faster and reliable deliveries become the most importance. Better product/service quality and superior in customer service follow this delivery. These initial results on manufacturing strategies were further sub-

TABLE 8.2 Survey Questions on Supplier-Selection Strategies for Maintenance Services

Strategies	Rating*				
Quality					
Product performance	5	4	3	2	1
Product reliability	5	4	3	2	1
Product conformance	5	4	3	2	1
Cost					
Competitive prices	5	4	3	2	1
Payment terms flexibility	5	4	3	2	1
Price adjustment provisions	5	4	3	2	1
Delivery					
Delivery lead-time	5	4	3	2	1
Delivery staff performance	5	4	3	2	1
Shipment condition	5	4	3	2	1
Responsiveness					
Prompt response to request	5	4	3	2	1
Labor flexibility	5	4	3	2	1
Machine flexibility	5	4	3	2	1
Management					
Quality management system	5	4	3	2	1
Performance history	5	4	3	2	1
Warranties and claims polices	5	4	3	2	1
Flexible contracts terms and conditions	5	4	3	2	1
Technical Service					
Technical support available	5	4	3	2	1
Design Capability	5	4	3	2	1
Technical problem solving ability	5	4	3	2	1
Environmental and Safety Aspects					
Environmental management systems	5	4	3	2	1
Insurance provision	5	4	3	2	1

NOTES * 5—high, 1—low.

jected to the one-way ANOVA test. This task helped assess whether there was a significant difference among the four industrial types with the Alphas value of 0.01.

H_0 *The results on the ranking among strategic objectives had no significant difference among the industries.*

H_1 *The results on the ranking among strategic objectives had significant differences at least two industries.*

TABLE 8.3 Survey Questions on Perceived Importance of Productivity

Productivity	Rating*				
Average lead time	5	4	3	2	1
Inventory turnover	5	4	3	2	1
Mean time to repair (MTTR)	5	4	3	2	1
Mean time between failures (MTBF)	5	4	3	2	1

NOTES *5—high, 1—low.

TABLE 8.4 Results on Manufacturing Strategies

Strategic objectives	Mean	Std. dev.	Rank	*p*-value
Delivery	4.460	0.693	1	0.935
Quality	4.340	0.676	2	0.992
Customer-focus	4.133	0.848	3	0.402
Cost	4.130	0.829	4	0.951
Know-how	4.029	0.850	5	0.959
Flexibility	3.950	0.759	6	0.975

NOTES Significant at the 0.05 levels.

The test showed that there was no significant difference among companies across the four industries. For instance, the statistical results indicated that there was no significant difference on the delivery priority among the four industries (i.e., p-value = 0.935 which was greater than Alpha of 0.01—so it failed to reject H_0).

The supplier-selection strategies on maintenance services supported the efforts on manufacturing operations. Respondents were asked to rank the importance of their supplier selection in when outsourcing their maintenance services. The top priorities were delivery and quality. The one-way ANOVA was also applied to test whether the responses were significantly different among participating firms across the four industries. The results showed that there was no difference.

For the identification of possible circumstances derived (from the interrelationships between manufacturing and supply-selection strategies), the correlation analysis was adopted. For this study, a positive correlation implied the complimentary perceived by top executives among these strategies. Due to the ordinal data (i.e., opinions and perception), the Spearman Rank correlation was used at the significant level of 0.05—reflecting a wider area for acceptance than the 0.01 level. Altogether, there were a total of nine circumstances.

The next important task was to match the nine circumstances with the level of importance on productivity measurement perceived by top

TABLE 8.5 Results on Supplier-Selection Strategy for Maintenance Service

Strategic objectives	Mean	Std. dev.	Rank	*p*-value
Delivery	4.375	0.841	1	0.493
Quality	4.358	0.719	2	0.939
Responsiveness	4.250	0.770	3	0.363
Management	4.163	0.708	4	0.529
Cost	4.050	0.829	5	0.119
Environment & safety	4.013	0.907	6	0.059
Technical-service	3.992	0.921	7	0.528

NOTES Significant at the 0.05 levels.

TABLE 8.6 Correlation Analysis between Manufacturing and Supplier Selection Strategies

Manufacturing	Maintenance services						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Delivery	0.264	0.404*	0.095	0.344*	0.095	0.144	−0.054
(2) Quality	0.280	0.407*	0.242	0.282	0.169	0.062	−0.076
(3) Customer-focus	0.405*	0.410*	0.243	0.374*	0.428*	0.258	0.217
(4) Cost	0.286	0.281	0.241	0.281	0.199	0.028	0.078
(5) Know-how	0.236	0.357*	0.240	0.316*	0.246	0.085	0.216
(6) Flexibility	0.087	0.267	0.003	−0.116	0.149	0.041	−0.105

NOTES Column headings are as follows: (1) delivery, (2) quality, (3) responsiveness, (4) management, (5) cost, (6) environment/safety, (7) technical service.

