# DEVELOPMENT OF A MEASURMENT FOR TECHNOLOGY LEARNING PROCESS (TLP)

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# DECLARATION

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy, is entirely my own work and has not been taken from the work of others save and to the extent that such work has not been cited and acknowledged within the text of my work.

Signed:  Date: 22/08/2008

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# DEDICATION

Dedicated

To

My Mother and Father

To

Soul of My Uncle (Abd-Algader)

To

Soul of My Grandmothers (Saeda, and Salma)

To

My Sisters and Brothers

To

Rest of My Dabnoon's Family

# DEVELOPMENT OF A MEASURMENT FOR TECHNOLOGY LEARNING PROCESS (TLP)

**Mohammed Dabnoon**

## ABSTRACT

Advanced Manufacturing Technologies (AMTs) are widely used by manufacturing organisations all over the world. Unfortunately, the process of implementation of AMT projects has been unsatisfactory and sometimes led to total failure. In the literature, various reasons are brought forward for the deficiency of companies to deal with such technologies. Most cited reasons were managerial incompetence, organisational inertia and lack of and/or insufficient Technology Learning Process (TLP). Particularly, the Technology Learning Process (TLP) was widely recognised as a significant factor influencing technological change management. For instance, several authors believed that the failure of companies to manage technological change was due to the absence of effective TLP. Hence, studying and identifying the impact of TLP on the technological change management and on operations management is of real importance to reduce this rate of failure.

In order to understand how TLP was implemented and what measures were used to determine the practice level of TLP, face-to-face interviews with experienced industrial project managers were held. Based on these interviews, this study developed 46 parameters in order to assess the practice level of TLP in Irish organisations. These parameters were classified into four levels including Basic Level, Average Level, Advanced Level, and World-Class level.

To examine the impact of these parameters on the technological change management, postal and online questionnaires were designed and dispatched to all pharmaceutical and chemical firms in Ireland. This was a two-fold objective survey. The first objective was to verify the suitability of this set of parameters over a larger sample of pharmaceutical and chemical organisations. The second objective was to determine the level of TLP practice within the pharmaceutical and chemical firms in Ireland and to investigate the impact of each parameter of this set of parameters on the process of implementation of AMT projects and also on the organisation performance as a whole. The suitability of the proposed conceptual model on wide population was verified. The developed set of parameters was found not only to have significant impact on the process of AMT implementation but also have an influence on the organisation performance.

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# LIST OF ABBREVIATIONS

Advanced Manufacturing Technology …….AMT

Technology Learning Process ……....TLP

Numerical Control ……...NC

Computer/Direct Numerical Control ……C/DNC

Computer-Aided Design ……..CAD

Computer-Aided Manufacturing …….CAM

Computer-Aided Engineering ……..CAE

Group Technology ……GT

Computer-Aided Inspection/Testing/Tracking ……..CAI/T/T

Computer-Aided Process Planning …….CAPP

Programmable Logic Controllers ……..PLC

Flexible Manufacturing System ……FMS

Automated Parts Loading/Unloading ……APL/U

Automated Storage/Retrieval Systems …….AS/AR

Automated Tool Changes …….ATC

Automated Guided Vehicles …….AGV

Distributor Control Systems …….DCS

Cellular Manufacturing ……..CM

Manufacturing Floor Management System ……..MFMS

Computer Aided Quality Control …….CAQC

Robotics Industrial Association ……RIA

Integrated Computer Aided Manufacturing ……ICAM

Information Technologies …….IT

Shared Databases ……..SDB

Wide Area Network …….WAN

Local Area Network …….LAN

Material Requirement Planning ……MRP

Manufacturing Resources Planning ……...MRPII

Total Quality Management …….TQM

Just In Time ……JIT

Computer Integrated Manufacturing …….CIM

Society of Manufacturing Engineers ……SME

World-Class-Manufacturing ……...WCM

Lean Manufacturing ……LM

Supply-Chain Management ……..SCM

Design For Manufacturing ……...DFM

Statistical Package for Social Science ……..SPSS

Kaiser-Meyer-Olkin Test …….KMO

Socio-technical System ……..STS

Human Resource Management ……HRM

Industrial Development Authority …….IDA

# CHAPTER 1

## 1. INTRODUCTION

### 1.1 OVERVIEW

The main objective of this chapter is to introduce the research topic and explain the aims of the work, which was mainly based on a study of the Irish Pharmaceutical and Chemical industry. A motivation to conduct this research was followed by an explanation of the research questions and objectives of the research. An explanation on why Irish Pharmaceutical and Chemical industry was selected is also presented. This chapter describes the research methodology used in this study and the link between theory and practice. An outline of the significant contribution of this study is then provided, followed by the outline structure of the thesis.

### 1.2 ECONOMIC HISTORY OF REPUBLIC OF IRELAND

Ireland's economy was not long ago called the "basket case of Europe" [1]. It has been transformed in just 15 years. Irish economy has dramatically grown, where unemployment rates fell from 16 per cent in the early 1980s to under 5 per cent today, well below the average in the Union, at 8 per cent and just behind those in Luxembourg and Austria. Sweeney, (2004) [1] revealed that there is a major interest in Ireland's economic success, with many "econo-tourists" visiting, to learn. There may be some lessons from Ireland for other countries. Ireland has a population of four million or just one per cent of the EU 15 or 0.87 per cent of that of the 25 member states. Its Gross Domestic Product (GDP) is 1.45 per cent of that of the EU 15 member states.

The history of Ireland's economy for over two centuries has been one of mass emigration and relatively high unemployment. This has changed radically in the early 1990s when employment began to grow rapidly "more rapidly than even the much vaunted employment growth in the US" [2]. The extremely high growth levels of the Irish economy in the 1990s described as the Celtic Tiger has seen a 67 per cent

growth in total numbers in employment between 1998 and 2004. There has not been any rigorous analysis of the reasons for the success of the Celtic Tiger, possibly because there is a wide consensus on the reasons. The common reasons include European Union membership and Social Partnership, Foreign Direct Investments (FDI) particularly from the US, investment in education, an active industrial policy picking winning sectors, a demographic dividend and institutional and cultural reasons [1 and 2].

## 1.3 IRISH PHARMACEUTICAL AND CHEMICAL INDUSTRY

The pharmaceutical and chemical sector is a very important industry in the Irish economy and its continued development has contributed significantly to the recent economic prosperity. This sector has grown from a small constituent of the economy in the early 1970s to the point today. Ireland is one of the leading locations for the pharmaceutical and chemical industry in Europe [3]. The pharmaceutical and chemical industry in Ireland comprises a mix of international and local companies. One hundred and twenty overseas companies have plants in Ireland including 17 of the 20 top pharmaceutical companies in the world. The pharmaceutical and chemical industry is relatively new to the Irish economy. The sector started to become established in Ireland towards the late sixties. Primarily, the sector was largely involved in producing active ingredients in bulk for export to other countries to be processed into finished products. Destination was then directed towards developing the plants to produce the finished products [4].

The pharmaceutical and chemical sector is one of the principal contributors to the growth of the Irish economy in recent years [3]. In 1973, the sector employed less than 2,000 people. The sector now employs about 24,000 people. The growth of employment in this sector has reflected both expansions of existing companies and the arrival of new companies. Central Statistics Office figures published in 1997 explains that the pharmaceutical and chemical industry represents a significant source of wealth to the Irish economy, with exports in the sector totalling €11.173 billion. This represents 25% of total Irish exports and continues to make it the primary

growth sector in terms of exports. This provides compelling evidence of the remarkable recent growth rate of the sector in value terms. Much of this growth was driven by a huge influx of global pharmaceutical and chemical companies, many coming from the United States [3]. The pharmaceutical industry includes a range of related sub-sectors including drug products, drug substances, other intermediate inputs and diagnostics. Drug substances are the most important ingredients of a drug product. The strongest growth occurred in drug products, although the drug substance sub-sector experienced strong growth also, particularly in the second half of the 1990s. The multinationals that set up their plants in Ireland include such familiar names as Johnson & Johnson; Lilly; Merck Sharp & Dohme; Schering-Plough; Bristol Myers Squibb and Proctor & Gamble. However, some of the world's best-known products are made in Ireland including Viagra and Botox.

The pharmaceutical and chemical industry in Ireland is highly advanced, incorporating the latest technology, state of the art equipment and strict quality control procedures. Ireland's pharmaceutical and chemical industry offers a wide range of products and services, from research and development for new medicines to the manufacturing and marketing of new medicines for humans and animals. Many research centres were also established by several companies and have become involved in joint research projects with Irish universities. The support of the government agencies such as the Industrial Development Authority (IDA), the Science Foundation of Ireland, and Enterprise Ireland has begun to make things happen by encouraging mainly existing multinationals with operations in Ireland to invest in setting up or expanding activities related to Product Development and manufacturing scale up activities at their Irish subsidiaries. The IDA, however, has named Ireland the "healthcare capital of Europe" and states that over the last 10 years, every U.S medical device company looking for a European base has selected Ireland as its preferred site.

Irish government and its various related agencies are working hard to encourage the expansion of indigenous companies, particularly those looking to develop products related to Biopharmaceuticals. Irish third level institutions are also being far more proactive in finding ways to tie in with industry. Although, the growth of these

worldwide companies in Ireland has provided sub-contracting opportunities for Irish companies, in everything from software services to stainless steel fabrication. Irish government has changed its focus from mainly attracting companies to invest in Ireland, to helping existing companies develop their research and development activities. This strategy is strongly supported by colleges and universities throughout Ireland providing courses in engineering and biosciences [4].

## 1.4 ADVANCED MANUFACTURING TECHNOLOGY (AMT)

Manufacturing industries have evolved tremendously from cottage industries in the early 16th century to the global force as it is today. The characteristics of the present world market as described in Figure 1.1 include higher competition, shorter product life cycles, greater product diversity, fragmented markets, variety and complexity, and smaller batch sizes to satisfy a variety of customer profiles [5]. Furthermore, non-price factors, such as quality, product design, innovation, bundled services and delivery responsiveness are currently the primary determinants of product success in today's global arena [6]. To achieve these requirements, manufacturing companies need to be flexible, adaptable, responsive to changes, proactive, and be able to produce variety of products in a short time at a lower cost. In addition, they should be able to address new environmental requirements, complex social issues and concerns [7]. Hence, implementation of AMT offers the opportunity for companies to treat all these needs and achieve competitive advantage, sustainable at least over an intermediate to a long-term timeframe. The benefits and the positive effects of implementing AMTs have been well documented in the literature. AMT has long been the point of interest for researchers, practitioners and bureaucrats alike. The effectiveness, and thus the attractiveness, of AMT can be credited to their ability to reduce costs, provide high levels of quality, and more importantly, improve manufacturing flexibility and lead-time to market. In a highly integrated form, AMT are powerful instruments that can be mobilized to fulfil the strategic intent of manufacturers [8].

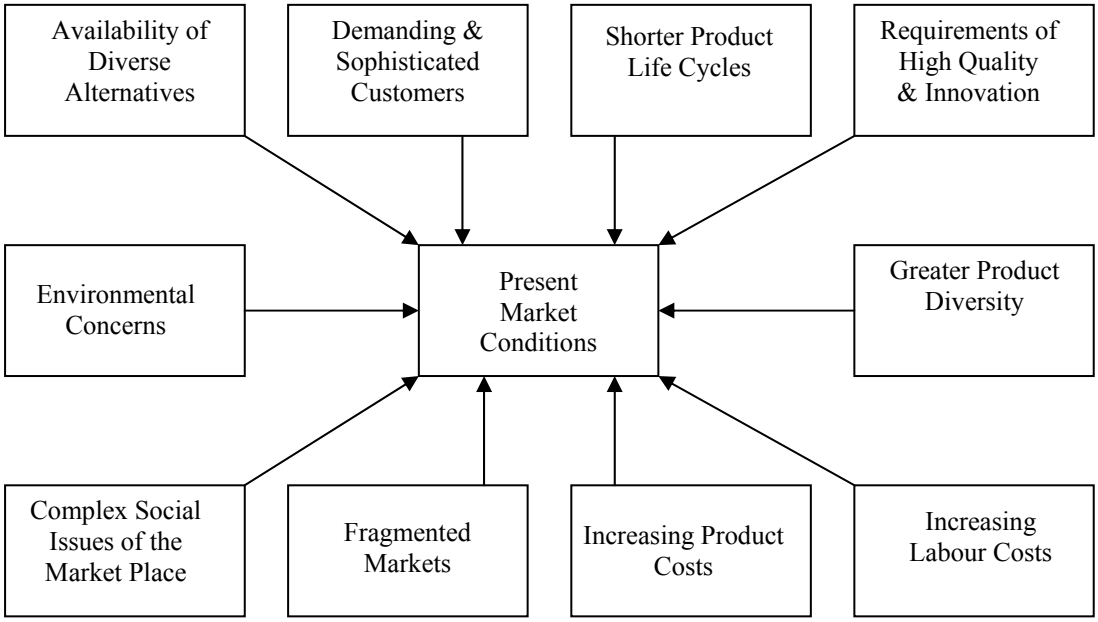


Figure 1.1 Conditions of Present Market & Drivers for Change Management [7, 9]

In the past 20 years, AMT has been widely used by manufacturing organisations all over the world. However, worldwide research has found that not all AMTs have performed as expected [10]. Some AMTs performed very badly and often resulted in total failure. Some AMTs performed "satisfactorily", but did not realise the full benefits/potential of the investments. Other AMTs performed well on the shop floor level, while the business performances of the companies were not improved. All these problems have caught the attention of both researchers and practitioners and several aspects related to AMT projects have been studied. For instance, some researchers have focused on justification techniques for AMT investments [11-13]. Others have investigated the relationship between the uses of AMT and performance improvements [14]. The relationship was investigated conceptually [15], by case studies [16] or by surveys [17] and [18]. However, since the beginning of the 1980s, management of technology, especially implementation of AMT has been a hot topic [10]. The debate was that AMT was more than just a case of a "plug in and switch-on" hardware investment. Often it was not the hardware itself that was to blame, but

rather, other non-technical aspects that were the dilemma. In the literature, various reasons were brought forward for the deficiency of companies to deal with such advanced technologies. Most cited reasons were managerial incompetence, organisational inertia and lack of and/or insufficient Technology Learning Process (TLP) [19-24]. Due to the lack of studies on TLP, this research has attempted to study the TLP and its impact on the management of AMT projects.

## 1.5 TECHNOLOGY LEARNING PROCESS (TLP)

There is no commonly used term for Technology Learning Process (TLP) in companies. Expressions such as Technology Intelligence Process (TIP), Technology Monitoring, Technology Watch, Technology Forecasting (TF), Technology Scouting, Technology Evaluation, and Technology Foresight Process (TFP) show the broad variety of expressions/definitions and include different activities in each firm. The technology learning term is used to understand the systematic recognition and observation of new or existing technologies, the evaluation of their potential and their importance for the competitiveness of the company, and storing and communication of information. Thus, Technology Learning Process (TLP) is the ground on which technological threats and opportunities in fast changing environment can be identified. TLP was widely recognised as a significant factor influencing innovation management. For instance, several authors believed that the failure of companies to manage technological change was due to the absence of efficient TLP [22-29]. TLP is one of the most striking mechanisms that provide top management with the necessary and sufficient information to make adequate strategic decisions. Iansiti, (2000) [24] revealed that to survive and prosper in rapidly changing technological environments, manufacturers must have technology learning process to recognise new technological possibilities, evaluate their potential impact on new and existing businesses, and decide which strategy to implement in actual applications.

There was a considerable agreement about the importance of an accurate and early anticipation of future needs and technological developments [30-32, 24 and 26]. However, there was a lack of empirical studies to address the role of TLP in the

management of AMT projects and its impact on the organisation performance as a whole [24-29 and 32]. Some researchers indicated that empirical studies on strategic planning or strategic management of technology have tackled TLP only to a small extent [33]. Further, the empirical work on TLP in industry was limited to large corporations, where investigations in small and medium-sized enterprises rarely exist [26].

## 1.6 OBJECTIVES OF THE STUDY

An investigation into the factors that enable managers to have the full promises of AMT investments is critical and requested by both researchers and practitioners alike. For instance, Machuca, et al (2004) [34] have stated that the key factors that firstly allow the greatest benefits obtained from investments in advanced technologies and secondly contribute to maintaining and improving the competitive position of investing companies, are a question that is still open to research. The research and investigation into this question is not only important for scholars of operations management, but also, and more especially, for company management and for the public authorities. The objective of public authorities is the strengthening of the capacity for innovation within their industrial fabric. A number of studies [35 and 36] have concluded that investment in advanced technologies alone does not lead to great improvements in a firm's performance if innovation does not extend to organisational and strategic issues. It would therefore seem to be necessary to determine which other activities and factors affect the performance of investments that have been made [37 and 38].

To do so, this study has attempted to investigate the contribution of TLP to the stages/phases of AMT implementation process. The stages/phases include Adoption phase and Installation phase. The adoption phase represents selecting, justifying, and acquiring of needed AMT tasks. The installation phase represents tasks such as installing, operating, and monitoring of adopted AMT. The AMT and the implementation process of AMT projects are explained in further detail in Chapter 2. This thesis has also attempted to examine the role of TLP in reduction of the

problems emerged during AMT implementation process. As well as the impact that TLP exerts on overall organisation performance was also examined. Many researchers have called for further investigation into the factors that have assisted to reduce problems of AMT implementation [34]. However, several other researchers such as Negash, S (2004) [39] have stressed that measuring the impact of TLP on technological change management and overall organisation performance was very important and needed to be addressed. Consequently, the main objective of this thesis was the potential impact of exploitation of TLP on implementation of new technologies and on the organisation performance. The following explains the aims emerged primarily from the main objective. These aims are as follows:

1. Identify how Irish organisations practice TLP,
2. Develop a measurement to assess the practice level of TLP in Irish manufacturing organisations (i.e. determine the parameters used to measure the level of TLP),
3. Identify essential factors that encourage managers to initiate the TLP,
4. Identify primary factors that discourage manager from investing in TLP,
5. Study the link between the TLP practices and adoption of AMT projects (i.e. technological change management),
6. Study the link between the practice of TLP and implementation of AMT projects (i.e. technological change management),
7. Identify the impact of TLP on the organisation performance, and
8. Measure how effective TLP is in reducing AMT implementation problems.

The research objectives were addressed using findings from the Irish pharmaceutical and chemical industry. There were several reasons why firms in this area were chosen for study. Initially, the extremely high growth levels of the Irish economy (i.e. described as the Celtic Tiger): as explained in section 1.1 has stated that there was a major interest in Ireland's economic success, with many academic and practitioners alike visiting, to learn. Thus, there may be some lessons from Ireland for other countries.

The rapidity of the growth particularly in the pharmaceutical and chemical segment with the Industrial Development Authority (IDA), has named Ireland the

"healthcare capital of Europe". It has been stated that over the last 10 years, every U.S medical device company looking for a European base has selected Ireland as its preferred site. Republic of Ireland is one of the largest exporters of pharmaceuticals and fine chemicals in the world. Considerable attention paid by Irish government to this sector is critical reason. The establishment and subsequent rapid growth of this segment was a result of a focused strategy by the IDA to develop and encourage high technology industries in Ireland.

Rapidity of technological and organisational change: the pharmaceutical and chemical industry has undergone rapid changes from both organisational and technological points of view. An investigation of how to deal with such organisational and technological changes is of great importance for both industry and manufacturing sector as a whole.

The significant success of the pharmaceutical and chemical companies already established in Ireland was an essential key attracting the author of this thesis to study this segment. It will thus be useful for the industry as a whole to determine how the firms in this study both succeed and increase competitiveness.

## 1.7 RESEARCH METHODOLOGY

According to Selltiz et al (1959) [40] the purpose of research is to discover answers to questions through the application of scientific procedures. These procedures have been developed in order to increase the likelihood that the information gathered will be relevant to the question asked and will be reliable and unbiased.

Research is an activity that is difficult to define as it encompasses many areas including beliefs, choices, aspects and dimensions. Wolcott, (1990) [41] believed that research should be thought about as "problem setting rather than problem solving". This was a reasonable argument as so much of a research's efforts have to go into designing the research hypothesis, proposition, outlines and methods of data collection before even one piece of field work takes place.

The meaning of research was also important to be examined. Preece, (1994) [42] for instance placed a particular emphasis on academic research and believes that:

"Such research is conducted within a system of knowledge or understanding, but it should always be probing or testing that system. The research aims towards increasing a common heritage or knowledge, though sometimes it will fail. The increase of knowledge maybe something entirely new or original or, more commonly, it may consist of checking, testing, expanding and refining ideas which are themselves still provisional. In particular, a research should continually question the nature of knowledge itself, what it is and how it is known.

Creswell, (1994) [43] however, supplied a more pragmatic view and states that the definition of a research study is "one that advances a research question and reports data to answer the question". The most important issue here was the development of the research questions or the description of research objectives, as without a concrete set of propositions to examine, any study undertaken would lack a coherent focus.

According to Flynn et al (1990) [44] who have written on empirical research methods in operations management, "theory provides the foundation for all scientific research". They also believed that there are two ways in which the theoretical foundation can be established, and they are by 'theory verification' or 'theory building'.

*Theory verification* is the approach used where the focus was on testing the hypotheses rather than analysing its origin. Using this approach the hypotheses are constructed before the research starts and then tested when the data is obtained. On the other hand, *theory building* studies have used information in different ways and the starting point was based on propositions, assumptions or problems rather than definite hypotheses. Information was collected in order to define the propositions, and thus they were grounded in data even before the actual theory building begins [44]. The value of theory building lies in its permitting a wider range of observation and inquiry than the more traditional theory testing does (Flynn et al (1990, p.256)) [44].

This study has used the theory building approach, as the research hypotheses were set down following preliminary interviews and literature reviews. The

information collected during this research period was used to clearly define the research hypotheses and ensure their relevance to the industry being studied.

Adams et al (1991) [45] provided another way of looking at the research process. They believe that "research in any field seeks to generate new information or knowledge that, in turn, can be applied to solve problems, improve the quality of life and provide a better understanding of conditions in a field". This means that the results of a well conducted study can provide useful information for both academics and practitioners and build on the work that has already been carried out.

This is a pertinent point, since one of the objectives of this research was to try and forge a link between theory and practice. The aim here was to provide useful information and guidance for the innovation/change management and operation management as far as Irish manufacturing industries were concerned.

This aim is shared by Lawler et al (1995) [46], who stated that there were two standards that any research project must meet: "the project must help practitioners understand organisations in a way that will improve practice, and it must contribute to a theoretically and scientifically useful body of knowledge about organisations".

## 1.8 SIGNIFICANCE AND CONTRIBUTION OF THIS THESIS

There has been little or no substantial research conducted on either the management of Technological Learning Process (TLP) or the innovation management or operations management, with no links at all between all three aspects. This study therefore was imperative as the study has addressed the need for this kind of research in an Irish context. There were four main areas where this thesis provided a significant addition to knowledge. Briefly, this thesis addressed gaps in the TLP literature. The literature review also addressed the gaps in the innovation management and related operation management literatures. This thesis described how TLP is implemented and identified its key elements. This thesis developed a unique measurement of TLP (i.e. 46 parameters) to measure the practice level of TLP within Irish manufacturing organisations. This thesis investigated possible links between the management of TLP and the process of implementation of AMT, and also the overall

organisation performance. This study carried out a comparative study to examine not only the impact of TLP on the process of AMT implementation but also on the organisation performance in Irish pharmaceutical and chemical companies. Since there has been no research carried out, the work presented here has filled a large gap in the Irish and abroad contexts. Thus, the research conducted by this thesis provided significant information to the body of knowledge. This significant information can provide new insight to current situation for the information management department as far as Irish organisations are concerned. Chapter 6 in this thesis was dedicated to present theoretical and practical contribution of this research and discussed the findings and conclusions drawn from this research.

## 1.9 THESIS STRUCTURE

### 1.9.1 Introduction

Given the motivation and objectives of this research, the reminder of the first chapter briefly outlines the structure of the thesis by summarising the main topics addressed throughout this thesis.

### 1.9.2 Chapter 2 Literature Review

Literatures related to the Advanced Manufacturing Technologies (AMTs) are widely reviewed. This chapter describes the classification and complexity levels of AMT projects. Chapter 2 also covers literatures dealt with the process of implementation of AMT projects. Phases of the process of implementation of AMT projects are discussed. This chapter has also reviewed almost all the previous studies that had addressed any problem or barrier to the management of AMT implementation. This chapter provides a Table that lists all the literature (i.e. literature involved in problems challenge the management of AMT implementation) accompanied with the authors and issue year. This chapter describes the criteria used to assess the success of the process of AMT implementation. Subsequently, in order to understand Technology Learning Process (TLP), Chapter 2 also carries out a comprehensive literature survey. Based on this literature review, this chapter introduces and defines TLP. Benefits of

effective TLP are explained. Essential elements of TLP that identified by previous literature are summarised. Subsequently, this chapter demonstrates several indicators that were used to assess the performance of TLP. Finally, aspects of TLP, which included technology and non-technology aspects, are addressed.

### 1.9.3 Chapter 3 Research Methodology and Research Design

Chapter 3 discusses a number of issues related to research methodology. It starts by introducing some of the terminologies related to methodologies that would be used in this thesis. The specific research questions and objectives that guided this study are defined. The potential strategies for this study are discussed. The main research strategies that were used in the present research are case study approach and research survey approach. This chapter also tackles the issue of research design in the context of this thesis. In doing so, it presents a critical review of the theory on how to design a case study and survey research studies (i.e. the two main strategies used in this study). The chapter also describes a number of data collection and data analysis instruments and gives a summary of the specific instruments used during this study.

### 1.9.4 Chapter 4 Results and Discussion of Case Study Approach

This chapter is dedicated to analysis and discussed the qualitative data obtained from the interviews. An interview script, which described how the interview method conducted and outlined primary issues discussed by the interview method, is presented. Section 4.3 analysed and presented the results obtained from the interviews. This section is organised into 15 subsections in order to exhibit the results of the interviews held by this study. Section after section, this chapter presents and discusses the following issues: ‘the characteristics of the interviewed company’, ‘the type of technologies’, ‘the information required to introduce AMT projects’, ‘the issues that challenge implementation of AMT projects’, ‘the plan used to execute new technology’, ‘number and background of the people assigned to perform the execution plan’, ‘primary elements of TLP’, ‘how the interviewed company implemented the TLP’, ‘the set of parameters that were developed by this study to measure practice level of TLP’, ‘factors that encourage managers to initiate TLP and

also factors that discourage managers from invest in TLP', and 'the aspects of TLP'. Full discussion was provided which addressed all results of the case study. All contributions achieved as a result of this case study are presented. Subsequently, this chapter describes the potential propositions that have been emerged as a result of the qualitative data obtained by the case study. A rationale to justify these hypotheses is provided that has been supported by comprehensive survey of literature.

### 1.9.5 Chapter 5 Results and Discussion of Survey Research Approach

Considerable amount of the quantitative data is initially collected. This chapter intends to analyse and discuss the results obtained from the quantitative (i.e. Postal and Online Questionnaires) methods. The following sections provided the results of the statistical analysis, which was conducted to test the importance level and practice level of TLP in Irish manufacturing firms. This chapter tests the proposed hypotheses described in Chapter 4 and also explains the links between the developed set of TLP parameters and both the process of AMT implementation and organisation performance. Subsequently, the overall results are discussed. At the end of this chapter, the issues of research quality are tackled. It explains the criteria that were used to evaluate the overall quality of the research.

### 1.9.6 Chapter 6 Conclusions and Future Research

Chapter 6 presented the research contribution which explained theoretical and practical contribution of this research. Research conclusions were then summarised. Subsequently, further observations were also presented. This chapter explained the limitations arisen during this research process. At the end of this chapter, future work was suggested.

# CHAPTER 2

# 2. LITERATURE REVIEW

## 2.1 INTRODUCTION

The reviewing of existing literature relating to the topic was an essential first step and foundation when undertaking a research project [47]. According to Jankowics, (2000) [48], "literature review is a critical search for an analytical framework, or frameworks, which you can put to work to test a hypothesis/proposition, or to systematically investigate a set of issues". Thus, to understand the implementation process of AMT, the author of this thesis reviews literature related to the field of technological change management. In section 2.2, this chapter initially defines Advanced Manufacturing Technology (AMT) and describes the complexity level of such technologies. Section 2.3 of this chapter presents literature related to the process of AMT implementation. Subsection 2.3.1 describes the phases of the process of AMT implementation. Subsection 2.3.2 reviews and provides the problems that challenged the process of AMT implementation. Subsection 2.3.3 describes the criteria that were used to assess the success level of the process of AMT implementation. Section 2.4 of this chapter carries out a comprehensive literature survey that covers almost all aspects related to Technology Learning Process (TLP). Based on this literature review, section 2.4 of this chapter initially introduces and defines TLP. Benefits of effective TLP are then explained. During this section, essential elements of TLP identified by previous literature are summarised. Subsequently, section 2.4 demonstrates several indicators that used to assess the performance of TLP. This section concludes with describing technological and non-technological aspects of TLP.

## 2.2 ADVANCED MANUFACTURING TECHNOLOGY (AMT)

The term Advanced Manufacturing Technology (AMT) refers to computer-aided technologies used in manufacturing companies. Noori (1990) [49] defined AMTs as

new technologies, which were used directly by the firm in the production of a product. Youssef (1992) [50] and Burgess, et al (1998) [51] distinguished hard-based from soft-based AMTs. While hard-based AMT referred mainly to physical technologies used in engineering, processing and administration, soft-based AMT covered philosophies and supporting software such as Total Quality Management (TQM) and Just-In-Time (JIT). AMT has widely been regarded as a new and valuable weapon to rise to the challenge proposed by the new market situation to manufacturing industries [52 and 49].

According to the Computer Integrated Manufacturing (CIM) wheel model by the Society of Manufacturing Engineers (SME), there are one business and four technical components of a CIM system [53]. The four technical components are planning and controlling, information resources management, product and process definition, and factory automation. The four components and relevant AMTs involved are described below [54]. The planning and controlling component includes such elements as planning/scheduling and controlling of facilities, materials, tools and shop floor activities. Hardware and software are available to automate each of the elements. Material Requirements Planning (MRP) is an important concept with a direct relationship to CIM. MRP involves using the bill of materials, production schedule, and inventory records to produce a comprehensive, detailed schedule of the raw materials, and components needed for a job [53]. As other manufacturing technologies have evolved from automation to integration, MRP has also developed. The new version of MRP is known as MRP II. In the 1980s, Manufacturing Resources Planning (MRP II) evolved to incorporate the financial accounting system and the financial management system along with the manufacturing and materials management systems. This allowed companies to have a more integrated business system that derived the material and capacity requirements associated with a desired operations plan, allowed input of detailed activities, translated all this to a financial statement, and suggested a course of action to address those items that were not in balance with the desired plan [55]. By the early 1990s, continuing improvements in technology allowed MRP II to be expanded to incorporate all resource planning for the entire enterprise. Areas such as product design, information warehousing,

materials planning, capacity planning, communication systems, human resources, finance, and project management could now be included in the plan. Hence, the term, Enterprise Resources Planning (ERP) was coined. However, ERP can be used not only in manufacturing companies, but also in any company that wants to enhance competitiveness by most effectively using all its assets, including information [55].

Information resources management is the nucleus of CIM [54]. Information, updated continually, and shared instantaneously, is what CIM is all about. One of the major objectives of this nucleus is to overcome the barriers that prevent the complete sharing of information among all other CIM components. The AMTs used for this purpose include Shared Databases (Shared DB), Wide Area Network (WAN), and Local Area Network (LAN). Each of these represents different levels of information integration and sharing. In addition to these stand-alone and islands of automation technologies, the term CIM is also a comprehensive measure of computerised information sharing.

The product and process definition component of the CIM wheel contains three elements: design, analysis and simulation, and documentation [54]. This is the component where products and process are designed, engineered, tested through simulation, and documented through drawing specifications and other tools. Stand-alone technologies include Computer-Aided Design (CAD), which can be used to automate the drawing and analysis process and Computer-Aided Engineering (CAE), which can automate the simulation and analysis process. The islands of automation in this component is Computer-Aided Process Planning (CAPP) which aims to link design, engineering and manufacturing processes by converting design parameters into processing codes [54].

The factory automation component contains those elements that are associated with fabricating and assembling products, for example, material handling, assembling, inspecting and testing, and materials processing (i.e. fabricating) [54]. The AMT technologies suited to these elements include Numerical Control (NC) and Computer Numerical Control (CNC) and Direct Numerical Control (DNC), Computer-Aided Inspection/Testing/Tracking (CAI/T/T), Computer-Aided Manufacturing (CAM), Automated Parts Loading/Unloading (APL/U), Automated

Tool Changes (ATC), Robotics, Automated Storage/Retrieval Systems (AS/AR), and Automated Guided Vehicles (AGV).

AMTs are also classified according to the degree of automation and integration. Bessant, et al (1988) [56] suggested four levels of integration. They are stand-alone, islands of automation, archipelagos of automation (i.e. partial integrated) and the fully integrated systems. Stand-alone AMT refers to single machines or equipments that are not directly connected with other machines or systems by computers. An NC machine is a typical example of stand-alone AMT in fabrication and a single CAD system is a stand-alone AMT in design process. An island of automation refers to a special group of automated machines that work together but have no direct communication with other machines and systems outside their group. FMS is a typical island of automation is manufacturing. Islands of automation exist also in design, engineering and process planning processes. Integration refers to the connection of at least two different functions by computer. For example, a CAPP system can link design and engineering processes by converting design parameters into manufacturing plans and codes. MRP II systems can link design, manufacturing and finance functions to dynamically update the changes of raw materials or components. Integration varies from partially integrated to fully integrated. Combining the four CIM components [53] and levels of integration [56], the 16 AMTs are illustrated in Table 2.1.

Table 2.1 AMT in the four components of a CIM system [53]

| CIM components and their AMTs | | | | |
|---|---|---|---|---|
| Level of Integration | Design and Engineering | Plan and Control | Information Management | Fabrication and Assembly |
| From standalone to integrated | CAD<br>CAE<br>CAPP | MRP<br>MRPII | LAN<br>WAN<br>Shared DB CIM | NC/CNC CAI/T/T<br>FMS/FAS APL/U<br>ATC, Robot, AS/RS, AGV |

### 2.2.1 Complexity Levels of AMT Projects

Encompassing a broad range of hardware and software-based technologies, AMT could be characterized not only by their rate of adoption or diffusion but more importantly by the breadth and depth with which they are implemented and used in organisations, as adoption by itself did not guarantee performance gains [57-59]. It is thus important to differentiate between the adoption of a technology and its implementation, that is, the degree and scope of its usage within the organisation. In this regard, an organisation's level of AMT sophistication defined the extent to which various technologies and applications have been assimilated or mastered, and to what extent these formed a coherent, integrated whole [60-62]. Researchers had been interested in precisely defining AMT, in finding what makes a firm more innovative and sophisticated in this regard, and in the success or performance impacts of these systems [63 and 64].

Many researchers attempted to classify and identify the complexity of AMT within companies. While some classified manufacturing technology as unit/batch, mass, continuous production based on the type of production [65]. Other authors classified AMT into four levels [8, 66 and 67].

Few years later, Small, et al (1995) [13] had broadly categorized AMTs into three groups and seven sub-groups. The AMTs were cross-classified as stand-alone systems, intermediate systems, and integrated systems. Small, et al (1995) [13] also reported that the classification scheme links technologies that had similar benefits and costs. The manufacturing technologies were classified into three groups and seven sub-groups as shown in Figure 2.2.

Few years later, several researchers had used and emphasised that the classification of AMTs was organised into three categories including stand-alone systems, intermediate systems and integrated systems [64 and 68]. Furthermore, these three categories were described with various levels of complexity [13, 68 and 69].

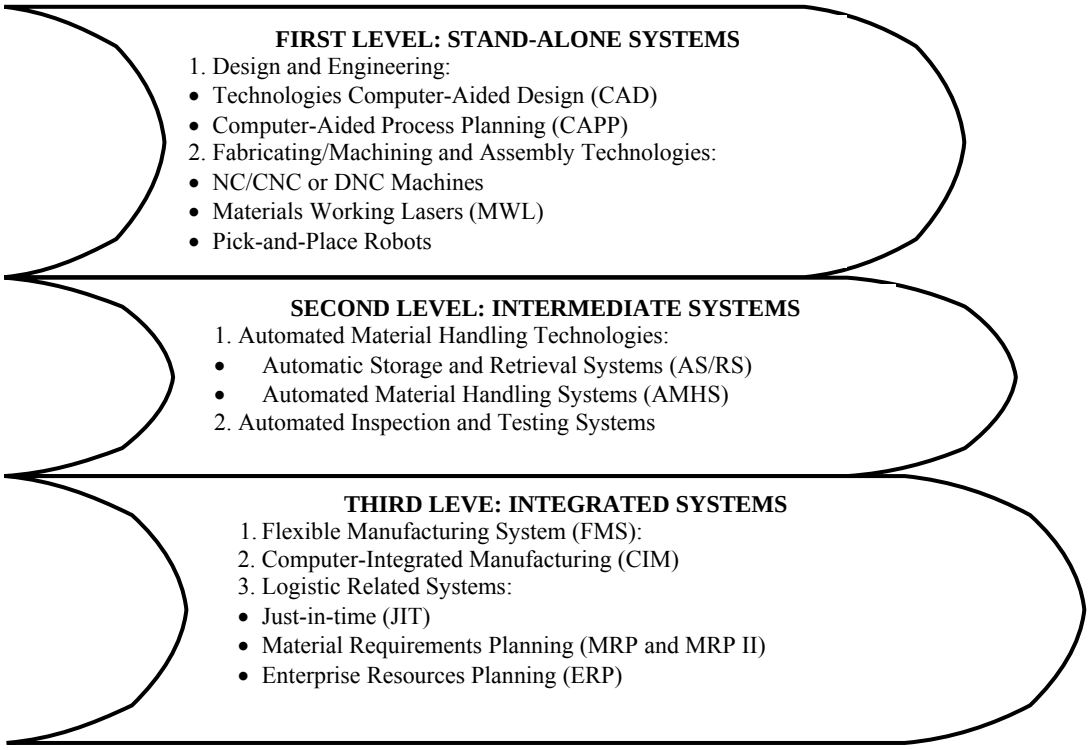


Figure 2.2 Levels of Sophistication of AMT Projects

The complexity levels were as follows:

- The low complexity group consists of firms that were using only stand-alone and intermediate technologies, primarily CAD and CNC,
- The moderate complexity group comprises firms that were using CAD and CNC and at least one of the integrated information technologies of JIT and/or MRPII,
- The high complexity group include firms that had adopted at least one of the integrated process technologies (FMS or CIM), at least one of the integrated information technologies (JIT or MRPII) and the stand-alone technologies of CAD and CNC.

It was found that the general trend in empirical research on AMT had been to examine implementation and performance of individual technologies (e.g. CAD, CNC, or FMS) or of specific technology classifications (e.g. stand-alone systems or integrated systems). However, firms must have often combined technologies from

across various technology classifications to achieve a desirable set of strategic and technical capabilities. A firm's combination to technologies presented an interesting unit of analysis that has not received significant coverage in the AMT literature. Therefore, the present study aimed to adopt the last classification developed by Small, et al (1999) [69], in order to investigate the impact of sophistication level of AMT on the Technology Learning Process (TLP).

## 2.3 PROCESS OF IMPLEMENTATION OF AMT PROJECTS

AMT had widely been regarded as a new and valuable weapon to rise to the challenge proposed by the new market situation to manufacturing industries [52 and 49]. In the past 20 years, manufacturing companies all over the world had broadly used AMT projects. However, worldwide research found that not all AMT performed as expected post-implementation. Some AMTs performed very badly and resulted in total failure. Some AMTs perform satisfactorily, but did not realise the full potential or benefits. Other AMTs performed well on the shop floor level, while the business performances of the companies were not improved [10]. An estimated 50-75% of US firms experienced some degree of failure in implementing AMT [70]. AMT implementation failures seemed to occur when the AMT's capabilities and needs were mismatched with the organisation's existing business processes and procedures. AMT implementation failures also occurred because there was yet little industry experience in AMT and because AMT could be complex and difficult to implement [71]. All these problems had caught the attention of both researchers and practitioners. Since the beginning of the 1980s, management of technology, especially implementation of AMT had been a hot topic [10]. Other researchers investigated the relationship between the uses of AMT and performance improvement. The relationship was investigated conceptually [15], by case studies [16] or by survey [17 and 18]. However, several literatures urged studies to investigate issues with regards to the steps involved in the management of AMT [72-74 and 68].

Despite the claim that AMT was devoted to the improvement of manufacturing operations and its great potential to improve business performance as whole, managers in many companies that have adopted AMT were chastened by the failure of these technologies to live up to their promise [37]. The promises of AMT investment were not immediate because as the firm adopted the new technology it must also have adapt to it. The adaptation would rely on a number of factors. Depending on implementation process, some firms would be more successful than others in capturing the full potential of the technology [75]. The implementation process could cause pain if poorly managed. But if managed well the implementation process could be a source of enormous gain [76]. Implementation of AMT is innovation in itself. It was not sufficient to simply invest in the technology; firms must also have been concentrated on the implementation and management of the technology to achieve the desired promises [77].

The implementation of AMT often was a complex process requiring managers and workers to adapt to a new environment in which their role was changed and in which the machines and processes used were different. It was not simply a matter of substituting a machine with more bells and whistles or a faster machine for a machine containing traditional technology; rather it was a matter of dealing with change [78]. In addition, the implementer of AMT was in a weak position, especially when facing a stronger and more experienced supplier from an industrialised country [79]. Nobody managed to gain competitive advantage by employing technology on its own [80]. The implementation process would require time during which the firm needed to adapt to those advanced technologies. To ensure the greatest promises from AMT investment, firms must have directed their energy in that area, which yielded the greatest promises [75]. As technologies became more powerful and complex, the source of competitive advantage lied less in the particular hardware or software package purchased than in the ability to deploy it [81].

With increasing investment in computers and computer-based information systems, the evaluation of these systems was becoming an important issue in the management and control of these new systems [82]. Bessant, (1993) [81] pointed out that the benefits from AMT arose not only from the equipment and software used but

also from changed working practices, skills disposition, inter-functional relationships, planning and control procedures.

The performance of organisations using AMT was dependent to a large extent on how well implementation was and not on the technology itself. The way the technology was implemented had a serious affect on its performance and as a result on business performance [83]. The process of AMT implementation was very complicated and required skills and managerial know-how. The process was also highly delicate and costly and as a result, there was a need to put much effort and time into the transfer phase of AMT introduction into the organisation [74]. However, the evaluation of the systems as they are developed and implemented could take place at the completion of various stages of the systems development life cycle [84].

In the press, managers trumpet the success of AMT. But all too often the private answer to 'How is the new equipment working?' is badly. Yet the introduction of new technology was essential for long-term survival [76]. One of the most significant tasks facing management today was to ensure that the expectations from AMT are fulfilled following implementation. Unfortunately, the results from introducing technological change were often disappointing and occasionally disastrous [85].

Mere installation of AMT did not guarantee that a firm would reap all the potential benefits. While most firms achieved some benefits, many AMT projects were not fully exploiting the system capabilities. Issues in both the pre-installation (Adoption phase) and installation (i.e. implementation phase) phases of AMT projects appeared to have a direct impact on their eventual performance. Therefore, managers of firms that were contemplating the adoption of AMT needed to recognise, understand and address these issues in order to overcome or circumvent the problems encountered by earlier adopters [68]. While decisions concerning planning and justification would determine if and how a project is implemented, the ultimate performance of an AMT projects often was dependent on actions taken during the project installation and post-commissioning phases. Unfortunately, many of the problems resulting from inadequate or improper pre-installation planning were noticed only after installation of the technologies [86 and 72]. For instance, Bessant, et al (1986) [87] had suggested that companies needed to look more closely at post-

adoption factors that were what happened once the technology was installed and commissioned.

Problems such as inadequate organisational planning and preparation for the adoption of the AMT or faulty execution of other aspects of the implementation process had contributed to the failure to achieve the potential benefits [25, 72, 88 and 89]. However, much of the information about planning and implementing AMT currently available to managers had been gleaned from small sample case studies or from offerings in the conceptual literature [73]. Small, et al (1997) [68] stressed that further research should have been concentrated on establishing practical guidelines to aid executives as they charted new strategic courses for their firms. In response to this request, the researchers of this study had reviewed and presented the studies that have revealed stages/phases of the process of implementation of AMT.

### 2.3.1 Phases of Process of Implementation of AMT

Machuca, et al (2004), [34] stated that the devising of a model that could predict the successful implementation of any new technology was almost as great a challenge as inventing a general-purpose machine that had the ability to think. The different degrees of complexity of the various systems, the fact that the objectives pursued by the adoption of AMT could be specific to each case and that the ways of accessing the new technologies may also be very different, meant that it could not be any other way. In addition, a number of studies [90-93 and 68] demonstrated how differences in business practice and type of organisation could to a certain extent explain variations in the competitive performance of AMT users. Nevertheless, a number of frameworks for action had been devised within which the activities to be carried out during the adoption process for flexible technologies should be included. They provided general guidelines to help companies with this task [93-99 and 68]. Firstly, these papers for the most part distinguished between the two large phases or stages normally found in any investment process: adoption phase and implementation phase. The hypothetical dividing-line between these two phases was marked by the acquisition of the new asset, although it was not easy to make a clear-cut distinction.

#### 2.3.1.1 Adoption Phase

As far as the adoption phase is concerned, it was crucial to highlight the importance of pre-investment actions and conditions, not only for the investment to be made, but also for the adoption phase to be successful. Amongst other aspects, the company should have focused on a preliminary study during adoption that allowed it to decide on the suitability of adding the new asset to its technological portfolio. This should have included strategic planning and staff consultation as well as other more general aspects related to management skills, attitudes and the technology it already had available [100].

#### 2.3.1.2 Installation Phase

The implementation phase should have represented the transitional period during which members of the organisation affected by the innovation were trained and commit themselves to its use [101]. This was therefore the crucial link between the decision to have adopted the innovation and its later routine use. All efforts should have been directed at ensuring the most effective and efficient introduction of the new system possible (one of the issues looked at during the later monitoring stage). Success in this aspect would to a great extent be dependent upon the quality of the analysis made during the previous stage. According to Liker et al. (1993), [102] research should be guided by the relative importance of the different aspects of the process. It should also be borne in mind that, although it is difficult to refute that poor implementation could be the end of a good design, neither could it be stated that a poor design can be made up for by optimum implementation. Nevertheless, some people did continue to say that the implementation phase was the least understood part of the overall innovation process, despite over 40 years of research into the subject [103 and 34]. It was also observed that the majority of the previous studies had underestimated or neglected either the role of initial exploration (i.e. initial information) or post implementation role in the process of implementation of AMT.

### 2.3.2 Problems Challenge Implementation of AMT Projects

Adoption of AMT projects involved major investment and a high degree of uncertainty and, hence, warranted considerable attention within a manufacturing firm at the strategic level. As a result, issues involving adoption and implementation of AMT projects assumed greater importance. While many have stated that companies could attain significant competitive advantages through AMT projects, others believed that implementing AMT was one of the most lengthy, expensive and complex tasks a firm could undertake. Thus, the key question in making effective use of AMT was how well it was actually implemented.

Based on several studies, various barriers and/or problems were occurred during the process of AMT implementation. Afzulpurkar et al (1993) [104] had identified some of the issues and problems arisen from implementing a Cellular Manufacturing (CM) project and discussed the following issues, namely scope of CM projects, simulation modelling, cell design, cell operational logistics, and labour issues in CM. Many researchers agreed that the full benefits were not realised because of, for example, economic, technical and organisational problems [105-107, 72 and 87]. Voss, (1986), [100] had reported that most AMT failures were due to organisational problems, and has also identified the following emerging issues: technological (configuration, computability); economic (justification, government support); manpower (skills, industrial relations, number); and organisation (new strategies, need for change, new methods).

Boer et al (1990) [108] reported that manufacturing companies were not benefiting from AMT owing to:

- Technical problems (engineering faults, problems with standardization and integration of both hardware and software) occurring after installation;
- Changes in the marketplace during the implementation process; and
- Insufficient knowledge of and attention to the organizational prerequisites for the effective operation of FMS

Babbar, et al (1990) [109] had reported that the problem lied not in the level of technology, but rather in its implementation. The researchers had identified some major problems of adopting AMT, such as:

- Lack of co-ordination with the company's strategic plan;
- Implementation without an appropriate manufacturing strategy;
- Inadequate communication networking among system components;
- Failure to recognize the relative importance of system components, cost breakdowns, and contribution of various production activities to cycle time;
- Failure to remove organisational barriers between functional areas; and
- Adapting to and planning for continuous change over time

Generally, it was clear that success depended strongly on getting a good fit between the technology and the organisation into which it was to fit. Securing this compatibility invariably required some form of organisational adaptation and, in particular, the resolution of a number of integration issues.

At a technical (i.e. technological) level, the main questions concerned getting different hardware and software systems to work together. Often, manufacturers felt that software represented the major technical problem. Hardware problems mainly revolved around linking machine tools with handling systems and, since these technological developments had been evolving incrementally over a long period, they posed few insurmountable difficulties.

Although technical barriers were seen as important, researchers and practitioners alike believed that the real difficulties lay on the organisational level. AMT forced change in the way in which firms operated and in particular required a much higher level of responsiveness. The changes extended right across the organisation, from design through to marketing, and were required at all levels from strategic management to the shop-floor. Thus, effective non-technological techniques that would be consistent with the demands of advanced technologies are needed. Some adequate non-technological techniques such as new forms of purchasing and stockholding practice, high levels of quality control, alternative approaches to project

appraisal in the financial sphere, and design-for-manufacture, must have been emphasized from the short to the long term in corporate strategy.

Briefly, Table 2.2 presented several studies that had identified the barriers and difficulties facing companies in adopting and implementing such advanced technologies.