TABLE 8.7 Circumstances between Manufacturing and Supplier-Selection Strategies

(1)	(2)	(3)
1	Delivery	Quality
2	Delivery	Management
3	Quality	Quality
4	Customer-focus	Delivery
5	Customer-focus	Quality
6	Customer-focus	Management
7	Customer-focus	Cost
8	Know-how	Quality
9	Know-how	Management

NOTES Column headings are as follows: (1) Circumstances with complimentary relationships, (2) manufacturing, (2) maintenance services.

executives. The correlation analysis was again applied. The results indicated that all nine circumstances had a strong correlation with. The explanation of when to measure productivity, based on manufacturing and supplier-selection strategies, is illustrated in Table 8.8.

TABLE 8.8
Correlation Analysis between Circumstances and Productivity

Circumstances		Productivity
1	Manufacturing: Delivery	0.344*
	Supplier-selection: Quality	0.342*
2	Manufacturing: Delivery	0.344*
	Supplier-selection: Management	0.551*
3	Manufacturing: Quality	0.274*
	Supplier-selection: Quality	0.405*
4	Manufacturing: Customer-focus	0.433*
	Supplier-selection: Delivery	0.611*
5	Manufacturing: Customer-focus	0.433*
	Supplier-selection: Quality	0.405*
6	Manufacturing: Customer-focus	0.433*
	Supplier-selection: Management	0.551*
7	Manufacturing: Customer-focus	0.433*
	Supplier-selection: Cost	0.580*
8	Manufacturing: Know-how	0.388*
	Supplier-selection: Quality	0.405*
9	Manufacturing: Know-how	0.388*
	Supplier-selection: Management	0.551*

NOTES * Correlation significance at 0.05.

The illustrations of the scattering plots of the first circumstance: (1) delivery from manufacturing strategies and productivity, and (2) quality from supplier-selection strategies and productivity is shown in Figures 8.2, 8.3, and 8.4.

In summary, this study revealed the following. There were nine circumstances that productivity measurement was needed. These findings were derived from two strategic objectives—manufacturing operations and supplier-selection for maintenance services. They were analyzed in a two-stage manner by the correlation analysis. The first stage was to identify a circumstance that illustrated the complimentary relationships between manufacturing and supplier-selection strategies. They were a total of nine circumstances. The second stage was to match each circumstance with productivity. Apparently, all nine circumstances appeared to correlate strongly with the perceived importance on productivity. For instance, based on the first circumstance, the description from the study is as follows. When delivery was selected as a manufacturing strategy and quality was chosen as a supplier-selection strategy for maintenance services, productivity measurement was needed for an effective management process.

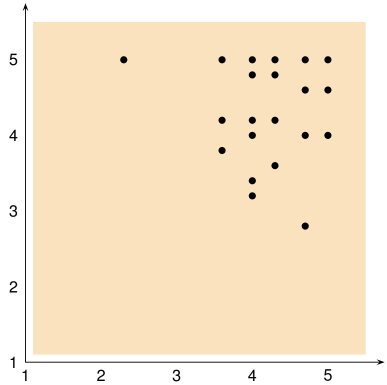

FIGURE 8.2 Scattering Plot between Delivery and Quality

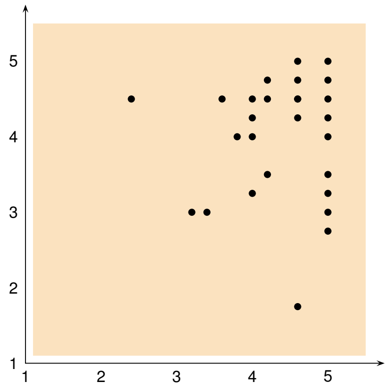

FIGURE 8.3 Illustration of Scattering Plot between Delivery and Productivity for Circumstance 1

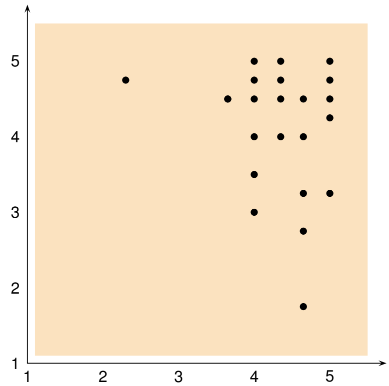

FIGURE 8.4 Illustration of Scattering Plot between Quality and Productivity for Circumstance 1

TABLE 8.9 Summary on When-to-Measure Productivity

Manufacturing	Supplier Selection for Maintenance Services						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Delivery	—	✓	—	✓	—	—	—
(2) Quality	—	✓	—	—	—	—	—
(3) Customer-focus	✓	✓	—	✓	✓	—	—
(4) Cost	—	—	—	—	—	—	—
(5) Know-how	—	✓	—	✓	—	—	—
(6) Flexibility	—	—	—	—	—	—	—

NOTES Column headings are as follows: (1) delivery, (2) quality, (3) responsiveness, (4) management, (5) cost, (6) environment/safety, (7) technical service.

For the follow-up sessions, participating executives agreed with the findings, especially those who rated that a customer-focus as their im-

TABLE 8.10 Profiles of Participants

Sex	Total	Type of work		Education		No. of years of experience
		(1)	(2)	(3)	(4)	
Male	5	3	2	2	3	11.4
Female	11	6	5	6	5	8.5
Total	16	9	7	8	8	9.4

NOTES Column headings are as follows: (1) Senior level (5 years of work experience with at least one person under supervision), (2) operational level, (3) bachelor degree, (4) more than bachelor degree.

portant manufacturing strategy. Productivity was perceived to play an important role in better cost competitiveness (i.e., not necessarily the lowest cost) and more efficient use of resources when dealing with customers (i.e., enhancing an ability to become proactive). At the same time, when selecting suppliers for maintenance services based on quality and management, the impacts on a manufacturer needed to be reflected by better productivity. They viewed that becoming more productive was a result of supplier selection.