Table 2.2 Problems challenge the process of implementation of AMT projects

| **Problems Challenge AMT Implementation** | **Authors with Issue (Year) [Ref No.]** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Beatty et al (1988) [110] | Boer et al (1990) [108] | Lederer et al (1992) [111] | Earl, (1993) [112] | Galliers, (1994) [113] | Sambasivarao, et al (1995) [114] | Sohal, (1996) [16] | Sohal , (1997) [6] | Millen, et al (1998) [115] | Hofmann, et al (2005) [116] |
| Resources needed to maintain the system were under-estimated (more engineers and computer operators were required) | ✓ | | | | | | ✓ | ✓ | | ✓ |
| Failure to perceive true benefits | ✓ | | | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| High risk for managers | ✓ | | | | | | | | | |
| Lack of coordination and cooperation between senior management and other departments | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Opposition by workforce/staff (Resistance) | ✓ | | | ✓ | | ✓ | | ✓ | ✓ | ✓ |
| Hasty decisions and chronic fire fighting | ✓ | | ✓ | | | | | | | |
| Incompatibility of systems (i.e. Problems with interconnection of equipments) | ✓ | ✓ | | ✓ | | | | ✓ | ✓ | ✓ |
| Changes in the marketplace during the implementation process | | ✓ | | | | | | | | |
| Insufficient knowledge of and attention to the organisational prerequisites for the effective operation of AMT | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | |
| Difficult to secure top management commitment | | | ✓ | ✓ | ✓ | | ✓ | | | |
| Final planning output documentation not very useful | | | ✓ | | | | ✓ | | | |
| Implementing the projects requires more analysis | | | ✓ | | | ✓ | ✓ | | | |
| Planning methodology requires too much top management involvement | | | ✓ | ✓ | ✓ | | ✓ | | | |

Table 2.2 Problems challenge the process of implementation of AMT projects (Continued)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Output of planning is not in accordance with management expectations (i.e. High hopes and hidden costs) | ✓ | | ✓ | ✓ | | | | | | |
| Technological constraints arose | | | | ✓ | ✓ | | | | | |
| AMT skill deficiencies | ✓ | | | | ✓ | | ✓ | ✓ | ✓ | ✓ |
| Nature of business | | | | | ✓ | | | | | |
| User education resources | | | | | ✓ | | | | | |
| Political conflicts | | | | | ✓ | | | | | |
| Middle management attitudes | | | | | ✓ | | | | | |
| Implementation without an appropriate manufacturing strategy | | | | | | ✓ | ✓ | | | |
| Inadequate communication networking among system components | | | | | | ✓ | | ✓ | ✓ | ✓ |
| Failure to recognize the relative importance of system components, cost breakdowns, and contribution of various production activities to cycle time | | ✓ | | | | ✓ | ✓ | | | |
| Adapting to and planning for continuous change over time | | | | | | ✓ | | | | |
| Under-estimation of the discipline necessary on the shop-floor | | | | | | | ✓ | | | |
| Operators often forgot to scan parts initially | | | | | | | ✓ | | | |
| A conflict between short-time production requirements and long-term goals (i.e. introduction of the AMT) | | | | | | | ✓ | | | ✓ |
| On-going support of the information services department was under-estimated | | | | | | | ✓ | ✓ | ✓ | ✓ |
| Problems with the outside software development consultants resulted in a delay in project completion | | | | | | | ✓ | | | |
| Training of support personnel and production staff was underestimated (this needed to be on-the job) | | | | | | | ✓ | | | ✓ |
| Lack of integration across functions | | | | | | | ✓ | ✓ | ✓ | ✓ |
| Production management skill deficiencies | | | | | | | | ✓ | ✓ | ✓ |
| Adverse effect on workflow | | | | | | | | ✓ | ✓ | |
| Disruptions during implementation | | | | | | | | ✓ | ✓ | ✓ |
| Obsolescence of technology | | | | | | | | ✓ | ✓ | ✓ |
| Production interruptions during installation of the AMT | | | | | | | | | | ✓ |
| **Total** | **36** | | | | | | | | | |

### 2.3.3 Assessment of the Success of AMT Implementation

Another important issue was how the success of AMT implementation was measured. The number of dimensions comprising manufacturing performance had been the subject of much debate over the years. Skinner,(1974) [117] described several performance measures, including short delivery cycles, superior quality and reliability, dependable deliveries, fast new product development, flexibility in volume changes, and low cost. Wheelwright, (1987) [118] focused on efficiency, dependability, quality, and flexibility. Leong, et al (1990) [119] contended that five dimensions were the most critical: quality, delivery, cost, flexibility and innovativeness. Ferdows, et al (1990) [120] focused on four generic manufacturing capabilities, namely, cost efficiency, quality, dependability and flexibility in one of the earliest empirical studies of manufacturing competitive dimensions. Even more recently, Vickery, et al (1996) [121] found that manufacturing performance in the furniture industry consisted of four distinct dimensions: delivery, value (quality/cost), flexibility, and innovation. However, a related study also indicated that while manufacturing had the lion's share of responsibility for delivery, quality, cost, and flexibility, it had a much smaller degree of responsibility for innovation [122]. Vokurka, et al (1998) [123] also empirically investigated the impact of different manufacturing improvement techniques on the competitive performance capabilities of cost, quality, delivery flexibility and time. Delivery flexibility was meant to tap the firm's capability of meeting promised delivery dates, which was a function of timing and variety.

Sohal, et al (1991) [124] reported that in response to a survey on the assessment methods of AMT projects, the respondents indicated that improvements in quality, obtaining competitive advantage, reducing costs, increasing throughput, and increasing flexibility were considered the most important benefits at the time of assessment. Organisations also considered disruptions during implementation and failure to achieve financial targets as measures to assess the process of AMT implementation. Voss, (1988) [10] measured the success of AMT depending on the realisation of benefits at three levels: realisation of productivity increases (e.g.

reduced labour, increased throughput, reduced cycle-time, etc.), realisation of non-productivity benefits such as reduced lead-times, quality improvements, increased flexibility and customer responsiveness, and translation of these benefits into competitive gain in the market-place.

Respondents in Olorunniwo's study [125] were asked if, in their opinion, their cellular implementation projects had been successful or not, all of them reported that their projects were successful. With a considerable amount of time, effort, and money expended on projects, it is understandable why no managers would have wished to categorise a project as anything less than successful. On the other hand, the success of AMT implementation had usually been measured by providing the percentage of improvements in numerous performance measures. For example, performance measures commonly used by some authors included reductions in: work-in-progress, set-up time, material handling, work space area, tooling expense, labour cost, lot sizes, scrap and rework, and improvements (or perceived increases) in: product quality, and inventory turns [126-128].

Most organisations believed that they have successfully implemented new operating technology when two conditions are met: firstly, when all the bugs have been ironed out and it was working technically correctly; secondly, when the operation was working reliably and there was little downtime, and/or the AMT has a high utilisation rate. However, getting the AMT to work may have been only half the battle. The full success can only be considered to have been realised if the benefits being looked for are realised, and ideally realised in the market place through increased competitiveness. The full benefits could include increased productivity, reduced lead-time, improved quality, flexibility, etc [10].

The purpose of this research was not to delineate or examine every conceivable dimension of manufacturing performance. Rather, the dimensions most strongly supported by the literature have been focused on in order to use them in this research.

## 2.4 TECHNOLOGY LEARNING PROCESS (TLP)

By the end of the millennium, firms had made heavy investments in people, process, and technology, yet there was a perception of a growing gap between how AMT was actually used and its full or potential use [6, 7, 16, 63, 68 and 129-133]. It has become increasingly apparent that the critical issue was not what technology firms have, but rather, how firms learn to evaluate, adopt, and use that technology effectively in their work. Effective management of this misunderstanding requires effective learning organisation. Many scholars have suggested that firms must adopt an efficient learning process to survive and grow in today's turbulent environment [134 and 135]. The more firms continue to learn, the more effectively AMT is used and, thus, the greater its impact on work [136].

The increased complexity of manufacturing technology demands higher commitments to learning than past manufacturing advancements [137]. Sohal et al (1991) [124] concluded that an organisational learning process is a key ingredient in the process of AMT implementation. Researchers and practitioners alike believe that successful process of AMT implementation goes through several avenues of learning process. For instance, Miller, (1996) [138] has described some avenues of learning process. He has suggested that "organisational learning is the acquisition of new knowledge by actors who are able and willing to apply that knowledge in making decisions or influencing others in the organisation". Thus, learning process entails acquisition of knowledge and in addition, use of that knowledge in some way. These characteristics suggest two types of organisational learning, acquisitive and experimental [139]. Experimental learning occurs largely inside the firm and generates new knowledge that is distinctive to the organisation such as Learning-By-Doing (LBD) [131]. The experimental avenue is usually used during the implementation process of advanced technology. Acquisitive learning takes place as the firm acquires and internalizes knowledge external to its boundaries [140]. The acquisitive avenue is usually conducted before the adoption of new technology such as Technology Learning Process (TLP).

There is no commonly used term for Technology Learning Process (TLP) in companies. Expressions such as Technology Intelligence Process (TIP), Technology Monitoring, Technology Watch, Technology Forecasting (TF), Technology Scouting, Technology Evaluation, and Technology Foresight Process (TFP) show the broad variety of expressions/definitions and include different activities in each firm. The technology learning term is used to understand the systematic recognition and observation of new and/or existing technologies, the evaluation of their potential and their importance for the competitiveness of the company, and storing and communication of information. Thus, Technology Learning Process (TLP) is the ground on which technological threats and opportunities in fast changing environment can be identified. Many authors have defined that the TLP is regarded as an intentional or unconscious initiated process of technology scanning, monitoring, and valuation [141-143].

TLP is the process by which strategic decision makers are kept informed about technological opportunities and threats. Investing in the right AMT can be crucial to gaining competitive advantage, while failing to spot a ground-breaking new development could be disastrous. As technology lifecycles shorten and business becomes more global, the effectiveness of TLP becomes increasingly important. Information about a new technology may be available on the internet and elsewhere but many companies find themselves swamped by reports with no way to interpret the potential impact on their business. In addition, once information is public it may be too late to act effectively, allowing competitors to seize the advantage. Most companies that depend on technology to support their products have established informal ways of keeping abreast of the latest technology developments. They may even have invested in an expensive computer-based system hoping it will solve all their needs. However, a company that invests in such infrastructure alone is unlikely to achieve the full potential of its investment. It is essential to take a comprehensive and systematic approach to achieve effective results [134]. In addition, literature split the TLP into two phases namely scanning phase and monitoring phase. For instance, Ashton, et al (1991) [142] distinguished between the scanning phase (i.e. an

undirected perspective of technology Learning), and the monitoring phase (i.e. a directed perspective). The TLP scanning phase is concerned with:

- Identification, observation, and analysis of new technologies outside the company existing areas, and
- Development of statements on future trends of science and technology.

Whereas the TLP monitoring phase is dealt with:

- Observation of technologies and research results already existing (state of the art),
- Analysing technologies relevant for competition and the company's position in the areas.

By analysing the TLP, Lichtenthaler, (2004) [28] found that companies coordinate the TLP on three parallel layers. First, the companies have created specific technology learning positions, using the so-called structural coordination. Second, they often form technology learning projects of limited duration to cover specific topics, using the so-called hybrid coordination. Third, companies try to encourage informal TLP. The credit of TLP comes from its role to increase the ability of companies to adopt appropriate technologies. Lichtenthaler (2004) [29] reported that companies studied have greatly increased their ability to adopt technologies through the creation of an exploratory marketing as part of long-term technology planning. The TLP does not only limit to the adoption phase, instead many researchers indicate to the broad involvement of the TLP in all stages/phases of the AMT implementation process [26].

### 2.4.1 Benefits of Effective TLP

Effective TLP delivers targeted and meaningful information early enough to enable new opportunities to be exploited profitably or threats countered before they harm the business. High-performing TLP will:

- Access sources inside and outside the organisation to find information before competitors,
- Support senior decision makers by simplifying the TLP gathering process and identifying the information that is critically important,

- Become a part of the company's decision-making structure and reflect the culture of the organisation,
- Deliver results that meet the demands of stakeholders, and
- Evolve and improve over time.

### 2.4.2 How TLP Works

TLP can take many forms depending on the organisational structure and planning horizons of the business but it usually involves six key stages:

- Identifying and prioritising key technology challenges and needs,
- Searching for information on relevant technologies,
- Filtering and interpreting information to support decision making,
- Sharing TLP gathered information with relevant people in the organisation,
- Deciding on a course of action using relevant TLP, and
- Acting on the decision or storing gathered information of TLP for use at a future date.

Whatever approaches are used to achieve these steps it is essential to consider how the TLP will operate as a whole, taking into account the business organisation and culture. A successful system should:

- Motivate the people involved and define their roles clearly,
- Establish a strong information handling process, and
- Support the process with a well-designed infrastructure.

### 2.4.3 Effective TLP should include

- Watch-lists of emerging technologies,
- Filter criteria and stakeholder reporting requirements,
- 'Listening posts' in key international locations that monitor technology and market trends,
- Internal 'gatekeepers' who sustain the flow of information across company boundaries,
- Pre-defined information 'tripwires' that indicate the need to alert decision makers, and

- Databases and document handling processes.

Several authors express that the TLP fundamentally influences the effectiveness of technology management [24, 26, 32 and 144-146]. All of them believe that the TLP comprises the activities related to the identification, acquisition, analysis and communication of relevant information on the new technologies and their developments to support technological and more general decisions of the company. The activities of TLP were recently stressed by Reger, (2001) [26], who developed a model, which described the core elements of TLP. In his model, the relationship between TLP and the innovation activities (e.g. Adoption of AMT projects) was clearly explained.

### 2.4.4 Indicators of Lower Performance of TLP

- Your organisation is often caught on the backfoot, forced to respond to competitor technology rather than taking the initiative,
- You worry that an unforeseen, 'disruptive' technology could significantly affect your business,
- You believe that your firm is missing out on opportunities to expand,
- Technology investment decisions are taken without sufficient external information,
- Information technology investment designed to deliver information to decision makers is not providing the expected benefits, and
- Decision makers are swamped with data, but have little useful information to help them make decisions.

If this is the case, then it is likely that TLP in the company is under-performing. Surveyed literature emphasized that although organisations had different understandings of TLP and engaged in it with varying degrees of intensity, there was a consensus among them about the need for TLP. However, managers should not mismanage the TLP by limit it to one aspect namely a technology aspect. Conversely, TLP must cover both technology and non-technology aspects. The following paragraph is devoted to address both technology and non-technology aspects.

### 2.4.5 Aspects of TLP

The TLP inherently involves learning technologies. However, simply focusing on technologies alone is no longer enough. With the increased importance that today's companies place on knowledge, people are becoming one of the most valuable resource for firms. Deriving value from this resource is not a question about technologies, but rather about non-technologies, such as effective management. Consequently, technological learning is not solely about learning technologies any more. Rather, it is best construed as learning in technology-driven firms. Therefore, learning must include technologies and non-technologies. Literature stressed that TLP is needed in at least two levels. For instance, Sohal, et al (1991) [124] described the basic of these two levels. Clearly, workers must understand how to effectively operate new equipment (technical or technological level). But to gain the business benefits, a detailed understanding of a broad range of managerial issues is required (non-technological or managerial level). Based on several studies, the present study splits the TLP into two fundamental aspects namely technology aspects and non-technology aspects. These two aspects of TLP are discussed and Figure 2.3 briefly describes the contents of each aspect.

#### 2.4.5.1 Technological Aspects

The main objective of intentional or unconscious initiation of TLP is to scan and monitor the trends and development of advanced technologies. Accordingly, the first purpose of TLP is to address the technological aspects. Therefore, TLP is useful mechanism to determine the best and applicable technology that adapt well with the rest of the systems within the organisation. A selection process of advanced technologies is one of critical problems hindering the success of implementation process. The mis-selection of advanced technologies can cause lot of trouble to the company. This trouble sometimes has driven the organisation to disastrous results or even destroyed the whole company. Researchers and practitioners alike believed that the trouble resulted from mis-selected technology could be seen at the adoption phase of the implementation process [10, 68, 130, 147 and 148]. Thus, an application of

TLP makes managers more familiar with AMT and enables them to eliminate or reduce technological/technical barriers.

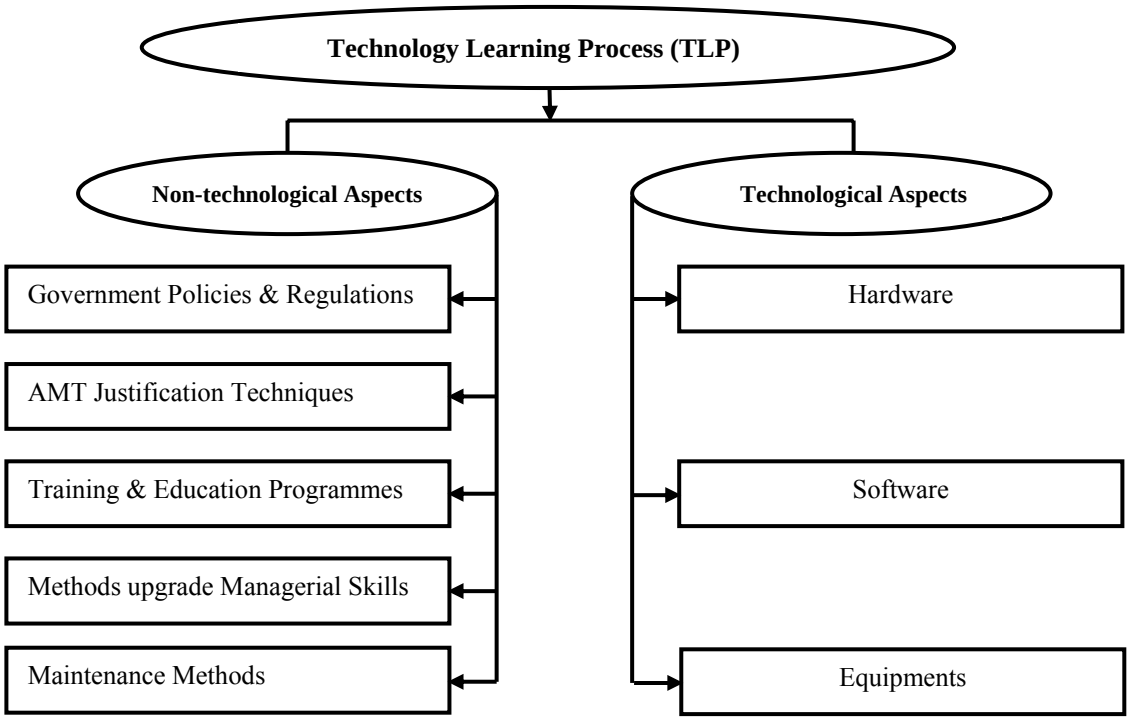


Figure 2.3 Main Aspects of Technology Learning Process (TLP)

Focussing particularly on the technological/technical barriers, literature revealed that technological barriers were often oriented toward hardware and software barriers. For instance, Sambasivarao, et al (1995) [114] revealed that if any problem occurred in the production system, ultimately it was seen in the hardware. Hence, the adoption, implementation and integration of the hardware with the software and other system procedures play a major role in implementing the automated projects. Hardware such as machine tools, material-handling equipment, inspection and production facilities should be configured carefully by the technical experts. Thus, technical experts should find avenues to acquire AMT which fit into the present facilities smoothly.

On the other hand, software is said to be one of the most difficult technological aspects of any automation project [114]. This is also one of the major factors on which the entire success of automation project depends. The software for AMT should have a good capability for handling huge amounts of data and flexibility for

future modifications. The software should include all the important areas of a manufacturing concern, namely engineering software, business software and manufacturing software, and all this software should share a common database and should have well a capability for handling huge amounts of data. The management should have a clear idea on the software issues and it should first decide whether to develop the software internally or employ consultants and/or procure standard software from market. It has been observed that business packages are available commercially in the market. However, engineering and manufacturing software may have unique features because of the hardware and system procedure constraints and may have to be developed either internally or by employing consultants.

Apparently, the technological issues were seen orienting towards compatibility issues and production issues. Compatibility issues included 'lack of integration across functions', 'lack of integration of manufacturing information systems', 'disruptions during implementation', and 'problems with interconnection of equipment'. Whereas, production issues comprised such problems as 'adverse effect on workflow', 'effect on the production process and bottlenecks', 'production interruptions during installation of the AMT', and 'obsolescence of technology'.

In order to deal with these issues, manufacturers who contemplate to use AMT, have to initially perform TLP before any adoption to any advanced technologies. Many researchers have referred the failure of companies to manage technological change to the absence of efficient TLP [24-29]. Thus, TLP is an important activity in manufacturing organisations to meet the challenges of technological change [26].

#### 2.4.5.2 Non-technological Aspects

While TLP is believed to be a powerful weapon to sweep and/or avoid technical barriers in AMT implementation, it is also powerful weapon to eliminate and/or avoid the non-technological barriers. Chen, et al (2003) [149] revealed that TLP was no longer about learning technologies solely. Instead, it should involve learning both technological and non-technological aspects, such as effective management techniques. More often, the non-technology is more important than technology itself. In order for manufacturers to have competitive advantage of introducing advanced

technologies, knowledge should not only be gathered for technological aspects but also about non-technological aspects. Basically, the functions that technological and non-technological actors play in learning are different. The technological actors learn technological knowledge and build up the technological capabilities of organisations, such as patents and technological documents. Where the non-technological actors learn knowledge on management and build up managerial personnel capabilities, such as institutions and routines. The technological and non-technological capabilities are consistent with the concepts of 'human capital' and 'structural capital' respectively in technology-driven firms [150 and 151].

Due to the importance of learning process in increasing technological and non-technological capabilities, literatures revealed that organisations must effectively engage in various forms of knowledge creation before and during the adoption of an AMT [152]. Literatures also indicated that there are different methods to manage different types of knowledge. For instance, Hansen et al. (1999) [153] argued that for technological knowledge, learning by doing, learning by using, and learning by R&D may be appropriate for acquirement, assimilation, and improvement of technologies, respectively. For non-technological knowledge, benchmarking or "best practice" are good tools [154-156 and 136]. Thus, it is essential for firms to enhance the breath, depth, and speed of TLP in order to effectively manage the implementation of new technologies [134 and 135].

An initiation of TLP, which comprises both technology and non-technology aspects, is a key factor for the success of AMT implementation. For instance, based on a case study called 'ZDZK Automation LTD CO', Chen, et al (2003) [149] reported that the ZDZK has adopted and managed advanced technologies successfully because it learned technologies from many sources (such as universities, research institutes, customers, suppliers, employees, and international and domestic leading firms). At the same time, the ZDZK learned non-technologies actively. One manager said that because they lacked experience in management, they often appropriated effective managerial methods from other firms and imitated them when needed.

Since organisations previously concentrate solely on technology aspects during the TLP, the present study suggests that along with scanning and monitoring technological aspects, non-technological aspects must be also incorporated and addressed during the TLP. The integration of non-technological aspects during the TLP is an important factor that can contribute to increase the degree of success of AMT implementation. Non-technological, managerial, and organisational factors powerfully influence the adoption of AMT and the impact of their adoption on product quality, labour productivity, and the skill requirements of labour [137]. The present study organises the non-technology aspects into two groups. One group is named economic issues and the other is managerial issues. The concerns of each group are listed below:

1 Economic Issues:
   - Updated justification techniques that best-in-class companies use
   - Fluctuation of government policies and regulations
   - Technical backing and assistance from government
   - Liberalization of market economy

2 Managerial Issues:
   - Seeking appropriate training and education programmes
   - Seeking the methods to upgrade the managerial and technical skills
   - Seeking the avenues to translate the experiences of other people and industries
   - Seeking effective safety methods in terms of efficiency and convenience of the employees
   - Seeking the effective maintenance methods and problem-solving used to prevent trouble
   - Seeking the effective methods to motivate the employees

Based on foregoing discussion, it is evident that non-technological aspect of TLP is as much important as technological aspect. To be efficient, TLP must scrutinise and observe both technological and non-technological changes and developments that may influence current and/or future businesses.

# CHAPTER 3

# 3. RESEARCH METHODOLOGY

## 3.1 INTRODUCTION

The purpose of this chapter is to examine various research methodologies and to provide justification for the selection of appropriate methodologies to tackle the research problem, to answer the research questions, and to support the objectives of this thesis. Initially, this chapter makes explicit the definition of certain terms related to research methodology that is used frequently during the thesis. The topic of research methodology has suffered from the fact that a large number of different definitions have been used when referring to the same term and this has had the potential to create confusion among researchers [157].

This chapter also describes the nature of the specific phenomena studied in this thesis. This section presents the specific research problems and corresponding research questions in order to sharpen the scope of this study. Philosophical assumptions have always been an integral part of scientific research, and this thesis is no exception. This chapter gives a critical review of the different philosophical research paradigms and describes the impact that choosing a specific research paradigm could have on designing the research methodology. The chapter concludes by describing and discussing the specific research strategies adopted for this research.

## 3.2 DIVERSITY OF TERMINOLOGY

What exactly is a research methodology? Concerned about the differences between authors in the definition of terms such as research methodology, research strategy and research method, this researcher decided to avoid any confusion by describing what these terms mean in the context of this thesis.

Different researchers have offered different definitions of methodology according to their own personal views. Rather than trying to suggest another

definition of methodology, it might be more beneficial to identify the prominent operational features of a research methodology. Based on the review of the work on research methodology found in the literature e.g. [157-159] and, a research methodology has:

- uncovered and justified research assumptions and place them within the traditions of enquiry (i.e. philosophical paradigms),
- showed how research questions are articulated, and
- explained and justified the particular research strategy and methods used in the study.

A similar variety of definitions existed for the terms 'research strategy' and 'research methods'. In this study, research strategy referred to a general approach to, or general type of, investigations [160]. Other authors have labelled this with the term research approach and so both terms were used interchangeably during this thesis. Examples of research strategies included case studies, experiments, and surveys.

On the other hand, this study referred to 'research methods' when describing those investigative tools or instruments employed during a research study. These tools were specific for data collection and data analysis. Examples of research methods included interviews, observation and pattern matching.

## 3.3 RESEARCH PROCESS OF THIS STUDY

Demonstrating a clear, logical and reflexive relationship between research questions, field questions, literature review, data analysis and research report was a key feature of successful research [159]. These were methodological issues that needed to be incorporated in all the phases of the research, not only in the 'methodology chapter'. As shown in Figure 3.4 that summarised the research process of this study, the research process was usually described as a sequential process, which involves several clear defined steps. However, according to Blumberg, et al (2005) [161] it did not necessarily require that each step was completed before going on to the next one.

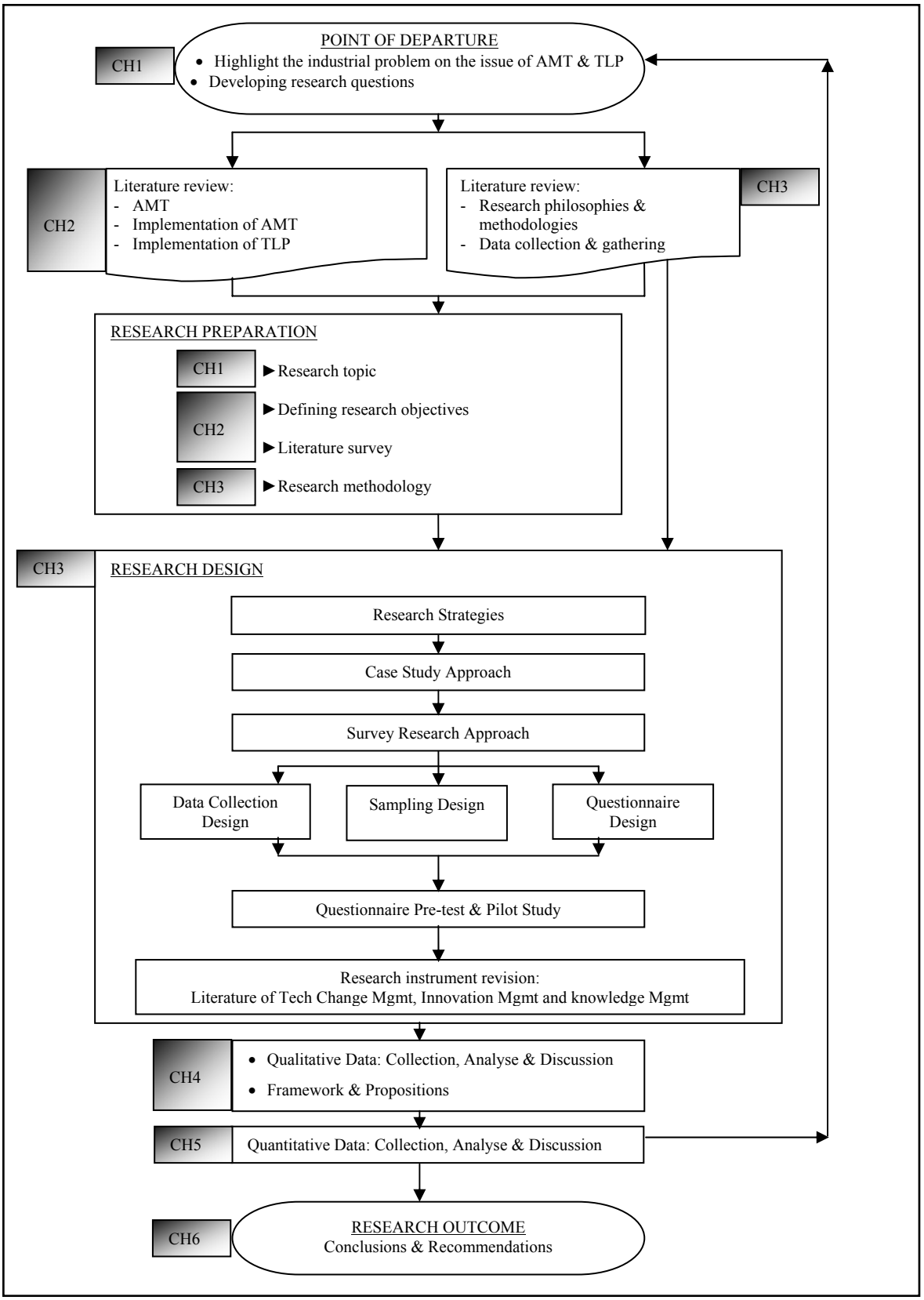


Figure3.4 Summary of the Current Research Process

Despite these real life variations, the idea of a basic sequence was useful in developing a research project and in keeping things orderly as it unfolded. Some methodologists suggested that the use of research models [162]:

- offering a guide that directs the research action, helping to reduce time and costs to a minimum,
- helping to introduce a systematic approach to the research operation, thereby guaranteeing that all the aspects of the study will be addressed and that they will be executed in the right sequence, and
- encouraging the introduction of an effective organisation and coordination of the project.

Sarantakos, (1993) [162] presented a research model in terms of steps and elements, as shown in Table 3.3.

Table 3.3 the Research Model-Sarantakos, (1993) [162]

| STEPS | ELEMENTS |
|---|---|
| ONE: RESEARCH PREPARATION | ►Selection of research topic<br>►Defining research objective<br>►Formulation of hypothesis<br>►Selection of research methodology |
| TWO: RESEARCH DESIGN | ►Selection of sampling procedures<br>►Selection of methods of data collection<br>►Selection of methods of data analysis<br>►Arrangement of administrative procedure |
| THREE: EXECUTION | ►Data collection |
| FOUR: PROCESSING | ►Grouping and presentation of data<br>►Analysis of interpretation of data |
| FIVE: REPORTING | ►Publication of the findings |

Another author, Punch, (1998) [163] presented another model of research, which showed research questions with hypothesis as shown in Figure 3.5. The research questions were the straightforward ones of '*what*' (what question was the research trying to answer? what was it trying to find out?) and '*how*' (how was the research answering these questions?). This model of research helped to organize the planning, execution and writing up of the research.

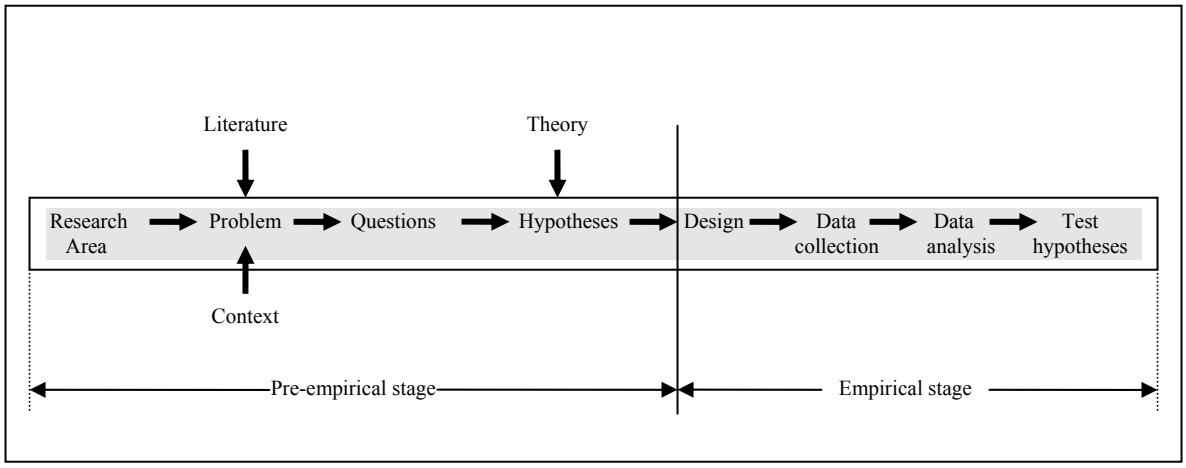


Figure 3.5 the Research Model 'quoted from Punch (1998) [163]'

## 3.4 RESEARCH QUESTIONS AND PURPOSES

The primary question of this thesis was to develop set of parameters to measure practice level of TLP. Perhaps the most difficult part of a research project was to design good research problems and questions that directed the thinking enough and not too much [164]. As a result of the initial review of the literature, the generic question initially defined was:

*RQ. How could we help managers to assess Technology Learning Process (TLP) within their organisations?*

While always keeping in mind the main research problem, the development of research problems and questions was an evolving, changing and incremental process [164]. The research question of this thesis also evolved and emerged as new findings were unfolded. The initial question (i.e. RQ) was evolved into the following two more specific questions (i.e. RQ1 and RQ2):

*RQ1. How did TLP practice in manufacturing organisations?*

*RQ2. What were the parameters used to measure the practice level of TLP?*

In addition, new research questions emerged as a result of the exploratory research phase carried out with several industrial specials. These sub-objectives are as follows:

- To identify essential encouragements to practice TLP,
- To identify primary constraints to initiate TLP,
- To identify the practice level of TLP within Irish manufacturing organisations,
- To determine how important the parameters of TLP are in Irish manufacturing organisations?
- To determine the significance of the contribution of TLP to the adoption phase of the AMT implementation process,
- To determine the significance of the contribution of TLP to the installation phase of the AMT implementation process,
- To determine the effectiveness of TLP in reducing AMT implementation problems, and
- To determine the impact of TLP on the organisation performance.

Yin, (1994) [165] suggested that, in order to identify the specific elements to study, it was also useful to define the propositions of a particular study. This enabled the research to direct the attention to something that should be studied within the scope of the study. In this thesis, fife hypotheses were proposed. These hypotheses derived from the generic objectives were defined in Chapter 1 and were defined in order to solve the research problem and answer the research questions. These hypotheses guided the researcher in planning and structuring the research work in a logical form. The fife hypotheses proposed in this study was presented with complete discussion and supported from literature in Chapter 4.

## 3.5 OVERVIEW OF RESEARCH PHILOSOPHIES

Science may be said to progress on its methods. The production of knowledge depends very much on the techniques for collecting, analysing and interpreting data and on the way they are applied [166]. Nodoushani, (2000) [167] stated that throughout the short history of positivist epistemology research has been defined as the formal process of inquiry by an organised quest for principles, theory or even "laws of nature".

According to Blumberg, et al (2005) [161], research was based on reasoning (theory) and observations (data or information). How observation and reasoning are related to each other is a still ongoing and old philosophical debate on the development of knowledge. Although many researchers conducted sound research without a thought for underlying philosophical considerations, some knowledge of research philosophies was beneficial for a researcher as it helped to clarify the research design and facilitated the choice of an appropriate one. Furthermore, Easterby, et al (1991) [158] emphasised that by understanding the basic assumptions of research philosophies could enable researchers to reach beyond their past experiences.

There were two most distinguished research philosophies that were often been discussed in the literature, with clearly differentiates extremes: positivism and interpretivism (also called phenomenological). Different names have been used to identify both philosophies. The former was also known as objectivist, traditional or mainstream while terms such as, phenomenological, humanistic, hermeneutic and subjectivist have been used when referring to the latter [158, 161 and 162].

Taking the previous comments into account, it could be argued that prior to selecting specific research strategies and research tools, it was important to have a good understanding of different philosophical paradigms. Easterby, et al, (1991) [158] argued that there were three reasons why an understanding of philosophical issues is important:

- It could help clarify research designs,
- Knowledge of philosophy could help the researcher to recognise which research design may have worked and which may not, and
- Knowledge of philosophy could help the researcher identify, and even create, designs that may be outside his or her experience.

### 3.5.1 Positivism versus Interpretivism

Research paradigms were often discussed based on a spectrum with two clearly differentiated extremes, the positivist paradigm and the interpretivist paradigm. Each of these philosophical paradigms included ontological and epistemological

assumptions. In words of Long, et al (2000, p.190) [160] ontology 'refers to assumptions held about the nature of the social world', while epistemology 'refers to assumptions about the basis of knowledge and in what manner knowledge can be transmitted to others'.

#### 3.5.1.1 Positivism

Positivism is a research philosophy adopted from the natural science. Its three basic principles [161] are:

- The social world exists externally and is viewed objectively,
- Research is value-free, and
- The research is independent, taking the role of an objective analyst.

According to positivism, knowledge developed by investigating the social reality through observing objective facts. This view was important implications for the relationship between theory and observation, as well as for how research is conducted. Theory development started with hypothesising fundamental laws and deducing what kind of observations supported or rejected the theoretical predictions of the hypotheses.

Positivism implied the following assumptions: the social world was observed by collecting objective facts; and the social world consisted of simple elements to which it could be reduced.

Scientists followed this research tradition believing that observable facts were objective, because they were external, i.e. cannot be influenced, and research was conducted value-free.

#### 3.5.1.2 Interpretivism

Unlike positivists, interpretivists hold the view that the social world cannot be understood by applying research principles adopted from the natural science and propose that social sciences require a different research philosophy. The basic principles of interpretivism [161] are:

- Social world is constructed and is given meaning subjectively by people,
- Research is part of what is observed, and

- The research is driven by interest.

Interpretivists have argued that simple fundamental laws were insufficient to understand the whole complexity of social phenomena. Knowledge was developed and theory built through developing ideas inducted from the observed and interpreted social constructions. Interpretivists attempt to understand subjective realities and to offer interpretative explanations, which are meaningful for the participants of the research [161].

### 3.5.2 Research Implication of Positivism and Interpretivism

The opposing stances taken by positivists and interpretivists were summarized in Table 3.4 [161]. These differences in basic principles and assumptions had several implications for how researchers should have conducted research.

Positivism started from the idea that the world could be described by objective facts, which were then investigated. Therefore, one needed to assess whether observations were indeed objective facts. The constructs used were operationalised to ensure that observing the same phenomenon was measured in the same way. In practice, constructs were often operationalised in quantitative terms, as presenting facts using numbers facilitates comparisons. On the other hand, interpretivist is interested in subjective meanings and interpretations of phenomena to detect what is happening in a specific situation.

Table 3.4 Differences in basic principles and assumptions between positivism and interpretivism [161]

| Basic Principles | Positivism | **Interpretivism** |
|---|---|---|
| View of the world | The world is external and objective | The world is socially constructed and subjective |
| Involvement of researcher | Researcher is independent | Researcher is part of what is observed and sometimes even actively collaborates |
| Researcher's influence | Research is value-free | Research is driven by human interest |
| **Assumptions** | | |
| What is observed | Objective, often quantitative, Facts | Subjective interpretation of meanings |
| How is knowledge developed? | Reducing phenomena to simple elements representing general laws | Taking a broad and total view of phenomenon to detect explanations beyond the current knowledge. |

In the positivist side, Easterby, et al (1991) [158] noted that the research methods used have focused on developing and testing hypothesis. This was done by taking large samples and measuring the phenomena using objective method (i.e. quantitative) rather than subjective methods. Furthermore, as shown in Table 3.5, Easterby et al (1991) [158] summarised the differences characteristics of these two research philosophies.

Table 3.5 Differences in characteristics between positivism and interpretivism [158]

| | **Positivism** | **Interpretivism** |
|---|---|---|
| **Research should** | Focus on facts<br>Look for causality and fundamental laws<br>Reduce phenomena to simplest elements<br>Formulate hypotheses and then test them | Focus on meaning<br>Try to understand what is happening<br>Look at the totality of each situation (i.e. historical-contextual characteristics)<br>Develop ideas through induction from data |
| **Preferred methods includes** | Operationalising concepts so that they can be measured<br>Taking large samples<br>Quantitative methods | Using multiple methods to establish different views of phenomena<br>Small samples investigated in depth or over time<br>Qualitative methods |

In the interpretivist side, researchers claim that the world is subjective and socially constructed, and that the individual is part of this reality. Knowledge is also subjective because is driven by human interest and individual experience. From this perspective, the researcher believes that there are multiple realities that are all equally valid. As a result, the researcher needs to immerse him/herself in each situation to understand the phenomena including its historical-contextual characteristics [160]. The interpretivist paradigm tries to understand and explain the phenomena, and so the research methods will focus on studying small samples in-depth over time. This will include the use of multiple methods to establish different views of the phenomena [158]. The subjective nature of the interpretivist paradigm means that the researcher needs to use qualitative methods to understand the phenomena.

Personal considerations and preferences prior to starting a research project influence the behaviour of the researcher and research methods adopted. In fact, these preferences are an important part of a research paradigm [168]. Consequently, they

will partially dictate which side of the philosophical spectrum the particular research paradigm falls into.

## 3.6 POTENTIAL RESEARCH STRATEGIES

Research strategy is a general approach to, or general type of, investigation. According to Yin, (1994, p.1) [165] research strategies could be compared based on three main criteria. Table 3.6 described these criteria:

1. the type of research question,
2. the control the researcher had over behavioural events, and
3. the focus on contemporary as opposed to historical phenomena

Each research strategy had its own advantages and disadvantages and therefore, it was important to be aware of these in order to make the most out of any of the strategies. Yin, (1994) [165] criticised the view that certain research strategies should have only be used during specific phases of the research. For example, case studies were not only applicable to the exploratory phase, but were equally applicable to an explanatory or descriptive phase. This applied to the other research strategies as well. Yin, (1994) [165] argued that instead of looking at the phase of the research, the researcher should have focused on the three criteria defined above when choosing a research strategy.

Table 3.6 Relevant situations for different research strategies, Yin, (1994) [165]

| Strategy | Form of research question | Requires control over behavioural events? | Focuses on contemporary events? |
|---|---|---|---|
| **Experiment** | how, why | yes | Yes |
| **Survey** | who, what, where<br>how many<br>how much | no | Yes |
| **Archival analysis** | who, what, where<br>how many<br>how much | no | yes/no |
| **History** | how, why | no | No |
| **Case study** | how, why | no | Yes |

There were several commonalities between different research strategies and more than one strategy could be equally applicable in a specific situation. The objective here was not to champion any particular strategy, but to ensure that the authors did not ignore those strategies that offered more advantages for that specific situation.

Next, a description of the research strategies that were used during this study is carried out. The proposed research strategies are typically linked to the phenomenological research perspective. The chapter finished with a full discussion on research design.

### 3.6.1 Case Study Research

Several definitions of case study have been published but Yin's (1994) [165] definition appeared to be the most widely used. Yin, (1994) [165] defined case studies as:

- an empirical inquiry that investigated a contemporary phenomenon within its real-life context, especially when
- the boundaries between phenomenon and context were not clearly evident,
- it relied on multiple sources of evidence

Today, case studies are a major research strategy in operations management. In an era when organisations continuously have needed to change and rapid transfer of knowledge was required, many practitioners were highly interested in learning from other cases rather than waiting for statistical relevance from large samples [169]. In addition, many of the breakthrough concepts and theories in operations management have been developed from field case research [170]. From the review of the existing literature the following were the benefits of case studies [164, 165, 171 and 172]:

- The phenomenon could be studied in its natural setting, which allowed generating and/or testing the new theories with the ultimate end users. This increased the validity and acceptance of the research by practitioners,
- It enabled the full understanding of the nature and complexity of the phenomenon. This comprehensive data analysis generated new and creative insights that could answer the why, what or how questions,

- It allowed exploratory investigations where the variables were unknown and the phenomenon was not at all understood

The same authors referred to a number of challenges related to case studies. These were:

- Resource requirement of direct observation (i.e. cost, time and access)
- Need for multiple methods for triangulation
- Lack of control, complications of context and temporal dynamics
- Need for good interviewing skills, and
- Difficulties for generalisation

Stake, (1995) [164] classified case studies into three different groups: intrinsic, instrumental and collective. Intrinsic case studies focused on understanding one particular case, not on learning from other cases or solving a general research problem. Instrumental case studies were used to answer a specific research question or solve a general research problem. Collective case studies were instrumental case studies that comprised several cases. These were also known as multiple case studies [165, 170 and 171]. In addition to single and multiple case studies, Voss et al (2002) [170] distinguished between retrospective and longitudinal case studies. Retrospective case studies collected and analyse data based on historical events while longitudinal case studies were particularly valuable to understand cause and effect relationships over a longer period of time.

Lanning (2001, p.47) [173] stated that although they were different, examples and qualitative methods (interviews in particular) were sometimes interpreted as equivalent to case studies. Case studies, however, required a deeper study of the phenomena in the context of each particular case. On the other hand, even if interviewing was a widely used research method in case studies, case studies typically combined interviews with other data collection methods such as, archives, questionnaires and observations. Also, it was widely agreed [164, 165 and 171] that case studies could involve either or both, qualitative and quantitative methods.

Case studies could fulfil various purposes [165, 171 and 170]. This included description, exploration, creation of theory, or testing of theory. In any case, case study was not a methodological choice but a choice of what was to be studied. Table 3.7, Voss et al, (2002) [170] illustrated a useful classification that relates the research purpose with the research questions to answer and research strategies to use.

Table 3.7: Matching research purpose with methodology, Voss et al, (2002) [170]

| Purpose | Research Question | Research Structure |
|---|---|---|
| Exploration<br>Uncover areas for research and theory development | Is there something interesting enough to justify research? | In-depth case studies<br>Unfocused, longitudinal field study |
| Theory building<br>Identify/describe key variables<br>Identify linkages between variables<br>Identify 'why' these relationships exist | What are the key variables?<br>What are the patterns or linkages between variables?<br>Why should these relationships exist? | Few focused case studies<br>In-depth field studies<br>Multi-site case studies<br>Best-in-class case studies |
| Theory testing<br>Test the theories developed in the previous stages<br>Predict future outcomes | Are the theories we have generated able to survive the test of empirical data?<br>Did we get the behaviour that was predicted by the theory or did we observe another unanticipated behaviour? | Experiment<br>Quasi-experiment<br>Multiple case studies<br>Large scale sample of population |
| Theory extension/refinement<br>To better structure the theories in light of the observed results | How generalisable is the theory?<br>Where does the theory apply? | Experiment<br>Quasi-experiment<br>Case studies<br>Large-scale sample of population |

## 3.7 RESEARCH STRATEGIES OF THIS RESEARCH

This study was looking for a deep understanding of the phenomena in developing TLP measurement. In particularly, the study wanted to learn how TLP was managed and measured, how significant TLP was in influencing innovation management, and how this research could provide a solution to the industrial problem. This would enable the author to gain new insights into the subject of the study and at the same time answer the research questions. The objectives were to contribute to extending current knowledge in innovation management and technological change and, at the same time, to find a practical solution to a current organisational problem.

The previous arguments have helped contribute to the decision to assign a case study and survey research as the research strategies in this study. The findings were based on a structured in-depth interview carried out with several managers as well as a postal and online questionnaire administered to large sample of manufacturing companies in Republic of Ireland. Combining qualitative and quantitative approaches facilitated the acquisition of both in-depth information and survey data. The results of the qualitative and quantitative investigations allowed the research propositions to be addressed in a rich and rigorous way, and served to guide clearly the final conclusions.

A use of either quantitative or qualitative methods alone in the thesis would not have been appropriate due to the nature of the research questions and propositions. Relying solely on survey questioning would have resulted in a lack of in-depth information on how TLP was practiced. On the other hand, a complete emphasis on interview method would have meant that the overall view from specialists at different levels in the organisation would not have been taken into account, resulting in only a top-level view of the firm. The qualitative data in terms of interview findings were strengthened and confirmed by the results from the postal and online questionnaires which surveyed senior managers and specialists in large sample of the population (i.e. Pharmaceutical and Chemical Industry).

Obviously, the case study approach was used in order to obtain detailed information regarding the extent of activities involved in TLP. The survey research approach was used to examine the outcomes obtained from the case study. This would not have been possible with a survey methodology alone. Evidence from interviews and questionnaires in the Chemical and Pharmaceutical industry was used in order to determine both the extent of the TLP practices and its influence on innovation management (i.e. implementation of new technologies) and the overall organisation performance. The practice of TLP within companies was explored, and the impact of TLP was analysed.

## 3.8 RESEARCH DESIGN

The following sections tackle the issue of research design in the context of this thesis. In doing so, the following sections present a critical review of the theory on how to design case study approach.

## 3.9 WHAT IS RESEARCH DESIGN?

Several authors have defined the meaning of research design. For instance, Yin, (1994, p.18) [165] stated that 'Research design was the logic that linked the data to be collected and the conclusions to be drawn to the initial questions of the study'. The research design should not be confused with a project plan. Research design guides the investigator in the process of collecting, analysing and interpreting observations and allows one to draw inferences concerning causal relationships and to define the domain of generalisability [165]. The main objective of the research design was to ensure that the data collection and analysis methods chosen at the different phases of the research were appropriate to answer the original research questions. Hence, one could argue that this was the most critical phase of the research since it partly dictated the quality and validity of the research outputs generated in the latter phases of the research.

On the other hand, Stake, (1995) [164] argued that although the adoption of rigorous research methods was important to generate reliable findings, good thinking rather than good methods was the key to good research. In other words, research methods were only useful when the researcher really understood the aims and the reasons for the study.

## 3.10 PHASES OF THE RESEARCH

This research was carried out in four different phases, including 'Pre-understanding', 'Theory Building', 'Theory Testing', and 'Evaluating the research'. The pre-understanding phase focused on identifying and selecting a relevant and novel research topic. The initial review of the literature (i.e. Chapter 2) and the initial

discussions with the several industrial specialists allowed better understanding of the research problem, identifying the gaps in current research and defining the research questions. This clearly focused the scope of the study.

The theory building phase aimed at gaining new insights to develop measurement (i.e. parameters) that help to measure the practice level of TLP. Using a case study strategy, a list of potential parameters was identified (Chapter 4). During this phase new research questions emerged and conceptual model, which linked the TLP with several other functions within a firm, was developed. Based on these questions and the conceptual model, several hypotheses were developed (Chapter 4, Section 4.5).

The theory testing phase (Chapter 5) was to refine the knowledge regarding the measurement of TLP, to evaluate the validity and generalisability of the TLP measurement, and to test the proposed hypotheses. Postal and online questionnaires were carried out in order to achieve the above objectives. The opinion of academics from some colleges and industrial specialists from several organisations in the subject also played a valuable role in this phase.

The validating and evaluating phase focused on making the contribution (practical and theoretical) of this research explicit and demonstrating the validity and reliability of the research findings.

## 3.11 THEORY BUILDING AND THEORY TESTING

The key objective of this research was to develop a measurement to assess the practice level of TLP and then to examine the impact of this TLP measurement on several functions within an organisation. For doing so, it was essential to learn how case study and survey research (the two main research strategies within this thesis) developed the theory and then test it. Wacker, (1998) [174] argued that theory is made up of four components: definition of terms and variables, the domain of the theory (i.e. setting in which the theory can be applied), a set of relationships and specific predictions.

Case study was particularly relevant for theory building [170-172 and 175]. Building theory through case study was based on a grounded theory approach [175]. Grounded theory emphasised the emergence of theory solely from evidence and thus, it required large and rich amounts of primary data. Case study was a prime source of this data [170].

Based on findings of theory building (i.e. induction approach), researchers of this study have proposed several hypotheses. To test these hypotheses, this study utilized theory verification/testing approach (i.e. deductive approach). In comparing between theory building and theory testing, Preece, (1994) [42] explained that "theory building provided ideas, whereas theory testing was used to test and to confirm or reject ideas, wholly or impart". Obviously, this research has found that survey research was an appropriate research approach for theory testing. Because of its nature, survey research enabled researchers to study large sample (i.e. validity and applicability of developed measurement of TLP on large sample) and thus, survey research was best suited for rigorous theory testing. The purposes of the survey research involved two elements including descriptive and explanatory elements. Pinsonneault, et al (1993) [176] differentiated between descriptive and explanatory in terms of purposes of survey research:

- The purpose of survey research in description was used to find out what situations, events, attitudes or opinion are occurring in a population. It aimed to describe a distribution or to make comparisons between distributions, and
- The purpose of survey research in explanation was used to test theory and casual relations. It aimed to ask about the relationships between variables.