Designing Productivity Measurement: Key Consideration Factors

This research represented an attempt to gain better insights on what reflected critical factors when identifying productivity measures (Phusavat and Takala, 2005; and Takala et al., 2006). The interview sessions were conducted with the executives from both production and service functions in one organization. The reason for this study was due to a lack of knowledge of prioritized consideration factors when trying to design and develop productivity measurement for an organization. Without this knowledge, productivity measures might not be useful and would result in a waste of resources and time.

Several steps were undertaken for this study. The first step involved literature review which provided an overview on a design process of productivity (and performance) measurement. Key criteria when identifying productivity measures were outlined. The second step included the interviews with a group of middle and senior executives who had applied productivity information for operational analysis and improvement in the past. Altogether, there were 16 participants in this study. They had applied productivity information for an average of nine years in their work and task responsibilities.

To assure their qualifications, they were asked to outline their opinions on what constituted effective productivity measures. The results were as follows: (1) reliability, (2) ability to point out strength and weakness, (3) easy to understand, (4) ability to cover various processes, (5) ability to provide information for the comparisons with others, (6) acceptance of management, (7) transparent, (8) ability to link to financial management, (9) ability to reflect efficiency and effectiveness, (10) ability to link with other relevant subjects such as quality of work life, (11) cost-effective data collection process.

The third step dealt with the application of the Analytic Hierarchical Process or AHP. It is important to note the following. The AHP is a multi-attribute decision tool. It integrates the results (in this case, the opinions from the participants) with pair-wise comparisons. Essentially, there are three principles underlying the AHP: (1) the principle of constructing hierarchy, (2) the principle of establishing priorities, and (3) the principle of logical consistency. The AHP depends mainly on the experience of the participants. Finally, the last step was to interpret and describe the AHP results in order to prioritize design consideration factors. The Sand Cone Concept was adapted for this step. This concept is based on the analogy of a sand cone in which consists of three layers. The bottom layer represents the most important foundation while the top and middle layers become less significant respectively (Phusavat et al., 2011).

Based on the literature reviews, there were seven criteria commonly cited for key consideration when identifying productivity measures (Helo, Takala, & Phusavat, 2009). The reliability of a measure indicates that the information accurately reflect what it intends to capture. The term strategic congruence implies that a measure supports a business strategy of a company. The term measurement coverage shows that a measure provides a broad picture that reflects key features in an operation. The ability to support different types of work illustrates that a measure can provide useful information for managers and staffs alike. The user acceptance is highly important for executives (to referred to as a measurer) and for staffs who are responsible for operations (to be referred to as a measure). The last design criterion involved the simplicity when deploying a measure.

All seven design criteria were presented to all 16 participants. This task involved the use of the AHP to help prioritize the seven design criteria. Note that the AHP helped arrange these criteria into a hierarchic order, assisted in assigning the numerical values to subjective

TABLE 8.11 Prioritization on Design Criteria

Design criteria	(1)	(2)	(3)
1. Reliability	24%	18%	35%
2. Strategic congruence	16%	18%	13%
3. Measurement coverage	14%	14%	13%
4. Ability to support different type of work	13%	13%	13%
5. User acceptance—measurer	13%	13%	11%
6. User acceptance—measuree	13%	15%	10%
7. Measurement simplicity	7%	8%	5%
Total	100%	100%	100%
Consistency ratio	0.8%	1.1%	3.4%

NOTES Column headings are as follows: (1) overall, (2) senior staff, (3) operational staff.

TABLE 8.12 IMPL Results

Design criteria	(1)	(2)	(3)
1. Reliability	0.43	0.29	0.30
2. Strategic Congruence	0.30	0.27	0.38
3. Measurement coverage	0.72	0.81	0.67
4. Ability to support different type of work	0.50	0.56	0.43
5. User acceptance—measurer	0.80	0.72	1.06
6. User acceptance—measuree	0.58	0.54	0.63
7. Measurement simplicity	1.59	1.69	0.92

NOTES Column headings are as follows: (1) overall, (2) senior staff, (3) operational staff.

judgments on the relative importance of each criterion, and finally synthesized this judgment to determine which design criterion would receive the highest priority (Table 8.11).

In regard to the consistency of the surveys, these priorities (or prioritized design criteria) were obtained with the 0.8% consistency ratio. This was considered to be excellent to the standard of 20% for the size of 10–30 participants. Furthermore, Saaty (2001) stated that the 10% or less was acceptable. The implementation index (IMPL) was also used. The IMPL was derived by dividing standard deviation by the priority of that aspect (also known as a variability coefficient). The lower the index represented to the higher the reliability of the priority of that characteristic. All IMPLs were lower than the acceptable level of 1.0 with the lowest indexes placed on reliability and strategic congruence (Table 8.12).