This study used the survey research strategy where the research attempted to examine the importance and practice level of TLP and the linkage between the practice of TLP and implementation of AMT projects (i.e. innovation management) and also the relationship between the practice of TLP and the overall organisation performance of the companies examined.

Each research strategy used in this research addressed one of the two main objectives (i.e. development of measurement of TLP and test the impact of this

measurement on several functions within a firm). The following sections of this chapter concerned with the design of the case study research approach, which was used to develop a set of parameters for measurement of TLP practice.

## 3.12 CASE STUDY RESEARCH APPROACH

According to Yin, (1994) [165] five components of research design were especially relevant for case study:

1. a study's questions
2. its proposition, if any,
3. its unit(s) of analysis
4. The logic linking the data to the propositions, and
5. The criteria for interpreting the findings

There is a general agreement [165, 170, 171 and 177] in that the starting point should be the definition of the research framework and questions, at least in broad terms. As Mintzberg (1979, p.585) [178] noted "no matter how small our sample or what our interest, we have always tried to go into organisations with a well defined focus". The researcher should have a prior view of the general constructs and concepts that he/she intends to study, and their relationships [170]. These constructs and concepts were generally built upon the existing literature and the objectives of the study. Component 1 for this research was described in Chapter 1 and 4.

Yin's (1994) [165] components 2 and 5 were related to the collection and analysis of data and evaluation of the findings from the case study. These components were discussed in Chapters 4 and 5. Initially, it was important to focus on two issues that researchers needed to tackle when designing case study research: (1) the number of cases needed to answer the research questions, and (2) which cases to choose.

### 3.12.1 Case Study Design and Site Selection

Case study research work could involve either a single-case or a multiple-case research design. The rationale behind each option is beyond the personal preferences of the researcher or the resource limitations for carrying out a particular research

project. Each of these research options had a specific purpose and thus, the selection of one approach over the other needed to be based on theoretical justification. In words of Yin, (1994) [165], a single case study research design should be adopted when the case represents:

- a critical case that meets all the conditions for testing a theory
- a unique or extreme case
- a revelatory case that provided access to a situation that was previously inaccessible for investigation

Where multiple-case studies deepened theoretical understanding and explanation, and increased the potential for generalising the theory, the main drawback of multiple case studies was the amount of resources required [177]. Noteworthy, the depth of analysis in multiple case studies was generally less than in single case study. Due to the lack and/or undervaluation of TLP in some organisations, researchers of this study intended to focus on one organisation, which is known as one of top ten successful organisations. With reasonable time and cost, concentration on one organisation enabled the author to comprehensively analyse and answer questions of this research. As a result, single-case study was used in this research.

The experts involved in this study were chosen after preliminary discussions with the company contact concerning the aims and objectives of the research project. The selected firm for participation in the study was identified through various sources, e.g. visiting websites of the top 1000 Irish companies, Irish manufacturing website and utilising the Kompass Directory for Ireland. Initially contacts were made by telephone with four companies, primarily at senior management levels. Unfortunately, TLP was very poor in some of these firms. In addition to telephone calls, managers have received invitation letter, which explained the following: ‘what is this study about?’, ‘What is the objective of this study?’, ‘Who are we looking for?’, ‘Confidentiality?’, ‘Why participate?’, ‘Support?’ More information was provided in Appendix A.1. However, after many unsuccessful telephone calls, one company was appointed as the case-study for this research project. After approval, a

site visit was arranged to meet with senior management. Size of the company involved in the research was about 3500 employees, and manufactured different products using a variety of manufacturing processes. The selected company was planning to establish a dedicated department for TLP, and also had recently made a significant investment in an Advanced Manufacturing Technology (AMT), which was the focus of investigation by the authors. In this research, the method used to execute the single case study was face-to-face interviews. Thus, section 3.12.2 intended to discuss this method.

### 3.12.2 Face-To-Face Interviews

Face-to-face interviews were probably the most popular research method. At one level they were easy to carry out, especially at the "free-range conversation" end of the spectrum where the interview could be conducted in a relaxed atmosphere. However there were difficulties with this particular method. One of the main difficulties was that the success of the interview very much depended on the skills of the interviewer. The interviewer needed to be able to employ a good technique for eliciting the required insights, creating and maintaining a smooth flow throughout the interview. In addition, many factors determine the results of the interview. For instance, the interviewer needed to appreciate that a social interaction was taking place, personal biases, and skills in recognising what was relevant and what needed to be recorded. Other decisions needed to be made about the degree of structure to be used in the interview (presumably, the less the experience of the interviewer, the higher the degree of structure needed prior to the interview) [179]. This method also employed an interviewer who met in-person with respondents either spontaneously (in a public place) or via scheduled appointment [180].

1 Advantages

- Quick response possible
- Interviews could be done in one location
- Face-to-face contact offered personal element, trust
- It could interview groups of people (e.g. team or families) at one time
- It could reach inaccessible audiences

2. Disadvantages

- Time consuming if interviews were conducted at subjects' locations
- Respondents may be more likely to have given socially acceptable answers.

As the main objective of this research was to address the way that manufacturing organisations managed an implementation of TLP and then to developed a set of parameters that helped to determine the sophistication level of TLP practice, a massive qualitative data was required. Face-to-face interviews method was found a suitable method to achieve that objective. Baker, (2001) [181] suggested that the researcher should first undertake qualitative research before attempting to quantify the direction and extent of any hypothesised relationships. Face-to-face interviews were then held with several individuals who are knowledgeable about and experienced with TLP and AMT implementation. A qualitative analysis of these interviews was carried out to arrive at the findings reported. Readers interested in the details of the interviews can consult (Appendix A.2 and A.3).

### 3.12.3 Case Study Script

A case study approach was used to detail the whole process of TLP implementation and document all activities involved in the management of TLP implementation and classify them into categories or levels. This approach enabled studying experiences and opinions of experts and specialists in the learning and innovation management field, and eventually developed a set of parameters that helped to examine practice level of TLP. An interview guide (i.e. script) was developed and was used in the interviews (Appendix A.3). Several visits were made to the company under study. During the initial meeting with senior managers (typically strategic capacity department and the production/manufacturing department), the aims and objectives of the research project were described and discussed in some detail. In this research, the experiences of several managers who have involved in learning process and innovation management were analysed.

The interviewees had different responsibilities within their organisation such as strategic capacity department, and production/manufacturing department. However, both interviewees had been involved in the planning and management of advanced

technologies projects within their organisation. Interviews were averaged one to two hours in length. With the permission of the interviewees, all interviews were recorded on tape. None of the interviewees objected to this. At the end of each interview, the interviewees were asked for their comments and to identify or clarify any ambiguous or missing aspects. All such comments were noted and, whenever considered appropriate, were used to re-design the interview guide for all subsequent interviews. In all sessions, the interviewees expressed a willingness to hold a short interview face-to-face, by telephone, or by e-mail should the need for clarification arise.

### 3.12.4 Interviewees Profile

Several departments within the company under study were contacted and requested to participate in the study. However, two departments were accepted to take place in the study including strategic capacity department and the production/manufacturing department. Managers of these two departments were members of the team that was involved in establishing and implementing TLP.

Since 1993, the interviewee has begun working for the company under study. Throughout his experience, he went to Holland and USA for few years as part of training program. As a manager of strategic capacity department, the interviewee was given several responsibilities. These responsibilities were as follows:

- To understand the environment and the demand changes and how may these changes affect his factory?
- To help influence the people corporately who are trying to figure out the options to make sure that the Ireland options are on the table with the rest of the company's factories over the world,
- To help to influence and educate his local management team so that when they go to the finally face-to-face meeting with their counterparts and want to argue for one result or another, they know why and they know the background etc, and
- To help work with the other local factories managers (i.e. as other factories managers discuss the interviewee's analysis and make suggestions, and the interviewee should be able to discuss theirs and make suggestions).

The experience length of the other interviewee was over 15 years. In respect of AMT implementation, the interviewee revealed that he has been a manager of manufacturing department for 9 years and also a member of implementation team that assigned to deal with AMT projects. Members of implementation team and he had joined several training programmes to strengthen their skills and ability to drive the implementation process successfully.

### 3.12.5 How the interviews were conducted

These interviews with a strategic capacity manager and manufacturing manager in a pharmaceutical and chemical company in Republic of Ireland had focused mainly on identifying how the interviewed company implemented Technological Learning Process (TLP), determining what activities were involved in TLP and how new technologies are implemented whenever they are observed.

A total of three interviews were conducted with two specialists. In the large majority of these interview sessions, one interviewer was present. The number of interviewees in each interview was one interviewee. All interviews were taped to ensure that all comments were recorded accurately. A standard script (i.e. guideline) was provided to support the interviewer in each interview. This script provided a consistent framework and ensured that the interviewer would have comparable information from each of the interviews. While the questions were used to support the interviews and to ensure coverage, they were not followed mechanically; areas of interest were often probed in depth.

A few steps were followed to analyse this interview. The analysis process started, which transcribe the interview's Cassette-Tape (tape-record) down, went over the tape many times for clarification, organised related topics together, focused only one important topic at a time and then verified and certified the last draft of the interview. This process was a time-consumer and generated 28 pages. The analysis process organised this interview into 11 sections. First eight sections were concerned with the case study profile such as interview profile, company history, products, company position among Irish companies, recent achievement, company characteristics, level of technology, and success factors. Subsequently, the remaining

two sections presented the way by which interviewed company observed technological developments and changes, and described the plan that used to execute any new technologies. The last section was requesting the interviewees to identify all activities involved in practicing TLP.

# CHAPTER 4

## 4. CASE STUDY RESULTS AND DISCUSSION

### 4.1 INTRODUCTION

The qualitative data, obtained through the face-to-face interviews method addressed in Chapter 3, are analysed and discussed throughout this Chapter. In order to make the research results more understandable, this chapter is devoted only to analyse and discuss the results obtained from the qualitative (i.e. interviews) method.

The information in this chapter is based upon interviews with senior managers who were knowledgeable about and experienced with practice of TLP. The qualitative analysis of these interviews is performed to arrive at the findings reported here. Section 4.2 discusses the case study script. Section 4.3 provides details of the analysis of the data collected from the interviews. Subsection 4.3.5 describes lifecycle of TLP within the interviewed organisation, Subsection 4.3.6 describes in detail the primary elements and stages of TLP and how it is executed, Subsection 4.3.10 and Subsection 4.3.11 develop the set of parameters that help to measure the practice level of TLP and Subsection 4.3.14 provides full discussion for the results of this case study.

### 4.2 CASE STUDY SCRIPT

A single case study approach was used to detail the whole process of TLP practice, document all activities involved in this process, and then organise them into categories or levels. This method enabled studying experiences and opinions of experts and specialists in the TLP field and eventually develops a set of parameters that were used to alert managers about new opportunities and threats advanced technologies may cause to their businesses. An interview guide (questionnaire) was developed and used in the interviews. The interview guide focused the inquiry procedures, and ensured reasonably consistent inquiry procedures at all sessions. Several visits were made to the company. During the initial meeting with senior

management (typically strategic capacity department and the production /manufacturing department), the aims and objectives of the research project were described and discussed in some detail. In this research, the experiences of two Irish senior managers were analysed. This study was also aimed to discuss with senior managers the following issues:

- Required information when decision took to introduce any AMTs,
- Issues that challenge AMTs Implementation,
- Implementation plan of AMT projects,
- How do organisations implement Technological Learning Process (TLP),
- Aspects of Technological Learning Process (TLP),
- Parameters used to Measure Practice Level of TLP, and
- Encouragements and constraints of TLP practice.

The interviewees had different responsibilities within their organisation such as strategic capacity manager, and production/manufacturing manager. However, the interviewees had been involved in the planning and management of advanced technology projects within their organisation. Interviews were averaged one to two hours in length. With the permission of the interviewees, all interviews were recorded on tape. None of the interviewees objected to this. At the end of each interview, the interviewees were asked for their comments and to identify or clarify any ambiguous or missing aspects. All such comments were noted and, whenever considered appropriate, were used to re-design the interview guide for all subsequent interviews. In all sessions, the interviewees expressed a willingness to hold a short interview face-to-face, by telephone, or by e-mail should the need for clarification arise.

## 4.3 ANALYSIS OF DATA FROM INTERVIEWS

These interviews, which held with a strategic capacity manager and production manager in pharmaceutical and chemical company in Ireland, focused mainly on identifying how this company implemented TLP and how new technology was implemented whenever it was observed. The taped interviews were transcribed and documented. This process took a considerable amount of time as each interview went

through a number of drafts, sometimes going back to meet the manager for further details or replaying the taped interviews. The interviews were then sent to the interviewed managers for verification and permission for general use in publication (see Appendix A.4).

Comprehensively, a few steps were followed to analyse these interviews. The analysis process started with transcribe the interview's Cassette-Tape (tape-record) down, the tape gone over many times for clarification, organised related topics together, and focused only on important information. The last draft of the interviews was verified and certified. This process took considerable time and generates all in all 28 pages. The analysis process organised this interviews into several sections. First sections were concerned with the case study profile such as interview profile, company history, products, company position among Irish companies, recent achievement, company characteristics, level of technology, and success factors. Subsequently, the remaining sections presented the way by which interviewed company observed technological developments and changes, and described the plan that used to execute any new technologies. The last section is dedicated to discuss the parameters that used to alert managers about new opportunities and/or threats new technology may cause to their businesses.

### 4.3.1 Overview of the Interviewed Organisation

The interviewees described the organisational culture, identified the AMT projects that have recently been introduced, and summarised the major tools and techniques employed. For instance, strategic capacity manager revealed that the organisation culture is basically driven by six values. These six values are as follows: 'results orientation, which is really the drive of the company', 'learn from what they do whether it went well or bad and keep changing the organisation to make it better all the time', 'risk taker', 'making sure that managers are not just focusing on the success of the organisation, without thinking about the customers and what they need', and 'effectively ensuring that the organisation makes its commitments that everyone understands how they work and everyone knows they are working together etc to a certain level of discipline'.

Manager of manufacturing department described the organisational culture as energetic, non-political, layer organisation, and dynamics. Staffs were very stable. The majority of engineers were actually contract staff. Even within contract organisation, the staffs were quite stable. Workforce was 3.000 employees, where the automation group was 100 engineers.

### 4.3.2 Type of Technologies

The strategic capacity manager explained that the main systems in the main production building are mainly Total Dissolved Solids (TDS) and Distributor Control Systems (DCS). Beside the TDS and DCS, production manager added that FMS, PLC, LAN, WAN, MRP and ERP are also advanced technologies that all used in the manufacturing department. In relation to the organisational changes that sometimes occur, the manufacturing manager revealed that the organisational change is between yearly and every few years. In response to how many people involved in developing and implementing AMT, the production manager stated that the main control systems were developed in multiple locations around the world. It would be certainly over 21 people.

### 4.3.3 Information Requirements for AMT Implementation

Interviewed managers agreed on a number of critical items of information that should be acquired prior to any movement towards investing in any AMT projects. The items of information include: 'Quality of the new technology', 'Performance, availability and ease of use', 'Skill and training service for each job', 'Supplier capabilities and performance', 'Determine the impact new technologies have on the business', 'The return on investment', 'The disruption affect on the business', 'The transition period, The cost of introduction', and 'The complete support of the members of the organisation'.

Particularly, production manager reported that interfacing with computers was quite important for the company as it had multiple control systems and computer systems interfaced together. Computer network experience was also very important. He also considered a project management experience as a must-have experience for

members of the implementation team. The implementation team must have also been familiar with systems they use in site. It was important that people work with them were experienced in pharmaceutical and biopharmaceutical plants and that they were familiar with the validation lifecycle of such a plant and the paper work and changing requirements that go with the pharmaceutical industry.

Production manager also warned against the danger of people falling in love with the technology or the glamour or the newness of the advancement in the technology. If that would happen, it would be possible to lose site of what benefits the technology would bring to the business, how it would help the business make money, increase market share, sell more products, reduce costs etc. The organisation must develop its system according to its business needs in order to avoid wasting money. Accordingly, the assessment of any investment in new AMT must be done on the basis of these business needs and these criteria should influence the nature of information that must be collected.

Strategic capacity manager revealed that information was not only collected from suppliers, but also from the wider organisation. This exchanged information between the various projects that are been conducted within the global organisations so that lessons learned from projects may be used to improve the whole process. Strategic capacity manager also reported that the quality of the new technology was very important for the organisation. The nature of the product sometimes (sensitivity of the product) compelled the company to seek the latest information on new technology developments. In other words, technology solutions implemented had to be state-of-the-art. The interviewed manager explained that this company produced pharmaceutical products and therefore must have ensured that there was no risk for people who use them. As a result, if there was any system, which in anyway improved the quality or reduced the risk, then they would have to implement it. The systems that improved the quality or reduced the risk were imposed by regularity authorities on pharmaceutical manufacturers to be implemented.

### 4.3.4 Issues challenge AMT Implementation

Implementation of AMT projects was not a low-cost or risk-free venture. In fact, the vast majority of companies believed that AMT systems have had at least a moderate chance of hurting their businesses because of the potential for implementation issues [182]. Interviewed managers highlighted several issues that might impact on the success of AMT projects. For instance, they stressed that the difficulty is that AMT is just one part of the overall change. There could be several other factors affecting the organisation. For instance, people that the organisation was working with, customers and business environment were all affecting the organisation. The introduction of new software package or new product on the floor would not necessarily change the organisation on its own. Rather it was the combined impact of introducing the new technology in cooperation with other changes that was most likely to result in changes to the organisation. For instance, the introduction of most AMTs was conducted in cooperation with new training programming, which may have resulted in a change of behaviour of individuals and this might have improved the business.

Obviously, strategic capacity manager stated that sometimes sacrifices must be made in order to complete a project according to stated deadlines. Thus, maintaining the schedule for the project was very important to ensure that manufacturing could start as planned. Furthermore, production manager reported that some systems have been very successful, where others were less successful. Those that weren't initially successful were continuously worked on until they were successful. In that way, the interviewed manager believed none of the AMT implementation projects have failed. For instance, some projects weren't that successful to begin with. They worked but with decreased productivity. However, the company under study had worked on identifying solutions that would eliminate the causes of productivity issues. As a result, senior managers in the company were by now satisfied with the system and its productivity. The interviewed managers agreed that the important thing was to learn from the mistakes and failures of projects and to ensure that the same mistakes were not repeated again. They emphasised learning not just for a particular system itself but also for any future system so that they really were able to understand exactly what

they were getting into. The effect of this policy was that more and more things would tend to work the way they were intended to be first time.

### 4.3.5 Technology Learning Process (TLP)

In order to understand how the Technology Learning Process (TLP) was implemented, the interviewer posed the following question "how does the interviewed company decide to expand an existing technology to a bigger scale or how does it decide that this is the next technology that it is going to bring on site?" The interviewee replied that on a corporate level, heads of R&D in the company would accurately and sufficiently answer this question. However, on a local level, the interviewed manager explained the process by which they identify the next technologies that they go after.

Many organisations comprised of several factories. These factories also included several units. Every unit is interested in managing or making particular tasks. Thus, no unit was concerned with technologies that pertained to other units within the organisation. As a result, each unit within the organisation was responsible for scanning and monitoring, gathering, and analysing the information related to its activities. For instance, the interviewee categorised the organisation at a factory A to a factory B. Within the factory A, there were two different types of units set up, namely M, and C units. As a member of the M unit, the interviewee reported that the factory A did not try to get any technology associated with any thing associated with the factory B. Moreover, within the factory A, people who worked for the M unit would not typically have pitched for products of the C unit.

### 4.3.6 Primary Elements and Stages of the TLP (i.e. process that was used to learn about new trends and/or developments occur to technology and business as a whole)

On a quarterly basis, the TLP was organised and operated within the company under study. The horizon of the TLP was from four to five years. The TLP took in all markets demands across all customers in all technologies. In addition, vendors, suppliers, and competitors were also taken into consideration during this process. All

gathered information of all markets demands was put into a system. This system provided units and factories managers with accurate information at a role of demand for each product. The information generated by this system was useful to help managers to study and expect the new trends of technology. The observation and collection stage carried out in every unit of the factories within the company was of great role for innovation process. For instance, strategic capacity manager reported that his colleagues basically observed the preliminary demand vectors and then they began to analyse their findings. Although, the new changes weren't sometimes seen in numbers, factories' managers could see the new trends and developments of technology. If any, the new trends and/or changes of technology would then be subjected to the stage of analysis and evaluation.

As the observation and collection stage was completed, analysis and evaluation stage had commenced. The interviewed managers explained that the information altogether would be then analysed and compared against the capacity, which has been put in place in all of the units of the organisation. However, there was an assigned group that was charged with analysing the gathered information, every unit in order its activities requested to analyse its own information. The assigned group for information collection and analysis and all the units within the organisation consistently worked with each other. Ensuring collaboration between units was very important and the main means for innovation process. For instance, where any unit observed a new demand and/or changes from previous quarters, this would suggest that the organisation needed to position or reposition capacity in different ways. Depending on what the trends and/or the changes were, all the units within the organisation were requested to conduct what it was known as sensitivity analysis. This analysis aimed to define the units' ability to position or reposition themselves in order to accommodate the new demand (i.e. either development of new product or adoption of new technology). In some cases, the units within the organisation needed to put a new capacity in place. In other cases, the units needed to flex their capacity from what they had into something different. In summary, preparation of the analysis and evaluation stage provided every unit with information that explained how much

the unit could do, how fast the unit could do, and how much could cost to make the new changes happen.

Every unit then compared its analysis results with all of the options of the other units within the organisation. Based on this comparison, the unit was able to judge if it would be able to make the new changes beyond the time, the cost, and the capacity. The unit also was able to identify what else did the new change do to the unit? For instance, 'Does the new change eliminate the unit from other technologies it might go after?' and 'Does the new change bring the unit down a certain path that suggests the unit will only adopt the new change going forward?' Taken all these internal factors along with some other external circumstances into consideration, top management may have then been able to determine which unit or factory that is ready to convert to the new trends of technology. The top management might have come with a conclusion that it was not worthwhile bringing another technology on the site.

As every unit in the organisation worked up to the time when the TLP was finalised, internal and external factors discussed earlier should have been addressed and given in a response's document as to the ability to respond to the TLP changes.

Next stage, all factories managers across the world (i.e. all the sites internal and external to the country where the company was located) held a face-to-face meeting. Throughout this meeting, every manager should have presented the response's document that contained not only the changes that were observed but also the responses to these changes. The main purpose of this document was to show all the demand changes and to present the updates from all the units and factories on which the managers suggested what they might do to respond. Every manager in the meeting attempted to evaluate his counterparts' observations. In other words, every manager attempted to look for either lack of rational in his counterparts' observations, or lack of data. Thus, in this evaluation stage, collaboration and communication between managers were key factors to realise the right answer for their company.

In recommendation stage, as a result of this meeting, all managers made some recommendations which showed the best way to respond to these technological changes. These recommendations would be ratified by all the managers who took part in the face-to-face meeting. In case, where the managers recommended an adoption

of new technology or development of new product, decisions around availability of some resources such as land, tools and infrastructure as a whole must have been undertaken. Several questions for instance whether the land existed or needed to be new were answered mainly through a Space Working Committee (SWC). Thus, barriers occurred as a result of these questions that would be solved through the contacts between SWC and the factories managers. An investigation into the availability of these resources informed the managers whether their existing factories were applicable enough to adopt the new changes otherwise the new changes will have been driven to the early stages of planning.

Given significant recommendations, justification stage would begin. To justify the adoption of new changes, factories managers would have to agree on a factory that was able to meet the requirements of new technology adoption. An allocation of one factory or another to adopt the new changes was controlled by several elements such as how many technologies the factory had, its ability to change, degree of compatibility between new and old technologies etc. However, across all sites, the managers would have determined the adequate site that should have adopted the new changes. Every manager had to justify why this site should have adopted the new changes rather than the other. Once rationales to adopt the new changes in particular site are presented, the final decision could be confidently made by top management. Nevertheless, the factories managers, on a local level, had the choice to put the next technology in a particular factory, a group of expertises on a corporate level, who independently involve in the TLP, may have recommended different sites in new countries that the company hasn't been occupied yet.

At different points of time, a trigger to start a new technology somewhere was usually observed. In case, where new information/trigger came in the TLP horizon, the units and factories would have what it calls 'Mid Cycle MRP' and the managers of factories ran again through a set of analysis and evaluation. In response to the new information, several high volume sites, which were known as To Be Decided (TBD1, TBD2, and/or TBD3), went and followed the new trigger. Due to the life cycle of the various technologies the company had, the TLP made sense for managers to keep up

with the new trends and developments of new technologies. This TLP was applied to all technologies all the time.

### 4.3.7 Aspects of Technology Learning Process (TLP)

TLP was not only established to learn about technological aspect but also to learn about non-technological aspect. In order to trace different types of knowledge, the interviewees distinguished between technological and non-technological aspects. For instance, one of the activities involved in TLP was a benchmark analysis. From manufacturing point of view, the benchmarking analysis was a method used to investigate non-technological aspects (i.e. methods and techniques to improve quality, to improve maintenance to improve inspection and control systems, inventory, supply chain etc). This method could provide managers with the best non-technological aspects used within rival companies. In this respect, the interviewees explained that their company was used to monitor several close and rival companies. For instance, as a rival company, P and E would be one of the key sources of scrutiny in order to pursue and observe where the rivals are going with their products, processes and technologies. It is usually Research and Development (R&D) department at corporate level that would be tasked to conduct the benchmarking analysis across other rival companies. The primary purpose of this analysis was not only to identify the best non-technological aspects but also to understand where the competition is heading.

### 4.3.8 Implementation Plan of any new technology

When a new technology is identified, evaluated and the decision is taken to bring it on a site, the execution plan would start. The interviewed managers defined the execution plan as a stage where the top management has decided to adopt and implement a new technology on a site. The interviewed company had people to get trained ready to bring the technology in. Those people were responsible for that process and they would have brought the technology back and put the new technology in place. The typical manner in which the interviewed company got this new technology on board was that effectively the interviewed company had

development sites which are chartered to ensure that the process was defined as clinically as possible in order to the implementation process could be replicated in the high volume manufacturing sites.

Numbers of candidates were assigned to go on a seed assignment to these development sites for a period of time. This period of time depended on the nature of the new technology and the schedule whether it was for first site or second site to implement it. Thus, these candidates might go for three months, six months, one year, or they might have gone for two years. The candidates worked with these development sites in each of the processes areas.

The candidates, who were assigned for the seed assignment in these development sites, had to learn the new technology by working with the people as they developed it so that the candidates could bring the new technology over. Effectively, the candidates had to bring over a tight set of documentation that clearly described the nature of the facilities, the nature of the tools and the nature of the maintenance etc. The interviewed managers reported that their company prided itself on its ability to efficiently use this method. The interviewed managers revealed that the ability to copy exactly the kinds of phrases was very important firstly: to have the exact same product develop very fast in multiple factories and secondly: to get the volume of the new process technology up very quickly. The matter of doing that was just how clinical the candidates worked with the development sites in honour to ensure that the high volume manufacturing site was at the same level or better.

### 4.3.9 Number and Background of Implementation Team

The interviewed managers identified that number of the candidates who participated in the seed assignment were really depending on the nature of the technology, the ability to release candidates, and the speed at which candidates returned and made it reality. It could have been in the region of hundreds of people. They were sometimes one to two hundreds and sometimes more dependent on the level of the technology.

The experience of candidates, who had assigned to go for the seed assignment, was varied. The interviewed managers revealed that typically the candidates wouldn't be only experienced in the latest technology but also have to be experienced in the

pharmaceutical and chemical field. The candidates must have been familiar with systems their company use in site. It was important that the candidates were experienced in pharmaceutical and biopharmaceutical plants and that the candidates were familiar with the validation lifecycle of such a plant and the paper work and changing requirements that go with the pharmaceutical industry. The candidates could be technicians who have worked in the factory on a day to day basis moving the product or conducting all the maintenance on the equipment. The candidates could be engineers who could be in charge of defining the process and being responsible for the maintenance performance or quality performance of the tool sets. Generally, the selected process of candidates for the seed assignment depended on the mix (i.e. whatever a firm had in the factory) and on the circumstances every time.

In addition, the interviewed managers explained that in some cases, their company hired people directly from colleges/universities. Their first experiences were that they would have gone directly to development site and learn the process from the start. In other cases, the experienced people were usually asked to perform the assignments and the company promised them to bring less experience people to back them in the areas they are in. The insistence of the company to assign an experience people to do the seed assignment was because they would be able to transfer it quicker.

### 4.3.10 Measurement of Technology Learning Process (TLP)

Based on the face-to-face interviews with some experts, preliminary parameters that help to determine practice levels of TLP were developed. Specifically, 51 parameters were developed and then organised into four levels including Basic Level, Average Level, Advanced Level, and World-Class level. To verify and validate these 51 parameters, 15 specialists and academic people were contacted. Where 7 specialists were from industry sector (i.e. pharmaceutical and chemical companies), the remaining 8 people were from academic sector including 4 from Dublin Institute of Technology (DIT) in Dublin and 4 academic people from Liverpool University in UK. Two academic people and three senior managers had expressed their willing to participate in the assessment process. Based on their responses, 5 parameters were

merged with the similar ones. Almost all parameters were rephrased and written in understandable manner. The academic participants had reorganised the weigh of several parameters. In other words, several parameters were transferred to high levels where others transferred to lower levels. Overall, the discussion with the specialists and academic participants had yielded 46 parameters that contributed to defining the practice level of TLP within manufacturing organisations. However, Table 4.8 showed these parameters on one column and provides some explanation on the other column.

Therefore, based on the findings of this research, to measure the practice level of learning process within any manufacturing organisation, certain parameters would be tested to determine whether a company is in a lower or higher level of TLP. For instance, the interviewees revealed that collecting information from customer and suppliers was not like establishing a department dedicated to TLP. In addition, information systems such as internet were effectively a huge source for people on a normal day to day basis. It was also important that employees both technicians and managers alike were involved in publication and papers etc. However, the interviewees explained that all sorts of learning activities were used in this company, from basic learning activities such as gathering information from customers and competitors to advanced learning activities such as implementation of limited duration projects that dealt with specific technology problems and assessed the impact of fundamentally new technology trends. Obviously, it was higher learning levels (e.g. advanced level and/or world class level) that contributed to generate new ideas. As mentioned earlier, all (46) activities/parameters that helped to measure whether a company practices or neglect TLP was summarised and listed in Table 4.8. In following sections, the 46 parameters and their classification was further discussed.

### 4.3.11 Parameters to Measure Practice Level of TLP

As a result of the sessions with interviewees and the following discussions with practitioners and academic people, the 46 parameters, which had developed to measure the practice level of TLP, were classified into four levels including Basic Level, Average Level, Advanced Level and World-Class Level. To define these four

levels, every level in the following sections was addressed individually. This was an attempt to explain the characteristics of each level, to show the difference among the four levels and also to provide the basis on which the weigh of every level of TLP was determined. For instance, the basic level was considered as the lower level, where the world-class level was deemed as the highest level among the practice levels of TLP. The following was an in-depth explanation for the parameters of TLP practice and their classification.

#### 4.3.11.1 Characteristics of Basic Level of TLP

Building external co-operations and collaborations with some sources (i.e. suppliers, customers, users, stockbrokers, local chamber of commerce and investment banks), participating in some associations (i.e. professional associations, trade associations, local press and trade press), and scrutinizing several sources (i.e. government sources, business literature and periodical, and prospectus) were all representing the inferior parameters with which this research has been called as a Basic Level. Thus, the basic level represented poor parameters that companies usually conducted to learn about the market change and developments of technologies. As shown in Table 4.8, companies that applied parameters from 1 to 12 would be categorized under the basic level. This was because these parameters were widely available, easy to conduct, and seemed to be deployed by a considerable number of companies. Moreover, there was consensus among literature that these parameters were simple and common parameters to be practiced as methods to be learned about the developments of technologies. Therefore, this study suggested that companies that practice these parameters were paying very basic (i.e. lower) efforts to learn about new opportunities and threats of advanced technologies.

#### 4.3.11.2 Characteristics of Average Level of TLP

Generally, second level of TLP was concerned with informal learning methods. This level presumed that along with communicating the strategy of a company more openly and letting all employees participate; there are other parameters that must have been practiced. These parameters included an establishment of informal

discussion networks, availability of Internet and Intranet, application of technology roadmaps, application of balanced scorecards, application of listening posts, application of watch-list, application of benchmark/best practice, and application of risk analysis. As the practice of these parameters was not complicated and possible for majority of companies, this study had named this level as the Average Level. However, Table 4.8 described the 13 parameters of the average level ranging from number 13 to parameter number 25. These parameters, as mentioned earlier, represented companies that stimulated and steered the independent/autonomous behaviour (i.e. informal methods) to learn about technological developments, trends and market changes. Table 4.8 also revealed that these parameters were ranked as the second lowest level among the four levels of TLP. The basis this study relied on to rank the parameters of this level in the second lower level of TLP classification, referred to several factors such as needless of substantial money (i.e. cost-free) to conduct such parameters, simplicity to practice (requires no particular structure), suitable for all organisations (no matter what size or resources organisation has to use these parameters) and feasibility and fruitful of information. Due to these factors, this study presumed that implementing these parameters (i.e. parameters from 13 to 25) plus most of the previous parameters was classified under the average level.

#### 4.3.11.3 Characteristics of Advanced Level of TLP

Third level was essentially characterized by the need to allocate some resources that support managers to constitute R&D department, accumulate documents of R&D, utilize documents of R&D, update tools of R&D, and share the formal and informal knowledge with R&D department and also among other departments, providing support and commitment of top management, provide qualified and skilled people, provide training programmes, coordinate between human resource planning and learning strategy. As shown in Table 4.8, the third level included mainly 10 parameters ranging from 26 to 35. These 10 parameters were actually termed Advanced Level. In this research, companies that adopted these 10 parameters (i.e. from 26 to 35) along with the previous parameters of the basic and average levels were classified under the advanced level. The justification to consider this level as an

advanced level is because companies needed to look at several functions such as R&D and allocate sufficient resources such as finance and skills to be considered as advanced organisation in practicing TLP.

#### 4.3.11.4 Characteristics of World-Class Level of TLP

For some companies, the characteristics of the fourth level of TLP were a quite challenge to be accomplished. For instance, this level required companies to establish centralized and decentralized units, to launch projects of limited duration in order to learn about trends of advanced technologies and overall market changes. Literature emphasise that an implementation of the projects of limited duration assisted to learn and tracked specific technology problems and assessed the impact of fundamentally new technology trends. Managers must have also performed some other parameters including 'collaboration with universities and research institutes', 'collaboration with start-ups and leading companies', 'organisation of technology colloquia', 'arrangement of innovation workshops', 'utilization of venture capital funds', 'availability of gatekeepers' and 'provide needed financial resources'. In comparison with the previous levels (i.e. basic, average, and advanced levels), some companies may have found it difficult to provide the needed resources to perform all the characteristics of the fourth level of TLP. As a result, this study termed this level as a World-Class Level. Particularly, the world-class level represented parameters ranging from 36 to 46 shown in Table 4.8. The main justification to term this level as world class level was due to the huge financial resources and efforts that the parameters of this level required (e.g. constitute a dedicated centralized and/or decentralized units in their organisations, and implement projects of limited duration) to sustain the TLP operations at a very high level. To this end, companies that applied the parameters ranging from 36 to 46 along with the parameters of the previous levels were categorized under the world-class level.

In the light of previous discussion, the practice level of TLP got sophisticated as it moved towards the world-class level. Figure 4.6 showed the progress of TLP towards the sophisticated level. In addition, Figure 4.6 briefly defined each level of these four levels. For instance, companies that have had very strong cooperation with

external sources such as customer, supplier, etc were fallen under the basic level. Companies that use informal methods to gather information about technological developments and market changes plus parameters of previous level were categorized under the average level. Companies that established R&D department and also provided support and commitment of top management along with the parameters in previous levels (i.e. combined both basic and average activities) were classified under advanced level. Eventually, companies that had structural layer (i.e. centralized and decentralized units and/or department) and conducted projects of limited duration plus the parameters of previous levels (i.e. basic, average, and advanced levels) were considered as the world-class level.

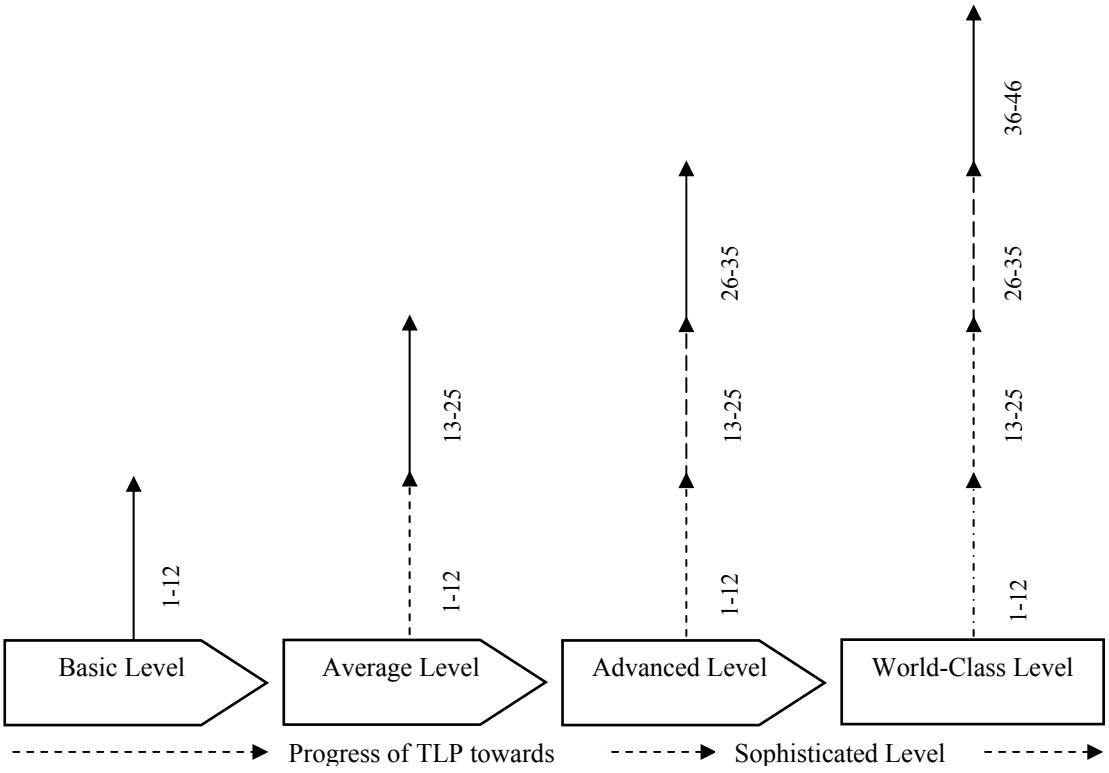


Figure 4.6 Sophistication Levels of Technological Learning Process (TLP)

Table 4.8 includes two columns labelled 'Index and Parameters'. An index column in Table 4.8 describes almost all the concepts that may have assisted managers to learn about the developments and trends of advanced technologies. Parameters column in the same Table defines these concepts and clarifies their linkage to TLP.

Table 4.8 Parameters of Technology Learning Process (TLP) Practice

| Index | Parameters |
|---|---|
| **Basic Level** | |
| 1. Suppliers | High level of cooperation with suppliers. The suppliers have a good deal of valuable information to offer to companies |
| 2. Customers/Users | High level of cooperation with customer/users. Customers/Users are usually interested in comparing a vendor's capabilities with those of competition |
| 3. Government Sources | Regular scrutiny of government sources. The government sources contain very detailed information on foreign investments as well as domestic data. They may help in determining a competitor's facilities, capabilities and expansion plans |
| 4. Professional Association | Participation in activities of professional association. This provides an opportunity to talk with personnel of the competition |
| 5. Trade Associations | Participation in activities of trade association. This can yield valuable new information and gain useful intelligence without divulging very much about one's own operations |
| 6. Business Literature and Periodical | Regular scrutiny of business literature and periodicals. This can provide articles dealing with a competitor's technologies, products and operations |
| 7. Local Chamber of Commerce | High level of cooperation with local chamber of commerce. This often gives information on employment, the size of the competitor's facility and the products being manufactured and technologies being used at a particular location |
| 8. Local Press | Subscription in local press. Worthwhile to subscribe to the local newspaper of the community where a competitor is located. Especially in a small community, much information might be found on employment, organisation and expansions |
| 9. Trade Press | Subscription in trade press. A great deal of information is published there. It is almost mandatory to regularly review this material |
| 10. Stockbrokers | Collaboration with stockbrokers. They often have made in-depth studies of a competitor's strengths and weaknesses |
| 11. Prospectus | Frequent scrutiny of prospectus. The prospectus reveal the major stockholders along with financial and organisational details |
| 12. Investment Bankers | High level of cooperation with investment banks. Investment banks may be able to provide useful information regarding markets and technology changes |
| **Average Level** | |
| 13. Firm's strategy | Consideration of firm's strategy as an information need. Communicating firm's strategy (e.g. innovation need) more openly are of vast important to help informal technological learning activities |

| | |
|---|---|
| 14. IT Usage in Knowledge Management (e.g. Intranet) | High level of Intranet application. Bulletin Board System (BBS) and E-mails can be used to facilitate the knowledge sharing of employees and are also very efficient tools to contact customers and suppliers who are considered to be important sources of innovation |
| 15. IT Usage in External Cooperation (e.g. Internet) | High level of Internet application. With access to the Internet, firms can retrieve more information about the technologies they are interested in and can make a more informed decision about the introduction of technologies |
| 16. Networks of Internal Informants | Establishment of informal discussion networks. It creates new relationships across disciplines and businesses |
| 17. Job Rotation | Regular rotation of jobs among employees. It leads to strengthen the informal technological learning networks in the organisation |
| 18. Communication Routines | Establishment of communication routines. Well-established communication routines is very critical factor to support informal technological learning process and accelerate the bottom-up mechanism |
| 19. Extra Budget | Availability of extra budget. For instance, extra travel budget assists organisation's members to be updated with the latest developments of technology |
| 20. Technology Roadmaps | Application of technology roadmaps. The technology roadmaps are supported by Innovation Matrix to show technology uncertainty (how well understood) versus required availability (in how many years) |
| 21. Balanced Scorecard | Application of balanced scorecards. The balanced scorecards motivate breakthrough improvements in critical areas such as technology, product, process, and market development |
| 22. Listening Posts | Application of listening posts. The listening posts monitor and understand the competition, governmental research programmers and partners and customers needs, concerns and comments |
| 23. Watch List | Application of watch list. The watch list is used to closely monitor and spot irregularities in the environment of an organisation |
| 24. Benchmarking | Application of benchmarking or best practice. It is very important to benchmark key competitors and identify the actions that might affect your current organisational interests |
| 25. Risk/Sensitivity Analysis | Application of risk/sensitivity analysis. Risk analysis is a technique to identify and assess factors that may jeopardize the success of a project |
| **Advanced Level** | |
| 26. Structure of R&D Personnel | Establishment of an appropriate pyramidal structure of R&D personnel |
| 27. Accumulation of R&D Documents | High levels of accumulation of R&D documents. Yearly accumulation of R&D documents can enable the organisation to build its own database |
| 28. Usage of R&D Documents | Exploitation of R&D documents. Ratio of R&D documents used to other documents |
| 29. R&D Tools | Advancement in R&D tools |
| 30. Knowledge Sharing in R&D Department | High level of formal and informal knowledge sharing in R&D department |
| 31. Knowledge Sharing among Departments | High level of formal and informal knowledge sharing among R&D, production, and marketing departments |
| 32. Top Management Support | High levels of support and commitment of top management. For instance, CEO's attitude and effect to support technological learning |
| 33. Human Resource | High levels of coordination between human resource planning and learning strategy |
| 34. Capabilities of Personnel | Availability of high levels of education, skills, work experiences, etc |
| 35. Training Programs | Availability of training plans and programmes for formal and informal technological learning |

| World-Class Level | |
|---|---|
| 36. Centralized and Decentralized Technological Learning Units | Establishment of dedicated units and/or department. These units are dedicated to learn the trends and developments of advanced technologies and the tasks of these units are delegated through a hierarchical order of positions and departments |
| 37. Limited Duration Projects | Implementation of projects of limited duration. Top management forms projects of limited duration to deal with specific technology problems and to assess the impact of fundamentally new technology trends |
| 38. Gatekeepers | Availability of gatekeepers. The gatekeepers are members who frequently contact people from outside the organisation to sustain the flow of information across company boundaries |
| 39. Venture Capital Funds | Utilisation of venture capital funds. The venture capital funds used as a tool to get access to new technological tends and solutions at a very early stage |
| 40. Technology Envoys | Ability to dispatch people overseas. Technology Envoys are usually sent to a region of the world to build up a network with institutions, universities and start-up companies |
| 41. Technology Colloquia | Organisation of technology colloquia. The technology colloquia are organised to assess different technological developments/trends and/or possible research directions |
| 42. Innovation Workshops | Arrangement of innovation workshops. The innovation workshops are arranged to invite leading users and suppliers |
| 43. Universities and Research Institutes | Collaboration with universities and research institutes. Firms should proactively cooperate with universities and research institutes |
| 44. Leading Firms and Start-up Firms | Collaboration with start-up and leading companies. It is essential to exchange technological knowledge with domestic and international leading firms |
| 45. Incentive Systems | Availability of incentive system. The incentive systems are effective to stimulate the bottom-up flow of technology trends |
| 46. Financial Resources | Availability of financial resources. Provide researchers with the financial resources to follow their own research interest and promote bottom-up mechanism |
| 46 activities of TLP | |

### 4.3.12 Encouragements to initiate TLP

An issue concerned with the factors that encouraged managers to initiate TLP was fully discussed with the interviewees. The information provided by the interviewees was also checked out by several other specialists. Obviously, the researchers of this study had contacted several senior managers through an e-mail method in order to verify the information obtained from the interviewees and then elaborate on it.

The interviewees believed that in the current economic climate, business case must always be strong. The interviewees considered many factors such as ‘a cost of making change to manufacturing of registered products’, ‘an availability of capital funds’, ‘production problems’, ‘maintaining company knowledge amount in a time of

high staff turnover', 'experienced personnel', 'adequate project management skills', 'intensive competition with foreign competitors', 'fascination for new technology', and 'new innovative ideas within team' were all critical factors to invest in TLP. Generally, the interviewees explained that there was always pressure to get product out, to achieve revenue and then pressure to improve the cost to increase margin. The interviewees revealed that their organisation usually carried out some activities of TLP such as limited duration projects due to the introduction of a new product in manufacture.

Specialists who had been contacted through the E-mail method to verify the information obtained from interviewees were entirely agreed with what interviewees revealed. For instance, first specialist was agreed and also added that the main drivers to initiate TLP were new product introduction, which leads to technical changes in processes as well. Second specialist was fully agreed and illustrated that their company manufactures continually different products of varying sizes and lead times. As such any production problems always take precedence. In their business, the market place and trends are fickle and changing by the season. Therefore, flexibility was a key. No single product was manufactured twice in a week. Batch-wise production was linking 1500 raw material suppliers through 4000 raw materials into an ever changing portfolio of finished products which summed up the business. Eventually, third specialist complained that one of the problems with universities in Ireland is that the universities viewed themselves as centres of learning-for learning's sake as opposed to being key drivers supporting the economy's needs and/or leading an economy change. The universities didn't seem to understand that the more successful an economy is, the more money that is provided for research, technological development etc. as a result, the university sector must play a leading role in Ireland.

### 4.3.13 Constraints to initiate TLP

In pharmaceutical and chemical industry, regulatory restrictions limited what changes a company could implement. With many trends and technologies proposals, limited resources prevented all but a few from being implemented. Training budget priorities

were also critical to discourage organisations from investing in TLP. However, the researchers of this study summarised the discussion with the interviewees in points including 'lack of financial and human resources', 'deficiencies in experienced and skilled people', 'limited information Systems (IS)', 'lack of communication routines', 'regulatory constraints in pharmaceutical and chemical industry', 'training budget priorities', 'cost intensive', and 'time consuming'.

The same specialists who were contacted through the E-mail method to verify the encouragements to initiate TLP (refer to section 4.3.12) were also requested to check out the constraints that believed to discourage organisations from invest in TLP. Although, specialists have agreed on what the interviewees had provided, further elaboration by some specialists was forwarded. For instance, one specialist stressed that the most constraining to establish TLP was lack of commitment to TLP by top management. Another specialist believed that TLP can be hindered by expenses (i.e. labour plus facilities), and IT communication links.

### 4.3.14 Discussion

This study described the ground on which the TLP was implemented. As a result of the interviews analysis, it was found that although the TLP did not categorise or was tagged under any of the terminologies cited in the literatures (e.g. Technology Intelligence Process, Technology Foresight Process, Technology Forecast Process, Competitive Intelligence System etc), it was known as a Technological Learning Process (TLP) and was performed on quarterly basis. Broadly, the TLP comprises of two phases included scrutiny phase and observation phase. Where the scrutiny phase concerned with scanning all markets demands across all customers in all technologies, the observation phase devoted to monitor any new trends (i.e. new triggers) of technology that were found through the scrutiny phase. Basically, the TLP carried out on quarterly basis and took into account all markets demands across all customers in all technologies. Every quarter however passed by few tasks starting with scrutiny, through identification and evaluation to recommendation. As has been shown in Figure 4.7, at the end of every quarter, discussion was held in which the input from all factories was considered.

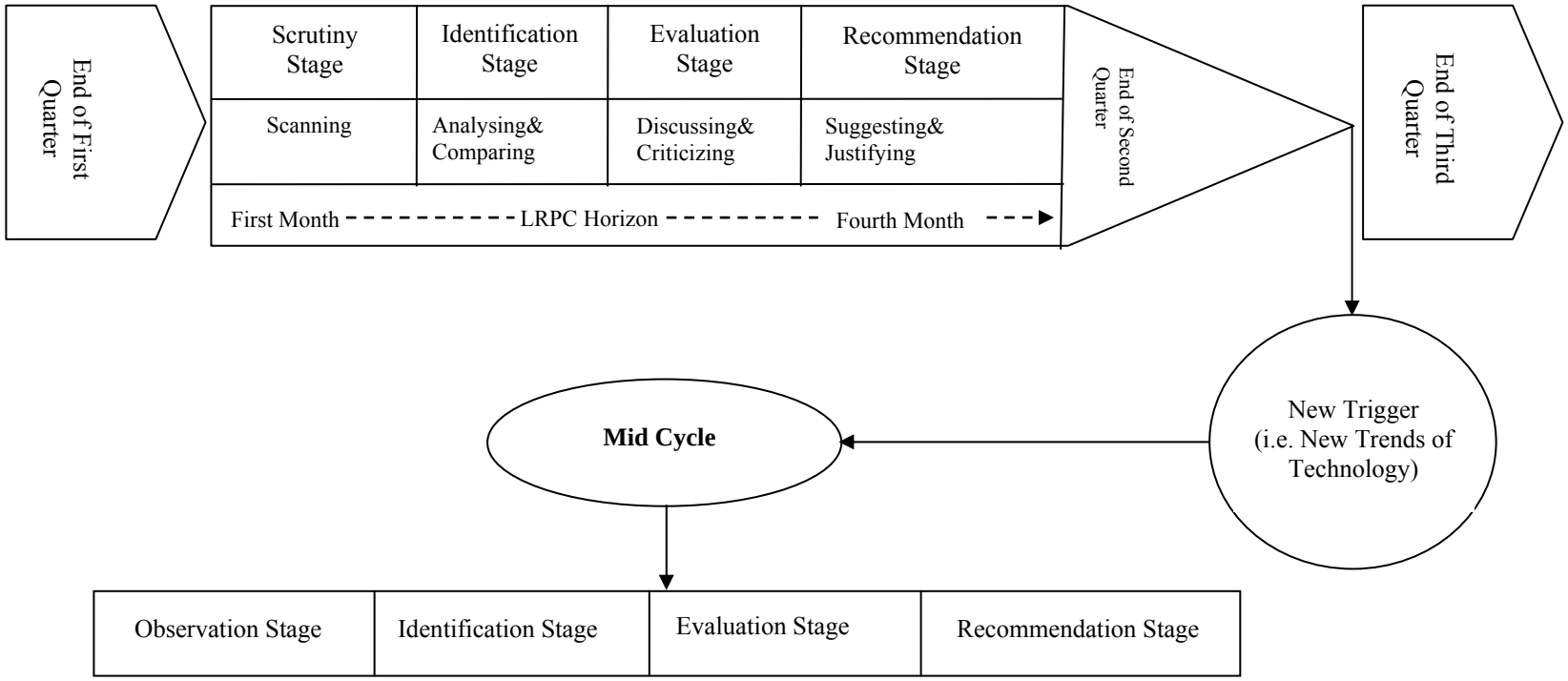


Figure 4.7 Technology Learning Process (TLP) on Quarterly Basis

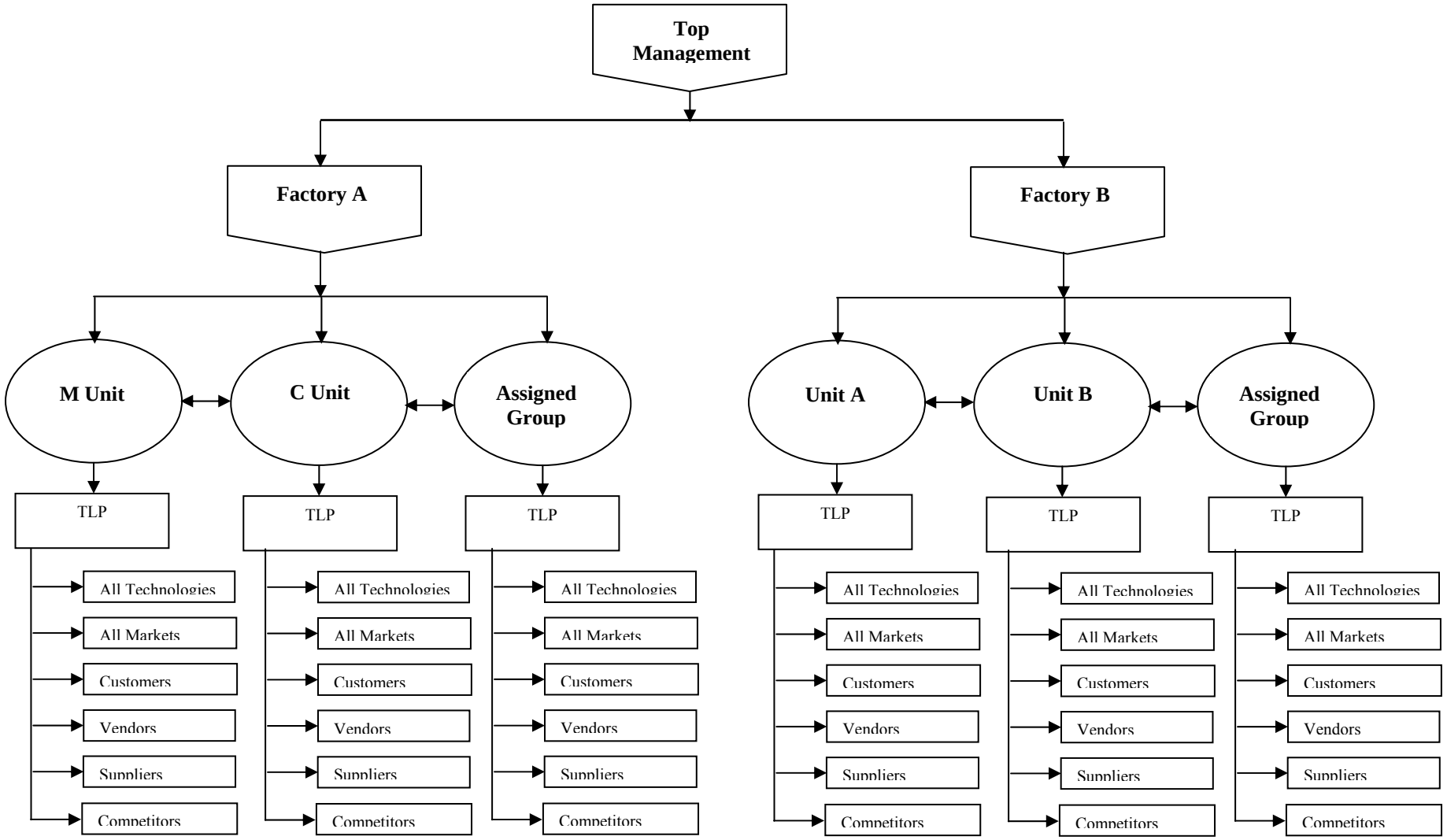


Figure 4.8 Structure of Technology Learning Process (TLP)

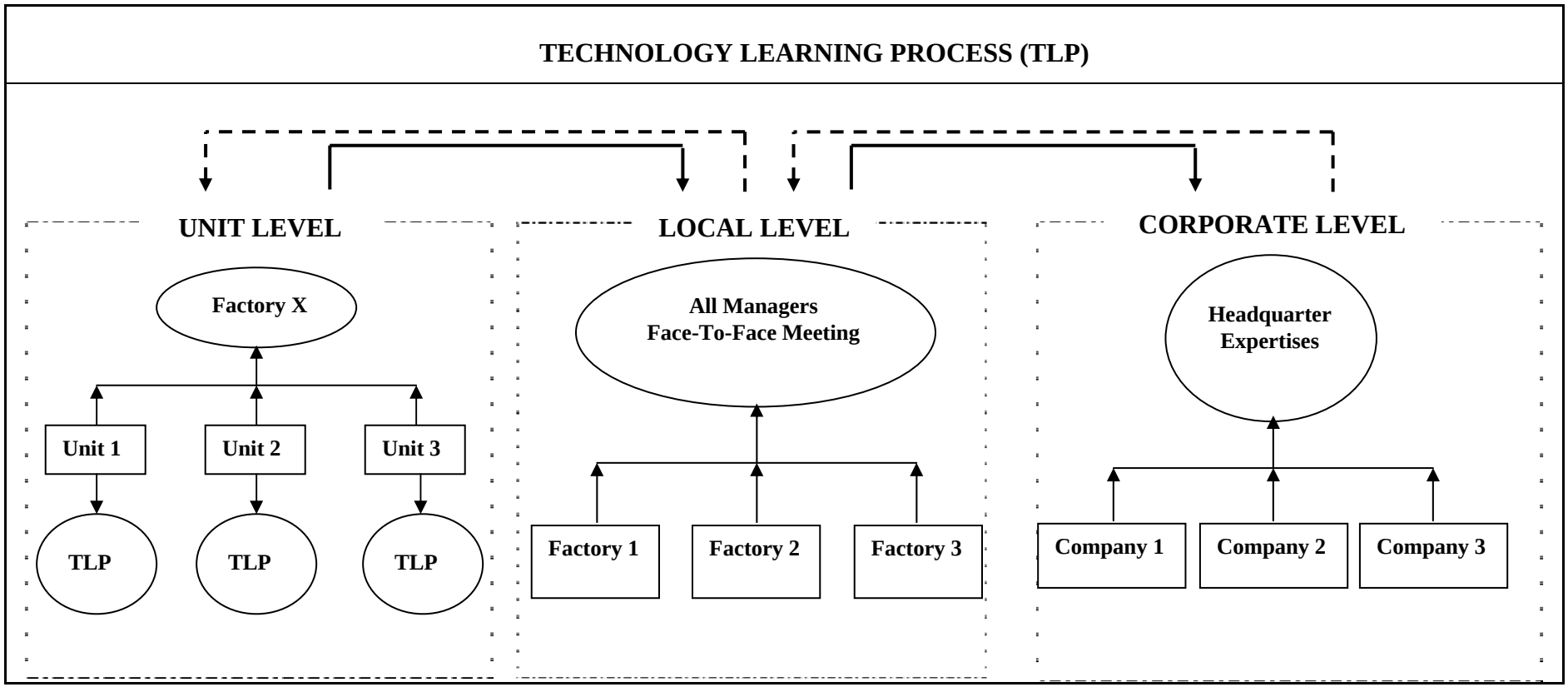


Figure 4.9 Coordination Levels of the Technology Learning Process (TLP)

At different point of time, a trigger to start new technology somewhere was usually scrutinized. However, where new trigger/trend of technology came in the process horizon, Mid Cycle, which represents observation phase, would be generated. The new trigger/trend of technology that scanned by scrutiny phase would be monitored by observation phase.

This study indicated that the TLP was coordinated and organised into three different levels including unit, local, and corporate levels. As described in Figures 4.8 and 4.9, at a unit level, people scanned and monitored the developments/trends of new technologies. Despite every unit supposes to scan, analyse, discuss, and justify the demand and technological changes, a group of expertises are also assigned to conduct these tasks. All the units and the assigned group of expertises must have consistently worked with each other. At a local level, factories' managers across the company held a meeting to not only discuss the demand and technological changes but also the responses to these changes. The main aim of this meeting was to investigate all the demand and technological changes and to present the updates from all units. At a corporate level, headquarter at mother's company assigned group of expertises to pursue the TLP. This group of expertises involved independently in the discussion and justification of final decision that made at the local level. Figures 4.8 and 4.9, attempted to describe the coordination levels of the TLP. However, during recommendation stage of TLP, issues related to adoption of new technology were all studied and were justified by all factories managers on local level and verified by expertises on corporate level. This was one of the key factors that contributed to the success of new technology implementation and utilisation. Furthermore, an execution plan, which was used when the decision is taken to bring and implement a new technology on the site, was described.

In order to demonstrate what influenced the TLP, this case study indicated that collaboration and communication between companies were factors that had great influence on the TLP. The interviewees believed that on regular basis, communication and collaboration between companies enabled their managers to figure out where the next technology might have come from and how they might have collaborated together to manage the new trends of technology.

A scope of the TLP within this case study is also investigated. It was found that this process covered two aspects of knowledge namely technological aspect and non-technological aspect. The interviewees indicated that non-technological aspect is as important as technological aspect. The interviewees demonstrated that as one of TLP parameters, benchmarking analysis was a method used to investigate non-technological aspects. This method could provide managers with the best non-technological aspects used within rival companies.

Almost all the parameters involved in management of TLP were also identified. The interviewees explained that the majority of these parameters were practised in their company from basic parameters such contacting suppliers and monitoring publications to advanced parameters such as launch limited projects to generation of new ideas, and collaboration with universities and institutes. Overall, encouragements and constraints to initiate TLP were identified and subjected to verification by several specialists who had agreed on what interviewees had provided.

### 4.3.15 Contributions of the Case Study Approach

This study had made several important contributions to the field of technological knowledge management and innovation management. First contribution was that this study has described in detail how TLP was executed. Primary elements and/or stages of TLP were explained. On quarterly basis, the TLP was found to pass by few elements/stages starting with scrutiny, through identification and evaluation to recommendation that were taken into account all markets demands across all customers in all technologies. Furthermore, aspects of the TLP including technological and non-technological aspects were identified. However, the life-cycle of TLP was depicted and exhibited by Figures 4.7, 4.8 and 4.9.

The most significant contribution of this study was the development of a set of parameters for measurement of TLP practice. We have identified forty-six parameters that should be involved in management of TLP practice. These structured and disciplined parameters extended some findings and clarified some conflicting findings in prior studies. The forty-six parameters were classified into four levels and the characteristics of each level of TLP was discussed and explained. This classification facilitated the understanding of the sequence and

interactions of parameters. Thus, these parameters were believed to greatly enhance the basis on how technological threats and opportunities in a fast changing environment can be identified. It was also believed that development of such parameters could assist a firm to anticipate technological discontinuities, global changes or 'weak triggers', so that the firm is not taken unaware or submerged by new paradigms or new competitors.

The third major contribution was concerned with encouragements and constraints to initiation of TLP. This study had identified the factors that were believed to be very important in encouraging managers to initiate TLP. Furthermore, this study had summarised the factors that were believed to be critical in discouraging managers from investing in TLP.

Fourth contribution of this case study was that this study explained the plan that was usually followed whenever managers agree to adopt and implement a new technology. In addition, the background and number of people who were responsible for implement the new technology were also explained. Moreover, essential information that companies frequently sought when investing in AMT, were identified. Describing the nature of required information was important especially for companies that have neglected or underestimated the role of early information gathering. Insufficient and inefficient information was often a major contributor to the failure of investment in AMT projects. Apart from this, the issues that challenged implementation of AMT projects were also discussed and summarised.

## 4.4 THE RESEARCH FRAMEWORK

*What you don't know could hurt you* [76]. This belief resulted from the fact that knowledge was a critical issue for several organisations that attempted to learn about and adopt new technologies. Chew, et al (1991) [76] reported on the unsuccessful attempts of JRC (i.e. JRC is a name of a larger aluminium processing plant) to introduce a new system. They explained that it was a failure of information that brought the plant to its knees. The problem was not imperfect technology or improper organisation. The problem was imperfect knowledge about the interaction of the technology with the organisation. Poor management of

information could result in both monetary losses and a weakening of competitive advantage [183].

Back to the 1970s and 1980s, several authors called for a systematic and continuous observation and evaluation of technological changes and developments [184-188]. To continuously observe and evaluate the technological changes, an intentional initiation of TLP was greatly appreciated. Past researches agreed that it was essential not to leave the initiation of technology learning to chance [143]. Organisations that left TLP to chance were likely to miss the opportunity to have taken a leading role in introducing new competitive technologies.

Technology management based on limited information often produced unsatisfactory results. Currie, (1989) [85], for instance, demonstrated that the process of gathering more information about CAD after implementation was more common than one might expect. The additional information obtained after implementation included: knowledge of software, the maintenance contract, and the training services available to CAD users. Thus, collecting information in order to identify the requirements of the new technology should have been the first. The wisdom was to understand initially the implications of technology change management, not to have implemented it and then have tried to understand it. As companies invested in AMT on the basis of limited information, it was not surprising to find many organisational and technical problems once the system was installed. Moreover, an immediate rejection of new technologies was the case among organisations that underestimated the role of TLP [29]. Thus, in order to effectively manage and implement advanced technologies, an integration of TLP into the planning and decision-making processes must have been greatly considered [24-27 and 146].

### 4.4.1 Previous Conceptual Models of TLP

Due to the key role of TLP in the technology management, many authors have developed conceptual models to identify the main activities and the core elements of the TLP. For instance, in order to put TLP into work, Norling, et al (2000) [189] developed a conceptual model, which described the main elements of TLP. The sequential of these elements had been shown in Figure 4.10. One year later,

Reger (2001) [26] developed a conceptual model in which TLP comprised five core elements. Figure 4.11 showed Reger's model and described the five core elements associate with it. As can be seen from Figure 4.11, a fifth element of Reger's model was clearly the bridging interface between the TLP and the adoption and implementation of new technologies. As a result, the TLP was intended not only to provide background on which the managers could predict what challenges may have hindered the firm to gain competitive advantage, but also to have provided acute knowledge and information to effectively adopt and justify the investments in AMT projects.

Based on decisions recommended by TLP, firms may or may not have begun the process of AMT implementation. Basically, the process of AMT implementation was a process which consists of various phases that organisations go through. These phases were described and discussed by several authors [10, 93 and 190-193]. For instance, Voss, (1988) [10] revealed that a lifecycle of implementation process consisted of three phases including: adoption phase; implementation phase; and post-implementation phase. Although, a six-stage model was developed by Kwon, et al (1987) [191], and supported by Schroder, et al (1999) [93], many recent studies still adopt and use Voss's model to study the process of AMT implementation [68, 194 and 195]. Figure 4.12 showed the sequential phases of the process of AMT implementation in Voss's model.

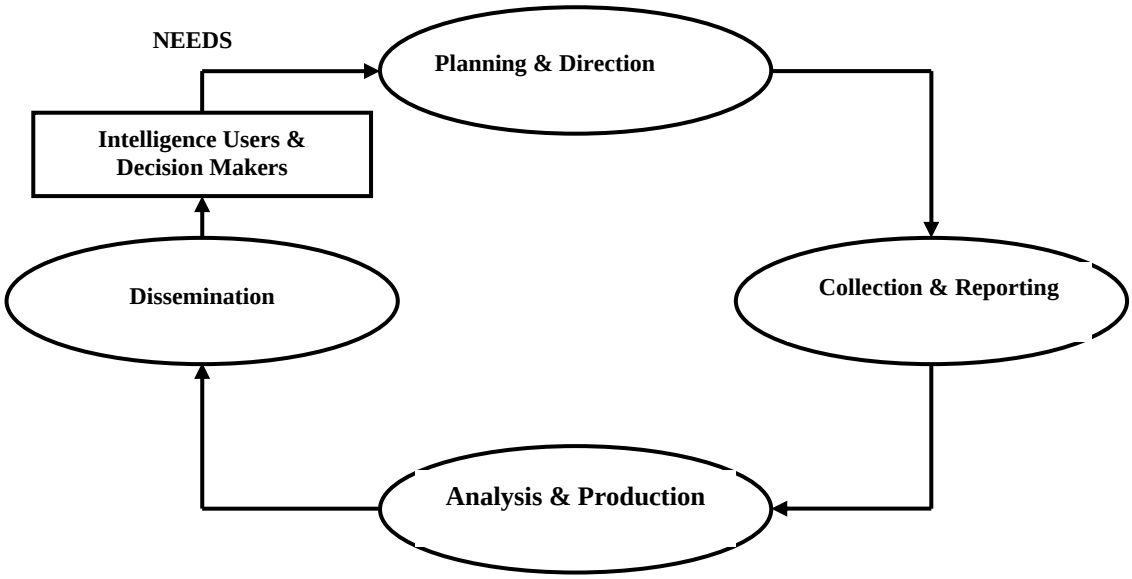


Figure 4.10 Norling's Model 'Four Important Steps Comprise the Competitive TIP'

The authors of this study found that in section 4.3.14, the conceptual model developed by this study (refer to Figure 4.7), which described the primary elements/stages of TLP, was compared to previous models. Interestingly, the conceptual model developed by this study and previous models were almost sharing same elements. In the present study, it is argued that a combination of these conceptualisations, particularly 'the conceptual model developed by this study and Voss's model', offered an overall process that spanned from initiation phase, adoption phase, implementation phase, to post-implementation phase. The initiation phase represented the conceptual model developed by this study that comprised the core elements and activities of TLP, whereas the remaining three phases represented Voss's model which concerned with phases of AMT implementation process.

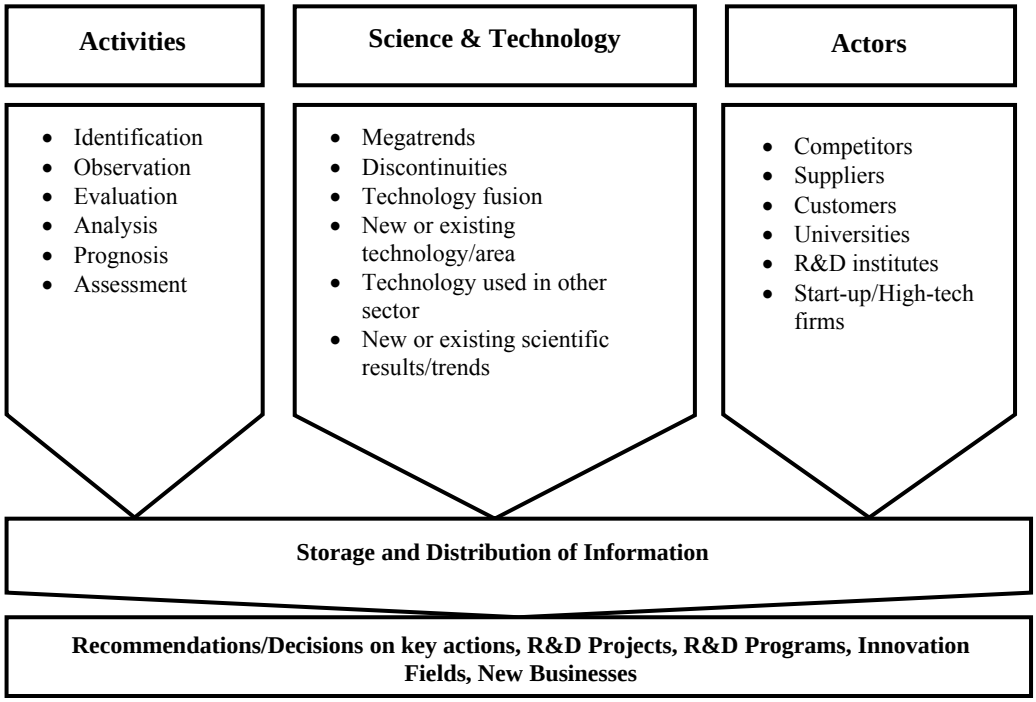


Figure 4.11 Reger's Model 'Core Elements of Technology Intelligence Process (TIP)

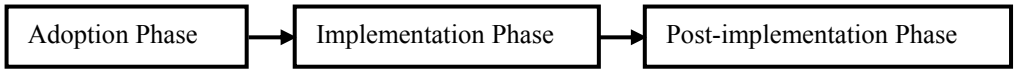


Figure 4.12 Voss's Model 'The Implementation Process of AMT projects'

### 4.4.2 Conceptual Model of This Study with the Research Framework

To extend our knowledge of AMT implementation and to particularly study the correlation between TLP and implementation process of AMT projects, the present study proposed a conceptual model that links four sets of constructs.

As can be seen from Figure 4.13, the first set comprised the conceptual model developed by this study for TLP that was mainly focusing on technology and non-technology aspects. Generally TLP was responsible for identify, acquire, evaluate and analysis, communicate information to decision makers, participate in planning and decision making processes, and making recommendations on useful technological and non-technological aspects. The technological request (e.g. any systems of AMT) and non-technological request (quality techniques, maintenance methods etc), which were supposed to be identified and recommended by TLP, constituted the second set.

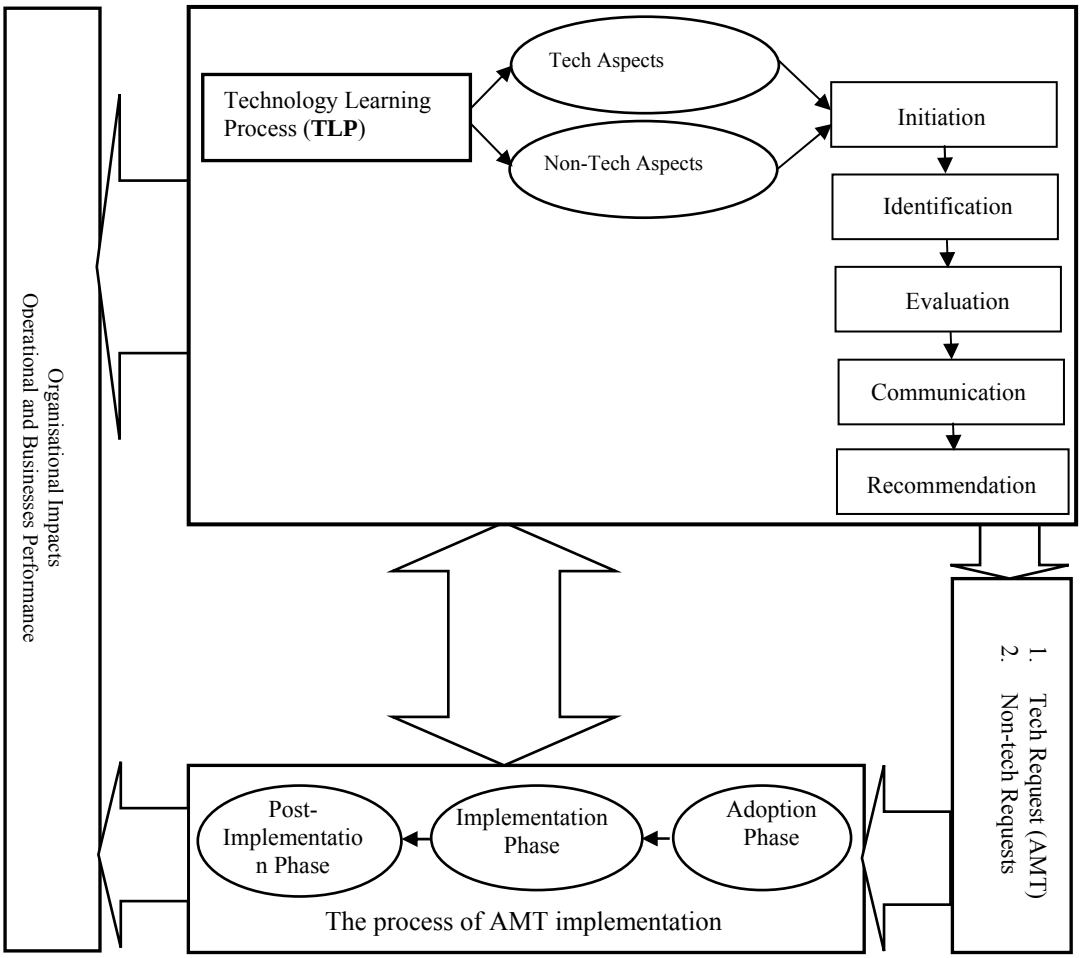


Figure 4.13 New Conceptual Model Developed by This Research

The third set represented the three phases of the process of AMT implementation as proposed by Voss, (1988) [10]. The final set of constructs represented the degree of success and organisation's performance when TLP was involved in the process of AMT implementation. Based on this model, the management of advanced technologies was imagined as building an electrical circuit, where the TLP phase has been considered as the black green board that the process of AMT implementation will be welded on to, i.e. it is the foundation for the process of AMT implementation.

Whereas there can be found more theoretical literature concerning TLP [142 and 196], however, there was a lack of empirical studies that examined the impact of TLP on strategic planning or strategic management of technology [197, 33, 24 and 29]. Consequently, the present study attempted to empirically examine the seemingly relationship between the TLP and AMT.

## 4.5 RESEARCH HYPOTHESES AND RATIONALE FOR HYPOTHESES

Given the research framework, this section was dedicated to show the hypotheses of this study and discussed their rationale. Basically, literatures believed that to effectively respond to technological changes and developments, TLP must be deemed as a key function in the corporate strategy during which the initial decisions of AMT investments are formulated. For instance, Reger, (2001) [26] stated that TLP was needed in an enterprise to make decisions on priorities and resource allocation in the area of R&D and technology and was essential for securing the long-term innovative capability and competitiveness of the enterprise. A major benefit of the TLP is that it could provide feedback to management about available AMTs, match available technologies to the process requirements of the manufacturing concern, and ensure the compatibility of these technologies with the plant's existing systems [24-28]. This information is critical for minimizing or avoiding problems with new technology once it was used for regular production. Frohlich, (1998) [152] expressed that a newly installed AMT that does not smoothly mesh with a plant's existing structure has a far lower chance of eventual success. Therefore, the establishment of TLP was not only a

key for diminish the trouble emerged during adoption phase, but also essential for a timely adoption of new technologies. The timely adoption of AMT assisted manufacturers to effectively compete and foster the position of the company within marketplace [24-28]. Because of the importance of technology adoption decisions, activities of TLP were responsible for choosing technical alternatives to be followed in a development project [24]. TLP also enabled project managers to define and interpret threats and opportunities, and coordinating the match between new knowledge and existing organisational routines [198].

Several scholars believed that competition was becoming more knowledge-based [199 and 134]. This belief has won more attention when many researchers refer the failure of AMT implementation to the absence of the efficient learning process [22-29]. Thus, being able to achieve competitive advantages was dependent on the firm's ability to utilize knowledge throughout the company [200 and 201]. Whereas utilization of knowledge did not mean to devote the efforts to one aspect of the organisation, majority of managers concentrated their efforts of TLP on technological aspects and neglected non-technological aspects.

An essential issue among manufacturing organisations then was a misconception of managers to the role of TLP. Actually, many managers believed that TLP was applied only for technological purposes. Simply focusing on technological purposes alone was no longer enough [149]. With the increased importance that today's companies place on knowledge, people are becoming one of the most valuable resource for firms. Deriving value from this resource is not a question about technologies, but rather about non-technologies. Consequently, technological learning is not solely about learning technologies any more. Rather, it is best construed as learning in technology-driven firms. Therefore, TLP must extensively include technological aspects and non-technological aspects.

### 4.5.1 First Hypothesis:

> H1: Organisations that adopt high complex level of AMT projects were likely to place greater emphasis on TLP than companies that have less complex AMT projects,

With escalation in the complexity of new technologies, an acute knowledge of external changes, along with the capacity to facilitate change internally must be

acquired from deep, fundamental research [202]. In the literature, there was claim that top management could not limit themselves to go/no-go decisions based simply on quantifiable operational advantages assessed by means of a set of questionable justification methods [203]. Instead, as suggested by Boer, et al (1990) [108], the need for increased knowledge about how to tackle AMT adoption on the part of top management was a key factor that helps managers to develop a vision statement and an implementation plan [203]. Some researchers stressed that because of the complexity of new technologies and technical/analytical decisions to be made in introducing AMT projects, many technical problems arise [204 and 205]. In order to deal with the high complexity of advanced technologies, many have argued that TLP should be organised as a project-based learning process, especially in the early stages of the technology life cycle [206, 203, 196 and 28]. An early evaluation was complicated by high uncertainty and complexity of new technologies. With regard to the high uncertainty and complexity inherent to advanced technologies and the internal resistance caused by it, the initiation of the TLP was most crucial for their success [143]. As a result, the present study believed that the consideration of TLP is influenced by the complexity degree of AMT. In order to explore this, the first hypotheses were assumed.

### 4.5.2 Second Hypothesis:

> H2: Organisations, which practice TLP to learn about changes and developments of new technologies, were more likely to achieve great degree of success in the process of AMT implementation

An initiation of TLP, which comprised both technological and non-technological aspects, was a key factor for the success of AMT implementation. During the interviews held by this study, which were addressed in Chapter 4, the interviewees had attributed most of their success in adoption and implementation of AMT projects to their effectiveness of TLP and its input in the decision making process. This finding was supported by a research conducted in China. This Chinas research held interviews with several senior managers and revealed that utilisation of TLP for technological and non-technological purposes was a powerful weapon

to succeed in adoption and implementation of advanced technologies. The technological aspects were learned from many sources (i.e. universities, research institutes, customers, suppliers, and international/domestic leading firms). On the other hand, the non-technological aspects (i.e. effective management techniques) were actively monitored. For instance, one interviewee in the China study revealed that because they lacked experience in management, they often appropriated effective managerial methods from other firms and imitated them when needed. The practice of TLP should have involved learning both technological and non-technological aspects. More often, the non-technological aspects were more important than technology itself [124 and 149]. Based on this discussion, it was evident that the implementation of TLP for technological and non-technological proposes was an important factor that could contribute to increase the degree of success of AMT implementation. Consequently, the second hypothesis was proposed.

### 4.5.3 Third Hypothesis:

> H3: Organisations, which applied TLP to explore changes and developments of new technologies, would perceive higher levels of performance (i.e. involvement of TLP into decision making process would positively influence the organisation performance)

To determine the strategic and operational benefits offered by AMT, firms should regularly scan and monitor the usage and performance of AMT not only in their core industry but also out side their industry. Thus, top management should allocate the necessary time, resources and skills to scan and monitor technology improvement opportunities [30 and 31]. Obviously, success of AMTs implementation was attributed to the integration and involvement of TLP in the decision making and planning processes. For instance, Iansiti (1997) [207] and West, et al (1998) [208] indicated that TLP was associated with overall project performance. Others revealed that competitive success is influenced by the firm's ability to engage in technological learning so that its knowledge base can be increased in areas vital to be competitive [209 and 134]. The TLP had powerful influence on product quality, labour productivity, and the skill requirements of labour [137]. Thus, successful process of AMT implementation relied to large

extent on the initiation of TLP. As a result, this study aimed to test the impact of TLP on the organisation performance as a whole. For this purpose, this study aimed to test the third hypothesis presented above.

### 4.5.4 Fourth Hypothesis:

H4: Organisation size had an influence on the initiation of Technology Learning Process (TLP)

In order to meet the challenges of fast changing environment, TLP was an important activity and useful mechanism for both large and small manufacturers [26]. However, Merri, et al (1998) [210] revealed that generally learning a process was far more difficult and proportionately more expensive for SMEs than for large businesses. Several researchers indicated that TLP was characterized by a cost-intensive and is time consuming [24 and 26]. As a result, there were some compelling reasons to suspect that exploitation of TLP in technology management could be influenced by the size of the company. According to several researchers, TLP was found actively functioning in large size companies [197, 33 and 24-27]. For instance, Lichtenthaler, (2004) [29] interviewed several large size companies and indicated that larger-sized companies dedicate particular department, which is established to fulfil the activities of TLP. So far, there was no evidence found in the literature about the role of TLP in AMT adoption among SMEs industry. This was might be due to characteristics in limitations of SMEs compared to large size companies. Compared with large size companies, SMEs are generally constrained by limited financial and human resources, less ready access to information, limited information abroad and commercial contacts and weakened structure in their management capacity [211]. Moreover, SMEs were more risk-averse, reluctant to engage outside help, and had deficiencies in experienced people who were able to identify, analyse the organisation's needs and then communicate the perceived value of technological innovation to decision makers [210-216]. Based on this preliminary evidence, it was believed that organisation size influenced the process of TLP. To investigate this question, the present study suggested the fourth hypotheses shown above.

### 4.5.5 Fifth Hypothesis:

> H5: Irish organisations that adopt AMT projects after 1990s are likely to invest in TLP more than those who adopt AMT projects before 1990s (i.e. late adopters of AMT are more likely to invest in TLP than early adopter of AMT)

Not unexpectedly, since most computerised technologies rapidly evolved, early AMT adopters experienced many more technical and none-technical problems than followers. Frohlich, M (1998) [152] revealed that AMT pioneers spent more money on equipment, tended to be publicly owned, were larger in size, and have less prior experience with the new technology than later adopters. Based on foregoing discussion, short statement could be summarised. This statement of early adopters of AMTs was different from later adopters of AMT projects. By reviewing the historical developments of Irish economy, this statement has gained some support.

In Republic of Ireland, recent economic performance has attracted considerable attention, earning it the label "Europe's Celtic Tiger". Changing patterns in time-space contexts became particularly evident with rapid economic developments in Ireland in the 1990s. It was also witnessed that since the 1990s, that manufacturing has boomed causing massive developments in the construction and materials industries for plant and building [217]. Particularly, the rapidity of the growth of the pharmaceutical and chemical sector, which started to become established in Ireland towards the late sixties, is clearly observed after 1990s where the exports grew by a massive 6,373% to £5 billion from £79 million. As a result of this growth, Industrial Development Authority (IDA) in Ireland has named Ireland the "healthcare capital of Europe" and states that over the last 10 years, every U.S medical device company looking for a European base has selected Ireland as its preferred site. The IDA statement was backed up by the fact that 17 of the world's top 20 pharmaceutical companies were represented in Ireland [3 and 4].

Before 1990s, The Republic of Ireland was deemed as a peripheral economy in relation to mainland European states and by the 1990s Ireland was Europe's most dynamic economy recording a growth rate three times the EU average [217].

Notably, by 1990 dominant technological designs and industry standards had emerged that greatly changed the implementation experiences of AMT late adopters from those of pioneers [218]. Due to the economic growth, extensive support to manufacture sector in Ireland and intensive competition, Irish organisations that invested in advanced technologies after 1990s should have vast chance to adopt strategies and policies to successfully manage investment in AMT projects. Based on foregoing discussion, this study intended to test the fifth hypothesis proposed above.

# CHAPTER 5

# 5. SURVEY RESEARCH RESULTS AND DISCUSSION

## 5.1 INTRODUCTION

This chapter concerns with the design of the survey research strategy and its methods. This strategy was employed to extract data that can help to test the five hypotheses proposed in chapter 4. In doing so, this chapter describes a number of methods and instruments for data collection and data analysis and identifies those chosen for the purpose of this study. The criteria that were used to evaluate the quality of this research are also presented. The statistical techniques that were used in this study are also presented. Subsequently, the results obtained by the survey research approach are presented. Particularly, the five hypotheses that were proposed in chapter 4, section 4.5, are all tested and followed by full discussion.

## 5.2 SURVEY RESEARCH APPROACH

Pinsonneault, et al (1993) [176] distinguished between surveys and survey research. A survey is a means of gathering information about the characteristics, actions, or opinions of a large group of people, referred to as a population. As such, there are many data collection and measurement processes that were called surveys (e.g., marketing surveys, opinion surveys, and political surveys polls to name some of the most common). On the other hand, survey research is conducted to advance scientific knowledge. In general, survey research is the best-known source of primary data collection in the social sciences. Undoubtedly this owes a great deal to their widespread use in polling opinion on political issues or other matters of current interest and concern such as health and food, or the effects of environmental pollution [181]. Baker, (2001) [181] revealed that survey research is the evaluation, analysis and description of a population based upon a sample drawn from it. The essential element in the survey research is that an individual furnishes the data in a conscious effort to answer a question. Some people have gone so far as to regard the questionnaire technique as being synonymous with social sciences. Unfortunately, this research approach is so

universally employed in the marketing field that many researchers used the survey research when one of the other approaches (i.e. the case studies or experimental), is more appropriate. Through his review of the literature, Baker, (2001) [181] has revealed that survey research is a term that is susceptible to a variety of interpretations. The most common interpretation is that it denoted a project that aims to get information from a sample of people by use of a questionnaire. The questions may have been designed to obtain information that is retrospective, concurrent, or projective with regards to time. The questions may have been asked in a personal interview, by telephone, by post, or sent to the respondent by e-mail. Surveys are concerned with understanding or predicting behaviour and offer as their definition [181]: survey research is the systematic gathering of information from (a sample of) respondents for the purpose of understanding and/or predicting some aspect of the behaviour of the population of interest. Consideration of these definitions indicates that survey research is concerned with [181]:

- Fact-finding
- By asking questions
- Of persons representative of the population of interest
- To determine attitudes and opinions; and
- To help understand and predict behaviour

### 5.2.1 Purposes of Survey Research Approach

A survey research can be classified into three groups [181]: factual, opinion and interpretive, each of which is seen as having a distinctive purpose. As the name implies, factual survey research is concerned with securing hard, quantitative data on issues such as usage, preference and habits, (e.g. How much beer do you drink? What is your preferred brand? Where do you normally drink beer?). In other words, such survey research is concerned with actual behaviour, while in opinion survey the objective is to get respondents' views upon the topic under consideration. Such opinions are almost always qualitative and may or may not have been based upon actual experience. For example, a non-drinker may have had quite strong perceptions about brands of beer without ever having consumed them. However, consumers' attitudes and beliefs based upon past knowledge and experience are of particular value in helping to plan future strategy (e.g. in

designing a new product, developing a copy platform or selecting a distribution channel). As with factual survey research, a major purpose is to attempt to quantify the strength and direction of opinion as a basis for future decision-making [181].

By contrast interpretive survey is used in circumstances where the respondent is asked to explain why they held particular beliefs or behave in a particular way rather than simply stated what they do, how, when and where, etc. Interpretive survey is often the first step in primary data collection when the researcher is trying to get a feel for the topic under investigation and would often involve the use of projective techniques such as picture and cartoon tests, word and object association tests, sentence completion tests, and role playing. In-depth interviewing and focused group interviews are also widely used, often to define questions to be used in a formal questionnaire for use in the factual or opinion survey [181].

### 5.2.2 Advantages and Disadvantages of Survey Research Approach

From the literature, Baker, (2001) [181] found that the survey research is the most usual form of primary research undertaken and attributes its popularity to the following factors:

- The objectives of most research required factual, attitudinal and/or behavioural data. Survey research provided the researcher with the means of gathering both qualitative and quantitative data required to meet such objectives,
- One of the greatest advantages of survey research was its scope, a great deal of information could be collected, from a large population, economically, and
- Survey research conformed to the specifications of scientific research in that it is logical, deterministic, general, parsimonious and specific.

Baker, (2001) [181] also detailed the main advantages of survey research, which have been cited by several authors in the related literature. These advantages are as follows: ‘Comprehensive’, ‘Customised’, ‘Versatile’, ‘Flexible’, and ‘Efficient.

By stating that a survey research is a comprehensive, Baker, (2001) [181] meant that the approach was appropriate to almost all types of research (factual, opinion and interpretive categories of survey). The other four advantages were closely interrelated and boiled down to the fact that one could design survey research to suit all kinds of problems and budgets. On the other hand, survey research also had several disadvantages, for instance, Baker, (2001) [181] cited the following:

- The unwillingness of respondents to provide the desired data. The overriding concern here was of the non-response error, which can invalidate research findings,
- The ability of respondents to provide data. In studying managerial decisions, it was important to target individuals in the organisation with the knowledge and experience of the subject under examination, and
- The influence of the questioning process on the respondents. Respondents may have given the answers they think the researcher will want to hear, thus distorting the accuracy of the data.

Survey research was less appropriate than other approaches such as case studies and naturalistic observation when detailed understanding of context and history of a given computing phenomena was desired [176]. A survey research was more of a research strategy than a method, since it typically used either questionnaires or interviews, or both. Thus, the strengths and weaknesses of the survey research approach rested on the relative strengths and weaknesses of the interviews and questionnaires used within it.

### 5.2.3 Postal Questionnaire Method

Postal questionnaire is a very popular research method. There are a wide variety of designs feasible, and it is important to construct the questionnaire carefully. This involves developing the question types, the layout style and ensuring that satisfactory levels of reliability and validity can be achieved [219]. To summarise briefly the literature on postal questionnaire beginning with close-ended questionnaires, which, although quick and easy to complete and analyse, may only have generated results of a superficial character. Equally, open-ended questionnaires may have permitted deeper more probing questions and also

enabled a relatively high degree of flexibility in the answers. However, they are correspondingly more difficult to complete and analyse involving a much greater investment of time from both the researcher and respondent [70]. Postal method however used a printed questionnaire that is posted or delivered to respondents and permitted them to respond at will and return the questionnaire via post.

1. Advantages
    - Required minimum staff to prepare & mail,
    - Relatively inexpensive
    - Collected a great deal of information from a large population
    - Its information was accurate within sampling error and could provide an accurate portrayal of values, attitudes, and beliefs
2. Disadvantages
    - Took time, required follow-up to get responses
    - Problems related to 'junk' mail
    - Required literacy
    - Was difficult to get accurate mailing lists

### 5.2.4 Web Page-based Questionnaire

This method involved sending a questionnaire on a web site, with respondents typically replying from individual computers remotely, although computers could also be set up at a central interview site [179].

1. Advantages
    - Quick response possible
    - Could be inexpensive if web server, web designer, and software were available
    - Web software could tally, summarize response data
    - Postage was reduced or eliminated
    - Easy for respondents to reply
2. Disadvantages
    - Respondents must have had access to Web
    - Reminders still needed, although e-mail may have substituted for mailed announcement/reminder cards.

### 5.2.5 Telephone Questionnaire

This method involved calling respondents via telephone, typically on a spontaneous (as perceived by the respondent) basis, although it could also be done via scheduled appointment in consideration of the respondent's schedule. It was also possible to use an automated system where users replied via touch-tone telephone to a computer-based interview system [180].

1 Advantages

- Quick response possible
- Could be inexpensive if dialling was local and staff were available

2 Disadvantages

- Caller ID, answering machines limit access. Essential to have established credibility in competition with telemarketers
- Not everyone had a telephone
- Unpublished phone numbers (unless random dialling is used)

The assessment of the impact of the measurement of TLP developed by this study was based on the results of comprehensive questionnaires that were used as a basis of extracting information from the manufacturing organisations. However, collecting information from manufacturing organisations was through both postal questionnaire and web page-based questionnaire methods. The purpose of using two methods of survey research was for two reasons: an attempt to increase the response rate and to collect the experiences and opinions of external manufacturing organisations (e.g. international manufacturing organisations outside Republic of Ireland).

### 5.2.6 Postal Questionnaire Method

The postal questionnaire was characterised by its effectiveness of drawing responses from a large sample. Due to the need to examine the parameters of TLP, which were developed based on single case-study, the postal questionnaire in this research was employed. Obviously, the forty-six parameters of TLP that emerged from the interview sessions were rephrased as questions format. These questions were designed to ask participants to identify their practice level of TLP and also determine the importance degree of these TLP parameters. Thus, this method was used to verify the applicability of the developed TLP parameters and also to

assess the practice of TLP and its effects on a large sample within Irish manufacturing organisations. This study involved a survey of all (i.e. 120 firms) pharmaceutical and chemical firms in Republic of Ireland. The arrangements and procedure reported by Sudman, (1982) [220] and Fink, (1995) [221] in terms of questionnaire design were applied to develop this questionnaire.

### 5.2.7 Design and Contents of Postal Questionnaire

The first two sections of this questionnaire (Appendix B.5) dealt with the general characteristics of the organisations, and the most frequently AMT that manufacturing organisations invested in. Third section was dedicated to the process of AMT implementation. First part of third section was concerned with the degree of success in phases of AMT implementation. The second part of third section dealt with the difficulties and problems that organisations faced during adoption and implementation phases of AMT projects. Fourth section was dedicated to the activities involved in TLP implementation (i.e. parameters of TLP developed by this study). This section requested participants to identify the TLP activities that they practiced and at the same time explained the importance of these activities. Members of TLP, encouragements and constraints were all addressed in this section. Fifth section included 15 questions, which were used to describe the improvements occurred on organisation performance.

During the development process of this questionnaire, several actions were taken to diminish the possibility of a low response. For instance, a preliminary invitation booklet was initially sent (from Appendix B.2 to B.4). This booklet defined issues such as: ‘What this study is about?’, ‘What have we done to date?’, ‘Who are we looking for?’, and ‘Why should you participate?’ Additionally, the invitation booklet included instructions for the questionnaire. This instructions booklet was concerned with several matters such as confidentiality, how could respondents complete the questionnaire? Where can respondents find some support if they found some difficulty? Finally the same booklet also provided respondents with a glossary of terms used in the questionnaire. Furthermore, a participation letter, which included cash incentives, was enclosed with the questionnaire booklet (consult Appendix B.2). This letter was sent within one week of sending the preliminary invitation booklet. Finally, a reminder letter was

also sent to increase the rate of responses within a few weeks of sending questionnaire booklet (see Appendix B.6).

The surveyed sample focused primarily on manufacturing organisations involved in pharmaceutical and chemical industry. The potential sample for participation in the study was determined primary through Industrial Development Agency (IDA) Ireland. The IDA Ireland is an Irish Government agency with responsibility for securing new investment from overseas in manufacturing and internationally traded services sectors. It also encourages existing investors to expand and develop their businesses. The information collected from IDA [http://www.idaireland.com/home/index.aspx?id=38] was also supported by the Irish Manufacturing website [http://www.irishmanufacturing.com]. One reason for using these sources was that the majority of companies that joined these sources were accepted and registered based on their Irish Government company registration code. Additionally, these sources provided detailed information such as the name of the company, its business nature (what kind of products it produces), its telephone numbers, fax numbers and email address, and its contact name and so forth. Another major reason for using these sources was that the data in these sources are kept up-to-date, which reduced the possibility of failing to contact a company due to an address change.

### 5.2.8 Scales

As a result of the lack of adequate established scales in operations management, Adam, et al (1989) [222] observed that "theory building seems to be endlessly stalled for want of high quality empirical research". Thus, empirical methods were more appropriate for the investigation of strategic issues in operations management. In order to measure each group, scales comprising multiple items were developed. During the development process, scales that had been used in the literature were utilised to foster the process of validation for the developed scales. The sources of the scales are presented below:

#### 5.2.8.1 Types of Advanced Manufacturing Technology (AMT)

For this study, a firm's technology type was determined by the level of complexity of the technologies contained in its portfolio of technologies. Three technology groups were defined as low complexity, moderate complexity, and

high complexity portfolio firms. Each respondent (i.e. firm) was classified into only one of the three technology portfolios. Typical technologies being used by each of the groups were detailed below:

1. Low complexity: Computer-Aided Design (CAD); Computer Numerical Control (CNC)
2. Moderate complexity: (all technologies in the low complexity group); Just-In-Time (JIT) and/or Manufacturing Recourses Planning (MRPII)
3. High complexity: (all technologies in the moderate complexity group); Flexible Manufacturing Systems (FMS) and/or Computer-Integrated Manufacturing.

Based on literature, a list of 20 advanced technologies was identified. In order to determine which advanced technologies respondents used, scale of 'Yes' or 'No' was provided. In other words, each type of the technologies listed was provided with 'Yes' and 'No' so that respondents were requested to tick 'Yes' for technologies that was used in their organisations.

#### 5.2.8.2 Process of AMT Implementation

The contribution of TLP to the process of AMT implementation was captured by asking the respondents to determine their level of success in phases of the process of AMT implementation. A five-point scale was used to measure the level of success in each phase of the process of AMT implementation (i.e. adoption phase and installation phase). Where 1 represents failure and 5 corresponds to very successful.

#### 5.2.8.3 Barriers/Problems Challenge AMT implementation

From the literature survey, 25 critical problems were identified that manufacturing companies faced when implementing AMT projects. While the list did not purport to capture all problems that affected successful implementation, it was nevertheless sufficiently comprehensive to provide a greater understanding and a framework within which to develop and empirically test the relationship between TLP and AMT investment risks (i.e. the impact of TLP on reduction of AMT implementation problems). Based on literature, the problems that majority of manufacturers faced when invest in AMT projects were organised into four groups including technological/technical barriers, organisational barriers,

manufacturing barriers and strategic barrier. For each item in the questionnaire, subjects responded to a five-point Likert-type scale where 1 = not problem, 2 = minor, 3 = somewhat problematic, 4 = major, and 5 = very major problem. The 5-point scale provided sufficient alternatives along the continuum for respondents to express their opinion.

#### 5.2.8.4 Measurement of Practice Level of TLP

The practice level of TLP was measured using a set of parameters developed mainly from the case study (i.e. several interviews held by this study with Irish experts) (Chapter 4). Some of the parameters presumed by the interviewees were proposed in the literature. The forty-six parameters emerged through the case study were organised into four levels. Each level includes proportion of these parameters. In order to measure the practice level of TLP, the parameters of each level were rephrased as questions so that the respondents were asked to identify the parameters that they practice in their organisations on a five point Likert scale, ranging from 'not practiced' through 'hardly practiced', 'occasionally practiced', 'fairly practiced' to 'regularly practiced'. However, the final scale of each level was constructed by taking the average of its all parameters. For instance, the final scale of the first level was constructed by taking the average of its twelve parameters and was labelled Basic Level (BL). The same procedure was applied to the reminding three levels. Thus, the second level, consisting of thirteen parameters, was termed Average Level (AL), the third level comprising ten parameters and was named Advanced Level (DL), and the fourth Level consisting of thirteen parameters and was called World-Class Level (WCL).

#### 5.2.8.5 Importance Degree of the Developed Parameters of TLP

Same forty-six parameters, which were rephrased into questions to measure practice level of TLP, were recalled to assess the importance of the TLP regardless of practice or neglect. Obviously, participants to this study were requested to assess the importance of the developed parameters of TLP on a five point scale, ranging from 'not important' through 'somewhat', 'moderate', 'important' to 'very important'. This scale was also used to examine the importance of several other issues. For instance, in order to study the encouragements that inspire managers to initiate TLP, the participants of this

research were provided with a list of encouragements and were asked to assess their importance on the same scale described above. The same scale was applied to assess the importance of a list of constraints that discourage managers from investing in TLP.