TABLE 8.13 Weight Assigned on the Set of Design Criteria

Design criteria	Weight
1. Reliability	24%
2. Strategic Congruence	16%
3. Measurement coverage	14%
4. Ability to support different type of work	13%
5. User acceptance—measurer	13%
6. User acceptance—measuree	13%
7. Measurement simplicity	7%

The discussion sessions were held with the research's participants. The Sand Cone analogy was clearly explained. It was decided that the first two design criteria which received the highest priority would be the foundation—so called the must-have group. Then, the lowest prioritized criterion would be classified as the option. It was referred to as the nice-to-have group. The remaining four design criteria would be categorized as the support group. It was called as the should-have group.

To ensure that the results from the sand cone analogy were applicable, four interviews with the manufacturing firms in both Thailand and Finland were conducted. These firms were part of small and medium enterprises which required an effective productivity measurement system. First of all, they shared the similar opinions on the importance of design consideration. They believed that the terms reliability and strategic congruence were indeed critical when identifying productivity measures.

The managing directors and executives from these four firms also agreed that implementing ready-to-make measures would not be very helpful despite their suitability for large firms. As a result, an identification of productivity measures was important to their businesses. New products, new technology, and new staffs were one of many reasons that their companies had constantly reviewed productivity measures. They found that by classifying the design criteria into the sand cone model, they would be able to identify productivity measures that would benefit a company's operations (Figure 8.5).

Finally, the research enhances an understanding on productivity measurement by addressing the issues relating to design consideration when identifying productivity ratios. The proposed design criteria are prioritized from the premise that productivity measurement should be

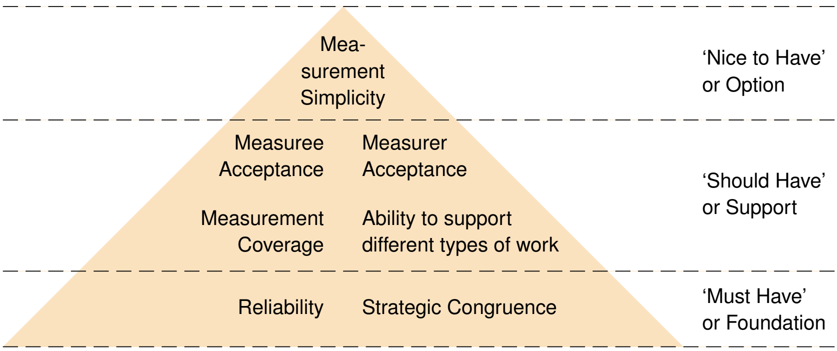

FIGURE 8.5 Prioritized Design Criteria for Productivity Measurement (by the Sand Cone Model)

consistent with a set of strategies at the organizational and operational levels. The reliability of information (i.e., information reflecting what is intended to be measured) is also perceived to be critical for future usage of productivity ratios to be identified later. This is to ensure quality information and top executives' awareness on current problems and ability to anticipate future challenges for a functional unit or an organization. Other less important criteria are classified as should-have and nice-to-have.

Value added Productivity Measurement: Applications and Insights

The study applied the value-added concept, especially relating to productivity measurement, and to analyze the specific circumstances in which it should be appropriate. This concept had become more important due to the rapid changes in a company's operations such as shifting from a "push" to "pull" approach, use of information and communication technology, emerging importance of human capital, and more intense business competition.

The term value added reflects the ability for a firm to generate the value that meets customer requirements and needs (Kess, Lesjak, Aphiphalikitthchai, & Phusavat, 2013). Perceived value shows that customers are satisfied with the products and services received, given the amount of money paid. Because of the importance of intangible assets (e.g., knowledge, human capital, etc.), measuring the value added has been widely practiced and is used to reflect an output of an organization. This is the case for most small and medium enterprises that have prioritized the innovation and creativity for their operations, including new product development and process improvement.

Due to the constant changes in a company's operations such as shifting from a "push" to "pull" approach, use of information and communication technology, emerging importance of human capital, and more intense business competition; measuring a company's value added appears inevitable. The reason is that it indicates its innovativeness and long-term competitiveness (Lee et al., 2011). In general, value-added productivity measurement has been widely utilized in the competitive markets over the past decades. On the other hand, for those conducting the businesses in a less-open market (e.g., regulated or semi-controlled markets), the problem remains whether the value added productivity measurement should be used.

Given the circumstance aforementioned, the overall objectives of this research were to apply the value added (especially value added productivity measurement) and to analyze the specific conditions in which the measurement information can be analyzed. This analysis focused on the usefulness of the value added concept and value added productivity information for the executives and what conditions it should be further applied. Simply put, this research dealt the following questions. When the value- added productivity measurement should be applied? What conditions would be suitable for its applications? Moreover, the research highlighted the importance of the value added within the management process and its emerging need to promote innovation and creativity within an organization.

For the company under study, it is the large sugar refinery plant which is located in the northeast region of Thailand. This company is currently trading in the Stock Exchange of Thailand. It is part of the large conglomerate which has expanded its business areas covering agriculture, foods, and energy areas. For Thailand's agricultural sector, the cane and sugar industry is one of the largest in terms of size and export value. Due to the growing competition from neighboring countries such as India, Vietnam, and Indonesia, there is an urgent need to ensure that the industry remains productive and competitive for the foreseeable future.

For this study, the value added was measured the effectiveness of production activities and dealt with the fairness in distribution economic gains brought about by the gains in efficiency. It had been an integral part of a company since the value added could blend the data from current accounting practices. In other words, the value added would indicate how well a firm could add positive value its outputs. The value added equation for the research was that as follows.

Value added = Sales – Cost of Goods Sold – Depreciation.

The research involved company selection, data collection (from Stock Exchange of Thailand), regression and statistical analyses, the discussion of the findings with the company executive, and the conclusion. The company under study was a large sugar refinery plant located in the Northeast region of Thailand. This selection was based on the strong growth of Thailand' sugar industry which has to deal with emerging competition from neighboring countries such as Vietnam and Indonesia. There were several statistical techniques applied; namely Pearson Correlation, Factor Analysis, and Multiple Regression. The interpretation of the findings was part of this step. Then, the interview was to be conducted with the company's executive to evaluate how productivity information was viewed.

The company under study had been successfully in the sugar industry and enjoyed the business growth over the past decade. The data was collected though the company's financial reports released by the Stock Exchange of Thailand. The following information was value-added and the profit from Year 2005 (representing the first year of the company's entry into the Stock Exchange of Thailand) until 2011. The company under study is a large sugar refinery plant located in the northeastern, western, and eastern region of Thailand, is based on the strong growth of Thailand' sugar industry which has to deal with emerging competition from neighboring countries such as Cambodia, Vietnam and Indonesia.

Then, an attempt was made to examine the interrelationships between productivity and profitability. Indicators to be used in this examination were based on several studies and were similar to the framework suggested by Asian Productivity Organization and Thailand Productivity Institute.

The primary aim for applying the regression analysis was to examine the possible impacts from achieving high value-added productivity on the company's financial performance.

The next step involved the use of Pearson Correlation Test which helps assess the linear relationships between the two variables—how individual variables would relate to the profitability and interact among themselves. If the relationship between two variables was linear, the

TABLE 8.14 Partial Illustration of Data for the Company under Study (mio Baht)

Description	2005	2006	2007
Sales	5,213	6,086	8,468
Cost of goods sold	4,046	4,681	6,629
Depreciation	162	232	317
Net profit	459.11	678.95	835.86
Annual expense	4,897.66	5,441.66	7,428.15
Raw materials cost	3,396.50	4116.15	4,972.60
Labor cost	488	544	636
Selling and administrative expense	549.79	301.00	834.64
Average number of employees*	2,577	2,885	3,391
Average total capital	8,288.58	9,732.82	12,365.22
Average tangible fixed asset	5,586	6,494	8,351

NOTES * Persons.

TABLE 8.15 Illustrations of Value Added and Profits from the Company under Study

Indicators*	2005	2006	2007	2008	2009	2010	2011
Value added	1,006.00	1,173.00	1,523.00	2,306.00	2,400.00	2,437.00	4,134.00
% change	—	16.61	29.85	51.37	4.08	1.53	69.67
Profit	495.11	678.95	835.86	859.53	900.70	76.81	2032.20
% change	—	37.13	23.11	2.83	4.79	−91.47	2545.71

NOTES * Million Baht.

TABLE 8.16 Key Variables for Examining the Interrelationships between Productivity and Profitability

Variables	Formulation
x_1; Labor Productivity	= Value Added ÷ Number of Employees
x_2; Wage Level	= Personal Cost ÷ Number of Employees
x_3; Labor Share	= Personal Cost ÷ Value Added
x_4; Total Capital Productivity	= Value Added ÷ Average Total Capital
x_5; Capital Intensity	= Average Total Capital ÷ Number of Employees
x_6; Value Added Ratio	= Value Added ÷ Sale
x_7; Capital Utilization Ratio	= Sale ÷ Average Total Capital
x_8; Capital Shares	= Profit ÷ Value Added
y; Profitability	= Profit ÷ Average Total Capital

correlation would approach the value of one or 1.0. Two variables with the non-zero value would be described as having the correlations. The Pearson Correlation Coefficient used in this study was set at 0.70 due to the limited data. In other words, if the Pearson Correlation Coefficient

TABLE 8.17 Information from Key Indicators (Variables)

Variables*	2005	2006	2007	2008	2009	2010	2011
x_1	0.39	0.41	0.45	0.66	0.56	0.73	1.23
x_2	0.40	0.29	0.43	0.49	0.43	0.47	0.67
x_3	103.1	71.99	96.51	64.53	76.34	64.88	54.25
x_4	12.14	12.05	12.32	14.94	12.78	11.18	16.73
x_5	3.22	3.37	3.65	4.43	4.40	6.53	7.35
x_6	19.30	19.28	17.99	21.41	20.87	20.39	25.39
x_7	62.90	62.53	68.49	69.78	61.25	54.85	65.91
x_8	49.22	57.88	54.87	37.28	37.53	3.15	49.16
y	5.97	6.98	6.76	5.57	4.80	0.35	8.23

NOTES * See Table 8.16.