#### 5.2.8.6 Organisation Performance Measures

Organisation performance criteria were widely discussed in literature. For instance, Voss, (1988) [10] measured the implementation of AMT projects depending on the realisation of benefits such as reduced labour, increased throughput, reduced cycle-time, reduced lead-times, quality improvements, increased flexibility and customer responsiveness, and translation of these benefits into competitive gain in the market place. Others expressed that organisation's failure or success has usually been measured by providing the percent improvements in numerous performance measures [123-128 and 223]. Researchers conducting similar studies have reported that the number of people willing to answer objective questions on performance rather than subjective questions was often dramatically less [224-226]. This was most likely the result of reluctance on the part of respondents to divulge confidential information regarding performance. Therefore, subjective Likert scale questions were used to assess the performance of surveyed organisations.

A composite measure of performance for each firm was achieved using the 15 performance variables listed below: 'Product quality, Scrap and rework', 'Variety of products manufactured', 'Ability to change production lot sizes', 'Number of operators', 'Average labour cost', 'Operator output rates', 'Average numbers of tasks per operator', 'Delivery lead-times', 'Setup times', 'Changeover times', 'Manufacturing lead-times', 'Engineering/design lead-times', 'Time-to-markets', and 'Time for a major design change in an existing product'. These 15 variables were chosen to reflect the competitive priorities of cost, quality, flexibility, and time-based competition. Another major consideration was that the chosen variables should have reflected the capabilities of technologies being surveyed. The composite measure of performance for each firm was achieved using the measurement process described below. Each of the 68 respondents were asked to rate the firm's level of performance on each of the 15 performance

variables on a scale of 1 to 5 (where 1 represented a substantial decline in performance and 5 represented substantial improvement in performance). To test the relationship between TLP and overall organisation performance, only information from the firms that have achieved measurable changes in performance levels was used.

### 5.2.9 Responses Rate of Posted Questionnaire Method

Questionnaires were dispatched through the post to almost all (i.e. 120 firms) pharmaceutical and chemical firms exist in Republic of Ireland. Fourteen returned questionnaires indicating that the organisation did not have advanced manufacturing technologies. Twenty-two were undelivered. Of the remaining 84 organisations, a total of 17 usable questionnaires (or 20 %) were returned. The purpose of this study was to obtain the opinions of, and insight into the perceptions of a strategically important sample of managers. As several researchers [227 and 228] have pointed out, in such situations sample size was less important than experience, competency and objectivity of participants. The testimony of even a single expert informant on a particular topic was still valuable if treated with caution.

### 5.2.10 Barriers to Responses to the Postal Questionnaire

In general, it was believed that the factors that contributed to the relatively low response in this postal survey questionnaires were: 'the length of the questionnaire which contained a list of specific and many closed and open-form questions', 'the time pressures on the managers (i.e., a lack of available time', 'a lack of knowledge regarding the questions being asked', and 'fearing that handing over such information may negatively impact on his/her company'. These reasons were similar to those often cited in the literature for similar studies [225, 226 and 229].

### 5.2.11 Web Page-Based Questionnaire Method

To date, the Internet offered both web page questionnaire (also called online questionnaire) and e-mail for prospective researchers to use for data collection. The online questionnaire tended to collect broad-based data from individuals all over the world. These web page-based questionnaires could collect demographic information, as well as opinion data.

#### 5.2.11.1 Objective of Using Web-based Questionnaire Method

As the postal questionnaire was an ineffective method to invite overseas organisations to participate in this study, a web-based questionnaire was developed. The on-line questionnaire consisted of several functions to assist the respondent in completing the questionnaire including: radio buttons, check boxes, text boxes, and a submit button. Three tools have been used within the web page-based method interface to restrict respondents' choices: radio buttons, check boxes, text boxes, and submit button. Radio buttons were used in multiple-choice questions to which the respondent was enabled to choose only one answer. Radio buttons were useful when the number of choices was relatively small. Because the other choices were automatically deselected when one choice is made, radio buttons reinforced the rule that no more than one answer could given to a question are used in the questionnaire. Check boxes were used in multiple-choice questions to which the respondent was allowed to choose one or more than one answer. Check boxes were useful when it was allowed to select more than one answer. The text boxes were also used to obtain some details from the respondents. The submit button enabled respondents to return the completed form back.

The benefits of using an on-line questionnaire were numerous and some have been noted in the literature:

- A web page-based questionnaire could take advantage of the graphic power available through programming languages such as HTML and JavaScript to create an attractive, interesting, and compelling questionnaire that was inviting to respondents [230].
- Web page-based questionnaires have been noted for their ability to generate a high number of responses.
- This high volume of responses could be collected very quickly. For instance, studies have shown that several hundred responses could be generated over the course of a single weekend [231]. This time factor alone suggested huge benefits over traditional surveying techniques in terms of being able to collect and analyse data quickly, and implement decisions based on the findings.
- The costs of both data collection and analysis could be minimized by the use of web-based questionnaires [231]. Outside of high start-up costs for

equipment and web page design, the actual implementation of a survey could be almost free, with no costs for paper or postage. A direct transfer from the form to the analysis software could simplify data analysis, where limited data cleaning would be necessary [231].

#### 5.2.11.2 Executing a Web Page-based Questionnaire Method

It seemed apparent that web page-based questionnaire was a potentially useful tool for collecting data among domestic and international manufacturing organisations. This section outlined the steps taken to implement the web page-based questionnaire.

1. Step One: Questionnaire Pre-test

   In order to ensure that the online questionnaire was easy to complete, a pre-test was undertaken (see appendix B.1). 15 people including practitioners and academic people were requested to assess and complete this questionnaire. It was found that the time required completing the online questionnaire ranged from 20 to 25 minutes. The pre-test was used for the traditional assessment of validity and comprehension.

2. Step Two: Sampling

   In order to increase the response rate, the same sample of postal questionnaire was targeted. Along with Irish pharmaceutical and chemical firms, several worldwide manufacturing organisations were invited to participate in this study through this method. The information about these organisations is available on-line on [www.kompass.com]. Since the study intended to use an on-line questionnaire, it was not necessary to address the concerns of those organisations that do not use on-line services. Out of the several regions, United Kingdom and United Stated-owned manufacturing organisations were invited to participate in this study.

3. Step Three: Solicitation

   One week before the online questionnaire was sent out, each prospective sample member received a solicitation to participate in the study via e-mail (consult Appendix C.1). Mehta, et al (1995) [232] believed that with electronic e-mail questionnaires, notification is imperative: unsolicited e-mail questionnaires were “clearly unacceptable”.

4. Step Four: Administration

   A week after the notification message, the actual online questionnaire was e-mailed to both 120 Irish pharmaceutical and chemical firms and 100 EU and US manufacturing organisations. Instructions on completing the online questionnaire gave the respondent the option of returning the questionnaire either via e-mail or postal mail. Because e-mail messages contained the name of the respondent included on the message, respondents were guaranteed confidentiality. Response-O-Matic (ROM) was used in to administer the online questionnaire. ROM is a free form processor for HTML authors who desire to add forms to their web pages. Respondents received e-mail messages, which included a hyperlink to the on-line questionnaire [http://www.student.dcu.ie/~dabnoom2/TLP.htm]. This e-mail message asked respondents to visit the website and complete the survey.

   Once the respondent completed the online questionnaire and clicked on the submit button, the contents of the questionnaire form would be sent to the ROM for processing. ROM e-mailed the respondents' answers to the author and displayed a thank you page in the respondents' web browsers allowing them to check their answers to the questionnaire form. A hard copy of each questionnaire was printed upon receipt. The electronic copy was saved to a flash memory, and was deleted a few months after the study was completed. The receipt of each respondent's questionnaire was logged, and then the name and other identifying characteristics (e.g. domain name) of the respondent were stripped from the questionnaire.

5. Step Five: Reminder

   Those in the sample who did not respond within a week received a reminder message via e-mail, which included an additional copy of the online questionnaire (see Appendix C.2). These follow-ups have been widely used in postal questionnaires, and tend to increase response rates from eight to forty-eight percent for postal mail. More recent research into electronic mail by Sheehan, et al (1997) [233] indicated that a reminder message increased response rates by 25%.

#### 5.2.11.3 Response Rates of Web Page-based Questionnaire Method

This study found that an on-line questionnaire could be a viable method for administering domestic and international sample. The assessment of the success of the online questionnaire is examined in this section. Overall the response rate to the online questionnaire was 52 responses (54%). One hundred twenty invitations to participate in the online questionnaire were sent via e-mail. Of these 120 invitations, 17 respondents who had responded to this questionnaire through postal method were excluded. 11 were undeliverable. The undelivered reasons were due to full e-mail box and wrong email address. Additionally, 3 individuals who received the invitation declined to participate and another 3 people explained their lack of AMT projects. In total, 86 online questionnaires were sent via e-mail. Several reminder messages with an additional copy of the online questionnaire were sent to those recipients who had not replied one week after the initial mailing of the survey (Appendix C.2). In total, 56 responses were received, resulting in a 65% response rate. Of these 56 responses, five were unusable and eliminated from the study, resulting in a final sample size of 51 responses resulting in 59% response rate. In terms of pharmaceutical and chemical firms in Republic of Ireland, combination of the responses of both postal and online questionnaire methods was led to significant response rate that results in 68 responses, equals to 57% of all (120) Irish pharmaceutical and chemical firms. Noteworthy, no response was received from international organisations.

### 5.2.12 Evaluate the Research

It was important to define the research quality criteria early in the process in order to ensure that the appropriate tactics were adopted [165 and 234]. This section defined the specific criteria and corresponding research tactics adopted by the researcher. This research combined case study with survey research strategies. It was, therefore, important to consider the criteria for judging the quality of these two approaches when assessing the final research outcomes.

The criteria that were used to evaluate the quality of this research were construct validity [165, 158 and 234], internal validity [158, 165, 177, 172, 171 and 234], external validity [158, 164, 165, 177, 172, 171, and 234] and reliability

[158, 165, 177, and 234]. Each of these criteria was described in more detail when doing the final evaluation of this research at the end of this Chapter.

## 5.3 DATA PROCESSING

Once the responses started to trickle in, the process of editing and entering data into the computer was initiated. This task was made easy as most of the questions were pre-coded. There were four main steps: establish database; data entry; data analysis and generate report and documentation. The computer software used in the data entry and processing was SPSS (Statistical Package for the Social Sciences) for windows Release 14.0. SPSS was one of the most widely available and powerful statistical software packages.

SPSS is an integrated system of computer programmes designed for the analysis of social science data. The system provides a unified and comprehensive package that enables the user to perform many different types of data analysis in a simple and convenient manner. SPSS allows a great deal of flexibility in the format of data. It provides the user with a comprehensive set of procedures for data transformation and file manipulation, and it offers the researcher a large number of statistical routines commonly used in the social sciences [235].

In SPSS, data-management facilities can be used to modify a file of data permanently and can also be used in conjunction with any of the statistical procedures. These facilities enable the user to generate new variables (mathematical and/or logical combinations of existing variables) to record variables, and to sample, select, or weight specified cases. Furthermore, the user can add to or alter the data cases or the data-descriptional information in the file, such as labels, missing-value codes, etc [236].

SPSS enables the social scientist to perform an analysis through the use of natural language control statements. The text is a complete instructional guide to SPSS and is designed to make the system easily accessible to users with no prior computer experience. SPSS does three basic things for the user [235]:

- It helps users to store and organise their data,
- It helps users to manipulate their data, and
- It allows users to analyse this data using statistical procedures.

SPSS It covers a broad range of statistical procedures that allow the users to summarize data (e.g., compute means and standard deviations), determine whether there are significant differences between groups, examine relationships among variables, and graph results (e.g., bar charts, line graphs).

### 5.3.1 Statistical Tools and Analysis

Quantitative research involved measurement, usually of a number of variables, and across a sample. In addition to the usual descriptive statistics, simple frequency distributions, and cross-tabulations, SPSS used in this study contained procedures for analytical tools and analysis. It covered a broad range of statistical procedures that allowed summarizing data (e.g., compute *M*ean and *S*tandard *D*eviations), tested reliability and validity of the data, determined whether there are significant differences between groups, as well as to examining the relationships among variables (for both ordinal and interval data). In presenting the statistical procedures contained in SPSS, the focus was particularly on the statistical procedures and techniques that were used in this research.

### 5.3.2 Statistical Terminology

In discussing this research throughout this report, certain technical terms and statistic terminologies was used. Many of them were self-explanatory, and required no special consideration. However, there were terms or terminologies which were part of a somewhat specialized vocabulary of statistical research. They were discussed here, to clarify their usage. These terms and their short description were given [163 and 237]:

- Empirical:

  An *empirical* is a central term in this thesis. According to Ragin, (1994) [238], an *empirical* means that something (or its impacts) is observable, where '*observation*' is broadly interpreted. The essential idea is to use observable, real world experience, evidence and information as the way of developing and testing ideas. Ragin, (1994) [238] referred *Empiricism* as a philosophical position which sees observation as the foundation of scientific knowledge. Punch, (1998) [163] preferred the general term "data" to describe this evidence and information in a research context.

- Data

A *data set* is the measurements that are made on the subjects of an experiment.

- Statistic

  A *statistic* is a number calculated on sample data that quantifies a characteristic of the sample.

- Population

  A *population* is the complete set of individual, objects or scores that the investigator is interested in studying. In an actual experiment, the population is the larger group of individuals from which the subjects run in the experiment have been taken.

- Sample

  A *sample* is a subset of the population. In an experiment, for economical reasons, the investigator usually collects data on a smaller group of subjects that the entire population.

- Variable

  A *variable* is any property or characteristic of some event, object or person that may have different values at different times depending on the conditions.

- Independent variable

  The *independent variable* in an experiment is the variable that is systematically manipulated by the investigator. In most experiments, the investigator is interested in determining the effect that one variable has on one or more variables.

- Dependent variable

  The *dependent variable* in an experiment is the variable that the investigator measures to determine the effect of the independent variable.

### 5.3.3 *M*ean, *S*tandard *D*eviation and *V*ariance

The *Mean* is the average score of any group on a test, as common measures of central tendency. It is often of interest to compare the mean scores of different group on a test. The *M*ean, $X$, is given by the sum of all scores on the test divided by the number of the sample [239].

As with central tendency, statisticians have developed several ways to measure the variance in a set of measurement. One of the common measure of variability is the *standard deviation*. It goes with the mean because the deviations involved are deviations of individual measurements from the mean of the distribution. It summarizes the variability in a set of data where the more spread out the scores, the larger the standard deviation. From the standard deviation, the *variance* is obtained. The variance is the square of the standard deviation, which can give a numerical estimate of the amount of spread in the data [163]. In this research study, the *M*ean values were used for comparing the elements by using the SPSS Descriptive Statistics procedure.

### 5.3.4 Frequency Distribution

In addition to the *M*ean, *S*tandard *D*eviation and *V*ariance, *frequency distributions* are a useful way to summarize and understand data [163]. The individual scores in the distribution are tabulated, where absolute numbers and/or percentages may be used. The results can be presented as frequency distribution tables or as graphs such as histograms, bar charts, frequency polygons, pie charts forms.

### 5.3.5 Reliability Analysis

In this research study, an internal consistency reliability analysis was performed for the elements by using the SPSS Scale Reliability analysis procedure.

### 5.3.6 Validity Test

The construct validity for each elements measured in this study was evaluated by factor analysing using SPSS Data Reduction and Factor Analysis procedure [240]. The steps used in performing this analysis were performed using the guidelines provided by Saraph et al (1989) [241].

### 5.3.7 Factor analysis

The SPSS Data Reduction and Factor Analysis procedure and steps are used in performing the analysis [240]. According to Kline, (1994) [239], factor analysis consists of a number of statistical techniques the aim of which is to simplify complex sets of data. A factor is a construct operationally defined by its factor loadings. Factor loadings are defined as the correlations of a variable with a factor [239].

Factor analysis is a much more generalized procedure for locating and defining dimensional space among a relatively large group of variables. Because of the generality of factor analysis, it is difficult to present a capsule description of its functions and applications. The major use of factor analysis by social scientists is to locate a smaller number of valid dimensions, clusters, or factors contained in a larger set of independent items or variables. Factor analysis can help determine the degree to which a given variable or several variables are part of a common underlying phenomenon [236]. Kim, et al (1978) [242] also defined factor analysis as follows: factor analysis is a statistical technique used to discover which of the elements or variables in a sample population vary together and therefore may be candidates for grouping together into groups called components or factors.

Prior to the factor analysis, the Kaiser-Meyer-Olkin test (KMO) test is performed. The KMO measures of sampling adequacy is a statistic which indicates the proportion of variance in the variables which is common variance, i.e. which might be caused by underlying factors. The value of KMO test indicates the suitability of the data for factor analysis. As mentioned earlier, the high values (close to 1.0) generally indicate that a factor analysis may be useful with the data. If the value is less than 0.50, the results of the factor analysis probably won't be very useful [240 and 242].

Factor analysis is ideal to use where data are complex and it is uncertain what the most important variables in the field are. It is usual to regard factor loadings as high if they are greater than 0.6 and moderately high if they are above 0.3 [239].

### 5.3.8 T-test

Based on the results of *t*-test, any independent variable that did not exceed the significance level of 0.5% was used to explain the variability in the dependent variable. The t statistics could help to determine the relative importance of each variable in the model. As a guide regarding useful predictors, t values should have been below -2 or above +2 [239 and 240].

### 5.3.9 Inference Analysis

Inference or expectation is a probability statement which states the idea that science involves making decisions or drawing conclusions under conditions of uncertainty based on prior data experience or theory [243]. Fundamental to statistical inference is the fact that in research, as in all the science, one can never know the truth about something. All one can do is make an approximation or estimation or expectation [243]. Inference analysis is a kind of deductive reasoning approach. It is a process of analysing the sample and assuming that the other data in the population, which have not been seen, are similar to the data in the population, which have been seen [244].

## 5.4 SURVEY RESEARCH RESULTS AND DISCUSSION

The quantitative data, obtained through the methods addressed above, are analysed and discussed throughout the following sections. In order to make the research results more understandable, the following sections are entirely dedicated to analyse and discuss the results obtained from the quantitative (i.e. Postal and Online Questionnaires) method. The following sections explain the results of the statistical analysis that is conducted to test the five hypotheses proposed in Chapter 4, Section 4.5.

### 5.4.1 Characteristics of Surveyed Organisations

The first part of the questionnaire was designed to determine the profile of target companies. The profile of surveyed companies included four items as shown in Table 5.9. The respondents were asked to describe the nature of their business and identify how long they are in this business. The surveyed companies were classified as small, medium or large size depending on their number of employees. A report which was made available through the European Industrial Relations Observatory (EIRO) revealed that there was no single definition of a small firm, mainly because of the wide diversity of businesses. The conventional description of the key characteristics of a small firm remained that used by the government's Bolton Committee in its 1971 Report on Small Firms. This stated that a small firm is an independent business, managed by its owner or part-owners

and having a small market share. The Bolton Report also recognised that what was 'small' would vary according to sector and that, while it may be more appropriate to define size by the number of employees, in some sectors it was more appropriate to use turnover. It was most common, however, to measure size according to numbers of full-time employees or their equivalent Therefore, Using EIRO's [245] classification, a small company was not more than 50 employees, a medium size company was not more than 250 employees, whereas a large company had over 250 employees. The respondents were asked to determine the ownership of their organisations. The respondents were also asked to identify their position within the organisation. Table 5.9 was a cross-tabulation table that provides two-way tables. The structure of the table specified the columns, which represented frequency and ownership of the organisations and the rows represented variables of surveyed organisations including industrial group, foundation year, number of employees in the organisation, and respondent position in the organisation. In other words, Table 5.9 provides the frequency of the four variables of surveyed organisations by their ownership (Irish, EU or US).

A half (50% (34) companies) of the respondents was American owned organisations. Irish and European owned organisations accounted for 23.5% (16) and 26.5% (18) of the respondents respectively. Table 5.9 showed that all 68 respondents were categorised as belonging to the pharmaceutical and chemical industries sector. Table 5.9 also indicated that three quarters (75.0% (51)) of the organisations were established before 1990s, where one quarter (25.0% (17)) of responded organisations were built in and after 1990s. Table 5.9 showed that almost half (47.1%) of surveyed organisations were categorised as large sized organisations. The medium sized organisations accounted for 42.6% of the respondents. Just 10.3% of the respondents were small organisations (i.e., < 50 employee). Therefore, this study dedicated its results and conclusions to medium and large size organisations. One of the most important finding of Table 5.9 was that almost three quarters (73.5%) of the respondents held a senior manager position in their organisations.

Table 5.9 Frequency of the Surveyed Organisations Profile

| Variables | Scales | Frequency by Percentage | | | | |
|---|---|---|---|---|---|---|
| | | Irish | EU | USA | Total | |
| | | | | | No | % |
| Industrial Group | Pharmaceutical & Chemical Industries | 16 | 18 | 34 | 68 | 100.0 |
| Total | | 16 | 18 | 34 | 68 | 100.0 |
| Foundation Year | Before 1970s | 1 | 6 | 7 | 14 | |
| | 1970s | 3 | 4 | 6 | 13 | |
| | 1980s | 9 | 5 | 10 | 24 | |
| | 1990s | 3 | 3 | 10 | 16 | |
| | 2000s | 0 | 0 | 1 | 1 | |
| Total | | 16 | 18 | 34 | 68 | 100.0 |
| Number of Employees in the organisation | Less than 25 | 2 | 1 | 0 | 3 | 4.4 |
| | 25 to 50 | 2 | 2 | 0 | 4 | 5.9 |
| | 51 to 100 | 3 | 2 | 4 | 9 | 13.2 |
| | 101 to 250 | 4 | 7 | 9 | 20 | 29.4 |
| | 251 to 500 | 4 | 3 | 7 | 14 | 20.6 |
| | More than 500 | 1 | 3 | 14 | 18 | 26.5 |
| Total | | 16 | 18 | 34 | 68 | 100.0 |
| Respondent Position in the organisation | Owner | 5 | 3 | 0 | 8 | 11.8 |
| | Manager/Head of Dept | 9 | 13 | 28 | 50 | 73.5 |
| | Engineer/Executives | 1 | 2 | 6 | 9 | 13.2 |
| | Champion | 1 | 0 | 0 | 1 | 1.5 |
| Total | | 16 | 18 | 34 | 68 | 100.0 |
| Would you like to receive the study findings? | No | 2 | 4 | 10 | 16 | 24 |
| | Yes | 14 | 14 | 24 | 52 | 76 |
| Total | | 16 | 18 | 34 | 68 | 100.0 |
| Would you like to be contacted again? | No | 6 | 9 | 12 | 27 | 40 |
| | Yes | 10 | 9 | 22 | 41 | 60 |
| Total | | 16 | 18 | 34 | 68 | 100.0 |

Many researchers stressed that senior managers and top management as a whole are the ones who were charged with the decisions to implement TLP activities and/or invest in AMT projects. Therefore, this finding was a confirmation that the respondents of this study are aware of TLP and AMT implementation and therefore it gave a high credibility for the responses.

Further interesting findings presented in Table 5.9 were that at the end of the questionnaire, this study has posed two questions for participants to assess the importance of the research's subject and to measure the credibility and reliability of their answers to all questions of the survey. To do so, respondents were requested to answer by 'Yes or No' whether they would like to receive the study findings? And also answer by 'Yes or No' whether they would like to be

contacted again? Of course any respondents who were interested in this study would score 'Yes' and look forward to receive the study findings. In relation to the credibility and reliability of the information provided, respondents who would provide credible information would not be hesitated to contacted again and will score 'Yes' to contacted again. Table 5.9 shows that almost all (%76) participants were interested in this research and wish if they could receive a copy of the results of this study. Furthermore, Tables 5.9 also reveals that two thirds (%60) of the participants were willing to be contacted again which was evident that the respondents knew what they were doing and what they were answering.

### 5.4.2 Types of AMT that respondents implemented within their firms

Almost all of the respondents indicated that there had been more than one AMT investment project undertaken within their organisations. Table 5.10 shows the percentage of the respondents that made an investment in AMT projects. In analysing the figures in Table 5.10 it was found that organisations were generally investing in AMT with the aim of providing greater flexibility, higher productivity and quality and better control of processes. For instance, almost all (82.4%) of the surveyed organisations had introduced Computer-Aided Design (CAD), over half (64.7%) of the respondents had implemented Programmable Logic Controllers (PLC), 35.3% of the respondents had made investments in Automated Material Handling System (AMHS), and over one third of the respondents had implemented Computer Aided Engineering (CAE) and Flexible Manufacturing Systems (FMS) (32.4% and 31% respectively).

In Table 5.10, the most frequently advanced technologies in which respondents invested in were 'in order of the frequency' (82.4%) CAD, (77%) Local Area Network (LAN), (71%) Enterprise Resource Planning (ERP), (65%) PLC, (65%) Material Requirements Planning (MRP), (57.4%) Manufacturing Resources Planning (MRPII), (41.2%) Wide Area Network (WAN), (35.3%) AMHS, (34%) Computer For Shop Floor Control (CFSFC), (32.4%) CAE and (31%) FMS.

Table 5.10 also shows that the remaining least invested in AMTs, sorted by lowest to highest frequency, were (9%) Distributed Numerical Control (DNC), (10.3%) Machine Intelligence/Expert System (MI/ES), (10.3%) Automated

Guided Vehicles (AGV), (16.2%) Automated Storage and Retrieval System (AS&RS), (19.1%) Numerical Control (NC), (21%) Manufacturing Systems Simulation Software (MSSS), (22.1%) Total Quality Management (TQM), (27%) Computer Integrated Manufacturing (CIM), (28%) Just-In-Time (JIT), (29.4%) Robotics, (29.4%) Computer Numerical Control (CNC), and (29.4%) Computer Aided Manufacturing (CAM). Generally, it was found that Irish-owned organisations were equally likely to invest in the AMT projects as American and European-owned organisations.

Table 5.10 Frequency of Size and Nature of the investment in AMT projects

| AMTs that Participants Implemented | Options | | Ownership | | | Total |
|---|---|---|---|---|---|---|
| | | | Irish | EU | USA | |
| Computer Aided Design | No | Count | 3 | 5 | 4 | 12 |
| | | % of Total | 4.4% | 7.4% | 5.9% | 17.6% |
| | Yes | Count | 13 | 13 | 30 | 56 |
| | | % of Total | 19.1% | 19.1% | 44.1% | 82.4% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Computer Aided Manufacturing | No | Count | 12 | 11 | 25 | 48 |
| | | % of Total | 17.6% | 16.2% | 36.8% | 70.6% |
| | Yes | Count | 4 | 7 | 9 | 20 |
| | | % of Total | 5.9% | 10.3% | 13.2% | 29.4% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Numerical Control Machines | No | Count | 13 | 13 | 29 | 55 |
| | | % of Total | 19.1% | 19.1% | 42.6% | 80.9% |
| | Yes | Count | 3 | 5 | 5 | 13 |
| | | % of Total | 4.4% | 7.4% | 7.4% | 19.1% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Computer Numerical Control | No | Count | 7 | 12 | 29 | 48 |
| | | % of Total | 10.3% | 17.6% | 42.6% | 70.6% |
| | Yes | Count | 9 | 6 | 5 | 20 |
| | | % of Total | 13.2% | 8.8% | 7.4% | 29.4% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Direct Numerical Control | No | Count | 15 | 15 | 32 | 62 |
| | | % of Total | 22.1% | 22.1% | 47.1% | 91.2% |
| | Yes | Count | 1 | 3 | 2 | 6 |
| | | % of Total | 1.5% | 4.4% | 2.9% | 8.8% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |

| | | | | | | |
|---|---|---|---|---|---|---|
| Automated Material Handling Systems | No | Count | 12 | 11 | 21 | 44 |
| | | % of Total | 17.6% | 16.2% | 30.9% | 64.7% |
| | Yes | Count | 4 | 7 | 13 | 24 |
| | | % of Total | 5.9% | 10.3% | 19.1% | 35.3% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Computer Aided Engineering | No | Count | 11 | 12 | 23 | 46 |
| | | % of Total | 16.2% | 17.6% | 33.8% | 67.6% |
| | Yes | Count | 5 | 6 | 11 | 22 |
| | | % of Total | 7.4% | 8.8% | 16.2% | 32.4% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Robotics | No | Count | 10 | 14 | 24 | 48 |
| | | % of Total | 14.7% | 20.6% | 35.3% | 70.6% |
| | Yes | Count | 6 | 4 | 10 | 20 |
| | | % of Total | 8.8% | 5.9% | 14.7% | 29.4% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Automated Guided Vehicles | No | Count | 16 | 15 | 30 | 61 |
| | | % of Total | 23.5% | 22.1% | 44.1% | 89.7% |
| | Yes | Count | 0 | 3 | 4 | 7 |
| | | % of Total | .0% | 4.4% | 5.9% | 10.3% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Automated Storage and Retrieval System | No | Count | 14 | 17 | 26 | 57 |
| | | % of Total | 20.6% | 25.0% | 38.2% | 83.8% |
| | Yes | Count | 2 | 1 | 8 | 11 |
| | | % of Total | 2.9% | 1.5% | 11.8% | 16.2% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Flexible Manufacturing Systems | No | Count | 13 | 13 | 21 | 47 |
| | | % of Total | 19.1% | 19.1% | 30.9% | 69.1% |
| | Yes | Count | 3 | 5 | 13 | 21 |
| | | % of Total | 4.4% | 7.4% | 19.1% | 30.9% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Computer Integrated Manufacturing | No | Count | 15 | 15 | 20 | 50 |
| | | % of Total | 22.1% | 22.1% | 29.4% | 73.5% |
| | Yes | Count | 1 | 3 | 14 | 18 |
| | | % of Total | 1.5% | 4.4% | 20.6% | 26.5% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |

| | | | | | | |
|---|---|---|---|---|---|---|
| Material Requirements Planning | No | Count | 4 | 12 | 8 | 24 |
| | | % of Total | 5.9% | 17.6% | 11.8% | 35.3% |
| | Yes | Count | 12 | 6 | 26 | 44 |
| | | % of Total | 17.6% | 8.8% | 38.2% | 64.7% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Manufacturing Resource Planning | No | Count | 6 | 11 | 12 | 29 |
| | | % of Total | 8.8% | 16.2% | 17.6% | 42.6% |
| | Yes | Count | 10 | 7 | 22 | 39 |
| | | % of Total | 14.7% | 10.3% | 32.4% | 57.4% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Enterprise Resource Planning | No | Count | 3 | 7 | 10 | 20 |
| | | % of Total | 4.4% | 10.3% | 14.7% | 29.4% |
| | Yes | Count | 13 | 11 | 24 | 48 |
| | | % of Total | 19.1% | 16.2% | 35.3% | 70.6% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Total Quality Management | No | Count | 14 | 16 | 23 | 53 |
| | | % of Total | 20.6% | 23.5% | 33.8% | 77.9% |
| | Yes | Count | 2 | 2 | 11 | 15 |
| | | % of Total | 2.9% | 2.9% | 16.2% | 22.1% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Just-In-Time | No | Count | 12 | 15 | 22 | 49 |
| | | % of Total | 17.6% | 22.1% | 32.4% | 72.1% |
| | Yes | Count | 4 | 3 | 12 | 19 |
| | | % of Total | 5.9% | 4.4% | 17.6% | 27.9% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Machine Intelligence/Expert Systems | No | Count | 16 | 17 | 28 | 61 |
| | | % of Total | 23.5% | 25.0% | 41.2% | 89.7% |
| | Yes | Count | 0 | 1 | 6 | 7 |
| | | % of Total | .0% | 1.5% | 8.8% | 10.3% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Programmable Logic Controllers (PLC) | No | Count | 5 | 10 | 9 | 24 |
| | | % of Total | 7.4% | 14.7% | 13.2% | 35.3% |
| | Yes | Count | 11 | 8 | 25 | 44 |
| | | % of Total | 16.2% | 11.8% | 36.8% | 64.7% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |

| | | | | | | |
|---|---|---|---|---|---|---|
| Local Area Network (LAN) | No | Count | 3 | 6 | 7 | 16 |
| | | % of Total | 4.4% | 8.8% | 10.3% | 23.5% |
| | Yes | Count | 13 | 12 | 27 | 52 |
| | | % of Total | 19.1% | 17.6% | 39.7% | 76.5% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Wide Area Network (WAN) | No | Count | 13 | 9 | 18 | 40 |
| | | % of Total | 19.1% | 13.2% | 26.5% | 58.8% |
| | Yes | Count | 3 | 9 | 16 | 28 |
| | | % of Total | 4.4% | 13.2% | 23.5% | 41.2% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Computers For Shop Floor Control | No | Count | 12 | 13 | 20 | 45 |
| | | % of Total | 17.6% | 19.1% | 29.4% | 66.2% |
| | Yes | Count | 4 | 5 | 14 | 23 |
| | | % of Total | 5.9% | 7.4% | 20.6% | 33.8% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |
| Manufacturing Systems Simulation Software | No | Count | 14 | 14 | 26 | 54 |
| | | % of Total | 20.6% | 20.6% | 38.2% | 79.4% |
| | Yes | Count | 2 | 4 | 8 | 14 |
| | | % of Total | 2.9% | 5.9% | 11.8% | 20.6% |
| Total | | Count | 16 | 18 | 34 | 68 |
| | | % of Total | 23.5% | 26.5% | 50.0% | 100.0% |

### 5.4.3 Problems/Barriers of Implementation of AMT Projects

Based on previous literature, this research had identified a list of 25 problems that were believed to hinder the implementation of AMT projects (refer to chapter 2, section 2.3.2). The participants to this study were provided with this list of 25 problems and barriers and requested to determine their weight in their organisations on a five-point scale starting from 'Not Problem through Minor, Somewhat Problematic, Major Problem to Very Major Problem'. After several statistical tests were carried out, the statistical results showed that out of 25 problems, 10 problems were found to significantly occurring during the implementation of AMT projects. As can been seen from the following four Tables 5.11, 5.12, 5.13 and 5.14, these 10 problems were 'Lack of integration of Manufacturing Information Systems (MIS)', 'Lack of integration across functions', 'Problems with interconnection of equipment', 'Obsolescence of technology', 'Underestimation of on-going support of the information services

department', 'Inadequate communication networking among system components', 'AMT skill deficiencies', 'Failure to recognise the resources needed to maintain the system', 'Disruptions during implementation', and 'A conflict between short-time production requirements and long-term goals'.

Table 5.11 Technological/Technical Problems Challenge AMT implementation

| | | Problems with interconnection of equipment | Lack of integration of Manufacturing Information Systems | Lack of integration across functions | Obsolescence of technology |
|---|---|---|---|---|---|
| Not Problem | | 4.6 | 6.2 | 9.2 | 13.8 |
| Minor | | 32.3 | 16.9 | 21.5 | 29.2 |
| Somewhat Problematic | | 55.4 | 52.3 | 41.5 | 43.1 |
| Major | | 7.7 | 21.5 | 27.7 | 13.8 |
| Very Major | | | 3.1 | | |
| Total | | 100.0 | 100.0 | 100.0 | 100.0 |
| N | Valid | 65 | 65 | 65 | 65 |
| | Missing | 3 | 3 | 3 | 3 |
| Mean | | 2.66 | 2.99 | 2.88 | 2.57 |
| Std. Dev | | .691 | .875 | .927 | .901 |

Table 5.12 Organisational Problems Challenge AMT implementation

| | | Lack of the necessary discipline on the shop-floor | Failure to remove organisational barriers between functional areas | Inadequate communication networking among system components | Discouragement and initial hesitation of senior management to provide full support | Underestimation of on-going support of the information services department | Poor communication between senior management and other departments |
|---|---|---|---|---|---|---|---|
| Not Problem | | 16.9 | 20.0 | 16.7 | 30.3 | 13.6 | 18.2 |
| Minor | | 43.1 | 53.8 | 31.8 | 39.4 | 39.4 | 51.5 |
| Somewhat Problematic | | 24.6 | 18.5 | 42.4 | 22.7 | 31.8 | 25.8 |
| Major | | 13.8 | 6.2 | 7.6 | 7.6 | 12.1 | 4.5 |
| Very Major | | 1.5 | 1.5 | 1.5 | | 3.0 | |
| Total | | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| N | Valid | 65 | 65 | 66 | 66 | 66 | 66 |
| | Missing | 3 | 3 | 2 | 2 | 2 | 2 |
| Mean | | 2.40 | 2.15 | 2.46 | 2.08 | 2.52 | 2.17 |
| Std. Dev | | .981 | .870 | .915 | .917 | .981 | .776 |

Table 5.13 Manufacturing Problems Challenge AMT implementation

| | | Production management skill deficiencies | AMT skill deficiencies | Problems with outside SW development consultants | Adverse effect on workflow | Opposition by workforce and staff | Lack of effective training programs of support personnel and production staff | Uncertainty and disagreement of engineers about the required changes | Failure to recognise the resources needed to maintain the system (i.e. engineers etc) |
|---|---|---|---|---|---|---|---|---|---|
| Not Problem | | 21.2 | 7.6 | 10.6 | 16.7 | 30.3 | 22.7 | 24.2 | 13.6 |
| Minor | | 42.4 | 37.9 | 43.9 | 47.0 | 47.0 | 33.3 | 50.0 | 37.9 |
| Somewhat Problematic | | 31.8 | 34.8 | 30.3 | 31.8 | 21.2 | 33.3 | 22.7 | 31.8 |
| Major | | 4.5 | 19.7 | 13.6 | 4.5 | 1.5 | 10.6 | 3.0 | 13.6 |
| Very Major | | | | 1.5 | | | | | 3.0 |
| Total | | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| N | Valid | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 |
| | Missing | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Mean | | 2.20 | 2.67 | 2.52 | 2.24 | 1.94 | 2.32 | 2.05 | 2.55 |
| Std. Dev | | .827 | .883 | .916 | .786 | .762 | .947 | .773 | .995 |

Table 5.14 Strategic Problems Challenge AMT implementation

| | | Failure to adapt to and plan for continuous change over time | Disruptions during implementation | Changing priorities in manufacturing function | Lack of co-ordination with the company's strategic plan | Implementation without an appropriate manufacturing strategy | Failure to achieve financial targets | Changes in the marketplace during the implementation process | A conflict between short-time production requirements and long-term goals |
|---|---|---|---|---|---|---|---|---|---|
| Not Problem | | 15.2 | 7.6 | 24.2 | 34.8 | 34.8 | 40.9 | 27.7 | 15.4 |
| Minor | | 45.5 | 47.0 | 45.5 | 40.9 | 33.3 | 28.8 | 38.5 | 44.6 |
| Somewhat Problematic | | 28.8 | 34.8 | 24.2 | 18.2 | 28.8 | 21.2 | 29.2 | 18.5 |
| Major | | 7.6 | 10.6 | 6.1 | 4.5 | 1.5 | 9.1 | 4.6 | 20.0 |
| Very Major | | 3.0 | | | 1.5 | 1.5 | | | 1.5 |
| Total | | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| N | Valid | 66 | 66 | 66 | 66 | 66 | 66 | 65 | 65 |
| | Missing | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| Mean | | 2.38 | 2.49 | 2.12 | 1.97 | 2.02 | 1.99 | 2.11 | 2.48 |
| Std. Dev | | .941 | .789 | .851 | .929 | .920 | 1.000 | .868 | 1.03 |

An interesting finding was that several major problems with which respondents faced were related to TLP. For instance, the respondents who complained from the lack of integration of MIS were basically complaining from the lack of TLP. The IS/IT was a backbone for TLP (i.e. collecting and distributing information within and external the origination). The same was also applied on the respondents who were complaining of 'underestimation of on-going support of the information services department' and 'inadequate communication networking among system components'. These functions were very important activities in promoting TLP.

### 5.4.4 The Importance-Practice Grid Methodology

This part of the research followed the methodology of Naude et al. (1990) [246] and Naude et al (1998) [247] in studying the relationship between the importance of different parameters in a manager's operational environment, and the extent to which a manager could control them. Managers' tasks demanded attention to important issues, but Naude et al. (1990) [246] showed that, particularly in transitional environments, managers frequently found themselves without sufficient control of these parameters. The importance-practice grid methodology enabled the authors of this study to isolate individual parameters and to study their influence on the management of AMT projects. By plotting the scores on a grid, the following distinct areas may be identified:

- Core parameters, which managers widely practiced them and saw as the most important; these parameters required the greatest management time, effort and planning,
- Complex parameters, which were hardly practiced but perceived as being very important,
- Simple parameters, which were practiced but of lesser importance, and
- Peripheral parameters, which were generally of limited practice and of little importance.

The importance-practice grid provided a useful methodology for identifying areas of potential managerial conflict, and can be extended to suggest action that would enhance to establish an accurate measurement for TLP. The terms core, complex, simple and peripheral were labels for easy reference to the quadrants.

Such labels cannot fully describe all possible combinations of complexity, importance, frustration, control and other challenges in managerial decision-making. The form of the importance-practice grid was shown in the following Figures on which the scores of TLP parameters have also been plotted.

The importance-practice grid depicted the degree of alignment between importance and practice: the greater the distance of an activity from the diagonal, the larger the degree of imbalance. This was likely to lead to frustration or inappropriate managerial intervention. The frustrating extremes for managers occurred in quadrants two and four. Naude et al., (1990) [246] explained that spending time and efforts on "simple parameters" (second quadrant) represented poor utilisation of managerial resources. On the other hand, managers wished to practice "complex parameters" (fourth quadrant), but often find themselves unable to do so.

In using the framework to analyse managerial perceptions, Naude et al., (1990) [246] demonstrated that first quadrant representing a balance between importance and practice is expected to be relatively stable. Parameters in other quadrants may have responded to long-term trends or unexpected events, which result in repositioning, particularly in the fourth quadrant, where high importance is not associated with corresponding practice. The resulting misalignment would require conscious management efforts to increase practice over these parameters. The challenge was then to address those parameters that, over time, moved from the diagonal into the fourth quadrant "complex quadrant". The discussion below concentrated on those parameters that reflected greater degrees of imbalance.

### 5.4.5 Levels of Technology Learning Process (TLP)

As demonstrated in Chapter 4, the interviewed managers suggested 46 parameters, which included most of the parameters organisations usually conducted to learn about trends and developments of new technologies. These 46 parameters were organised into four levels namely Basic Level, Average Level, Advanced Level, and World-Class Level. To examine how important these parameters were and to what extent these parameters were practiced, the importance-practice grid methodology was used. Parameters in each level of TLP were separately plotted on this Grid and the results were shown in the following sections.

#### 5.4.5.1 Parameters of Basic Level of TLP

The *M*ean importance and practice scores for the 12 parameters of the basic level of TLP are presented in Figure 5.14 (i.e. the importance-practice grid diagram). As can be seen from Figure 5.14, six parameters including '3, 7, 8, 10, 11, and 12' appeared in the First Quadrant (i.e. Peripheral Quadrant). These items are '(3) Check government sources that detail information on foreign & domestic investments', '(7) Join local chambers of commerce', '(8) Subscribe to the local press and check the local newspaper', '(10) Collaborate with stockbrokers who made deeply studies of a competitor', '(11) Keep track of the prospectus that reveals the major stockholders along with financial and organisational details', and '(12) Contact and visit the investment banks'. This was not unexpectedly because the interviewed managers didn't put mush weight over these parameters. However, the remaining parameters including '1, 2, 4, 5, 6, and 9' were fallen in the Core Quadrant (i.e. Third Quadrant) in the importance-practice grid. These parameters are '(1) Cooperate with suppliers that offer valuable information', '(2) Cooperate with customers/users', '(4) Participate in activities of professional associations', '(5) Participate in activities of trade associations', '(6) Scrutinize business literature and variety of periodicals', and '(9) Subscribe and review trade press'. Obviously, it was found that the six parameters located in the core quadrant were statistically the most significant among the parameters of basic level. Therefore, these six parameters were not only important but must have been practiced to learn about the developments of new technologies.

#### 5.4.5.2 Parameters of Average Level of TLP

The average level of TLP consisted of 13 parameters. The scores of these parameters were plotted on importance-practice grid. Figure 5.15 showed that apart from two parameters in the peripheral quadrant (i.e. First Quadrant) namely: '(4) Create informal discussion networks through intranet discussion platforms' and '(11) Use a Watch List to spot irregularities in the environment'. All parameters of the Average Level lied in the core and complex quadrants (i.e. Third and Fourth Quadrants).

As shown in Figure 5.15, the parameters including '5, 7, 8, 9, 10, and 13' had positioned in complex quadrant. The six parameters of the complex quadrant

were ‘(5) Rotate jobs among employees in order to strengthen the informal technological learning networks’, ‘(7) Provide members with extra travel budget to update your company with the latest developments of its technology’, ‘(8) Use Technology Roadmaps as a tool to learn and/or anticipate future tends of the new technologies’, ‘(9) Use a Balanced Scorecard to improve critical areas such as technology, product, process, and market development’, ‘(10) Use Listening Posts to get some feedback from customers & partners’, ‘(13) Conduct a sensitivity/risk analysis’. All surveyed managers agreed that the above six parameters were of high importance in learning about trends and developments of new technologies. Therefore, top management in manufacturing organisations must place heavily time, efforts and money to practice these parameters.

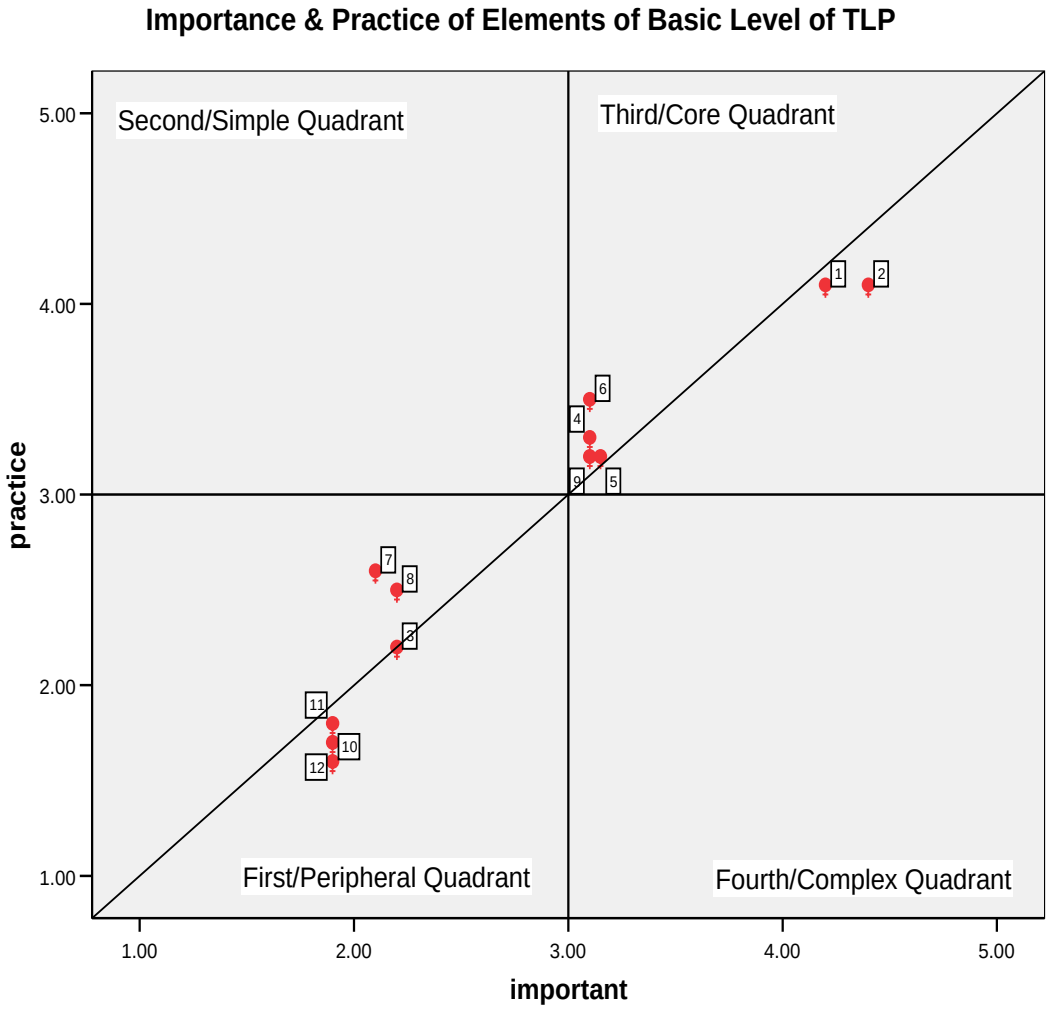


Figure 5.14 Importance-Practice Grid for Parameters of Basic Level of TLP

In addition, Figure 5.15 also showed that the remaining parameters including '1, 2, 3, 6, and 12' were situated in core quadrant (Third Quadrant). This is an indication that these five parameters were key players to predict the opportunities and threats of new technologies. These five parameters were as following: '(1) Participation of employees in the company's strategy (e.g. innovation need) through informal searching and learning activities', '(2) Use IT such as Bulletin Board System and E-mails', '(3) Accessibility to the Internet', '(6) Clearly establish communication routines to pass on the trends and developments of new technologies to top management', and '(12) Benchmark key competitors'.

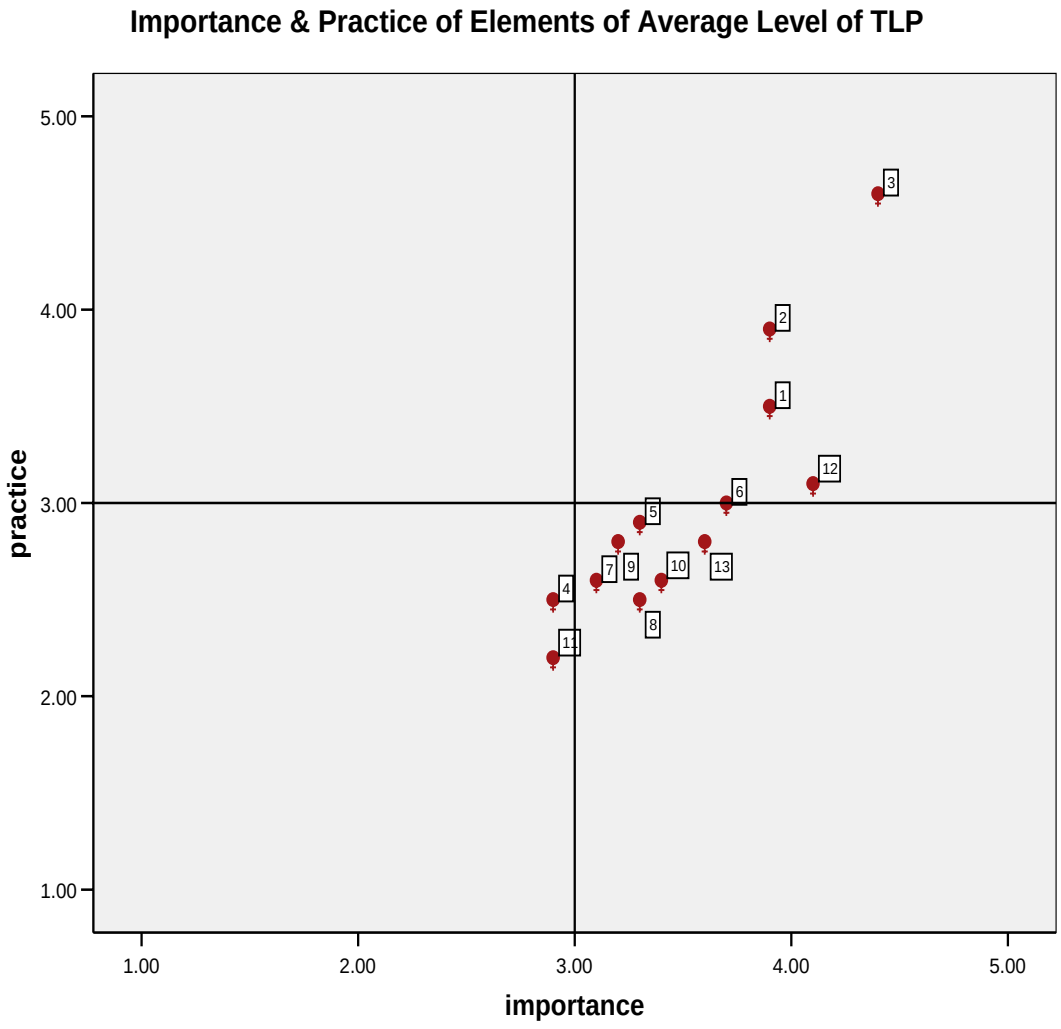


Figure 5.15 Importance-Practice Grid for Parameters of Average Level of TLP

### 5.4.5.3 Parameters of Advanced Level of TLP

Third level of TLP was termed by the authors of this research as advanced level. The advanced level comprised ten parameters. The practice level and the importance degree of these ten parameters were examined by using the Importance-Practice Grid. As a result of using this grid, Figure 5.16 showed that the ten parameters of advanced level of TLP were organised into two quadrants that is Core and Complex Quadrants.