TABLE 8.18 Results from the Pearson Correlations

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	y
y	0.11	0.13	0.12	0.58	[0.24]	0.23	0.76	0.94	1.00

between the two variables happened to be less than 0.70, the two variables would be described as having a low level of the co-relationship. If the Pearson Correlation Coefficient between two variables was greater than or is equal to the value of 0.70, these variables would have a linear relationship. Note that the results only show the absolute value.

Based on the findings, the results clearly demonstrated the relationship between x_7 and y, and x_8 and y. In other words, the Capital Utilization and Capital Share appeared to have the linear relationships with the profitability level of the company under study. The next task was to develop a regression to determine which variable influences the profitability level more. This step was critical as the study aimed to extend information from value added productivity measurement into the analysis stage. In this case, it appeared that Capital Share significantly impacted the profitability level. The value added was also embedded in both the Capital Share and Profitability. It showed that the value added played an important role in ensuring business success.

The above results showed that blending the value added concept with productivity and financial performance of an organization was possible. In addition, the information from having blended the value added (including value added productivity) pointed to useful insights into how the company's performance would be managed.

Interestingly, during the discussion, the company's executive sug-

TABLE 8.19 Results of Regression Analysis

Parameter	Regression model		p-value	Adj-R^2
$y =$	$-0.0456 + 0.0495x_7 + 0.130x_8$		0.001***	98.40%
	Predictor	Coefficient	p-value	*VIF*
	Constant	−0.0456	0.112	—
	Capital utilization ratio (x_7)	0.0495	0.279	2.034
	Capital's share (x_8)	0.1300	0.001***	2.178

NOTES *** Significance at the 0.001 level.

TABLE 8.20 Demonstration of the Quadratic Equation Model

Parameter	Relationships	p-value	Adj-R^2
$y =$	$-0.0030 + 0.1968x_8 - 0.114x_8^2$	0.009**	85.70%

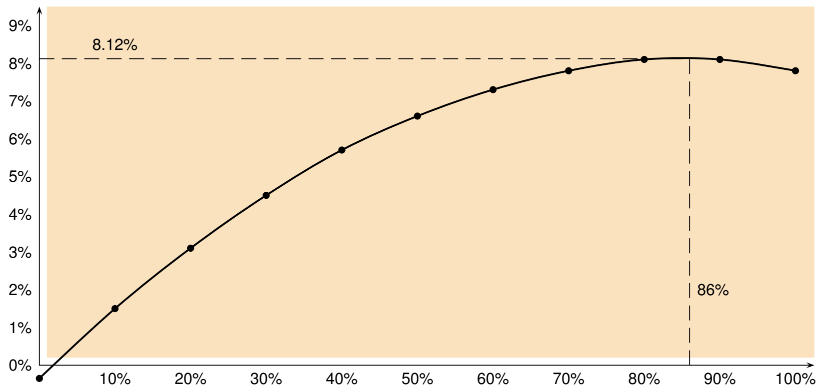

FIGURE 8.6 Interrelationships between Capital Share (x_8) and Profitability (y)

gested a possible extension of information analysis. As a result, the Quadratic Regression Model was applied. Note that, when adding 1% of capital's share, the profitability level was expected to be increased by 0.13%. The quadratic equation model showed the maximum profitability would be at 8.12% when the capital share's value was at 86%. This extension pointed to the need to apply statistical analysis more comprehensive so that information can be help for managerial evaluation and decision (Figure 8.6).

The interview session was conducted with the company's major board member. From this interview session, many lessons were pointed out and learned, especially with respect to the use of value-added productivity measurement. Essentially, the concept of value-added productivity was needed for all companies operating in the competitive and open markets. It was also agreed that, regardless of the products or and services, the concept value-added became prevalent among the companies today. It indicated how well a firm was able to keep up with customer requirements and expectation which explicitly implied intensive use of human capital and other technology for constant changes and improvement in its products, services, and work processes.

By combining the value added with productivity (i.e., substituting the outputs with the value added while dividing it with key input factors), it could help underline the importance of both terms to business operations, especially from the financial standpoint. Simply put, measuring value-added productivity provided useful feedback and information, and needed to be encouraged more in the future. Despite a strong endorsement by the company's executive, there were more insights into and careful consideration during the deployment of the value-added productivity in a firm.

When operating in a regulated or controlled market, the significance of measuring value-added productivity can become less. The reason is that, from the company viewpoint, the sugar is subjected to price control jointly managed by the farmer groups (associations and cooperatives), sugar producers, and Office of the Cane and Sugar Board (under Ministry of Industry). As a result, cost control and management (a.k.a. cost reduction) plays more critical roles than an attempt to add value to the sugar products.

It is the nature of the sugar industry that the attempt to add more value to by-products from the sugar production has been made over the years, including molasses (for beverages and alcohols), ethanol for fuel, bagasse for bio fuel and electricity generation, Monosodium glutamate or MSG for common food additive, and inulin for dietary fibers. Therefore, measuring the value-added productivity in one factory which is part of the agriculture-foods-nutrition chain may not yield useful information.

The study concludes together with this executive the following. The concept of the value-added (especially value-added productivity) is generally important for all firms and can provide useful information for a company management. The reason is that the value added has significant relationship with the profitability level. However, it is important to note that the value-added concept may not be helpful in all circumstance. The concept may not be applied under some specific scenarios: (1) regulated and controlled markets, (2) a company operating in a supply chain in which it has several business partners or spin-off firms using (or purchasing) its products for other production and operations.

For the company under study, it has extended its business scope through spin-offs, and joint ventures with local and international firms. They have formed inter-dependent supply chains in which an output from one company becomes an input for another such as by-products from sugar refinery for the MSG production. In conclusion, the specific conditions to be considered before use for value-added productivity measurement are stated, based on one case study. More studies and comparisons with other industries as well as supply chains need to be conducted in order to provide a future guideline for use. In summary, it is now inevitable that measuring a company's performance involves the value-added concept. The concept of value-added productivity measurement may not be helpful under some of the aforementioned circumstance: (1) regulated and controlled markets, (2) a company operating in a supply chain in which it has several business partners or spin-off firms using (or purchasing) its products for other production and operations.

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Conclusion

The book aims to extend the knowledge on productivity measurement and management. In this book, several issues relating to productivity-related research have been addressed: (1) what to measure (e.g., productivity measurement ratios and techniques such as value-added productivity), (2) how to measure (e.g., a linkage with databases and decision-making processes, productivity measurement model such as the MF-PMM, and productivity formulas), and (3) where to measure (e.g., at the operational and organization levels). In general, productivity measurement has generally covered various levels within and beyond an organization as well as has been studied by many disciplines (e.g., engineering, economics, business administration, and psychology). For Industrial Engineering (IE), the studies on productivity measurement initially began in 1870s when Frederick Taylor, and Frank and Lilian Gilbreth focused their improvement interventions on blue-collar workers with the use of motion and time studies.

Gradually, the work from industrial engineering in productivity measurement and management has started to expand and move towards the functional and organizational levels as productivity information was needed to effectively manage production and operation within a firm. Many models and formulas have been developed to help managers and engineers alike capture productivity in a more accurate manner. As the service sector emerged as the key contributor to the economic wealth and growth, industrial engineers embarked on applying and adapting engineering concepts to help develop productivity measurement tools for service providers. This can be highlighted by the surrogate concept. The use of input/output analysis remains critical as an industrial engineer use the analysis results for ratio identification and information analysis. Trend evaluation and benchmarking maintain their prominent role after productivity measurement.

The continued acceptance of ISO 9001: 2008, the MBNQA, and the European Foundation for Quality Management Excellence Model have helped strengthen the importance of performance/productivity measurement and analysis. Recent studies have called for a better linkage with information and communication technology design, especially in the areas of database robustness, cognitive styles of managers, quality of a management report. For examples, the Control Objectives for Information and related Technology (COBIT) is a set of best practices (framework) for IT management.[1] COBIT was earlier developed by the Information Systems Audit and Control Association and the IT Governance Institute in 1996. COBIT helps address several critical issues relating to performance/productivity measurement and analysis, including the accuracy of data on the performance levels and the integration of performance information and reports into decision-making processes at all levels within an organization.

The Information Technology Infrastructure Library (ITIL) is a set of recommended practices for managing the Information and communication technology services during design, planning, deployment, operations, and upkeep. ITIL is a registered trademark of the United Kingdom's Office of Government Commerce. ITIL can benefit performance/productivity measurement and analysis in several ways as it addresses the risk involving data security[2] and focuses on how a database is managed, ranging from data collection, data storage, data release and retrieval, and information report.

Currently, performance/productivity measurement and analysis symbolize and reflect good governance and transparency in an organization. Performance/productivity measurement and analysis underline that a manager should be accountable for his/her decisions and actions. More importantly, performance/productivity measurement and analysis can be used to drive organizational missions, policies, and objectives. In addition, they strengthen organizational capability to overcome current competition and to better prepare for future endeavors in the globalization era. Therefore, effective performance/productivity measurement and analysis should benefit any organization operating under financial limitations, demographic changes, changing expectations of customers and/or citizens.

Finally, ensuring that the public sector is accountable with good governance practices with a great deal of congressional oversights, the Office of Management and Budget of the US government developed a performance measurement-related tool in the early 2000s, known as Program Assessment Rating Tool or PART. Moreover, performance/productivity measurement also plays a crucial role in im-

1. See www.isaca.org/cobit
2. See www.itil-officialsite.com/home/home.asp

plementing value-for-money or performance audits, especially among European countries (as a result of European Court of Auditors), Hong Kong, and Singapore. Furthermore, the practices of audits in the public sector have gradually changed from internal (i.e., control, financial and compliance) to performance (sometimes known as value-for-money) audits. For examples, in Finland, Ministry of Finance's Financial Controller advocates the need to demonstrate performance of a public agency in terms of its quality on service delivery, efficiency in cost management, and effectiveness relating to the ability to solve or address citizens' needs.[3]

3. See www.vm.fi/vm/en/02_ministry/02_organisation_and_functions/12_controller/index.jsp

Final Remarks

The book is based on my academic work and research in the areas of performance/productivity measurement and analysis during the last 18 years at Department of Industrial Engineering, Kasetsart University. During this time, I have been fortunate to work with wonderful academicians, scholars, and colleagues from various places within Thailand and around the world. Nevertheless, I probably need to limit to only a handful of people whom have had lasting influences in my life. First of all, I would like to thank my mother (Sanpang Phusavat) for having the will and the vision to send me to the US in order to complete my high school diploma there. Otherwise, I might not have had an opportunity to pursue a career in Industrial Engineering or IE. Without the powerful recommendation written by my academic advisor from Foothill High School in Bakersfield, California, Mr. Robert Norwood, I probably could not have begun my undergraduate endeavor at Texas Tech University. As I started my undergraduate study, I became interested and had learned a lot about the historical development and the contributions of IE. I always knew that Dr. Richard Dudek's recommendation, my undergraduate advisor, was so crucial for my acceptance at Virginia Tech. Virginia Tech was a wonderful place to study. I am not surprised to hear that it is now ranked in the top five IE programs in the US.