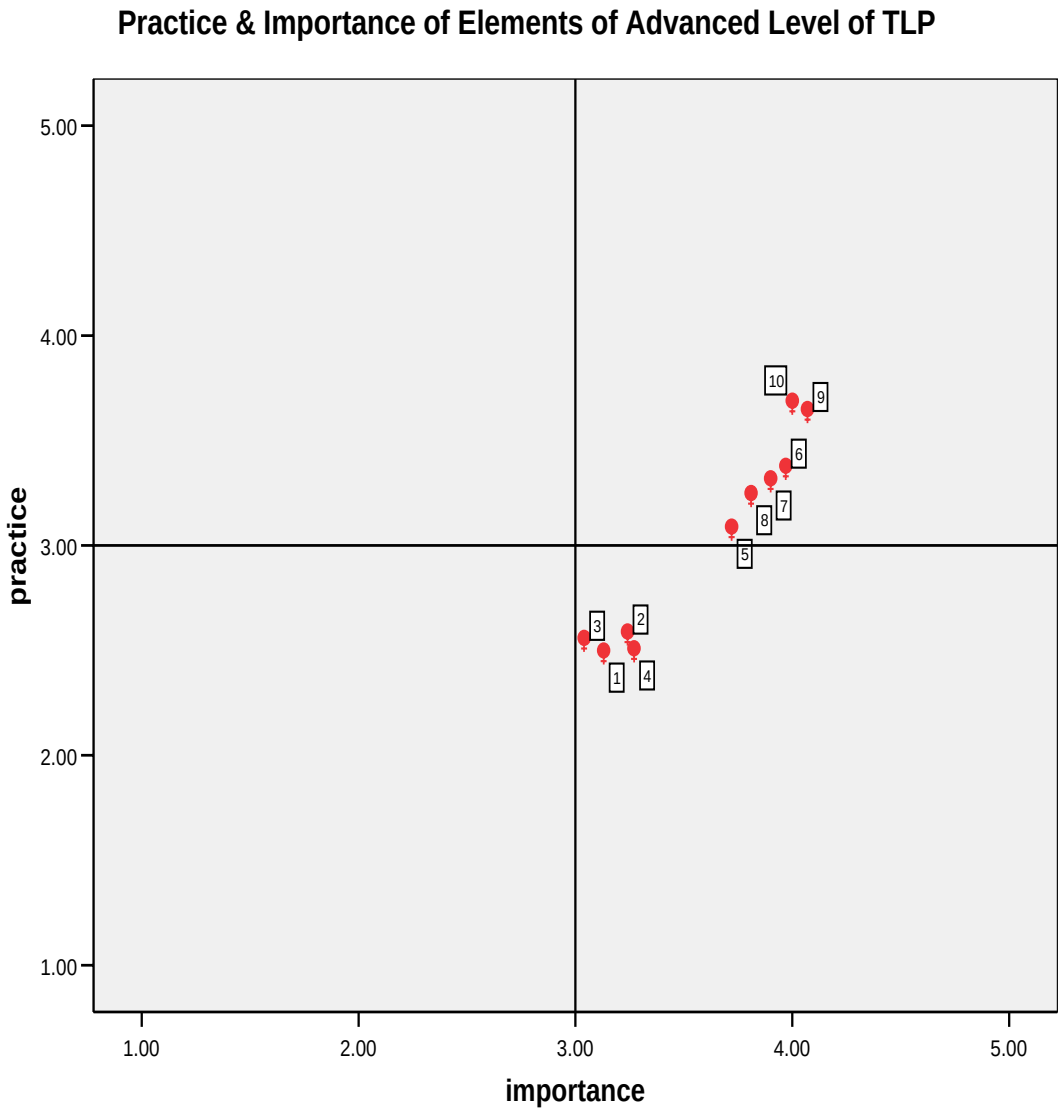


Figure 5.16 Importance-Practice Grid for Parameters of Advanced Level of TLP

The core quadrant comprised six parameters including: '(5) Share knowledge, whether formal or informal, within the R&D Dept', '(6) Share information among depts (i.e. formal and informal knowledge sharing among R&D, production, and marketing Depts)', '(7) Gain support and commitment of top management to anticipate technological breakthrough and global changes', '(8) Keep a constant balance between human resource planning and learning strategy in the organisation', '(9) Recruit high levels of education, skills, and experience among employees to manage technological learning', and '(10) Provide training programmes for employees to improve technological learning'. The respondents revealed that they were practicing these six parameters because they were very important to cope with rapid changes of new technologies.

As can be seen from Figure 5.16, the remaining four parameters were placed in the complex quadrant. The four parameters found in the complex quadrant are as follows: '(1) Establish a suitable pyramidal structure of R&D personnel', '(2) Build a reliable and accessible database as a result of your yearly accumulation of R&D documents', '(3) Use R&D documents in comparison to other documents', and '(4) Acquire up-to-date R&D tools'. All respondents stress that the above four (1, 2, 3 and 4) parameters were of great importance. As a consequence, the parameters 1, 2, 3 and 4 stated above must be received more attention of top management and try to implement them to improve TLP output.

Generally, it was found that although six of ten parameters were practiced, all parameters of the advanced level of TLP were described as very important to learn about the changes and the developments of new technologies.

#### 5.4.5.4 Parameters of World-Class Level of TLP

World-Class Level of TLP included eleven parameters. Practicing of these parameters indicates that participants were a world class in TLP. By examining these parameters, Figure 5.17 demonstrated that unlike previous levels, all parameters involved in the World-Class Level were not practiced. As shown in Figure 5.17, they were scattered over the peripheral and complex quadrants. Explicitly, five of the eleven parameters were found in the peripheral quadrant. The remaining six parameters were settled in complex quadrant. The five parameters that were found in peripheral quadrant are '(3) Use venture capital

funds as a tool to get access to new technological trends and solutions at a very early stage', '(4) Send technology envoys throughout the world in order to build up a network with institutions, universities and start-up companies', '(5) Organize technology colloquia to assess different technological developments and/or possible research directions', '(8) Collaborate with start-ups and leading companies', and '(11) Provide researchers with financial resources to follow their own research interest'. It was explicit that these five parameters were not practiced. The authors of this research believed that lack of practicing such parameters was referring to the lower of their importance degree. As can be seen from Figure 5.17, there was consensus among the respondents that these five parameters are not extremely important.

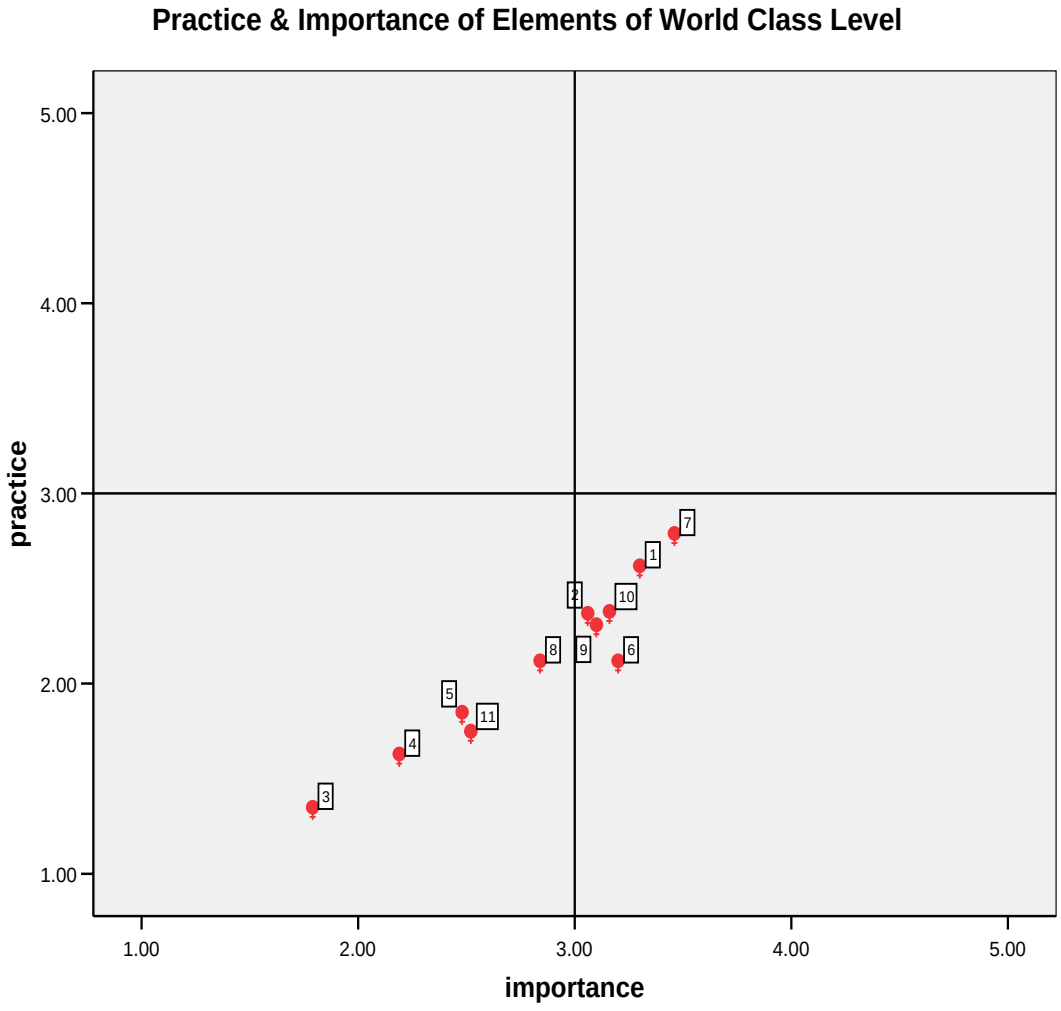


Figure 5.17 Importance-Practice Grid of World Class Level of TLP

It was worthwhile to note that this did not mean that organisations should ignore these parameters. The authors of this study understood from the interviews held earlier that managers did not ignore such parameters but they did not put much effort over it.

On the other hand, the six parameters found in complex quadrant were as follows: '(1) Launch projects of limited duration specifically dedicated to learn specific technological problems and developments', '(2) Appoint a gatekeeper (i.e. someone frequently in contact with people from outside the organisation to sustain the flow of information across company boundaries)', '(6) Arrange innovation workshops', '(7) Proactively collaborate with universities and research institutes', '(9) Establish centralized and/or decentralized units dedicated to learn developments and trends of new technologies, in which the tasks are hierarchically divided within the positions and departments', and '(10) Provide incentive systems suitable for technological learning and effective in stimulating the bottom-up flow of technological trends'. It was evident that the respondents agreed that these six parameters were intensively important despite of their inability to practice them. Generally, none of the parameters of world-class level were practiced whereas over half of them were very important. This is evidence that although Irish manufacturing organisations are classified as advanced level in learning about developments and trends of new technologies, they still need to put more efforts and money to be a world class in TLP.

The main findings from the previous sections were that although the TLP was classified under the Advanced Level, further efforts were needed to bring Irish manufacturing organisations to a world class in learning about trends and developments of new technologies. An important contribution of this study has been consideration of the extent to which manufacturing organisations implemented the parameters relevant to learning process. Parameters lying some distance from the diagonal and in the fourth quadrant of the importance-practice grid deserved the attention of managers and decision makers interested in a country's technological progress and a company's competitive standing. Of particular importance were parameters that lied in complex quadrant that "confront consideration and manipulation, and can be expected to frustrate those dealing with them".

This study had significant implications for managers and decision makers interested in developing and/or improve TLP. As a general statement, positive action was required for 'complex' parameters found in quadrant 4. To intensively compete and not be taken by surprise, Pharmaceutical and Chemical firms in Republic of Ireland must urgently address these parameters. In addition, consideration of these parameters efficiently promotes TLP and ensures the output of TLP is effectively significant. Otherwise there will be little opportunity to cope with changes and catch up developments of new technologies at an earlier stage.

## 5.5 HYPOTHESES TESTING

This section presented the results of the tests of the research hypotheses. Before proceeding to any analysis, the normality of the data was tested with a one-sample Kolmogorov-Smirnov test in order to indicate the appropriateness of parametric testing. After the normality analysis of the data, statistical tools such as *M*ean, Data Frequency Analysis, *t*-test, Scatter Plot and Bivariate Correlations have been all used to assess the impact of the TLP parameters on several functions such as the management of AMT and the performance of manufacturing operations.

**5.5.1 First Hypothesis:** Organisation that have adopted complex level of AMT projects were more likely to place greater emphasis on TLP than organisations that have adopted lower level of AMT projects,

As described earlier in chapter 2, the sophistication levels of AMT were passed by three levels including lower, moderate, and complex level. In order to test the above hypothesis, all responses have been accurately checked and discriminated into three groups. Based on involvement level in AMT projects, the respondents were organised in order their involvement level: lower level in which investment in AMT projects was very low, moderate level (i.e. the level of AMT in those organisations was moderate), and complex level (i.e. investment in AMT projects was very high comprising advanced technologies and systems). The discrimination process had identified that 4 respondents were found to invest in lower level of AMT projects. 34 respondents were found to represent moderate level of AMT. 30 organisations were found to invest in complex technologies (i.e. complex level). To measure the effect of the TLP on investment level of AMT,

each level of AMT would be examined separately. Although many statistical tools were used to test this hypothesis, the researchers depended on data frequency analysis and Mean figures to discuss the study results. This was an attempt to avoid any complications in the study findings.

#### 5.5.1.1 Lower Level of AMT against Four Levels of TLP

Initially, the respondents who were classified under the Lower Level of AMT were studied. Based on the discrimination process, the total of organisations that organised as the first level (i.e. lower level) of AMT were four companies. To examine the extent to which the TLP was implemented in organisations that have lower level of investment in AMT projects, the basic level of TLP was initially examined. Table 5.15 shows that the organisations that have a lower level of investment in AMT projects were practicing only six parameters of the basic level of TLP. By looking at a row headed Mean, it is evident that there were six parameters, which had high values of the Mean.

Table 5.15 Basic Level of TLP against Lower Level of AMT

| | 1) Cooperate with suppliers | 2) Cooperate with customers/users | 3) Check government sources | 4) Participate in activities of professional associations | 5) Participate in activities of trade associations | 6) Scrutinize business literature | 7) Join local chambers of commerce | 8) Subscribe to the local press | 9) Subscribe and review trade press | 10) Collaborate with stockbrokers | 11) Keep track of the prospectus | 12) Contact and visit the investment banks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | | 25 | 25 | 25 | | 25 | 50 | 25 | 75 | 75 | 75 |
| Hardly Practice | | | 50 | | | | 50 | 25 | 25 | 25 | | |
| Occasionally | | 25 | 25 | 50 | 50 | 75 | | | | | | |
| Fairly Practice | 50 | 25 | | 25 | | | 25 | | | | 25 | 25 |
| Regularly | 50 | 50 | | | 25 | 25 | | 25 | 50 | | | |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| t-test | 15.59 | 8.88 | 4.90 | 4.37 | 3.67 | 7.00 | 3.58 | 2.38 | 3.66 | 5.00 | 2.33 | 2.33 |
| Sig | .001 | .003 | .016 | .022 | .035 | .006 | .037 | .098 | .035 | .015 | .102 | .102 |
| Mean | 4.50 | 4.25 | 2.00 | 2.75 | 3.00 | 3.50 | 2.25 | 2.25 | 3.50 | 1.25 | 1.75 | 1.75 |
| Std. Dev | .577 | .957 | .817 | 1.26 | 1.63 | 1.00 | 1.26 | 1.89 | 1.92 | .500 | 1.50 | 1.50 |

These six parameters are '(1) Cooperate with suppliers', '(2) Cooperate with customers/users', '(4) Participate in activities of professional associations', '(5) Participate in activities of trade associations', '(6) Scrutinize business literature and those periodicals', and '(9) Subscribe and review trade press'. On the other hand, Table 5.15 also revealed that the remaining six parameters of the basic level were either hardly implemented or not implemented at all. The six neglected parameters of the basic level are '(3) Check government sources that contain very detailed information on foreign and domestic investments', '(7) Join local chambers of commerce', '(8) Subscribe to the local press and frequently check the local newspaper', '(10) Collaborate with stockbrokers who often have made deeply studies of a competitor', '(11) Keep track of the prospectus', and '(12) Contact and visit the investment banks'.

Table 5.16 Average Level of TLP against Lower Level of AMT

| | 1) Participation of employees in the company's strategy | 2) Use IT such as Bulletin Board System and E-mails | 3) Access to the Internet | 4) Create informal discussion networks | 5) Rotate jobs among employees | 6) Establish communication routines | 7) Provide members with extra travel budget | 8) Use Technology Roadmaps | 9) Use a Balanced Scorecard | 10) Use Listening Posts | 11) Use a Watch List | 12) Benchmark key competitors | 13) Conduct a sensitivity analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | | | 50 | 50 | 50 | 25 | 25 | 50 | | 50 | 25 | 75 |
| Hardly | | 25 | | 25 | 25 | 25 | 25 | 25 | 50 | 25 | 25 | 25 | 25 |
| Occasionally | 75 | 25 | | | 25 | 25 | 50 | | | 50 | 25 | 25 | |
| Fairly | 25 | 25 | 25 | 25 | | | | 50 | | 25 | | 25 | |
| Regularly | | 25 | 75 | | | | | | | | | | |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| t-test | 13.00 | 5.42 | 19.00 | 2.83 | 3.66 | 3.66 | 4.70 | 3.67 | 5.20 | 7.35 | 3.66 | 3.87 | 5.00 |
| Sig | .001 | .012 | .000 | .066 | .035 | .035 | .018 | .035 | .014 | .005 | .035 | .030 | .015 |
| Mean | 3.25 | 3.50 | 4.75 | 2.00 | 1.75 | 1.75 | 2.25 | 2.75 | 1.50 | 3.00 | 1.75 | 2.50 | 1.25 |
| Std. Dev | .500 | 1.29 | .500 | 1.41 | .957 | .957 | .957 | 1.500 | .577 | .817 | .957 | 1.29 | .500 |

Subsequently, 13 parameters of the average level of TLP were examined. Table 5.16 reveals that out of the 13 parameters, only 5 parameters of the second level of TLP were practiced. From Table 5.16, the five executed parameters of the

average level, which score high values of the Mean, are '(1) Participation of employees in the company's strategy (e.g. innovation need) through informal searching and learning activities', '(2) Use IT such as Bulletin Board System and E-mails', '(3) Access to the Internet', '(8) Use Technology Roadmaps as a tool to learn and/or anticipate future tends of the new technologies', and '(10) Use Listening Posts to get some feedback from your customers and partners'. Thus, a frequency figures and values of the Mean presented in Table 5.16 explained how the organisations, which have lower level of investment in advance technologies, were poorly investing in TLP.

Noteworthy, the organisations that have lower level of AMT were appeared to neglect majority of the average level parameters. For instance, these organisations did not 'create informal discussion networks through intranet discussion platforms', 'they do not rotate jobs among employees in order to strengthen the informal technological learning networks in their organisations', 'they do not establish communication routines to pass on the trends and developments of new technologies to top management', 'they do not provide their members with extra travel budget to update their organisations with the latest developments of advanced technology', 'they do not use a Balanced Scorecard to improve critical areas such as technology, product, process, and market development', 'they do not use a Watch List to spot irregularities in the environment of their organisations, 'they do not benchmark key competitors', and 'they do not conduct a sensitivity analysis'. Based on these results, it was obvious that consideration of the average level by the organisations, which classified under the lower level of AMT projects, was intensively weak.

Next participants who have been organised as lower level of AMT projects were requested to determine whether they practice the 10 parameters included in the advanced level of TLP. Table 5.17 reveals that almost all the parameters of advanced level of TLP were found to have very low values of the Mean. The only parameter, which was found significant at Mean value 3.00, was '(5) Share knowledge, whether formal or informal, within the R&D dept'. The conclusion reached from this analysis was that the organisations, which have very lower level in AMT, were found to have dedicated neither time nor resources to learn about the changes and developments in advanced technologies. The authors of this study

believed that this undervaluation of TLP in such organisations referred to several factors. For instance, organisations have had lower level of AMT were usually not interested in increasing the level of AMT more than what they have had, lack of resources, lack of skills on both levels top management level and shop-floor level, etc. However, apart from these reasons, implementation of TLP was more likely to assist such organisations to improve the management of AMT implementation.

Table 5.17 Advanced Level of TLP against Lower Level of AMT

| | 1) Establish a suitable pyramidal structure of R&D personnel | 2) Build a reliable and accessible database | 3) Use R&D documents in comparison to other documents | 4) Acquire up-to-date R&D tools | 5) Share knowledge within the R&D dept | 6) Share information among depts | 7) Gain support and commitment of top management | 8) Keep a constant balance between human resource planning and learning strategy | 9) Recruit high levels of education, skills, and experience | 10) Provide training programmes for employees |
|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 75 | 50 | 75 | 75 | 25 | 25 | 25 | 50 | 25 | 25 |
| Hardly Practice | 25 | 25 | | 25 | 25 | 25 | 50 | | 25 | |
| Occasionally | | | 25 | | | 25 | 25 | 50 | 25 | 50 |
| Fairly Practice | | 25 | | | 25 | | | | | 25 |
| Regularly | | | | | 25 | 25 | | | 25 | |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| t-test | 5.00 | 3.00 | 3.00 | 5.00 | 3.29 | 3.22 | 4.90 | 3.46 | 3.22 | 4.37 |
| Sig | .015 | .058 | .058 | .015 | .046 | .049 | .016 | .041 | .049 | .022 |
| Mean | 1.25 | 2.25 | 1.50 | 1.25 | 3.00 | 2.75 | 2.00 | 2.00 | 2.75 | 2.75 |
| Std. Dev | .500 | 1.50 | 1.00 | .500 | 1.83 | 1.71 | .817 | 1.16 | 1.71 | 1.26 |

Participants in this research were also requested to determine whether they implemented the 11 parameters included in the world-class level of TLP. As can be seen from Table 5.18, the Mean values of 11 parameters of world class level were all very low indicating that none of the parameters of world class level was practiced.

The conclusion that can be drawn as a result of examining the levels of TLP within the organisations, which have very low level of AMT projects, is that as

the investment level in AMT projects was kept low, the consideration level of TLP would be very low too.

Table 5.18 World-Class Level of TLP against Lower Level of AMT

| | 1) Launch projects of limited duration | 2) Appoint a gatekeeper | 3) Use venture capital funds | 4) Send technology envoys throughout the world | 5) Organize technology colloquia | 6) Arrange innovation workshops | 7) Proactively collaborate with universities and research institutes | 8) Collaborate with start-ups and leading companies | 9) Establish centralized and/or decentralized units dedicated to learn trends of new technologies | 10) Provide incentive systems suitable for TLP | 11) Provide researchers with financial resources |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 75 | 75 | 75 | 75 | 75 | 75 | 25 | 50 | 75 | 50 | 25 |
| Hardly | 25 | | 25 | | 25 | 25 | | 25 | | 25 | 50 |
| Occasionally | | | | 25 | | | 75 | 25 | 25 | 25 | 25 |
| Fairly | | 25 | | | | | | | | | |
| Regularly | | | | | | | | | | | |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| t-test | 5.00 | 2.33 | 5.00 | 3.00 | 5.00 | 5.00 | 5.00 | 3.66 | 3.00 | 3.66 | 4.90 |
| Sig | .015 | .102 | .015 | .058 | .015 | .015 | .015 | .035 | .058 | .035 | .016 |
| Mean | 1.25 | 1.75 | 1.25 | 1.50 | 1.25 | 1.25 | 2.50 | 1.75 | 1.50 | 1.75 | 2.00 |
| Std. Dev | .500 | 1.50 | .500 | 1.00 | .500 | .500 | 1.00 | .957 | 1.00 | .957 | .817 |

#### 5.5.1.2 Moderate Level of AMT against Four Levels of TLP

In studying the practice level of TLP within the organisations that implemented moderate level of AMT projects, the statistical results showed that there was evidence that the practice of TLP was significantly considered.

In comparison with the firms that have had lower level of AMT projects, firms that have had moderate level of AMT projects were found to have practiced the following parameters of the basic level of TLP: '(1) Cooperate with suppliers', '(2) Cooperate with customers and/or users', '(4) Participate in activities of professional associations', '(5) Participate in activities of trade associations', '(6)

Scrutinize business literature and those periodicals', and '(9) Subscribe and review trade press'. Table 5.19 shows the statistical figures of basic level of TLP versus moderate level of AMT.

Table 5.19 Basic Level of TLP against Moderate Level of AMT

| | 1. Cooperate with suppliers | 2. Cooperate with customers and/or users | 3. Check government sources | 4. Participate in activities of professional associations | 5. Participate in activities of trade associations | 6. Scrutinize business literature and those periodicals | 7. Join local chambers of commerce | 8. Subscribe to the local press and check the local newspaper | 9. Subscribe and review trade press | 10. Collaborate with stockbrokers | 11. Keep track of the prospectus | 12. Contact and visit the investment banks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | | 35.3 | 11.8 | 11.8 | | 41.2 | 35.3 | 11.8 | 67.6 | 55.9 | 61.8 |
| Hardly | 2.9 | 2.9 | 38.2 | 17.6 | 14.7 | 20.6 | 29.4 | 23.5 | 11.8 | 23.5 | 29.4 | 23.5 |
| Occasionally | 29.4 | 11.8 | 11.8 | 29.4 | 50.0 | 29.4 | 14.7 | 20.6 | 38.2 | 5.9 | 8.8 | 5.9 |
| Fairly | 35.3 | 32.4 | 14.7 | 26.5 | 8.8 | 35.3 | 5.9 | 17.6 | 35.3 | | 2.9 | |
| Regularly | 32.4 | 52.9 | | 14.7 | 14.7 | 14.7 | 8.8 | 2.9 | 2.9 | 2.9 | 2.9 | 8.8 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 26.62 | 31.25 | 11.51 | 14.87 | 15.15 | 20.26 | 9.70 | 10.97 | 17.11 | 9.96 | 10.02 | 8.33 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 3.97 | 4.35 | 2.06 | 3.15 | 3.00 | 3.44 | 2.12 | 2.29 | 3.06 | 1.47 | 1.68 | 1.71 |
| Std. Dev | .870 | .812 | 1.04 | 1.23 | 1.16 | .991 | 1.27 | 1.22 | 1.04 | .861 | .976 | 1.19 |

The firms that implemented moderate level of AMT were also found practicing the following parameters of average level of TLP: '(1) Participation of employees in the company's strategy', '(2) Use IT such as Bulletin Board System and E-mails', '(3) Access to the Internet', '(5) Rotate jobs among employees', '(6) Establish communication routines', '(9) Use a Balanced Scorecard', '(12) Benchmark key competitors', and '(13) conduct a sensitivity analysis'. Table 5.20 shows the statistical results obtained from testing the relationship between the average level of TLP and moderate level of AMT.

Table 5.20 Average Level of TLP against Moderate Level of AMT

| | 1. Participation of employees in the company's strategy | 2. Use IT such as Bulletin Board System and E-mails | 3. Access to the Internet | 4. Create informal discussion networks | 5. Rotate jobs among employees | 6. Establish communication routines | 7. Provide your members with extra travel budget | 8. Use Technology Roadmaps | 9. Use a Balanced Scorecard | 10. Use Listening Posts | 11. Use a Watch List | 12. Benchmark key competitors | 13. Conduct a sensitivity analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | 8.8 | | 29.4 | 23.5 | 8.8 | 23.5 | 32.4 | 32.4 | 23.5 | 38.2 | 20.6 | 17.6 |
| Hardly | 26.5 | 8.8 | 5.9 | 29.4 | 29.4 | 14.7 | 44.1 | 26.5 | 14.7 | 29.4 | 35.3 | 20.6 | 26.5 |
| Occasionally | 35.3 | 20.6 | 2.9 | 35.3 | 20.6 | 50.0 | 23.5 | 17.6 | 23.5 | 23.5 | 8.8 | 23.5 | 32.4 |
| Fairly | 35.3 | 26.5 | 20.6 | 5.9 | 23.5 | 23.5 | 5.9 | 23.5 | 20.6 | 20.6 | 14.7 | 29.4 | 20.6 |
| Regularly | 2.9 | 35.3 | 70.6 | | 2.9 | 2.9 | 2.9 | | 8.8 | 2.9 | 2.9 | 5.9 | 2.9 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 21.40 | 16.73 | 32.28 | 13.55 | 12.43 | 18.49 | 13.15 | 11.55 | 10.99 | 12.55 | 10.46 | 13.03 | 14.06 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 3.15 | 3.71 | 4.56 | 2.18 | 2.53 | 2.97 | 2.21 | 2.32 | 2.59 | 2.50 | 2.09 | 2.79 | 2.65 |
| Std. Dev | .858 | 1.29 | .824 | .937 | 1.19 | .937 | .978 | 1.17 | 1.37 | 1.16 | 1.16 | 1.25 | 1.10 |

The firms that have had moderate level of AMT projects were found practicing the following parameters of advanced level of TLP: '(3) Use R&D documents in comparison to other documents', '(5) Share knowledge within the R&D dept', '(6) Share information among depts', '(7) Gain support and commitment of top management', '(8) Keep a constant balance between human resource planning and learning strategy', '(9) Provide high levels of education, skills, and experience', and '(10) Provide training programmes for employees'. Table 5.21 explains the statistical figures reached as a result of studying the correlation between the advanced level of TLP and the moderate level of AMT projects.

Table 5.21 Advanced Level of TLP against Moderate Level of AMT

| | 1. Establish a suitable pyramidal structure of R&D personnel | 2. Maintain a reliable and accessible database | 3. Use R&D documents in comparison to other documents | 4. Update R&D tools | 5. Share knowledge within the R&D department | 6. Share information among depts | 7. Gain support and commitment of top management | 8. Keep a constant balance between human resource planning and learning strategy | 9. Provide high levels of education, skills, and experience | 10. Provide training programmes for employees |
|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 11 | 10 | 9 | 13 | 8 | 4 | 1 | 2 | | 1 |
| Hardly Practice | 12 | 9 | 9 | 13 | 6 | 7 | 8 | 9 | 4 | 5 |
| Occasionally | 3 | 8 | 7 | | 9 | 8 | 9 | 9 | 11 | 9 |
| Fairly Practice | 7 | 5 | 8 | 6 | 8 | 9 | 12 | 11 | 12 | 12 |
| Regularly | 1 | 2 | 1 | 2 | 3 | 6 | 4 | 3 | 7 | 7 |
| Total | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 |
| t-test | 10.88 | 11.40 | 12.02 | 9.76 | 12.36 | 14.36 | 18.13 | 16.61 | 22.39 | 19.24 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 2.27 | 2.41 | 2.50 | 2.15 | 2.77 | 3.18 | 3.29 | 3.12 | 3.65 | 3.56 |
| Std. Dev | 1.21 | 1.23 | 1.21 | 1.28 | 1.30 | 1.29 | 1.06 | 1.10 | .950 | 1.09 |

These firms were also found to have practiced some of the parameters included in world class level of TLP: '(1) Launch projects of limited duration', and '(7) Collaborate with universities and research institutes'. Generally, it was found that the practice level of TLP in firms that have had moderate level of AMT projects was effectively stronger than the practice level of TLP in firms that have had lower level of AMT projects. Table 5.22 shows the statistical figures obtained from examining the relationship between the world class level of TLP and the moderate level of AMT projects.

Table 5.22 World-Class Level of TLP against Moderate Level of AMT

| | 1. Launch projects of limited duration | 2. Recruit a gatekeeper | 3. Use venture capital funds | 4. Send technology envoys throughout the world | 5. Organize technology colloquia | 6. Arrange innovation workshops | 7. Collaborate with universities and research institutes | 8. Collaborate with start-ups and leading companies | 9. Build centralized and/or decentralized units dedicated to learn trends | 10. Provide incentive systems | 11. Provide researchers with financial resources |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 29.4 | 38.2 | 79.4 | 73.5 | 55.9 | 50.0 | 23.5 | 44.1 | 44.1 | 32.4 | 73.5 |
| Hardly | 11.8 | 29.4 | 11.8 | 14.7 | 23.5 | 32.4 | 20.6 | 32.4 | 17.6 | 26.5 | 17.6 |
| Occasionally | 35.3 | 20.6 | 5.9 | 11.8 | 14.7 | 8.8 | 38.2 | 14.7 | 26.5 | 26.5 | 8.8 |
| Fairly | 20.6 | 11.8 | 2.9 | | 5.9 | 8.8 | 8.8 | 8.8 | 8.8 | 14.7 | |
| Regularly | 2.9 | | | | | | 8.8 | | 2.9 | | |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 12.32 | 11.51 | 10.62 | 11.57 | 10.60 | 10.77 | 12.48 | 11.23 | 10.46 | 12.13 | 12.2 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 2.56 | 2.06 | 1.32 | 1.38 | 1.71 | 1.77 | 2.59 | 1.88 | 2.09 | 2.24 | 1.35 |
| Std. Dev | 1.21 | 1.04 | .727 | .697 | .938 | .955 | 1.21 | .978 | 1.16 | 1.08 | .646 |

#### 5.5.1.3 Complex Level of AMT against Four Levels of TLP

The following section was dedicated to investigate the relationship between the organisations, which had heavily invested in AMT projects (i.e. complex level of AMT), and the involvement level in TLP. Statistical results of the four levels (i.e. basic level, average level, advanced level, and world class level) of TLP were shown in the Tables 5.23, 5.24, 5.25, and 5.26 respectively.

Initially, the basic level, which represented 12 parameters, was tested. It was obvious that the organisations, which had a complex level of AMT, had practiced majority of the parameters of the basic level. Table 5.23 revealed that out of 13 parameters, only 3 parameters, which have had lower values of the Mean, were excluded of implementation within such organisations. These three parameters are '(10) Collaborate with stockbrokers who often have made deeply studies of a

competitor', '(11) Keep track of the prospectus', and '(12) Contact and visit the investment banks'.

Remarkably, Table 5.23 also illustrated that the organisations, which had adopted very complex technologies, cooperate with suppliers', 'cooperate with customers/users', 'check government sources that contain very detailed information on foreign and domestic investments', 'participate in activities of professional associations', 'participate in activities of trade associations', 'scrutinize business literature and those periodicals', 'join local chambers of commerce', 'subscribe to the local press and frequently check the local newspaper', and 'subscribe and review trade press'.

Table 5.23 Basic Level of TLP against Complex Level of AMT

| | 1) Cooperate with suppliers | 2) Cooperate with customers/users | 3) Check government sources | 4) Participate in activities of professional associations | 5) Participate in activities of trade associations | 6) Scrutinize business literature and those periodicals | 7) Join local chambers of commerce | 8) Subscribe to the local press | 9) Subscribe and review trade press | 10) Collaborate with stockbrokers | 11) Keep track of the prospectus | 12) Contact and visit the investment banks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | 3.3 | 26.7 | | | | 10.0 | 23.3 | 3.3 | 60.0 | 46.7 | 60.0 |
| Hardly | | 10.0 | 30.0 | 10.0 | 10.0 | 13.3 | 13.3 | 23.3 | 16.7 | 20.0 | 26.7 | 30.0 |
| Occasionally | 10.0 | 20.0 | 30.0 | 43.3 | 40.0 | 43.3 | 36.7 | 26.7 | 36.7 | 6.7 | 20.0 | 3.3 |
| Fairly | 56.7 | 36.7 | 10.0 | 36.7 | 36.7 | 26.7 | 33.3 | 13.3 | 26.7 | 10.0 | 3.3 | 3.3 |
| Regularly | 33.3 | 30.0 | 3.3 | 10.0 | 13.3 | 16.7 | 6.7 | 13.3 | 16.7 | 3.3 | 3.3 | 3.3 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 37.04 | 19.00 | 11.69 | 23.18 | 22.49 | 20.26 | 15.98 | 11.01 | 17.30 | 8.31 | 9.80 | 9.05 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 4.23 | 3.80 | 2.33 | 3.47 | 3.53 | 3.47 | 3.13 | 2.70 | 3.37 | 1.77 | 1.90 | 1.60 |
| Std. Dev | .626 | 1.096 | 1.094 | .819 | .860 | .937 | 1.074 | 1.343 | 1.066 | 1.165 | 1.062 | .969 |

In examining the Average Level, which represented 13 parameters of TLP, Table 5.24 showed that almost all (i.e. 12 out of 13) parameters of the average level were scoring very high values of the Mean. This indicated that the organisations, which had a complex level of advanced technologies, were regularly taken into account all these parameters to learn about and then managed the changes, advancement, and developments of advanced technologies.

Table 5.24 Average Level of TLP against Complex Level of AMT

| | 1) Participation of employees in the company's strategy | 2) Use IT such as Bulletin Board System and E-mails | 3) Access to the Internet | 4) Create informal discussion networks | 5) Rotate jobs among employees | 6) Establish communication routines | 7) Provide members with extra travel budget | 8) Use Technology Roadmaps | 9) Use a Balanced Scorecard | 10) Use Listening Posts | 11) Use a Watch List | 12) Benchmark key competitors | 13) Conduct a sensitivity analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 3.3 | 3.3 | | 23.3 | 6.7 | 10.0 | 16.7 | 30.0 | 20.0 | 23.3 | 33.3 | | 10.0 |
| Hardly | 10.0 | 10.0 | | 10.0 | 16.7 | 16.7 | 16.7 | 20.0 | 20.0 | 13.3 | 16.7 | 20.0 | 23.3 |
| Occasionally | 23.3 | 10.0 | 3.3 | 26.7 | 16.7 | 30.0 | 23.3 | 23.3 | 10.0 | 33.3 | 36.7 | 20.0 | 16.7 |
| Fairly | 26.7 | 30.0 | 30.0 | 20.0 | 50.0 | 30.0 | 30.0 | 16.7 | 26.7 | 23.3 | 6.7 | 40.0 | 30.0 |
| Regularly | 36.7 | 46.7 | 66.7 | 20.0 | 10.0 | 13.3 | 13.3 | 10.0 | 23.3 | 6.7 | 6.7 | 20.0 | 20.0 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 18.30 | 19.49 | 45.64 | 11.46 | 16.90 | 14.78 | 12.81 | 10.36 | 11.42 | 12.12 | 10.65 | 19.01 | 13.65 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 3.83 | 4.07 | 4.63 | 3.03 | 3.40 | 3.20 | 3.07 | 2.57 | 3.13 | 2.77 | 2.37 | 3.60 | 3.27 |
| Std. Dev | 1.15 | 1.14 | .556 | 1.45 | 1.10 | 1.19 | 1.31 | 1.36 | 1.50 | 1.25 | 1.22 | 1.04 | 1.31 |

Afterwards, statistical tests such as t-test, *M*ean, etc were applied to study the relationship between adoption of complex technologies and application of Advanced Level, which represented 10 parameters of TLP. The most interesting finding obtained from these statistical tests was that the organisations, which have

implemented a complex level of AMT projects, were very advanced in learning process about changes and developments of advanced technologies. As can be seen from Table 5.25, values of the Mean were very high for all parameters of advanced level that explains the considerable attention dedicated to such parameters of TLP.

Table 5.25 Advanced Level of TLP against Complex Level of AMT

| | 1) Establish a suitable pyramidal structure of R&D personnel | 2) Maintain a reliable and accessible database | 3) Use R&D documents in comparison to other documents | 4) Acquire up-to-date R&D tools | 5) Share knowledge within the R&D dept | 6) Share information among depts | 7) Gain support and commitment of top management | 8) Keep a constant balance between human resource planning and learning strategy | 9) Recruit high levels of education, skills, and experience | 10) Provide training programmes for employees |
|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 16.7 | 16.7 | 20.0 | 13.3 | 3.3 | 3.3 | 3.3 | | | |
| Hardly | 20.0 | 26.7 | 30.0 | 26.7 | 20.0 | 10.0 | 23.3 | 16.7 | 6.7 | |
| Occasionally | 26.7 | 23.3 | 16.7 | 10.0 | 20.0 | 23.3 | 13.3 | 23.3 | 33.3 | 33.3 |
| Fairly | 26.7 | 23.3 | 20.0 | 36.7 | 40.0 | 40.0 | 36.7 | 46.7 | 36.7 | 36.7 |
| Regularly | 10.0 | 10.0 | 13.3 | 13.3 | 16.7 | 23.3 | 23.3 | 13.3 | 23.3 | 30.0 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 12.78 | 12.30 | 11.17 | 12.84 | 17.17 | 19.20 | 16.18 | 20.89 | 22.98 | 26.87 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 2.93 | 2.83 | 2.77 | 3.10 | 3.47 | 3.70 | 3.53 | 3.57 | 3.77 | 3.97 |
| Std. Dev | 1.26 | 1.262 | 1.357 | 1.322 | 1.106 | 1.055 | 1.196 | .935 | .898 | .809 |

Same statistical tests were applied to examine world-class level, which represented 11 parameters of TLP. Statistical results obtained from Table 5.26 demonstrated that over half (50%) of the respondents agreed that they launched projects of limited duration specifically dedicated to learn specific technological problems and developments', 'appoint a gatekeeper', 'arrange innovation workshops', 'proactively collaborate with universities and research institutes',

'collaborate with start-ups and leading companies, whether international or not', 'establishing centralized and/or decentralized units dedicated to learn developments and trends of new technologies, in which the tasks were hierarchically divided within the positions and departments', and 'provide incentive systems suitable for technological learning and effective in stimulating the bottom-up flow of technological trends'.

Table 5.26 World-Class Level of TLP against Complex Level of AMT

| | 1) Launch projects of limited duration | 2) Appoint a gatekeeper | 3) Use venture capital funds | 4) Send technology envoys throughout the world | 5) Organize technology colloquia | 6) Arrange innovation workshops | 7) Proactively collaborate with universities and research institutes | 8) Collaborate with start-ups and leading companies | 9) Establish centralized and/or decentralized units dedicated to learn trends of new technologies | 10) Provide incentive systems suitable for technological learning | 11) Provide researchers with financial resources |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 23.3 | 26.7 | 80.0 | 46.7 | 40.0 | 23.3 | 6.7 | 33.3 | 23.3 | 26.7 | 43.3 |
| Hardly | 20.0 | 20.0 | 10.0 | 23.3 | 30.0 | 26.7 | 30.0 | 20.0 | 23.3 | 23.3 | 20.0 |
| Occasionally | 16.7 | 16.7 | 3.3 | 23.3 | 13.3 | 26.7 | 23.3 | 20.0 | 23.3 | 20.0 | 16.7 |
| Fairly | 26.7 | 20.0 | 3.3 | 3.3 | 13.3 | 10.0 | 30.0 | 23.3 | 23.3 | 20.0 | 16.7 |
| Regularly | 13.3 | 16.7 | 3.3 | 3.3 | 3.3 | 13.3 | 10.0 | 3.3 | 6.7 | 10.0 | 3.3 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 11.15 | 10.42 | 7.92 | 9.80 | 9.71 | 10.88 | 14.70 | 10.43 | 11.51 | 10.67 | 9.41 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 2.87 | 2.80 | 1.40 | 1.93 | 2.10 | 2.63 | 3.07 | 2.43 | 2.67 | 2.63 | 2.17 |
| Std. Dev | 1.41 | 1.47 | .969 | 1.08 | 1.19 | 1.33 | 1.14 | 1.28 | 1.27 | 1.35 | 1.26 |

Noteworthy, among the above practiced parameters of world class level, it was found that the respondents explained that they established centralized and/or decentralized units dedicated to learn developments and trends of new technologies, in which the tasks are hierarchically divided within the positions and departments. The respondents also explained that they launched projects of limited duration specifically were dedicated to learn specific technological

problems and developments. These findings confirmed that the organisations, which heavily involved in complex level of AMT projects, were also utilizing heavily in TLP. As a result, intendancy to invest in complex levels of AMT and to effectively compete counterparts required initially being world class TLP.

Briefly, it has been found that the implementation of TLP was very poor and did not exceed the basic level within the organisations that had very low level of AMT projects. In contrary, the organisations, which had implemented a complex level of AMT projects were found to significantly invest in TLP and classified as a world class TLP. It is obvious that whenever managers wished to increase their level of AMT projects, they should at first rise the practice level of TLP. Thus, the implementation of TLP had a positive effect on the success of AMT adoption and also had similar impact on AMT implementation.

As a result, it must be concluded that the second hypothesis, which assumes that the organisations that adopt high levels of AMT projects were more likely to place greater emphasis on TLP than companies that had less complex AMT projects, was accepted.

**5.5.2 Second Hypothesis:** Organisations, which practice TLP to learn about changes and developments of new technologies, are more likely to achieve great degree of success in the process of AMT implementation,

In order to test the degree of statistical association between the parameters of TLP (independent variables) and the process of AMT implementation (dependent variable), Data Frequency Analysis, Mean, and t-test Statistics were conducted. Basically, the process of AMT implementation was a process, which organisations go through. Several authors suggested that the process of AMT implementation was subjected to various phases and/or stages [10, 93 and 190-193]. For instance, Voss, (1988) [10] revealed that a lifecycle implementation process consists of the following three phases: adoption phase; implementation phase; and post-implementation phase. Although, a six-stage model was developed by Kwon, et al (1987), [191] and supported by Schroder, et al (1999) [93], many recent studies still adopt and use Voss's model to study the process of AMT implementation [68, 194 and 195]. As a result, Voss's model was also adopted and used in this research.

A broad range of empirical studies showed, however, that successful implementation of AMT projects continued to be significant challenge with correspondingly zero pay-off for the implementing organisations [248, 16, 63, 195 and 130-132]. The process of AMT implementation remained one of the most risky and stressful tasks a manufacturer can undertake. Frohlich, (1998) [152] reported that for every success story, you have half a dozen so-so stories and one or two outright disasters. Perhaps most ominous for practitioners, the number of pitfalls associated with AMT implementations is not decreasing and may even be increasing. Bray, (2002) [133] revealed that project implementation is among the most challenging tasks facing advanced technology leaders. He reported that a shocking statistic "65% to 70%" of all implementation projects fail to produce the benefits expected. Kumar, et al (2005) [7] observed that only a handful of companies have been successfully adopted and implemented the projects of AMT.

Given that, the experience of firms implementing AMT projects had not been uniformly positive. This study believed that in implementing the AMT projects, a firm typically conducted the phases/stages of "the process of AMT implementation" listed in Section C1 of the survey questionnaire. In the analysis of this study, firms with a Mean score of 4 points or better on both phases of AMT implementation process (Adoption Phase and Installation Phase) were categorized into the "successful" group. The others were used as the contrast group, i.e., firms that are "less successful". Based on this methodology, forty-five respondents who rated themselves as a very successful in performing both adoption phase and implementation phase were categorised under the successful group. On the other hand, eight participants who had failed to accomplish adoption phase and implementation phase were classified under less successful group. To examine the impact of TLP on the management of AMT implementation, successful group and less successful group were separately studied.

#### 5.5.2.1 Successful Organisations against Four Levels of TLP

Initially, In order to determine whether implementation of TLP had any influence on the successful group (i.e. organisations that had successfully carried out the process of AMT implementation), the four levels of TLP (i.e. Basic Level, Average Level, Advanced Level, and World-Class Level) were independently

tested. Although several statistical tools (i.e. Frequencies, Mean, Scatter/Dot Plot, Bivariation Correlations, and Discrimination Test) were used, Data Frequency Analysis, and Mean were presented in the following Tables.

In order to simplify the figures obtained from statistical analysis, the following Tables were designed from columns and rows (i.e. Cross-tabulation Tables). The columns represented the activities of TLP and the rows represented the practice level (e.g. Five-point Likert scale 'not practice through to regularly practice') and the figures of statistical analysis (Mean, Std-Dev, t-test, p-value).

Tables 5.27, 5.28, 5.29 and 5.30 explained the results of the relationship between the successful organisations and each level of TLP. Based on Table 5.27, it was evident that successful organisations were practicing the majority of the parameters of basic level. Almost all successful organisations admitted that they were regularly or fairly practicing six parameters of basic level. These six parameters are: '1) Cooperate with suppliers', '2) Cooperate with customers/users', '4) Participate in activities of professional associations', '5) Participate in activities of trade associations', '6) Scrutinize business literature and those periodicals', and '9) Subscribe and review trade press'. The successful group also explained that three activities of Basic Level were occasionally practiced. These activities are: '3) Check government sources that contain very detailed information on foreign and domestic investments', '7) Join local chambers of commerce', and '8) Subscribe to the local press and frequently check the local newspaper'. The remaining three activities of the Basic Level were described by the successful organisations as either hardly practice or not practice at all. These three activities are: '10) Collaborate with stockbrokers who often have made deeply studies of a competitor', '11) Keep track of the prospectus' and '12) Contact and visit the investment banks'. As a result, successful organisations are practicing majority of the parameters of the basic level of TLP.

The figures in Table 5.28 indicated that there is a positive relationship between the organisations that had succeeded to manage the implementation of AMT projects and the average level of TLP. Table 5.28 showed that out of 13 parameters, 12 parameters of the Average Level were practiced. Almost two thirds of the successful organisations were found to be practicing 12 parameters included in the average level of TLP.

Table 5.27 Basic Level of TLP against Successful Organisations

| | 1) Cooperate with suppliers | 2) Cooperate with customers/users | 3) Check government sources | 4) Participate in activities of professional associations | 5) Participate in activities of trade associations | 6) Scrutinize business literature | 7) Join local chambers of commerce | 8) Subscribe to the local press and the local newspaper | 9) Subscribe and review trade press | 10) Collaborate with stockbrokers | 11) Keep track of the prospectus | 12) Contact and visit the investment banks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | 2.2 | 35.6 | 11.1 | 11.1 | | 31.1 | 31.1 | 11.1 | 66.7 | 48.9 | 62.2 |
| Hardly | 2.2 | 4.4 | 35.6 | 6.7 | 6.7 | 13.3 | 22.2 | 28.9 | 13.3 | 20.0 | 28.9 | 26.7 |
| Occasionally | 22.2 | 4.4 | 15.6 | 35.6 | 46.7 | 37.8 | 22.2 | 17.8 | 35.6 | 4.4 | 13.3 | 2.2 |
| Fairly | 44.4 | 37.8 | 11.1 | 31.1 | 24.4 | 31.1 | 17.8 | 15.6 | 28.9 | 6.7 | 6.7 | 4.4 |
| Regularly | 31.1 | 37.8 | 2.2 | 15.6 | 11.1 | 17.8 | 6.7 | 6.7 | 11.1 | 2.2 | 2.2 | 4.4 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 34.07 | 27.80 | 12.93 | 19.15 | 19.50 | 25.11 | 12.83 | 12.59 | 18.45 | 10.47 | 11.86 | 10.36 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 4.04 | 4.04 | 2.09 | 3.33 | 3.18 | 3.53 | 2.47 | 2.38 | 3.16 | 1.58 | 1.84 | 1.62 |
| Std. Dev | .797 | .976 | 1.08 | 1.17 | 1.09 | .944 | 1.29 | 1.27 | 1.15 | 1.01 | 1.05 | 1.06 |

These 12 parameters were: '1) Participation of employees in the company's strategy (e.g. innovation need) through informal searching and learning activities', '2) Use IT such as Bulletin Board System and E-mails', '3) Access to the Internet', '4) Create informal discussion networks through intranet discussion platforms', '5) Rotate jobs among employees in order to strengthen the informal technological learning networks in your organisation','6) Establish communication routines to pass on the trends and developments of new technologies to top management', '7) Provide your members with extra travel budget to update your company with the latest developments of its technology', '8) Use Technology Roadmaps as a tool to learn and/or anticipate future tends of the new technologies', '9) Use a Balanced Scorecard to improve critical areas such as technology, product, process, and market development', '10) Use Listening Posts to get some feedback from your customers and partners', '12) Benchmark key competitors', and '13) Conduct a sensitivity analysis'.