I have always considered myself to be fortunate to earn both the master and doctoral degrees in Industrial and Systems Engineering from Virginia Tech. I met many outstanding professors who had shown me the importance of IE in the society. Productivity had always been and would continue to be the IE's trademark. I also became familiar with the work published or performed by three IE founding members—Frederick Taylor, and Frank and Lillian Gilbreths. The more I studied their work, the more I was proud to be an IE. As I chose to enroll in the MSE as one of the four available options for a graduate study, I realized how privileged and fortunate I was. I worked with exceptional professors and innovators such as Benjamin Blanchard, D. Scott Sink, Harold Kurstedt, Paul Torgersen, C. Patrick Koelling and Paul Rossler. Specifically for Professor Blanchard, your insights into Systems Engineering really helped make management system design or analysis so captivatingly. Lastly, I could not complete this paragraph without the special appreciation to my dear friend at Virginia Tech, Dr. William Hoehn.

Since 1995, I have been blessed from working at one of the most prestigious universities in Thailand, Kasetsart University. With strong support from the administration; I have been able to conduct, apply, and adapt the knowledge I learned from both Texas Tech and Virginia Tech very freely. Having worked with several firms and agencies such as Thai Flour Group, Provincial Electricity Authority, TRIS, and Office of Public Sector Development Commission help me realize how critical performance/productivity measurement and analysis are to an organization from both short- and long-term viewpoints. These opportunities have assisted me in broadening the applications of MSE knowledge. I have often recalled one of the last conversations I had as a doctoral student with Dr. Paul Torgersen and Dr. C. Patrick Koelling to help sustain my enthusiasm in this field. My two advisors gave me their advice that when I completed my doctoral work, I would everlastingly be obligated to promote and move IE knowledge forward—making sure that people would recognize the importance of and have a high regard for the contributions from IE, especially in the Management Systems Engineering areas. To both, I have tried to uphold these commitment and responsibility throughout my life. Finally, this dossier would not be possible without the support and understanding from my wife (Kanlada Phusavat) and the love of our two children (Kiranapa and Kasidhad Phusavat).

Biographical Notes

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Dr. Kongkiti Phusavat has earned his bachelor degree in Industrial Engineering from Texas Tech University, and master and doctoral degrees in Industrial and Systems Engineering from Virginia Polytechnic Institute and State University (Virginia Tech) in the US He is currently working at Department of Industrial Engineering, Kasetsart University, which is considered as one of Thailand's prestigious programs. His present administrative positions are Director of Center of Advanced Science in Industrial Technology (under the National Research University scheme) and Director of International Graduate Program in Industrial Engineering.

His current research studies and academic work are in the areas of productivity and quality measurement, performance management, acquisition logistics, and a networked government. Dr. Phusavat has published more than 80 articles in the referred international journals over the past decade. Dr. Phusavat has been a manager for more than 30 projects relating to public-sector reforms and good governance, organizational structure for state enterprises, service improvement in healthcare and education, and productivity improvement in private firms. He has contributed to book chapters published in Thailand and Europe. Dr. Phusavat is presently an executive advisor to Thai-Finnish Chamber of Commerce. He is also a committee on national education for Thailand's Board of Trade.

Dr. Phusavat has served as Editor in Chief and editorial board members for several leading international journals such as International Journal of Innovation and Learning. He has acted as a reviewer for a few research agencies in Thailand and Europe, namely Thailand Research

Funds, National Research Council of Thailand, Czech Science Foundation, and Austrian Science Funds. Finally, Dr. Phusavat has given a keynote speech in many international conferences held in Finland, India, Indonesia, Poland, Taiwan ROC, and Thailand; and has conducted the lectures for the universities in Australia, Finland, Malaysia, Poland, Slovenia, Taiwan ROC, Thailand, and the US.

Productivity has survived for more than one century due to the recognition of its impacts on long-term business competitiveness. From a simple definition of output divided by input established in the late 1800s, productivity has continuously gathered a lot of interests from researchers and practitioners alike. Interestingly, productivity has been studied by several academic disciplines in business administration, economics, engineering, and psychology. Nowadays, being productive implies cost effectiveness and excellent performance.

Despite the changes and uncertainties in global business environment, productivity has continued to evolve. In fact, the focus on productivity has played the key role in the expansion of low-cost airlines and the emerging product design which emphasizes commonality and interoperability. The text highlights the issues relating to productivity measurement and analysis at the organizational levels. These issues include what to measure, where to measure, how to measure, and when to measure productivity/performance. The recent development in productivity measurement which uses the term value added as a surrogate for a firm's output is also included.

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