However, Table 5.28 also revealed that only one third of the successful organisations have used a watch list in order to spot irregularities in the environment of their company (i.e. Item number '11' Use a Watch List to spot irregularities in the environment of your company). As a result, the conclusion drew from this is that successful organisations were practicing the parameters involved in second level of TLP.

Table 5.28 Average Level of TLP against Successful Organisations

| | 1) Participation of employees in the company's strategy | 2) Use IT such as Bulletin Board System and E-mails | 3) Access to the Internet | 4) Create informal discussion networks | 5) Rotate jobs among employees | 6) Establish communication routines | 7) Provide members with extra travel budget | 8) Use Technology Roadmaps | 9) Use a Balanced Scorecard | 10) Use Listening Posts | 11) Use a Watch List | 12) Benchmark key competitors | 13) Conduct a sensitivity analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | 4.4 | | 22.2 | 17.8 | 13.3 | 17.8 | 28.9 | 26.7 | 20.0 | 35.6 | 11.1 | 13.3 |
| Hardly | 17.8 | 4.4 | 2.2 | 24.4 | 26.7 | 17.8 | 28.9 | 24.4 | 15.6 | 28.9 | 31.1 | 20.0 | 24.4 |
| Occasionally | 33.3 | 22.2 | 2.2 | 33.3 | 17.8 | 35.6 | 28.9 | 17.8 | 15.6 | 24.4 | 17.8 | 24.4 | 20.0 |
| Fairly | 31.1 | 28.9 | 24.4 | 13.3 | 33.3 | 22.2 | 17.8 | 24.4 | 28.9 | 24.4 | 11.1 | 28.9 | 28.9 |
| Regularly | 17.8 | 40.0 | 71.1 | 6.7 | 4.4 | 11.1 | 6.7 | 4.4 | 13.3 | 2.2 | 4.4 | 15.6 | 13.3 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 23.61 | 23.97 | 48.30 | 14.69 | 15.43 | 16.95 | 15.32 | 13.24 | 13.36 | 15.35 | 12.45 | 17.08 | 15.98 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 3.49 | 3.96 | 4.64 | 2.58 | 2.80 | 3.00 | 2.67 | 2.51 | 2.87 | 2.60 | 2.18 | 3.18 | 3.04 |
| Std. Dev | .99 | 1.11 | .65 | 1.18 | 1.22 | 1.19 | 1.17 | 1.27 | 1.44 | 1.14 | 1.17 | 1.25 | 1.28 |

In studying the relationship between the successful organisations and the Advanced Level of TLP, it was found that all the parameters included in the Advanced Level were practiced. Table 5.29 showed that about two thirds of the successful organisations agreed that they 'build a reliable and accessible database as a result of their yearly accumulation of R&D documents, 'share knowledge, whether formal or informal, within the R&D department', 'share information among departments', 'gain support and commitment of top management to

anticipate technological breakthrough and global changes', 'keep a constant balance between human resource planning and learning strategy in their organisations', 'recruit high levels of education, skills, and experience among employees to manage technological learning', and 'provide training programmes for their employees to improve technological learning'. Table 5.29 also showed that roughly half of the respondents were practicing the remaining three parameters of the Advanced Level. These three parameters were '(1) Establish a suitable pyramidal structure of R&D personnel', '(3) Use R&D documents in comparison to other documents', and '(4) Acquire up-to-date R&D tools'.

Table 5.29 Advanced Level of TLP against Successful Organisations

| | 1) Establish a suitable pyramidal structure of R&D personnel | 2) Build a reliable and accessible database | 3) Use R&D documents in comparison to other documents | 4) Acquire up-to-date R&D tools | 5) Share knowledge within the R&D dept | 6) Share information among depts | 7) Gain support and commitment of top management | 8) Keep a constant balance between human resource planning and learning strategy | 9) Recruit high levels of education, skills, and experience | 10) Provide training programmes for employees |
|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 26.7 | 26.7 | 31.1 | 24.4 | 13.3 | 6.7 | 4.4 | 2.2 | | |
| Hardly | 28.9 | 20.0 | 22.2 | 31.1 | 17.8 | 15.6 | 28.9 | 15.6 | 8.9 | 4.4 |
| Occasionally | 15.6 | 24.4 | 17.8 | 6.7 | 24.4 | 20.0 | 17.8 | 20.0 | 28.9 | 33.3 |
| Fairly | 22.2 | 20.0 | 22.2 | 26.7 | 35.6 | 33.3 | 35.6 | 48.9 | 33.3 | 31.1 |
| Regularly | 6.7 | 8.9 | 6.7 | 11.1 | 8.9 | 24.4 | 13.3 | 13.3 | 28.9 | 31.1 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 13.18 | 13.47 | 12.71 | 12.93 | 17.23 | 19.47 | 18.91 | 24.10 | 26.70 | 28.66 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 2.53 | 2.64 | 2.51 | 2.69 | 3.09 | 3.53 | 3.24 | 3.56 | 3.82 | 3.89 |
| Std. Dev | 1.290 | 1.317 | 1.325 | 1.395 | 1.203 | 1.217 | 1.151 | .990 | .960 | .910 |

Obviously, the organisations that had successfully managed the implementation of AMT projects are directing extensive resources and efforts to enhance the TLP. Based on this study, these resources and efforts were classified

as an advanced level. As a result, a consideration and manipulation of the Technological Learning Process (TLP) is reached to advanced level within organisations that had successfully managed the implementation of AMT projects.

The study proceeded further to investigate whether world class TLP was implemented in the successful organisations. Table 5.30 shows that two thirds (66.6%) of the successful organisations were found to proactively collaborate with universities and research institutes (i.e. parameter 7). Over half (51%) of the respondents declared that they provide incentive systems suitable for technological learning and effective in stimulating the bottom-up flow of technological trends (parameter number 10 of Table 5.30).

Table 5.30 World-Class Level of TLP against Successful Organisations

| | 1) Launch projects of limited duration | 2) Appoint a gatekeeper | 3) Use venture capital funds | 4) Send technology envoys throughout the world | 5) Organize technology colloquia | 6) Arrange innovation workshops | 7) Collaborate with universities and research institutes | 8) Collaborate with start-ups and leading companies | 9) Establish centralized and/or decentralized units dedicated to learn trends of new | 10) Provide incentive systems suitable for technological learning | 11) Provide researchers with financial resources |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 26.7 | 33.3 | 80.0 | 66.7 | 48.9 | 35.6 | 13.3 | 42.2 | 35.6 | 22.2 | 57.8 |
| Hardly | 15.6 | 26.7 | 13.3 | 13.3 | 33.3 | 31.1 | 20.0 | 28.9 | 20.0 | 26.7 | 24.4 |
| Occasionally | 24.4 | 17.8 | 2.2 | 15.6 | 8.9 | 15.6 | 33.3 | 8.9 | 20.0 | 24.4 | 6.7 |
| Fairly | 26.7 | 13.3 | 2.2 | 2.2 | 6.7 | 8.9 | 22.2 | 17.8 | 20.0 | 20.0 | 8.9 |
| Regularly | 6.7 | 8.9 | 2.2 | 2.2 | 2.2 | 8.9 | 11.1 | 2.2 | 4.4 | 6.7 | 2.2 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 13.91 | 12.09 | 10.83 | 10.88 | 11.91 | 11.75 | 16.70 | 11.65 | 12.42 | 14.30 | 10.82 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 2.71 | 2.38 | 1.33 | 1.60 | 1.80 | 2.24 | 2.98 | 2.09 | 2.38 | 2.62 | 1.73 |
| Std. Dev | 1.31 | 1.32 | .826 | .987 | 1.01 | 1.28 | 1.20 | 1.20 | 1.28 | 1.23 | 1.08 |

The results obtained from the statistical analysis also indicated that one third of the successful organisations agreed that they appoint a gatekeeper, arrange

innovation workshops, and collaborate with start-ups and leading companies, whether international or not.

From the statistical analysis, two interesting findings were found. First and foremost interesting finding was that about half (44.4%) of the successful group were establishing centralized and/or decentralized units dedicated to learn developments and trends of new technologies, in which the tasks were hierarchically divided within the positions and departments (i.e. column number 9 of Table 5.30). The other interesting finding is that almost two thirds (58%) of the successful organisations acknowledged that they launch projects of limited duration specifically dedicated to learn specific technological problems and developments (i.e. column No 1 in Table 5.30)'. it is noteworthy to explain that practicing such activities undoubtedly required plenty of resources and efforts.

Based on these findings, there was evidence that the considerable attention and efforts paid by majority of the successful organisations to TLP were deemed as a World-Class Level. Generally, as presented in Table 5.27, 5.28, 5.29 and 5.30, the successful organisations were found practicing 9 out of 12 parameters in the first level of TLP, 12 out of 13 parameters in the second level, 10 out of 10 parameters in the third level and 7 out of 11 parameters in the fourth level of TLP. Consequently, these organisations that had successfully managed the implementation of AMT projects are a world class TLP.

#### 5.5.2.2 Less Successful Organisations against Four Levels of TLP

Next step of testing the first hypothesis was attempting to determine the extent to which the TLP was practiced by unsuccessful group. As stated earlier, the unsuccessful group represented the respondents who had failed to manage the implementation of AMT projects. Based on the discrimination test, the unsuccessful group consists of 8 organisations. The following section was dedicated to investigate whether the unsuccessful organisations had invested in TLP. Since the TLP comprises four levels starting with basic level through to world-class level, every level of TLP was examined and presented separately.

In order to present the statistical figures as simple as possible, many statistical tests such as frequency analysis and *M*ean were combined in one table. For instance, Table 5.31 presented figures of Frequency analysis, Mean, Std

Deviation, t-test, and P-Value. This approach was applied to almost all tables involved in presenting results of hypotheses testing. It is also worth noting that the statistical results related to the association between the unsuccessful organisations and the four levels of TLP were summarised in Tables 5.31, 5.32, 5.33 and 5.34.

Table 5.31 Basic Level against Less Successful Organisations

| | 1) Cooperate with suppliers | 2) Cooperate with customers/users | 3) Check government sources | 4) Participate in activities of professional associations | 5) Participate in activities of trade associations | 6) Scrutinize business literature | 7) Join local chambers of commerce | 8) Subscribe to the local press and the local newspaper | 9) Subscribe and review trade press | 10) Collaborate with stockbrokers | 11) Keep track of the prospectus | 12) Contact and visit the investment banks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | | 37.5 | | | | 25.0 | 75.0 | 12.5 | 75.0 | 87.5 | 62.5 |
| Hardly | | 25.0 | 37.5 | 50.0 | 37.5 | 25.0 | 25.0 | | 12.5 | 12.5 | | 25.0 |
| Occasionally | 12.5 | 12.5 | 12.5 | 50.0 | 62.5 | 37.5 | 37.5 | 12.5 | 37.5 | 12.5 | 12.5 | 12.5 |
| Fairly | 50.0 | 12.5 | 12.5 | | | 25.0 | 12.5 | | 12.5 | | | |
| Regularly | 37.5 | 50.0 | | | | 12.5 | | 12.5 | 25.0 | | | |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 17.00 | 8.08 | 5.29 | 13.23 | 14.35 | 8.88 | 6.33 | 3.33 | 6.62 | 5.23 | 5.00 | 5.62 |
| Sig | .000 | .000 | .001 | .000 | .000 | .000 | .000 | .013 | .000 | .001 | .002 | .001 |
| Mean | 4.25 | 3.88 | 2.00 | 2.50 | 2.63 | 3.25 | 2.38 | 1.75 | 3.25 | 1.38 | 1.25 | 1.50 |
| Std. Dev | .707 | 1.356 | 1.069 | .535 | .518 | 1.035 | 1.061 | 1.488 | 1.389 | .744 | .707 | .756 |

In order to investigate the exploitation of TLP within the unsuccessful organisations, the basic level of TLP was initially examined. A frequency in Table 5.31 shows that out of 12, 4 parameters only were practiced by the unsuccessful organisations. This result was also supported by the scores of *M*ean. By looking at a row headed *M*ean in Table 5.31, only four parameters of the basic level have recorded high scores of the *M*ean. These four parameters are 'Cooperate with suppliers (4.24)', 'Cooperate with customers/users (3.88)', 'Scrutinize business literature and those periodicals (3.25)', and 'Subscribe and review trade press (3.25)'. This is an indication that the unsuccessful organisations had very low

interest in practicing parameters of the basic level. Remarkably, majority of the parameters of the basic level were practiced by the successful organisations. This can from the beginning show the difference between the two groups i.e. the successful group and the unsuccessful group.

Table 5.32 Average Level of TLP against Less Successful Organisations

| | 1) Participation of employees in the company's strategy | 2) Use IT such as Bulletin Board System and E-mails | 3) Access to the Internet | 4) Create informal discussion networks | 5) Rotate jobs among employees | 6) Establish communication routines | 7) Provide members with extra travel budget | 8) Use Technology Roadmaps | 9) Use a Balanced Scorecard | 10) Use Listening Posts | 11) Use a Watch List | 12) Benchmark key competitors | 13) Conduct a sensitivity analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | | | 25.0 | 12.5 | 12.5 | 37.5 | 50.0 | 62.5 | 37.5 | 75.0 | 37.5 | 50.0 |
| Hardly | 50.0 | 50.0 | | 12.5 | 25.0 | 12.5 | 37.5 | 25.0 | 25.0 | 12.5 | | 37.5 | 25.0 |
| Occasionally | 25.0 | | | 25.0 | 12.5 | 62.5 | 25.0 | 12.5 | 12.5 | 37.5 | 25.0 | 12.5 | 12.5 |
| Fairly | 25.0 | 25.0 | 25.0 | 37.5 | 50.0 | 12.5 | | 12.5 | | 12.5 | | 12.5 | 12.5 |
| Regularly | | 25.0 | 75.0 | | | | | | | | | | |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 8.78 | 6.62 | 29.02 | 6.07 | 7.10 | 8.78 | 6.36 | 4.71 | 5.61 | 5.46 | 4.58 | 5.29 | 4.71 |
| Sig | .000 | .000 | .000 | .001 | .000 | .000 | .000 | .002 | .001 | .001 | .003 | .001 | .002 |
| Mean | 2.75 | 3.25 | 4.75 | 2.75 | 3.00 | 2.75 | 1.88 | 1.88 | 1.50 | 2.25 | 1.50 | 2.00 | 1.88 |
| Std. Dev | .886 | 1.39 | .463 | 1.28 | 1.20 | .886 | .835 | 1.13 | .756 | 1.17 | .926 | 1.07 | 1.13 |

Same analysis tools were also used to study the relationship between the unsuccessful organisations and the 13 parameters of average level of TLP. A frequency and *M*ean scores in Table 5.32 indicate that the unsuccessful organisations were practicing only three parameters of the average level of TLP. These practiced parameters were 'Use IT such as Bulletin Board System and E-mails', 'Access to the Internet', and 'Rotate jobs among employees in order to strengthen the informal technological. The values of the *M*ean for each of the above three parameters were 3.25, 4.75, and 3.00 respectively. Practicing 3 out of 13 parameters included in this level was very clear evidence that the unsuccessful

organisations were paying very shy attention to TLP. In contrast, the successful organisations were proved their interest in TLP by practicing 10 out of 13 parameters involved in the same level.

Table 5.33 Advanced Level of TLP against Less Successful Organisations

| | 1) Establish a suitable pyramidal structure of R&D personnel | 2) Build a reliable and accessible databases | 3) Use R&D documents in comparison to other documents | 4) Acquire up-to-date R&D tools | 5) Share knowledge within the R&D dept | 6) Share information among depts | 7) Gain support and commitment of top management | 8) Keep a constant balance between human resource planning and learning strategy | 9) Recruit high levels of education, skills, and experience | 10) Provide training programmes for employees |
|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 50.0 | 37.5 | 25.0 | 50.0 | 25.0 | 25.0 | 12.5 | 37.5 | 12.5 | 12.5 |
| Hardly | 37.5 | 37.5 | 25.0 | 25.0 | 12.5 | 12.5 | 12.5 | 25.0 | 37.5 | 25.0 |
| Occasionally | 12.5 | 12.5 | 25.0 | | 25.0 | 25.0 | 62.5 | 37.5 | 25.0 | 25.0 |
| Fairly | | 12.5 | 12.5 | 25.0 | 25.0 | 25.0 | | | 25.0 | 37.5 |
| Regularly | | | 12.5 | | 12.5 | 12.5 | 12.5 | | | |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 6.18 | 5.29 | 5.27 | 4.32 | 5.58 | 5.58 | 7.22 | 6.11 | 7.00 | 7.22 |
| Sig | .000 | .001 | .001 | .003 | .001 | .001 | .000 | .000 | .000 | .000 |
| Mean | 1.63 | 2.00 | 2.63 | 2.00 | 2.88 | 2.88 | 2.88 | 2.00 | 2.63 | 2.88 |
| Std. Dev | .744 | 1.07 | 1.41 | 1.31 | 1.46 | 1.46 | 1.13 | .926 | 1.06 | 1.13 |

Subsequently, an investigation was also carried out to find whether the unsuccessful organisations practiced any of the 10 parameters of the advanced level. Statistical tools such as a frequency, *M*ean, and t-test were applied. As a result, Table 5.33 showed quarter (25%) of the unsuccessful organisations was implementing two parameters of the advanced level. These two parameters were 'Use R&D documents in comparison to other documents', and 'Recruit high levels of education, skills, and experience among employees to manage technological learning'. It was also noticed that one third of the unsuccessful organisations was found concerning with three parameters of the advanced level. These three parameters were 'Share knowledge, whether formal or informal,

within the R&D dept', 'Share information among depts', and 'Provide training programmes for their employees to improve technological learning'. These results demonstrated that it was obviously two thirds (75%) of the unsuccessful organisations had no interests in implementing the parameters of the advanced level. Further, values of the *M*ean in Table 5.33 were low verifying the neglect of the unsuccessful organisations to parameters of the advanced level.

Table 5.34 World-Class Level of TLP against Less Successful Organisations

| | 1) Launch projects of limited duration | 2) Appoint a gatekeeper | 3) Use venture capital funds | 4) Send technology envoys throughout the world | 5) Organize technology colloquia | 6) Arrange innovation workshops | 7) Proactively collaborate with universities and research institutes | 8) Collaborate with start-ups and leading companies | 9) Establish centralized and/or decentralized units dedicated to learn trends of new technologies | 10) Provide incentive systems suitable for TLP | 11) Provide researchers with financial resources |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 50.0 | 50.0 | 87.5 | 62.5 | 75.0 | 75.0 | 37.5 | 50.0 | 62.5 | 75.0 | 50.0 |
| Hardly | 25.0 | 25.0 | 12.5 | 37.5 | 25.0 | 12.5 | 37.5 | 12.5 | 25.0 | 12.5 | |
| Occasionally | 25.0 | | | | | 12.5 | 25.0 | 37.5 | 12.5 | 12.5 | 50.0 |
| Fairly | | 25.0 | | | | | | | | | |
| Regularly | | | | | | | | | | | |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 5.58 | 4.32 | 9.00 | 7.51 | 7.64 | 5.23 | 6.36 | 5.35 | 5.61 | 5.23 | 5.29 |
| Sig | .001 | .003 | .000 | .000 | .000 | .001 | .000 | .001 | .001 | .001 | .001 |
| Mean | 1.75 | 2.00 | 1.13 | 1.38 | 1.25 | 1.38 | 1.88 | 1.88 | 1.50 | 1.38 | 2.00 |
| Std. Dev | .886 | 1.31 | .354 | .518 | .463 | .744 | .835 | .991 | .756 | .744 | 1.07 |

Based on the statistical results obtained from Table 5.34, the unsuccessful organisations were not any closer to world class TLP. A frequency analysis and *M*ean figures demonstrated that all parameters of world-class level of TLP were neglected. In contrary, the successful organisations have been found to practice many parameters of the world-class level.

Based on the statistical tests applied for both the successful group and unsuccessful group, it was evident that where the unsuccessful group had paid very low attention to TLP, the TLP was heavily practiced in the successful group. This finding stresses that the organisations that paid great attention to TLP and provided resources and efforts to promote TLP were very likely to succeed in managing the implementation of AMT projects.

Consequently, it could be safely concluded that the first hypothesis, which proposed that organisations, which practiced TLP to learn about changes and developments of new technologies, were more likely to achieve great degree of success in the process of AMT implementation, could be accepted.

**5.5.3 Third Hypothesis:** Organisations, which practiced TLP to explore changes and developments of new technologies, would perceive higher levels of operations performance (i.e. implementation of TLP would positively influence the organisations performance)

Participants to this study were asked to assess the changes in manufacturing performance that they consider are attributable to the adoption of new technologies. For this purpose, the respondents were provided with a list of 15 performance measures including 'Product Quality', 'Scrap and Rework', 'Variety of Products Manufactured', 'Ability to change production lot sizes', 'Number of operators', 'Average labour cost', 'Operator output rates', 'Average numbers of tasks per operator', 'Delivery lead-times', Setup times', 'Changeover times', 'Manufacturing lead-times', 'Engineering/design lead-times', 'Time-to-markets', and 'Time for a major design change in an existing product'. These 15 variables were chosen to reflect the competitive priorities of cost, quality, flexibility and time-based competition. The composite measure of performance for each firm was achieved using the measurement process described below. Each of the participants to this study were requested to rate their level of manufacturing performance on each of the 15 performance variables on a five point scale ranging from substantial decline in performance through decline in performance, no change in performance, and improvement in performance to substantial improvement in performance. The Cronbach's alpha value for the performance scale with 15 variables was 0.85. Therefore, this performance scale was deemed to be reliable.

A composite performance score was calculated for each firm by standardizing the summed scores achieved on all 15 performance variables. To maintain consistency in the analysis of the hypothesis testing results, all hypotheses were tested using only information from the firms that had conducted TLP, installed AMT and had achieved measurable changes in performance levels.

In order to test third hypothesis, all responses were carefully checked to discriminate the respondents who have achieved very high performance from those who have experienced very poor performance. The discrimination process identified that 2 firms were found to have substantial decline in manufacturing performance whereas 8 firms were determined to have significant improvement in performance of manufacturing operations. The following sections were devoted to present the statistical results and discussed findings obtained from both groups (i.e. firms with low performance and firms with high performance).

#### 5.5.3.1 Organisations with decline performance against Levels of TLP

To investigate whether the implementation of TLP had any influence on the organisation performance, firms that had a substantial decline in performance were initially studied. Although many statistical tests such as data frequency analysis, Mean, Scatter Plot, t-test, bi-variation correlation were used to test this relationship, few tests were presented in the following tables. As comprised of four levels, each level of TLP was independently studied. For instance, the basic level, which represented 12 parameters of TLP, was primarily tested. Table 5.35 showed that out of 12 parameters, only 3 parameters of the basic level were practiced. The firms that had substantial decline in performance were found to have very shy involvement in the parameters of the basic level.

Table 5.35 Declined Performance against Basic Level of TLP

| | 1) Cooperate with suppliers | 2) Cooperate with customers/users | 3) Check government sources | 4) Participate in activities of professional associations | 5) Participate in activities of trade associations | 6) Scrutinize business literature | 7) Join local chambers of commerce | 8) Subscribe to the local press and local newspaper | 9) Subscribe and review trade press | 10) Collaborate with stockbrokers | 11) Keep track of the prospectus | 12) Contact and visit the investment banks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | | 50.0 | 50.0 | | | 100.0 | 50.0 | 50.0 | 100.0 | 100.0 | 100.0 |
| Hardly | | | 50.0 | | 50.0 | | | 50.0 | | | | |
| Occasionally | 50.0 | 50.0 | | 50.0 | 50.0 | | | | 50.0 | | | |
| Fairly | 50.0 | | | | | 50.0 | | | | | | |
| Regularly | | 50.0 | | | | 50.0 | | | | | | |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 7.00 | 4.00 | 3.00 | 2.00 | 5.00 | 9.00 | | 3.00 | 2.00 | | | |
| Sig | .090 | .156 | .205 | .295 | .126 | .070 | | .205 | .295 | | | |
| Mean | 3.50 | 4.00 | 1.50 | 2.00 | 2.50 | 4.50 | 1.00 | 1.50 | 2.00 | 1.00 | 1.00 | 1.00 |
| Std. Dev | .707 | 1.41 | .707 | 1.41 | .707 | .707 | .000 | .707 | 1.41 | .00 | .00 | .00 |

In order to understand the practiced parameters of the second level, which comprise 13 parameters of TLP, statistical tests (i.e. data frequency analysis, *M*ean, and t-test) were conducted. Table 5.36 revealed that only two parameters of the average level have scored high values of the *M*ean. These two parameters are item number 2 and item number 3. The data frequency analysis shown in Table 5.36 also supported the results obtained from the *M*ean figures. Based on the frequency analysis, all the firms, which have significant decline in performance, agreed that they 'use IT such as Bulletin Board System and E-mails', and 'access to the Internet'. On the other hand, the 11 parameters of the average level were neglected by the firms that have substantial decline in performance.

Table 5.36 Declined Performance against Average Level of TLP

| | 1) Participation of employees in the company's strategy | 2) Use IT such as Bulletin Board System and E-mails | 3) Access to the Internet | 4) Create informal discussion networks | 5) Rotate jobs among employees | 6) Establish communication routines | 7) Provide members with extra travel budget | 8) Use Technology Roadmaps | 9) Use a Balanced Scorecard | 10) Use Listening Posts | 11) Use a Watch List | 12) Benchmark key competitors | 13) Conduct a sensitivity analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | | | 50 | | | | | 50 | 50 | 50 | 50 | |
| Hardly | 100 | | | 50 | 100 | 100 | 50 | 50 | | | | 50 | 100 |
| Occasionally | | | | | | | 50 | 50 | 50 | 50 | 50 | | |
| Fairly | | 100 | 50 | | | | | | | | | | |
| Regularly | | | 50 | | | | | | | | | | |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| t-test | | | 9.00 | 3.00 | | | 5.00 | 5.00 | 2.00 | 2.00 | 2.00 | 3.00 | |
| Sig | | | .070 | .205 | | | .126 | .126 | .295 | .295 | .295 | .205 | |
| Mean | 2.00 | 4.00 | 4.50 | 1.50 | 2.00 | 2.00 | 2.50 | 2.50 | 2.00 | 2.00 | 2.00 | 1.50 | 2.00 |
| Std. Dev | .000 | .000 | .707 | .707 | .000 | .000 | .707 | .707 | 1.41 | 1.41 | 1.41 | 1.41 | .000 |

Subsequently, 10 parameters of the advanced level were examined. It was not unexpectedly to find that all the parameters of the third level were neglected. As presented in Table 5.37, values of the *M*ean for the 10 parameters of the advanced level were all very low indicating none of the firms which had significant decline in performance, had paid attention to parameters of the advanced level of TLP.

Table 5.37 Declined Performance against Advanced Level of TLP

| | 1) Establish a suitable pyramidal structure of R&D personnel | 2) Build a reliable and accessible database | 3) Use R&D documents in comparison to other documents | 4) Acquire up-to-date R&D tools | 5) Share knowledge within the R&D dept | 6) Share information among departments | 7) Gain support and commitment of top management | 8) Keep a constant balance between human resource planning and learning strategy | 9) Recruit high levels of education, skills, and experience | 10) Provide training programmes |
|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 50 | 50 | 50 | 50 | 100 | 50 | | | | |
| Hardly | 50 | 50 | 50 | 50 | | 50 | 50 | 50 | 50 | 50 |
| Occasionally | | | | | | | 50 | 50 | 50 | 50 |
| Fairly | | | | | | | | | | |
| Regularly | | | | | | | | | | |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| t-test | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Sig | .205 | .205 | .205 | .205 | .205 | .205 | .126 | .126 | .126 | .126 |
| Mean | 1.50 | 1.50 | 1.50 | 1.50 | 1.00 | 1.50 | 2.50 | 2.50 | 2.50 | 2.50 |
| Std. Dev | .707 | .707 | .707 | .707 | .000 | .707 | .707 | .707 | .707 | .707 |

Further, the fourth level of TLP was world-class level. To examine the 11 parameters involved in this level, the firms, which had substantial decline in performance, were requested to explain whether they practiced any of the 11 parameters of the world-class level. As can be seen from statistical results shown in Table 5.38, none of the 11 parameters of the world-class level was used. As a result, the firms that had substantial decline in performance were nowhere close to world class TLP.

Table 5.38 Declined Performance against World-Class Level of TLP

| | 1) Launch projects of limited duration | 2) Appoint a gatekeeper | 3) Use venture capital funds | 4) Send technology envoys throughout the world | 5) Organize technology colloquia | 6) Arrange innovation workshops | 7) Proactively collaborate with universities and research institutes | 8) Collaborate with start-ups and leading companies | 9) Establish centralized and/or decentralized units dedicated to learn trends of new technologies | 10) Provide incentive systems suitable for TLP | 11) Provide researchers with financial resources |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 50 | 100 | 100 | 100 | 100 | 100 | 50 | 100 | 100 | 100 | 100 |
| Hardly | | | | | | | | | | | |
| Occasionally | 50 | | | | | | 50 | | | | |
| Fairly | | | | | | | | | | | |
| Regularly | | | | | | | | | | | |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| t-test | 2.00 | | | | | | 2.00 | | | | |
| Sig | .295 | | | | | | .295 | | | | |
| Mean | 2.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 2.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Std. Dev | 1.41 | .000 | .000 | .000 | .000 | .000 | 1.41 | .000 | .000 | .000 | .000 |

### 5.5.3.2 Organisations with Improved Performance against Levels of TLP

As described earlier, the discrimination process had also identified 8 respondents who have achieved very significant improvement in manufacturing performance. This section, therefore, concentrated on studying the impact of TLP on these 8 firms. As requested to assess their organisations performance on a five-point scale ranging from substantial decline in performance through to substantial improvement in performance, these companies were also asked to rate their implementation level in technological learning process at a five-point scale ranging from not practiced through to regularly practiced. As consisted of four

levels, TLP was examined within the organisations, which had substantial improvement in performance, level by level beginning with basic level and followed by average level, advanced level and ended up with world-class level.

Table 5.39 Improved Performance against Basic Level of TLP

| | 1) Cooperate with suppliers | 2) Cooperate with customers/users | 3) Check government sources | 4) Participate in activities of professional associations | 5) Participate in activities of trade associations | 6) Scrutinize business literature | 7) Join local chambers of commerce | 8) Subscribe to the local press and local newspaper | 9) Subscribe and review trade press | 10) Collaborate with stockbrokers | 11) Keep track of the prospectus | 12) Contact and visit the investment banks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | | 25.0 | | | | 37.5 | 25.0 | 12.5 | 50.0 | 50.0 | 50.0 |
| Hardly | | | | | 12.5 | 12.5 | 12.5 | 12.5 | 25.0 | 37.5 | 25.0 | 25.0 |
| Occasionally | | 12.5 | 62.5 | 50.0 | 50.0 | 37.5 | 12.5 | 25.0 | | | 12.5 | |
| Fairly | 50.0 | 25.0 | | 25.0 | 12.5 | 12.5 | 12.5 | 12.5 | 37.5 | | | |
| Regularly | 50.0 | 62.5 | 12.5 | 25.0 | 25.0 | 37.5 | 25.0 | 25.0 | 25.0 | 12.5 | 12.5 | 25.0 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 23.81 | 16.84 | 6.07 | 11.97 | 9.26 | 9.11 | 4.44 | 5.29 | 6.34 | 3.91 | 4.00 | 3.63 |
| Sig | .000 | .000 | .001 | .000 | .000 | .000 | .003 | .001 | .000 | .006 | .005 | .008 |
| Mean | 4.50 | 4.50 | 2.75 | 3.75 | 3.50 | 3.75 | 2.75 | 3.00 | 3.38 | 1.88 | 2.00 | 2.25 |
| Std. Dev | .535 | .756 | 1.28 | .886 | 1.07 | 1.17 | 1.75 | 1.60 | 1.51 | 1.36 | 1.41 | 1.75 |

In the beginning, 12 parameters of the basic level, which were common to use, were tested. Several statistical tests were used to determine which parameters of the basic level were practiced by the respondents who had accomplished very significant improvement in performance. Table 5.39 reveals that only three parameters of the basic level were underestimated. These three parameters were '(10) Collaborate with stockbrokers who often have made deeply studies of a competitor', '(11) Keep track of the prospectus', and '(12) Contact and visit the investment banks'. On the contrary, firms, which have perceived high performance, were found to practice nine parameters of the basic level. Thus,

these firms were found to 'cooperate with suppliers', 'cooperate with customers/users', 'check government sources that contain very detailed information on foreign and domestic investments', 'participate in activities of professional associations', 'participate in activities of trade associations', 'scrutinize business literature and those periodicals', 'join local chambers of commerce', 'subscribe to the local press and the local newspaper' and also 'subscribe and review trade press'. The basis on which this study was able to distinguish the practiced parameters from neglected parameters was a data frequency analysis supported by values of the Mean. Thus, by looking at the Mean values, it was easier to distinguish the nine practiced parameters from the three neglected parameters.

Table 5.40 Improved Performance against Average Level of TLP

| | 1) Participation of employees in the company's strategy | 2) Use IT such as Bulletin Board System and E-mails | 3) Access to the Internet | 4) Create informal discussion networks | 5) Rotate jobs among employees | 6) Establish communication routines | 7) Provide members with extra travel budget | 8) Use Technology Roadmaps | 9) Use a Balanced Scorecard | 10) Use Listening Posts | 11) Use a Watch List | 12) Benchmark key competitors | 13) Conduct a sensitivity analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | | | 12 | 25 | 25 | 12 | 37 | 25 | 25 | 50 | | 12 |
| Hardly | | | | 25 | 12 | | | 13 | 12 | 12 | 25 | 25 | 12 |
| Occasionally | 12 | | | 38 | | 37 | 25 | 25 | 25 | 25 | 12 | 12 | 13 |
| Fairly | 13 | 25 | 25 | | 50 | 13 | 25 | 12 | | 25 | | 38 | 25 |
| Regularly | 75 | 75 | 75 | 25 | 13 | 25 | 38 | 13 | 38 | 13 | 13 | 25 | 38 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| t-test | 17.58 | 29.02 | 29.02 | 6.00 | 5.69 | 5.69 | 7.64 | 4.68 | 5.12 | 5.58 | 4.00 | 8.63 | 6.81 |
| Sig | .000 | .000 | .000 | .001 | .001 | .001 | .000 | .002 | .001 | .001 | .005 | .000 | .000 |
| Mean | 4.63 | 4.75 | 4.75 | 3.00 | 3.13 | 3.13 | 3.75 | 2.50 | 3.13 | 2.88 | 2.00 | 3.63 | 3.63 |
| Std. Dev | .744 | .463 | .463 | 1.41 | 1.55 | 1.55 | 1.39 | 1.51 | 1.73 | 1.46 | 1.41 | 1.19 | 1.51 |

Next, the average level, which represented 13 parameters of TLP, was investigated. As shown in Table 5.40, almost all parameters of the average level were appeared to be implemented. All the values of the *M*ean were high except the parameter number 11, which had scored a very low value of the Mean. The parameter number 11 is concerned with 'using a Watch List to spot irregularities in the environment of a company.

Table 5.41 Improved Performance against Advanced Level of TLP

| | 1) Establish a suitable pyramidal structure of R&D personnel | 2) Build a reliable and accessible database | 3) Use R&D documents in comparison to other documents | 4) Acquire up-to-date R&D tools | 5) Share knowledge within the R&D dept | 6) Share information among depts | 7) Gain support and commitment of top management | 8) Keep a constant balance between human resource planning and learning strategy | 9) Recruit high levels of education, skills, and experience | 10) Provide training programmes for employees |
|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 12 | 12 | 25 | 12 | 12 | | | | | |
| Hardly | | | | | 12 | 12 | 12 | | | |
| Occasionally | 38 | 50 | 37 | 13 | 13 | 25 | 13 | 25 | 25 | 12 |
| Fairly | 37 | 25 | 25 | 50 | 38 | 25 | 62 | 62 | 37 | 25 |
| Regularly | 13 | 13 | 13 | 25 | 25 | 38 | 13 | 13 | 38 | 63 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| t-test | 8.04 | 7.89 | 6.00 | 8.28 | 7.00 | 9.73 | 11.97 | 17.10 | 13.98 | 16.84 |
| Sig | .000 | .000 | .001 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 3.38 | 3.25 | 3.00 | 3.75 | 3.50 | 3.88 | 3.75 | 3.88 | 4.13 | 4.50 |
| Std. Dev | 1.19 | 1.17 | 1.41 | 1.28 | 1.41 | 1.13 | .886 | .641 | .835 | .756 |

Obviously, the firms that had achieved substantial improvement in manufacturing performance, were found to 'enable employees to participate in the company's strategy (e.g. innovation need) through informal searching and learning activities', 'use IT such as Bulletin Board System and E-mails', 'access to the Internet', 'create informal discussion networks through intranet discussion platforms', 'rotate jobs among employees in order to strengthen the informal

technological learning networks in your organisation', 'establish communication routines to pass on the trends and developments of new technologies to top management', 'provide members with extra travel budget to update their companies with the latest developments of its technology', 'use Technology Roadmaps as a tool to learn and/or anticipate future tends of the new technologies', 'use a Balanced Scorecard to improve critical areas such as technology, product, process, and market development', 'use Listening Posts to get some feedback from your customers and partners', 'benchmark key competitors', and 'conduct a sensitivity analysis'.

Afterwards, the firms, which had significant improvements in manufacturing performance, were recalled to examine their capability in implementing the 10 parameters included in the advanced level. Statistical results displayed in Table 5.41 showed that values of the *M*ean for all parameters of the advanced level were significantly high. This is evidence that the firms, which had significant improvement in performance, had significantly used the 10 parameters of advanced level to learn about and manage the changes and developments of advanced technologies.

In order to investigate whether these firms have world class TLP, the 11 parameters of the fourth level were tested. Table 5.42 showed that among the 11 parameters of world-class level, only two parameters were undervalued. These two parameters were '(3) Use venture capital funds as a tool to get access to new technological trends and solutions at a very early stage', and '(11) Provide researchers with financial resources to follow their own research interest and promote bottom-up mechanism'. On the other hand, nine parameters of the fourth level were considerably used. Thus, the firms, which have perceived significant improvement in performance, were found to 'appoint a gatekeeper', 'send technology envoys throughout the world in order to build up a network with institutions, universities and start-up companies', 'organize technology colloquia to assess different technological developments/changes and/or possible research directions', 'arrange innovation workshops', 'proactively collaborate with universities and research institutes', 'collaborate with start-ups and leading companies, whether international or not', and 'provide incentive systems suitable

for technological learning and effective in stimulating the bottom-up flow of technological trends'.

The most interesting findings of Table 5.42 was that the organisations, which have achieved substantial improvement in performance, were found establishing centralized and/or decentralized units dedicated to learn developments and trends of new technologies. These organisations were also found launching projects of limited duration specifically dedicated to learn specific technological problems and developments. Obviously, implementation of such parameters would have required considerable resources and efforts. Rationally, allocation of such resources and efforts to TLP was not something easy unless benefits either direct or indirect were perceived as a result of its implementation.

Table 5.42 Improved Performance against World-Class Level of TLP

| | 1) Launch projects of limited duration | 2) Appoint a gatekeeper | 3) Use venture capital funds | 4) Send technology envoys throughout the world | 5) Organize technology colloquia | 6) Arrange innovation workshops | 7) Proactively collaborate with universities and research institutes | 8) Collaborate with start-ups and leading companies | 9) Establish centralized and/or decentralized units dedicated to learn trends of new technologies | 10) Provide incentive systems suitable for TLP | 11) Provide researchers with financial resources |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 25 | 12 | 63 | 25 | | 12 | 12 | 12 | | 25 | 50 |
| Hardly | | | | 12 | 50 | 25 | 13 | 12 | 25 | 12 | 12 |
| Occasionally | 12 | 38 | 25 | 50 | 12 | 25 | 12 | 50 | 25 | 50 | 25 |
| Fairly | 38 | 12 | | | 25 | 13 | 38 | 13 | 37 | | |
| Regularly | 25 | 38 | 12 | 13 | 13 | 25 | 25 | 13 | 13 | 13 | 13 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| t-test | 5.97 | 7.28 | 3.74 | 5.70 | 7.10 | 6.06 | 7.00 | 7.10 | 9.00 | 5.70 | 4.12 |
| Sig | .001 | .000 | .007 | .001 | .000 | .001 | .000 | .000 | .000 | .001 | .004 |
| Mean | 3.38 | 3.63 | 2.00 | 2.63 | 3.00 | 3.13 | 3.50 | 3.00 | 3.38 | 2.63 | 2.13 |
| Std. Dev | 1.60 | 1.41 | 1.51 | 1.30 | 1.20 | 1.46 | 1.41 | 1.20 | 1.06 | 1.30 | 1.46 |

Based on the statistical results obtained from testing both groups (i.e. the firms that have experienced substantial decline in performance and the firms that have achieved substantial improvement in performance), it was obvious that the implementation of TLP within the firms, which have experienced substantial declined in performance, was almost absent. As shown in previous Tables, out of all parameters (46) included in the four levels of TLP, only five parameters were practiced. Neglecting to implement TLP would greatly reduce overall organisation performance and effectively inhibit the ability to articulate the results and actions recommended to the business decision-makers [249]. Conversely, the organisations that have achieved substantial improvement in performance have been classified under world class TLP. In order to be world class TLP, a firm has to have practiced all the parameters included in all four level of TLP starting from basic level through average level and advanced level to world-class level. Many scholars argued that competitive success is influenced by the firm's ability to have engaged in TLP. For instance, Spender, (1996) [250], and Gulati, (1999) [139], argued that TLP was very important to a firm seeking to create competitive advantage and improve overall organisation performance. Hitt et al (2000) [134] also stressed that in this exciting competitive era, TLP played a vital role in the firm's competitive success. As a consequence, the finding of this study has supported the contentions debated by several authors.

Consequently, it can be judged that the third hypothesis "organisations, which apply TLP to explore changes and developments of new technologies, will perceive higher levels of performance (i.e. implementation of TLP will positively influence the organisation performance)" must be safely accepted.

### 5.5.4 **Fourth Hypothesis:** Organisation size has an influence on the implementation of Technology Learning Process (TLP)

In order to test this hypothesis, analysis process has gone by several stages. Initially, all responses were checked and distributed into three groups namely: small size organisations, medium size organisations, and large size organisations. The discrimination between the three sizes of the organisations was based on a report made available through the European Industrial Relations Observatory (EIRO) [245]. The EIRO explained that it is most common, however, to measure

size according to numbers of full-time employees or their equivalent. Therefore, a small size organisation is not more than 50 employees, a medium sized company must not have been more than 250 employees, and a large organisation was over 250 employees. This classification was used to classify every response under exact size group.

As a result of the discrimination process, 7 organisations were found to employ less than 50 employees, which had deemed as small size organisations. 29 respondents have described their organisations as medium size organisations. 32 participants explained that the numbers of employees in their organisations are over 250 employees that classified them as large size organisations. Afterwards, every size of organisations (i.e. small, medium, large size) was separately analysed. This approach had assisted authors of this study to determine whether the implementation of TLP can be influenced by organisation size. Actually, similar tests applied to the first two hypotheses were again employed. A presentation and discussion of the statistical results were presented on three stages. Firstly, small size organisations and their practice level in TLP were studied. Medium size organisations were then tested. Large size organisations were investigated in the end.

#### 5.5.4.1 Small Size Organisations against Levels of TLP

Initially, implementation of the 12 parameters of basic level within small size organisations was examined. It is worth to note that based on the discrimination process, seven organisations were found to employ less than 50 employees. Table 5.43 explained that values of the *M*ean indicated that six parameters were considered by small size organisations. These parameters were '(1) Cooperate with suppliers', '(2) Cooperate with customers/users', '(5) Participate in activities of trade associations', '(6) Scrutinize business literature and those periodicals', '(7) Join local chambers of commerce', and'(9) Subscribe and review trade press'.

Table 5.43 Small Size Organisations against Basic Level of TLP

| | 1) Cooperate with suppliers | 2) Cooperate with customers/users | 3) Check government sources | 4) Participate in activities of professional associations | 5) Participate in activities of trade associations | 6) Scrutinize business literature and those periodicals | 7) Join local chambers of commerce | 8) Subscribe to the local press | 9) Subscribe and review trade press | 10) Collaborate with stockbrokers | 11) Keep track of the prospectus | 12) Contact and visit the investment banks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | | 57.1 | 28.6 | 28.6 | | 42.9 | 71.4 | 14.3 | 85.7 | 57.1 | 57.1 |
| Hardly | | 14.3 | 14.3 | 42.9 | 14.3 | 14.3 | | | 14.3 | | 14.3 | 14.3 |
| Occasionally | 14.3 | | 14.3 | 14.3 | 42.9 | 28.6 | 28.6 | | 28.6 | | | |
| Fairly | 57.1 | 28.6 | | | | 28.6 | 14.3 | | 14.3 | | 14.3 | 14.3 |
| Regularly | 28.6 | 57.1 | 14.3 | 14.3 | 14.3 | 28.6 | 14.3 | 28.6 | 28.6 | 14.3 | 14.3 | 14.3 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 15.88 | 10.19 | 3.46 | 4.38 | 4.87 | 8.83 | 4.20 | 2.91 | 5.81 | 2.75 | 3.38 | 3.38 |
| Sig | .000 | .000 | .013 | .005 | .003 | .000 | .006 | .027 | .001 | .033 | .015 | .015 |
| Mean | 4.14 | 4.29 | 2.00 | 2.29 | 2.57 | 3.71 | 2.57 | 2.14 | 3.29 | 1.57 | 2.14 | 2.14 |
| Std. Dev | .690 | 1.11 | 1.53 | 1.38 | 1.40 | 1.11 | 1.62 | 1.95 | 1.50 | 1.51 | 1.68 | 1.68 |

In response to whether small size organisations practiced the average level, which represents 13 parameters of TLP, Table 5.44 explained that five parameters including 1, 2, 3, 6, and 10 have scored high values of the *M*ean. This was also supported by frequency results, which revealed that over half (50%) of the small firms acknowledged their implementation to these five parameters (i.e. 1, 2, 3, 6, and 10).

Table 5.44 Small Size Organisations against Average Level of TLP

| | 1) Participation of employees in the company's strategy | 2) Use IT such as Bulletin Board System and E-mails | 3) Access to the Internet | 4) Create informal discussion networks | 5) Rotate jobs among employees | 6) Establish communication routines | 7) Provide members with extra travel budget | 8) Use Technology Roadmaps | 9) Use a Balanced Scorecard | 10) Use Listening Posts | 11) Use a Watch List | 12) Benchmark key competitors | 13) Conduct a sensitivity analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | | | 28.6 | 42.9 | 14.3 | 42.9 | 28.6 | 42.9 | 14.3 | 57.1 | 42.9 | 42.9 |
| Hardly | 42.9 | 28.6 | | 28.6 | 14.3 | 28.6 | 42.9 | 28.6 | 42.9 | 42.9 | 28.6 | 42.9 | 42.9 |
| Occasionally | 42.9 | 28.6 | | 14.3 | 14.3 | 42.9 | | 14.3 | | 14.3 | | | |
| Fairly | | | 14.3 | 14.3 | 14.3 | | | 14.3 | | 14.3 | | | |
| Regularly | 14.3 | 42.9 | 85.7 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 7.07 | 6.76 | 34.00 | 4.50 | 3.97 | 5.73 | 3.74 | 4.50 | 3.74 | 5.20 | 3.36 | 3.74 | 3.74 |
| Sig | .000 | .001 | .000 | .004 | .007 | .001 | .010 | .004 | .010 | .002 | .015 | .010 | .010 |
| Mean | 2.86 | 3.57 | 4.86 | 2.57 | 2.43 | 2.71 | 2.00 | 2.57 | 2.00 | 2.71 | 1.86 | 2.00 | 2.00 |
| Std. Dev | 1.07 | 1.40 | .378 | 1.51 | 1.62 | 1.25 | 1.41 | 1.51 | 1.41 | 1.38 | 1.46 | 1.41 | 1.41 |

Small firms were also requested to determine whether they practiced any of the 10 parameters of advanced level of TLP. Table 5.45 summarised the results of statistical tests. As shown in Table 5.45, out of ten, only four parameters were practiced. These four parameters were '(5) Share knowledge, whether formal or informal, within the R&D department', '(6) Share information among departments', '(9) Recruit high levels of education, skills, and experience among employees to manage technological learning', and '(10) Provide training programmes for their employees to improve technological learning'. It was not all small firms that had practiced the above four parameters. Based on frequency results, it was about 50% of the small firms that had implemented such parameters. Obviously, out of ten parameters of advanced level, six parameters were neglected and four parameters were considered only by less than 50% of the small size organisations. As a result, a consideration of the advanced level was very poor within the small size organisations.

Table 5.45 Small Size Organisations against Advanced Level of TLP

| | 1) Establish a suitable pyramidal structure of R&D personnel | 2) Build a reliable and accessible database | 3) Use R&D documents in comparison to other documents | 4) Acquire up-to-date R&D tools | 5) Share knowledge within the R&D dept | 6) Share information among depts | 7) Gain support and commitment of top management | 8) Keep a constant balance between human resource planning and learning strategy | 9) Recruit high levels of education, skills, and experience | 10) Provide training programmes for employees |
|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 57.1 | 42.9 | 42.9 | 57.1 | 14.3 | 14.3 | 14.3 | 42.9 | 14.3 | 14.3 |
| Hardly | 28.6 | 14.3 | 14.3 | 28.6 | 42.9 | 28.6 | 42.9 | 28.6 | 14.3 | 28.6 |
| Occasionally | | 28.6 | 28.6 | | | 14.3 | 28.6 | 14.3 | 28.6 | 42.9 |
| Fairly | | | | | 14.3 | 14.3 | | | 14.3 | |
| Regularly | 14.3 | 14.3 | 14.3 | 14.3 | 28.6 | 28.6 | 14.3 | 14.3 | 28.6 | 14.3 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 3.36 | 4.04 | 4.04 | 3.36 | 4.86 | 5.28 | 5.35 | 3.87 | 5.81 | 5.73 |
| Sig | .015 | .007 | .007 | .015 | .003 | .002 | .002 | .008 | .001 | .001 |
| Mean | 1.86 | 2.29 | 2.29 | 1.89 | 3.00 | 3.14 | 2.57 | 2.14 | 3.29 | 2.71 |
| Std. Dev | 1.46 | 1.50 | 1.50 | 1.46 | 1.63 | 1.57 | 1.27 | 1.46 | 1.50 | 1.25 |

Although the implementation of the first three levels of TLP (i.e. basic level, average level, and advanced level) was significantly undervalued by the small size organisations, the fourth level (i.e. world-class level), which represented 11 parameters of TLP was investigated. Statistical results presented in Table 5.46 showed that values of the *M*ean in all parameters of world class level were very low indicating that none of the 11 parameters of world class level was practiced. As a result, the small firms were nowhere near to world class TLP. The lack of TLP implementation in small firms could be referred to many reasons. For instance, lack of resources, lack of competences and skills, and undervaluation of importance of such process may likely be used to explain abandonment of small firms to TLP.

Table 5.46 Small Size Organisations against World-Class Level of TLP

| | 1) Launch projects of limited duration | 2) Appoint a gatekeeper | 3) Use venture capital funds | 4) Send technology envoys throughout the world | 5) Organize technology colloquia | 6) Arrange innovation workshops | 7) Collaborate with universities and research institutes | 8) Collaborate with start-ups and leading companies | 9) Establish centralized and/or decentralized units dedicated to learn trends of AMT | 10) Provide incentive systems suitable for TLP | 11) Provide researchers with financial resources |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 57.1 | 57.1 | 71.4 | 57.1 | 57.1 | 71.4 | 42.9 | 28.6 | 85.7 | 71.4 | 42.9 |
| Hardly | 14.3 | 28.6 | 14.3 | 14.3 | 28.6 | 14.3 | 14.3 | 42.9 | | 14.3 | 28.6 |
| Occasionally | 14.3 | | | 14.3 | | | 28.6 | 14.3 | | | 14.3 |
| Fairly | | | | | | | | | | | |
| Regularly | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 3.46 | 3.36 | 3.03 | 3.46 | 3.36 | 3.03 | 4.04 | 4.38 | 2.75 | 3.03 | 3.87 |
| Sig | .013 | .015 | .023 | .013 | .015 | .023 | .007 | .005 | .033 | .023 | .008 |
| Mean | 2.00 | 1.86 | 1.71 | 2.00 | 1.86 | 1.71 | 2.29 | 2.29 | 1.57 | 1.71 | 2.14 |
| Std. Dev | 1.53 | 1.47 | 1.50 | 1.53 | 1.46 | 1.50 | 1.50 | 1.38 | 1.51 | 1.50 | 1.46 |

#### 5.5.4.2 Medium Size Organisations against Levels of TLP

The medium size organisations were the firms that their employees number is ranging from 51 to 250 employees as explained earlier. The practice level of TLP in such organisations was found to be significant comparing to small size organisations. As can be seen from Table 5.47, the medium size organisations were found to practice the following parameters of the basic level of TLP: '(1) Cooperate with suppliers', '(2) Cooperate with customers/users', '(4) Participate in activities of professional associations', '(5) Participate in activities of trade associations', '(6) Scrutinize business literature and those periodicals', (8) Subscribe to the local press', and '(9) Subscribe and review trade press'.

Table 5.47 Basic Level of TLP against Medium Size Organisations

| | 1. Cooperate with suppliers | 2. Cooperate with customers/users | 3. Check government sources | 4. Participate in activities of professional associations | 5. Participate in activities of trade associations | 6. Scrutinize business literature and those periodicals | 7. Join local chambers of commerce | 8. Subscribe to the local press | 9. Subscribe and review trade press | 10. Collaborate with stockbrokers | 11. Keep track of the prospectus | 12. Contact and visit the investment banks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | | 31.0 | 3.4 | 6.9 | | 34.5 | 31.0 | 10.3 | 58.6 | 41.4 | 48.3 |
| Hardly | 3.4 | 6.9 | 37.9 | 20.7 | 13.8 | 17.2 | 31.0 | 17.2 | 13.8 | 31.0 | 37.9 | 31.0 |
| Occasionally | 17.2 | 17.2 | 20.7 | 31.0 | 48.3 | 34.5 | 17.2 | 31.0 | 27.6 | 6.9 | 17.2 | 10.3 |
| Fairly | 37.9 | 34.5 | 10.3 | 34.5 | 17.2 | 34.5 | 3.4 | 10.3 | 37.9 | | | |
| Regularly | 41.4 | 41.4 | | 10.3 | 13.8 | 13.8 | 13.8 | 10.3 | 10.3 | 3.4 | 3.4 | 10.3 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 26.50 | 23.53 | 11.60 | 17.10 | 15.95 | 19.59 | 9.11 | 10.22 | 15.12 | 9.42 | 10.52 | 8.31 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 4.17 | 4.10 | 2.10 | 3.28 | 3.17 | 3.45 | 2.31 | 2.52 | 3.24 | 1.59 | 1.86 | 1.93 |
| Std. Dev | .848 | .939 | .976 | 1.03 | 1.07 | .949 | 1.37 | 1.33 | 1.15 | .907 | .953 | 1.25 |

Table 5.48 explains that the medium size organisations were also found practicing the following parameters of the average level of TLP: '(1) Participation of employees in the company's strategy', '(2) Use IT such as Bulletin Board System and E-mails', '(3) Access to the Internet', '(5) Rotate jobs among employees', '(6) Establish communication routines', '(9) Use a Balanced Scorecard', '(10) Use Listening Posts', '(12) Benchmark key competitors', and '(13) Conduct a sensitivity analysis'.

Table 5.48 Average Level of TLP against Medium Size Organisations

| | 1. Participation of employees in the company's strategy | 2. Use IT such as Bulletin Board System and E-mails | 3. Access to the Internet | 4. Create informal discussion networks | 5. Rotate jobs among employees | 6. Establish communication routines | 7. Provide members with extra travel budget t | 8. Use Technology Roadmaps | 9. Use a Balanced Scorecard | 10. Use Listening Posts | 11. Use a Watch List | 12. Benchmark key competitors | 13. Conduct a sensitivity analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | 3.4 | | 34.5 | 20.7 | 17.2 | 20.7 | 41.4 | 24.1 | 20.7 | 41.4 | 13.8 | 20.7 |
| Hardly | 24.1 | 13.8 | 6.9 | 24.1 | 17.2 | 13.8 | 34.5 | 27.6 | 24.1 | 27.6 | 31.0 | 17.2 | 24.1 |
| Occasionally | 37.9 | 13.8 | 3.4 | 34.5 | 20.7 | 34.5 | 27.6 | 13.8 | 20.7 | 20.7 | 17.2 | 27.6 | 27.6 |
| Fairly | 17.2 | 20.7 | 20.7 | 6.9 | 37.9 | 27.6 | 10.3 | 17.2 | 20.7 | 27.6 | 6.9 | 31.0 | 13.8 |
| Regularly | 20.7 | 48.3 | 69.0 | | 3.4 | 6.9 | 6.9 | | 10.3 | 3.4 | 3.4 | 10.3 | 13.8 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 16.71 | 17.24 | 27.93 | 11.63 | 12.37 | 13.23 | 11.59 | 9.85 | 10.82 | 11.88 | 9.77 | 13.52 | 11.19 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 3.35 | 3.97 | 4.52 | 2.14 | 2.86 | 2.93 | 2.48 | 2.07 | 2.69 | 2.66 | 2.00 | 3.07 | 2.76 |
| Std. Dev | 1.08 | 1.24 | .871 | .990 | 1.25 | 1.19 | 1.15 | 1.13 | 1.34 | 1.20 | 1.10 | 1.22 | 1.33 |

In Table 5.49, the medium size organisations were found to have practiced several parameters of the advanced level of TLP: '(1) Establish a suitable pyramidal structure of R&D personnel', '(3) Use R&D documents in comparison to other documents', '(5) Share knowledge within the R&D dept', '(6) Share information among departments', '(7) Gain support and commitment of top management', '(8) Keep a constant balance between human resource planning and learning strategy', '(9) Recruit high levels of education, skills, and experience', and '(10) Provide training programmes for your employees'.

Table 5.49 Advanced Level of TLP against Medium Size Organisations

| | 1. Establish a suitable pyramidal structure of R&D personnel | 2. Build a reliable and accessible database | 3. Use R&D documents in comparison to other documents | 4. Acquire up-to-date R&D tools | 5. Share knowledge within the R&D dept | 6. Share information among departments | 7. Gain support and commitment of top management | 8. Keep a constant balance between human resource planning and learning strategy | 9. Recruit high levels of education, skills, and experience | 10. Provide training programmes for your employees |
|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 20.7 | 27.6 | 27.6 | 37.9 | 13.8 | 3.4 | | 3.4 | | 3.4 |
| Hardly | 27.6 | 27.6 | 24.1 | 34.5 | 20.7 | 20.7 | 24.1 | 31.0 | 10.3 | 6.9 |
| Occasionally | 20.7 | 20.7 | 20.7 | 3.4 | 27.6 | 20.7 | 24.1 | 27.6 | 44.8 | 31.0 |
| Fairly | 31.0 | 20.7 | 17.2 | 17.2 | 31.0 | 37.9 | 37.9 | 34.5 | 34.5 | 41.4 |
| Regularly | | 3.4 | 10.3 | 6.9 | 6.9 | 17.2 | 13.8 | 3.4 | 10.3 | 17.2 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 12.31 | 10.87 | 10.32 | 9.01 | 13.54 | 16.57 | 18.05 | 16.65 | 22.44 | 19.92 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 2.62 | 2.45 | 2.59 | 2.21 | 2.97 | 3.45 | 3.41 | 3.04 | 3.45 | 3.62 |
| Std. Dev | 1.15 | 1.21 | 1.35 | 1.32 | 1.18 | 1.12 | 1.02 | .981 | .828 | .979 |

Further, Table 5.50 explains that several parameters of the world class level of TLP were practiced by the medium size organisations: '(1) Launch projects of limited duration' and '(7) Collaborate with universities and research institutes'. Generally, there was evidence that the practice level of TLP in the medium size organisations was significantly stronger than the small size organisations.

Table 5.50 World-Class Level of TLP against Medium Size Organisations

| | 1. Launch projects of limited duration | 2. Appoint a gatekeeper | 3. Use venture capital funds | 4. Send technology envoys throughout the world | 5. Organize technology colloquia | 6. Arrange innovation workshops | 7. Collaborate with universities and research institutes | 8. Collaborate with start-ups and leading companies | 9. Establish centralized and/or decentralized units dedicated to learn trends of new technologies | 10. Provide incentive systems suitable for TLP | 11. Provide researchers with financial resources t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 34.5 | 37.9 | 79.3 | 62.1 | 44.8 | 34.5 | 17.2 | 37.9 | 37.9 | 34.5 | 65.5 |
| Hardly | 13.8 | 24.1 | 13.8 | 24.1 | 34.5 | 41.4 | 27.6 | 27.6 | 27.6 | 24.1 | 17.2 |
| Occasionally | 20.7 | 17.2 | 6.9 | 13.8 | 17.2 | 17.2 | 37.9 | 17.2 | 20.7 | 20.7 | 10.3 |
| Fairly | 27.6 | 13.8 | | | 3.4 | 3.4 | 10.3 | 17.2 | 10.3 | 20.7 | 6.9 |
| Regularly | 3.4 | 6.9 | | | | 3.4 | 6.9 | | 3.4 | | |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 10.22 | 9.38 | 11.62 | 11.07 | 11.22 | 10.77 | 12.65 | 10.23 | 9.96 | 10.55 | 9.03 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 2.52 | 2.28 | 1.28 | 1.52 | 1.79 | 2.00 | 2.62 | 2.14 | 2.14 | 2.28 | 1.59 |
| Std. Dev | 1.33 | 1.31 | .591 | .738 | .861 | 1.00 | 1.12 | 1.13 | 1.16 | 1.16 | .946 |

### 5.5.4.3 Large Size Organisations against Levels of TLP

The essential issue in this section was the question of how significant the organisation size influenced the practice of TLP. In order to answer this, the respondents were presented with a list of TLP activities, which were identified by the interviews held with several Irish managers. The respondents were asked to indicate what activities they practiced to learn and manage the changes and developments of advanced technologies. As described earlier, the 46 parameters of TLP, which were anticipated to be practice in Irish manufacturing organisations, had been organised into four groups. Each group of the parameters represented one of four possible levels of company proficiency (Basic Level, Average Level, Advanced Level, and World-Class Level) in TLP.

After the discrimination process mentioned earlier, the large size firms were found to stand for 32 firms that are all belonging to pharmaceutical industry. Thus, the large size organisations were independently studied to identify possible levels of their proficiency in TLP practice.

Initially statistical tests were carried out to determine whether the large size organisations implemented any basic parameters in order to learn about changes and developments of advanced technologies. As described in Table 5.51, the basic level comprised 12 parameters of TLP. High values of the *M*ean shown in Table 5.51 indicated that 8 of these 12 parameters of the basic level were practiced. As a result, Table 5.51 revealed that the large size organisations were not much care to 'check government sources that contain very detailed information on foreign and domestic investments', 'to collaborate with stockbrokers who often have made deeply studies of a competitor', 'to keep track of the prospectus', and 'to contact and visit the investment banks'.

Table 5.51 Large Size Organisations against Basic Level of TLP

| | 1) Cooperate with suppliers | 2) Cooperate with customers/users | 3) Check government sources | 4) Participate in activities of professional associations | 5) Participate in activities of trade associations | 6) Scrutinize business literature and those periodicals | 7) Join local chambers of commerce | 8) Subscribe to the local press | 9) Subscribe and review trade press | 10) Collaborate with stockbrokers | 11) Keep track of the prospectus | 12) Contact and visit the investment banks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | | 3.1 | 25.0 | 6.3 | 3.1 | | 15.6 | 21.9 | 6.3 | 65.6 | 62.5 | 75.0 |
| Hardly | | 3.1 | 37.5 | | 9.4 | 15.6 | 21.9 | 34.4 | 12.5 | 18.8 | 18.8 | 21.9 |
| Occasionally | 21.9 | 18.8 | 21.9 | 46.9 | 43.8 | 43.8 | 28.1 | 18.8 | 46.9 | 6.3 | 12.5 | |
| Fairly | 50.0 | 34.4 | 15.6 | 34.4 | 28.1 | 25.0 | 34.4 | 21.9 | 25.0 | 9.4 | 6.3 | 3.1 |
| Regularly | 28.1 | 40.6 | | 12.5 | 15.6 | 15.6 | | 3.1 | 9.4 | | | |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 30.11 | 28.98 | 12.51 | 17.55 | 18.90 | 25.28 | 14.23 | 11.58 | 19.98 | 10.51 | 10.44 | 12.47 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 4.06 | 4.06 | 2.28 | 3.47 | 3.44 | 3.41 | 2.81 | 2.50 | 3.19 | 1.59 | 1.63 | 1.31 |
| Std. Dev | .716 | 1.01 | 1.02 | .950 | .982 | .946 | 1.09 | 1.16 | .998 | .979 | .942 | .645 |

On the other hand, Table 5.51 also demonstrated that the large size organisations 'cooperate with suppliers', 'cooperate with customers/users', 'participate in activities of professional associations', 'participate in activities of trade associations', 'scrutinize business literature and those periodicals', 'join local chambers of commerce', 'subscribe to the local press and frequently check the local newspaper', and 'subscribe and review trade press'.

Generally, where three parameters of basic level were neglected, the large size organisations had not only practiced but also emphasised on the importance of the remaining eight parameters of the basic level that were noticed by their high values of the Mean.

Second level of TLP was the average level, which concerned with 13 parameters of TLP. This study had used many statistical tools to examine whether the 13 parameters of the average level were practiced by the large size organisations. The most interesting finding obtained from statistical results presented in Table 5.52 was that all the 13 parameters of average level were implemented. This finding contributed in explaining the big gap between the small and large size organisations in relation to utilisation of TLP. Where only 5 parameters of the average level were practiced by small size organisations, the large size organisations had explained their desire and capability of using all parameters of the average level of TLP. As can be seen from Table 5.52, the large size organisations 'allow employee to participate in the company's strategy (e.g. innovation need) through informal searching and learning activities', 'use IT such as Bulletin Board System and E-mails', 'access to the Internet', 'create informal discussion networks through intranet discussion platforms', 'rotate jobs among employees in order to strengthen the informal technological learning networks in your organisation', 'establish communication routines to pass on the trends and developments of new technologies to top management', 'provide your members with extra travel budget to update your company with the latest developments of its technology', 'use Technology Roadmaps as a tool to learn and/or anticipate future tends of the new technologies'.

Table 5.52 Large Size Organisations against Average Level of TLP

| | 1) Participation of employees in the company's strategy | 2) Use IT such as Bulletin Board System and E-mails | 3) Access to the Internet | 4) Create informal discussion networks | 5) Rotate jobs among employees | 6) Establish communication routines | 7) Provide members with extra travel budget | 8) Use Technology Roadmaps | 9) Use a Balanced Scorecard | 10) Use Listening Posts | 11) Use a Watch List | 12) Benchmark key competitors | 13) Conduct a sensitivity analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 3.1 | 9.4 | | 21.9 | 9.4 | 6.3 | 15.6 | 21.9 | 28.1 | 25.0 | 28.1 | 3.1 | 9.4 |
| Hardly | 6.3 | 3.1 | | 15.6 | 31.3 | 15.6 | 25.0 | 18.8 | 9.4 | 12.5 | 21.9 | 18.8 | 21.9 |
| Occasionally | 25.0 | 15.6 | 3.1 | 28.1 | 18.8 | 43.8 | 28.1 | 25.0 | 15.6 | 40.6 | 31.3 | 21.9 | 25.0 |
| Fairly | 50.0 | 40.6 | 31.3 | 18.8 | 34.4 | 28.1 | 25.0 | 28.1 | 28.1 | 18.8 | 15.6 | 43.8 | 37.5 |
| Regularly | 15.6 | 31.3 | 65.6 | 15.6 | 6.3 | 6.3 | 6.3 | 6.3 | 18.8 | 3.1 | 3.1 | 12.5 | 6.3 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 26.85 | 22.41 | 39.73 | 15.60 | 25.46 | 21.36 | 23.73 | 18.89 | 14.51 | 17.45 | 14.11 | 30.66 | 28.29 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 3.69 | 3.81 | 4.63 | 2.91 | 2.97 | 3.13 | 2.81 | 2.78 | 3.00 | 2.63 | 2.44 | 3.44 | 3.09 |
| Std. Dev | .931 | 1.20 | .554 | 1.38 | 1.15 | .976 | 1.18 | 1.26 | 1.524 | 1.16 | 1.16 | 1.05 | 1.12 |

The large size organisations were also found to significantly 'use a Balanced Scorecard to improve critical areas such as technology, product, process, and market development', 'use Listening Posts to get some feedback from your customers and partners', 'use a Watch List to spot irregularities in the environment of your company', 'benchmark key competitors', and 'conduct a sensitivity analysis'.

Table 5.53 Large Size Organisations against Advanced Level of TLP

| | 1) Establish a suitable pyramidal structure of R&D personnel | 2) Build a reliable and accessible database | 3) Use R&D documents in comparison to other documents | 4) Acquire up-to-date R&D tools | 5) Share knowledge within the R&D dept | 6) Share information among depts | 7) Gain support and commitment of top management | 8) Keep a constant balance between human resource planning and learning strategy | 9) Recruit high levels of education, skills, and experience | 10) Provide training programmes |
|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 28.1 | 18.8 | 21.9 | 15.6 | 15.6 | 12.5 | 6.3 | | | |
| Hardly | 28.1 | 25.0 | 31.3 | 31.3 | 12.5 | 9.4 | 21.9 | 9.4 | 9.4 | 3.1 |
| Occasionally | 15.6 | 25.0 | 15.6 | 6.3 | 21.9 | 28.1 | 15.6 | 28.1 | 21.9 | 28.1 |
| Fairly | 18.8 | 21.9 | 28.1 | 37.5 | 34.4 | 28.1 | 37.5 | 46.9 | 37.5 | 37.5 |
| Regularly | 9.4 | 9.4 | 3.1 | 9.4 | 15.6 | 21.9 | 18.8 | 15.6 | 31.3 | 31.3 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 10.66 | 12.46 | 12.08 | 12.61 | 13.86 | 14.81 | 15.87 | 24.28 | 22.96 | 26.08 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 2.53 | 2.78 | 2.59 | 2.94 | 3.22 | 3.38 | 3.41 | 3.69 | 3.91 | 3.97 |
| Std. Dev | 1.34 | 1.26 | 1.21 | 1.32 | 1.31 | 1.29 | 1.21 | .859 | .963 | .861 |

Since all parameters included in the first two levels (i.e. basic and average levels) of TLP have cropped a great care from the large organisations, it was interesting to test whether the large firms devote same care to the 10 parameters of advanced level of TLP. Therefore, several statistical tests were conducted to examine the implementation of the advanced level within large firms. As can be seen from Table 5.53, almost all parameters of advanced level were implemented. Table 5.53 explained that with high values of the *M*ean, there is evidence that the advanced level was a significant player to learn about and manage the changes and developments of advanced technologies. As a result, the large firms were found to 'build a reliable and accessible database as a result of their yearly accumulation of R&D documents, 'use R&D documents in comparison to other documents', 'acquire up-to-date R&D tools', 'share knowledge, whether formal or informal, within the R&D department', 'share information among departments', 'gain support and commitment of top management to anticipate technological

breakthrough and global changes', 'keep a constant balance between human resource planning and learning strategy in their organisations', 'recruit high levels of education, skills, and experience among employees to manage technological learning', and 'provide training programmes for their employees to improve technological learning'.

Table 5.54 Large Size Organisations against World-Class Level of TLP

| | 1) Launch projects of limited duration | 2) Appoint a gatekeeper | 3) Use venture capital funds | 4) Send technology envoys throughout the world | 5) Organize technology colloquia | 6) Arrange innovation workshops | 7) Collaborate with universities and research institutes | 8) Collaborate with start-ups and leading companies | 9) Establish centralized and/or decentralized units dedicated to learn trends of new technologies | 10) Provide incentive systems suitable for TLP | 11) Provide researchers with financial resources t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Practice | 18.8 | 28.1 | 81.3 | 62.5 | 53.1 | 37.5 | 9.4 | 43.8 | 25.0 | 18.8 | 53.1 |
| Hardly | 18.8 | 21.9 | 9.4 | 12.5 | 18.8 | 21.9 | 21.9 | 21.9 | 15.6 | 28.1 | 21.9 |
| Occasionally | 31.3 | 21.9 | 3.1 | 21.9 | 12.5 | 18.8 | 31.3 | 18.8 | 34.4 | 31.3 | 15.6 |
| Fairly | 21.9 | 21.9 | 6.3 | 3.1 | 15.6 | 15.6 | 28.1 | 15.6 | 21.9 | 15.6 | 9.4 |
| Regularly | 9.4 | 6.3 | | | | 6.3 | 9.4 | | 3.1 | 6.3 | |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| t-test | 12.90 | 11.21 | 9.19 | 10.00 | 9.41 | 10.02 | 15.28 | 10.29 | 12.54 | 12.83 | 9.96 |
| Sig | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Mean | 2.84 | 2.56 | 1.34 | 1.66 | 1.91 | 2.31 | 3.06 | 2.06 | 2.63 | 2.63 | 1.81 |
| Std. Dev | 1.25 | 1.29 | .827 | .937 | 1.15 | 1.31 | 1.13 | 1.13 | 1.19 | 1.16 | 1.03 |

Subsequently, to order to identify the implementation level of TLP, the large organisations were also provided with 11 parameters, which deemed as world-class level. The respondents were asked to indicate the frequency with which these parameters were considered in their own learning process about new technology. A five-point scale ranging from "not practice" through "hardly practice", "occasionally practice," and "fairly practice," to "regularly practice" was used to determine the extent to which these parameters were being

implemented. Table 5.54 showed that the respondents agreed that over half (50%) of the large firms 'launch projects of limited duration specifically dedicated to learn specific technological problems and developments', 'appoint a gatekeeper', 'proactively collaborate with universities and research institutes', 'establish centralized and/or decentralized units dedicated to learn developments and trends of new technologies, in which the tasks are hierarchically divided within the positions and departments', and 'provide incentive systems suitable for technological learning and effective in stimulating the bottom-up flow of technological trends'.

The most interesting finding obtained from Table 5.54 was that the large size organisations paid a great attention and allocate considerable resources and efforts to the TLP. The attention to TLP could not only be seen from launching projects of limited duration. The attention to TLP could also have been seen from establishing units or/and departments (interested only in learning and managing trends and developments of new technologies).

Based on the statistical tests performed to measure whether organisation size has any influence on the implementation of TLP, it was found that small size firms were appeared to pay very poor attention to TLP, where the large size organisation had a significantly positively investment in TLP and were rated as a world class TLP. As a result, it can be judged that the fourth hypothesis "Organisation size has an influence on the initiation of Technology Learning Process (TLP)"must be safely accepted.

**5.5.5 Fifth Hypothesis:** Organisations that had adopted AMT projects after 1990s were more likely to invest in TLP more than those who had adopted them before 1990s (i.e. late adopters of AMT were more likely to invest in TLP than early adopter of AMT)

Not unexpectedly, since most computerised technologies rapidly evolved, early AMT adopters experienced many more technical and none-technical problems than followers. Frohlich, (1998) [152] revealed that AMT pioneers spent more money on equipment, tended to be publicly owned, were larger in size, and had less prior experience with the new technology than later adopters. Due to the confounding influence of technology maturity, the total sample was divided into

two subsets. One sample contained AMT early adopters (before 1990s) and the other sample concerned with late adopters (in and after 1990s). The decision on where to divide the sample was based upon several factors. Firstly, Republic of Ireland's recent economic performance had attracted considerable attention, earning it the label "Europe's Celtic Tiger". Changing patterns in time-space contexts became particularly evident with rapid economic developments in Ireland in the 1990s. It was also witnessed that since the 1990s, the manufacturing industry had boomed causing massive developments in the construction and materials industries for plant and building [217].

Before 1990s, The Republic of Ireland was deemed as a peripheral economy in relation to mainland European states and by the 1990s Ireland was Europe's most dynamic economy recording a growth rate three times the EU average [217]. By 1990, dominant technological designs and industry standards had emerged that greatly changed the implementation experiences of AMT late adopters from those of pioneers [218].

Based on the factors presented above, Irish-owned organisations were only selected and studied. Thus, results would be obtained of testing this hypothesis was concerned only with Irish manufacturers. The discrimination process conducted to separate Irish-owned organisations from foreign-owned organisations (i.e. EU and USA) had identified 16 Irish-owned organisations. These 16 Irish-owned organisations were also checked to discriminate the firms that had adopted AMT before 1990s from those who had adopted AMT projects afters 1990s. As a result of this process, 13 Irish-owned organisations were found to adopt AMT projects before 1990s, where 3 Irish-owned organisations had adopted AMT projects after 1990s. To test this hypothesis, these two groups (i.e. organisations adopt AMT before 1990s and firms adopt AMT projects after 1990s). The following sections analysed and discussed every group independently.

#### 5.5.5.1 Early Adopters of AMT against Four Levels of TLP

As described above, this section was concerned with manufacturers who had adopted AMT projects before 1990s. This study had termed this group as early adopters of AMT which was used all along the analysis and discussion process.

To study and identify the extent to which early adopters of AMT had considered the practice of TLP, the four levels of TLP were separately studied. Thus, the 12 parameters included in Basic Level of TLP were initially examined. Table 5.55 reveals that six parameters of the basic level (including parameters such as 1, 2, 4, 5, 6, and 9) were found significant at *M*ean-value 3.92, 3.92, 2.85, 3.08, 4.15, and 3.62 respectively. As a result, the early adopters of AMT projects were found to 'cooperate with suppliers', 'cooperate with customers/users', 'participate in activities of professional associations', 'participate in activities of trade associations', 'scrutinize business literature and those periodicals', and 'subscribe and review trade press'.

Table 5.55 Early Adopters of AMT against Basic Level of TLP

| | | 1) Cooperate with suppliers | 2) Cooperate with customers/users | 3) Check government sources | 4) Participate in activities of professional associations | 5) Participate in activities of trade associations | 6) Scrutinize business literature | 7) Join local chambers of commerce | 8) Subscribe to the local press | 9) Subscribe and review trade press | 10) Collaborate with stockbrokers | 11) Keep track of the prospectus | 12) Contact and visit the investment banks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | Valid | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 3.92 | 3.92 | 1.77 | 2.85 | 3.08 | 4.15 | 1.85 | 2.39 | 3.62 | 1.31 | 1.62 | 1.69 |
| Std. Dev | | .862 | .760 | 1.01 | 1.28 | .760 | .899 | 1.07 | 1.26 | .961 | .630 | .650 | 1.25 |

Table 5.55 also explains that the remaining six parameters (including 3, 7, 8, 10, 11, and 12) of the basic level of TLP were found insignificant at *M*ean-value equal to 1.77, 1.85, 2.39, 1.31, 1.62, and 1.69 respectively. Therefore, there were six basic parameters of TLP neglected by the early adopters of AMT. The neglected six parameters of the basic level of TLP were '(3) Check government sources that contain very detailed information on foreign and domestic investments', '(7) Join local chambers of commerce', '(8) Subscribe to the local press and frequently check the local newspaper', '(10) Collaborate with

stockbrokers who often have made deeply studies of a competitor', '(11) Keep track of the prospectus', and '(12) Contact and visit the investment banks'.

In studying the 13 parameters of average level of TLP, Table 5.56 revealed that the early adopters of AMT used only seven parameters and neglecting six parameters of the average level of TLP. The using seven parameters were '(1) Participation of employees in the company's strategy (e.g. innovation need) through informal searching and learning activities', '(2) Use IT such as Bulletin Board System and E-mails', '(3) Access to the Internet', '(6) Establish communication routines to pass on the trends and developments of new technologies to top management', '(7) Provide your members with extra travel budget to update your company with the latest developments of its technology', '(12) Benchmark key competitors', and '(13) Conduct a sensitivity analysis'.

Table 5.56 Early Adopters of AMT against Average Level of TLP

| | | 1) Participation of employees in the company's strategy | 2) Use IT such as Bulletin Board System and E-mails | 3) Access to the Internet | 4) Create informal discussion networks | 5) Rotate jobs among employees | 6) Establish communication routines | 7) Provide your members with extra travel budget | 8) Use Technology Roadmaps | 9) Use a Balanced Scorecard | 10) Use Listening Posts | 11) Use a Watch List | 12) Benchmark key competitors | 13) Conduct a sensitivity analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | Valid | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 3.08 | 3.39 | 4.77 | 1.39 | 2.15 | 2.85 | 2.69 | 2.08 | 2.15 | 2.54 | 2.15 | 3.23 | 2.77 |
| Std. Dev | | .862 | 1.56 | .832 | .506 | 1.07 | 1.14 | 1.38 | 1.12 | 1.14 | 1.13 | 1.07 | 1.09 | 1.17 |

On the contrary, the early adopters of AMT projects were also found to neglect six parameters of the average level of TLP. These six parameters were '(4) Create informal discussion networks through intranet discussion platforms', '(5) Rotate jobs among employees in order to strengthen the informal technological learning networks in your organisation', '(8) Use Technology Roadmaps as a tool to learn and/or anticipate future tends of the new technologies', '(9) Use a

Balanced Scorecard to improve critical areas such as technology, product, process, and market development', '(10) Use Listening Posts to get some feedback from your customers and partners', and '(11) Use a Watch List to spot irregularities in the environment of your company'.

Further, the advanced level, which represents 10 parameters of TLP, was also tested. The statistical results show that the early adopters of AMT projects were only practicing five parameters. as can seen from Table 5.57, these five parameters were '(6) Share information among departments', '(7) Gain support and commitment of top management to anticipate technological breakthrough and global changes', '(8) Keep a constant balance between human resource planning and learning strategy in their organisations', '(9) Recruit high levels of education, skills, and experience among employees to manage technological learning', and '(10) Provide training programmes for their employees to improve technological learning'.

Table 5.57 Early Adopters of AMT against Advanced Level of TLP

| | | 1) Establish a suitable pyramidal structure of R&D personnel | 2) Build a reliable and accessible database | 3) Use R&D documents in comparison to other documents | 4) Acquire up-to-date R&D tools | 5) Share knowledge within the R&D dept | 6) Share information among depts | 7) Gain support and commitment of top management | 8) Keep a constant balance between HR planning and learning strategy in organisation | 9) Recruit high levels of education, skills, and experience | 10) Provide training programmes for employees |
|---|---|---|---|---|---|---|---|---|---|---|---|
| N | Valid | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 1.92 | 2.46 | 2.39 | 2.15 | 2.39 | 2.85 | 3.31 | 2.92 | 3.00 | 3.46 |
| Std. Dev | | .954 | .967 | .870 | 1.14 | 1.33 | 1.35 | 1.18 | 1.12 | 1.08 | 1.13 |

Conversely, the early adopters of AMT projects were found to underestimate very essential parameters such as '(1) Establish a suitable pyramidal structure of R&D personnel', '(2) Build a reliable and accessible database as a result of their

yearly accumulation of R&D documents', '(3) Use R&D documents in comparison to other documents','(4) Acquire up-to-date R&D tools', and '(5) Share knowledge, whether formal or informal, within the R&D department'.

Table 5.57 revealed that the focus of early adopters of AMT was on the five managerial aspects included in the advanced level, where they had completely ignored the parameters related to Research and Development (R&D), which was very critical to TLP. This was evidence that the early adopters of AMT projects were neither convinced to devote any resources to TLP, nor relied on the output of TLP in their management of advanced technologies. The focus was on basic and simple parameters that cost neither money nor efforts.

Table 5.58 Early Adopters of AMT against World-Class Level of TLP

| | | 1) Launch projects of limited duration | 2) Appoint a gatekeeper | 3) Use venture capital funds | 4) Send technology envoys throughout the world | 5) Organize technology colloquia | 6) Arrange innovation workshops | 7) Proactively collaborate with universities and research institutes | 8) Collaborate with start-ups and leading companies | 9) Establish centralized and/or decentralized units dedicated to learn trends of new technologies | 10) Provide incentive systems suitable for TLP | 11) Provide researchers with financial resources |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | Valid | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 2.69 | 2.00 | 1.08 | 1.46 | 1.39 | 1.85 | 2.77 | 1.77 | 1.92 | 2.23 | 1.39 |
| Std. Dev | | 1.38 | 1.47 | .277 | .776 | .870 | 1.28 | 1.24 | 1.01 | 1.38 | 1.01 | .650 |

To determine whether the early adopters of AMT had a world class TLP, the 11 parameters of world-class level were tested. Table 5.58 shows that almost all parameters of world-class level were found to score very low values of *M*ean. This underlined and supported the conclusion reached in the advanced level that the early adopters of AMT projects were neither convinced to devote any resources to TLP, nor relied on the output of TLP in their management of

advanced technologies. The underestimation of TLP in early adopters of AMT projects may have referred to several factors. For instance, lack of financial resource, lack of skills and specialists in TLP, difficulty to communicate with others (i.e. lack of information technologies), origination structure, lack of competition environment, etc.

#### 5.5.5.2 Later adopters of AMT (i.e. after 1990) against Levels of TLP

This section focused on organisations that had adopted AMT projects after 1990s. Based on the discrimination process discussed earlier, the respondents that had lately adopted AMT projects were three respondents. Due to the concentration only on Irish-owned organisations in this hypothesis, several other manufacturers who had lately adopted AMT projects were neglected. This was because those organisations were owned by EU and/or USA manufacturers. To test whether late adopters of AMT projects considered any parameters of TLP, all level of TLP were recalled and studied. Although many statistical tests were used, values of the *M*ean were only presented. The following explained the statistical results for every level of TLP separately starting with basic level through average level, and advanced level to world-class level.

Statistical results obtained from testing the 12 parameters of basic level, were summarised in Table 5.59. Based on the statistical results, the late adopters of AMT projects were found to exercise all the basic parameters of TLP. In other words, the late adopters of AMT projects cooperate with suppliers', 'cooperate with customers/users', 'check government sources that contain very detailed information on foreign and domestic investments', 'participate in activities of professional associations', 'participate in activities of trade associations', 'scrutinize business literature and those periodicals', 'join local chambers of commerce', 'subscribe to the local press and frequently check the local newspaper', 'subscribe and review trade press', 'collaborate with stockbrokers who often have made deeply studies of a competitor', 'keep track of the prospectus', and 'contact and visit the investment banks'.

Table 5.59 Late Adaptors of AMT against Basic Level of TLP

| | | 1) Cooperate with suppliers | 2) Cooperate with customers/users | 3) Check government sources | 4) Participate in activities of professional associations | 5) Participate in activities of trade associations | 6) Scrutinize business literature | 7) Join local chambers of commerce | 8) Subscribe to the local press | 9) Subscribe and review trade press | 10) Collaborate with stockbrokers | 11) Keep track of the prospectus | 12) Contact and visit the investment banks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | Valid | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 4.00 | 4.67 | 3.33 | 3.00 | 3.67 | 3.33 | 2.67 | 3.33 | 3.00 | 3.00 | 3.00 | 2.67 |
| Std. Dev | | 1.00 | .577 | 2.08 | 2.00 | 2.31 | 1.53 | 2.08 | 2.08 | 2.00 | 2.00 | 2.00 | 2.08 |

Interestingly, the late adopters of AMT projects were also found to practice all parameters involved in the average level of TLP. Table 5.60 demonstrated that the 13 parameters of the average level of TLP were all significant at very high *M*ean-values ranging from 2.67 to 4.67. Thus, it was found that the late adopters of AMT projects 'enable employees to participate in the company's strategy (e.g. innovation need) through informal searching and learning parameters, 'use IT such as Bulletin Board System and E-mails', 'access to the Internet', 'create informal discussion networks through intranet discussion platforms', 'rotate jobs among employees in order to strengthen the informal technological learning networks in their organisation', 'establish communication routines to pass on the trends and developments of new technologies to top management', 'provide members with extra travel budget to update their company with the latest developments of its technology', 'use Technology Roadmaps as a tool to learn and/or anticipate future tends of the new technologies', 'use a Balanced Scorecard to improve critical areas such as technology, product, process, and market development', 'use Listening Posts to get some feedback from their customers and partners', 'use a Watch List to spot irregularities in the environment of their company', 'benchmark key competitors', and 'conduct a sensitivity analysis'.

Table 5.60 Late Adaptors of AMT against Average Level of TLP

| | | 1) Participation of employees in the company's strategy | 2) Use IT such as Bulletin Board System and E-mails | 3) Access to the Internet | 4) Create informal discussion networks | 5) Rotate jobs among employees | 6) Establish communication routines | 7) Provide your members with extra travel budget | 8) Use Technology Roadmaps | 9) Use a Balanced Scorecard | 10) Use Listening Posts | 11) Use a Watch List | 12) Benchmark key competitors | 13) Conduct a sensitivity analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | Valid | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 3.67 | 3.00 | 4.67 | 3.00 | 3.33 | 4.00 | 2.67 | 3.33 | 2.67 | 3.33 | 2.67 | 2.67 | 2.67 |
| Std. Dev | | 1.53 | 2.00 | .577 | 2.00 | 2.08 | 1.00 | 2.08 | 1.53 | 2.08 | 1.53 | 2.08 | 2.08 | 2.08 |

Subsequently, the advanced level, which represented 10 parameters of TLP, was tested. The statistical results were summarised in Table 5.51. The interesting finding of the statistical tests was that all parameters of advanced level of TLP were implemented by the late adopters of AMT projects. Thus, the late adopters of AMT projects were found to 'establish a suitable pyramidal structure of R&D personnel', 'build a reliable and accessible database as a result of their yearly accumulation of R&D documents', 'use R&D documents in comparison to other documents', 'acquire up-to-date R&D tools', 'share knowledge, whether formal or informal, within the R&D department', 'share information among departments', 'gain support and commitment of top management to anticipate technological breakthrough and global changes', 'keep a constant balance between human resource planning and learning strategy in their organisations', 'recruit high levels of education, skills, and experience among employees to manage technological learning', and 'provide training programmes for their employees to improve technological learning'.

Table 5.61 Late Adaptors of AMT against Advanced Level of TLP

| | | 1) Establish a suitable pyramidal structure of R&D personnel | 2) Build a reliable and accessible database | 3) Use R&D documents in comparison to other documents | 4) Acquire up-to-date R&D tools | 5) Share knowledge within the R&D dept | 6) Share information among depts | 7) Gain support and commitment of top management | 8) Keep a constant balance between HR planning and learning strategy in organisation | 9) Recruit high levels of education, skills, and experience | 10) Provide training programmes for employees |
|---|---|---|---|---|---|---|---|---|---|---|---|
| N | Valid | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 2.67 | 3.00 | 2.67 | 2.67 | 3.00 | 3.00 | 3.00 | 3.00 | 3.67 | 3.67 |
| Std. Dev | | 2.08 | 2.00 | 2.08 | 2.08 | 1.73 | 2.00 | 1.73 | 1.73 | 1.16 | 1.53 |

By using all the parameters involved in previous three levels (i.e. basic, average, and advanced levels), the later adopters of AMT projects had obviously expressed their greatly appreciation to implementation of TLP. The capability of later adopters to perform an advanced TLP indicated that the changes, (happened to Irish manufacturing sector in particular and/or Irish economy as a whole) had significant impact on the strategies and policies made to manage new businesses in Ireland.

Remaining level of TLP was world-class level. This level represented 11 parameters of TLP as a whole. These 11 parameters were subjected to many statistical tests in order to determine whether the later adopters of AMT projects considered any of them. Indeed, the late adopters of AMT projects have confirmed their implementation to all parameters of world class level. Table 5.62 revealed that apart from parameter number 10, the remaining 10 parameters of world class level were found to score significant values of *M*ean which indicated to their implementation. Thus, the late adopters were found to 'launch projects of limited duration specifically dedicated to learn specific technological problems and developments', 'appoint a gatekeeper', 'use venture capital funds as a tool to

get access to new technological trends and solutions at a very early stage', 'send technology envoys throughout the world in order to build up a network with institutions, universities and start-up companies', 'organize technology colloquia to assess different technological developments, trends, changes and possible research directions', 'arrange innovation workshops', 'proactively collaborate with universities and research institutes', 'collaborate with start-ups and leading companies, whether international or not', 'establishing centralized and/or decentralized units dedicated to learn developments and trends of new technologies, in which the tasks are hierarchically divided within the positions and departments', and 'provide researchers with financial resources to follow their own research interest and promote bottom-up mechanism'. Obviously, level after level, 'from basic level through to world class level', later adopters of AMT projects have explained their capability of performing world class TLP.

Table 5.62 Late Adaptors of AMT against World-Class Level of TLP

| | | 1) Launch projects of limited duration | 2) Appoint a gatekeeper | 3) Use venture capital funds | 4) Send technology envoys throughout the world | 5) Organize technology colloquia | 6) Arrange innovation workshops | 7) Proactively collaborate with universities and research institutes | 8) Collaborate with start-ups and leading companies | 9) Establish centralized and/or decentralized units dedicated to learn trends of new technologies | 10) Provide incentive systems suitable for TLP | 11) Provide researchers with financial resources |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | Valid | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 3.00 | 3.33 | 3.33 | 3.00 | 3.00 | 3.00 | 2.67 | 3.33 | 3.00 | 2.33 | 2.67 |
| Std. Dev | | 2.00 | 2.08 | 2.08 | 2.00 | 2.00 | 1.73 | 2.08 | 1.53 | 2.00 | 2.31 | 2.08 |

Generally, while implementation of TLP was found to be very poor in early adopters, all parameters in all levels of TLP were significantly practiced by late adopters. Consequently, the fifth hypothesis of this study, which assumed that Irish manufacturers who had adopted AMT projects after 1990s were more likely

to invest in TLP more than those who had adopted AMT before 1990s, could be safely accepted.

### 5.5.6 Further Investigation into TLP

Given that the research hypotheses were tested, this study had further investigated several other issues related to TLP such as encouragements and constraints to initiate TLP, and members who are responsible for TLP. Statistical results of these three issues were discussed and presented in separate section starting with factors encourage manager to initiate TLP and ended up with identifying people who are charged with TLP.

#### 5.5.6.1 Encouragements to initiate TLP

Participants to this study were provided with a list of encouragements and requested to determine their importance on a five-point scale range from not important through to very important. Notably, the participants were also asked to specify any other encouragements that they think were essential in initiation of TLP in their organisations.

Based on data frequency analysis and values of the *M*ean, which were presented in Table 5.63, almost all (87%) respondents agreed that problems during production were very significant to influence managers to initiate TLP. Over two thirds of the respondents also stressed that introduction of new product and shifting customer demand were critical players in encouraging managers to establish TLP. Over half (53%) of the respondents believed that intensive competition with foreign competitors was a major factor when they made decision to invest in TLP. Over one third (44%) of the respondents explained that availability of capital was important to engage in TLP. On the contrary, fascination for new technologies was found insignificant to influence the implementation of TLP.

In order of importance, the five factors that were believed to be important in encouraging managers to initiate TLP in their organisations were ‘problems during production’, ‘introduction of new product’, ‘shifting customer demand’, ‘intensive competition with foreign competitors’, and ‘available capital’.

Table 5.63 Encouragements to initiate TLP

| | | 1) Problems during production | 2) Intensive competition with foreign competitors | 3) Shifting customer demand | 4) Fascination for new technologies | 5) Available capital | 6) New Product Introduction |
|---|---|---|---|---|---|---|---|
| Not Important | | 3 | 12 | 7 | 26 | 12 | 4 |
| Somewhat Important | | 3 | 16 | 9 | 28 | 16 | 6 |
| Moderate Important | | 7 | 19 | 19 | 28 | 28 | 18 |
| Important | | 40 | 32 | 38 | 15 | 31 | 40 |
| Very Important | | 47 | 21 | 27 | 3 | 13 | 32 |
| Total | | 100 | 100 | 100 | 100 | 100 | 100 |
| N | Valid | 68 | 68 | 68 | 68 | 68 | 68 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 4.25 | 3.34 | 3.68 | 2.40 | 3.18 | 3.90 |
| Std. Dev | | .936 | 1.30 | 1.18 | 1.12 | 1.21 | 1.07 |

Figures in Percentage (%)

### 5.5.6.2 Constraints to initiate TLP

In an attempt to identify the constraints that dissuade organisations from investing in TLP, this study has provided the participants with a list of constraints and then requested them to rate the importance of these constraints on a five-point scale ranging from not important through to very important.

Table 5.64 revealed that the respondents emphasised that all the factors listed were very significant impediments discourage them from initiating TLP in their own organisations. Based on statistical results, values of the *M*ean were all significantly high indicating to the significance of these factors in hindering TLP. Obviously, the participants referred their inattention to TLP to several factors such as 'lack of financial and human resources', 'deficiencies in experienced and skilled people', 'time-consuming', 'limited Information Technologies/Systems (IT/IS)', 'regulatory constraints in your industry', 'cost-intensive', 'training budget priorities', and 'lack of communication routines'. The above factors were presented in order their weigh of *M*ean's value starting with the most significant

constraints ‘lack of financial and human resources (*M*ean value equals to 3.87)’, and ending up with ‘lack of communication routines (*M*ean Value equals to 3.24)’.

Table 5.64 Constraints to establish TLP

| | | 1) Lack of financial and human resources | 2) Deficiencies in experienced and skilled people | 3) Limited Information Technologies/Systems (IT/IS) | 4) Lack of communication routines | 5) Regulatory constraints in your industry | 6) Training budget priorities | 7) Cost-intensive | 8) Time-consuming |
|---|---|---|---|---|---|---|---|---|---|
| Not Important | | 6 | 1 | 6 | 6 | 12 | 4 | 1 | 1 |
| Somewhat Important | | 10 | 9 | 9 | 12 | 19 | 19 | 24 | 15 |
| Moderate Important | | 12 | 22 | 38 | 46 | 15 | 31 | 25 | 27 |
| Important | | 35 | 43 | 37 | 26 | 29 | 37 | 37 | 44 |
| Very Important | | 37 | 25 | 10 | 10 | 25 | 9 | 13 | 13 |
| Total | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| N | Valid | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 3.87 | 3.81 | 3.37 | 3.24 | 3.37 | 3.27 | 3.37 | 3.53 |
| Std. Dev | | 1.20 | .966 | .991 | .994 | 1.36 | 1.02 | 1.04 | .954 |

### 5.5.6.3 TLP Members

In response to question posed by this study ‘who was responsible for TLP in organisation’, the participants had identified three out of six members listed by this study. As can be seen from Table 5.65, the data frequency analysis and Mean value show that members of top management, engineers, and members of middle management were found to the people who often appointed to look after TLP.

Table 5.65 Members who are responsible for practicing TLP

| | | 1) Members of Top Management | 2) TLP Specialists | 3) Technology Agents | 4) Researchers | 5) Engineers | 6) Members of Middle Management |
|---|---|---|---|---|---|---|---|
| No | | 38 | 82 | 96 | 87 | 54 | 71 |
| Yes | | 62 | 18 | 4 | 13 | 46 | 29 |
| Total | | 100 | 100 | 100 | 100 | 100 | 100 |
| N | Valid | 68 | 68 | 68 | 68 | 68 | 68 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 1.62 | 1.18 | 1.04 | 1.13 | 1.46 | 1.29 |
| Std. Dev | | .490 | .384 | .207 | .341 | .502 | .459 |

### 5.5.7 Discussion

In section 4.3.10 a set of parameters that, interviewees believe, were useful to measure the practice level of TLP within an organisation was developed. The interviews contributed to detail and describe the parameters that managers usually performed to learn and managed the changes and developments of advanced technologies. Based on the results of those interviews, a conceptual model (Figure 4.13) was developed, which describes the possible association between the TLP and process of AMT implementation and organisation performance. The proposed conceptual model viewed implementation of TLP as consisting of four distinct levels. These four levels were comprised of forty-six parameters and every level was concerned with some of these parameters. The movement from basic level through average level, advanced level, to world class level indicated heavily practice to TLP and significant attention a firm paid to TLP. In other words, the level of TLP practice got sophisticated as it moved towards the world-class level.

This study verified the applicability of the proposed conceptual model on a wide population of organisations. The effects of the TLP (i.e. the forty-six parameters of the four levels) on the innovation and change management, the

performance of manufacturing operations and on some other issues were also tested. To investigate the effect of the TLP on the innovation management (i.e. the process of AMT implementation), these forty-six parameters were coined into questions format. Overall, the forty-six parameters generated sixty-seven questions, which were sent by online and posted survey to the Chemical and Pharmaceutical companies. The major findings of this study were summarised below.

To identify areas of potential managerial conflict, this thesis had used grid methodology to examine the practice level and importance degree of the four levels of TLP. The main findings from the importance-practice grid methodology (refer to chapter 5, section 5.4.4) were that although the practice of TLP was found in advanced level, further efforts were still needed to bring Chemical and Pharmaceutical organisations in Republic of Ireland to a world class TLP. The Chemical and Pharmaceutical organisations in Republic of Ireland had emphasised on the importance of almost all listed parameters of TLP including the parameters of world class level. Parameters lying some distance from the diagonal and in the fourth quadrant of the importance-practice grid deserved the attention of managers and decision makers interested in a country's technological progress and a company's competitive standing. Of particular importance were parameters lie in complex quadrant that "confront consideration and manipulation, and could be expected to frustrate those dealing with them".

This study had significant implications for managers and decision makers interested in developing and/or improving TLP. As a general statement, positive action was required for the TLP parameters found in quadrant 4. To intensively compete and not taken by surprise, Pharmaceutical and Chemical firms in Republic of Ireland must have urgently addressed these parameters. In addition, consideration of these parameters efficiently promoted TLP and ensured the output of TLP was effectively significant. Otherwise there would be little opportunity to cope with changes and catch up developments of new technologies at an earlier stage. Obviously, an important contribution of this study had been a consideration of the extent to which manufacturing organisations practice the parameters relevant to learning process and then determine how important these parameters are.

Since this study basically examined the five hypotheses, the focus was then on the five essential outcomes. Initially, this study had investigated the first hypothesis, which assumed that the organisations that adopt high levels of AMT projects were more likely to have placed greater emphasis on TLP than organisations that have adopted less complex AMT projects. Based on the statistical results, this assumption was accepted. It had been found that the implementation of TLP was very poor and does not exceed the basic level within the organisations that have adopted very low level of AMT projects. In contrary, the organisations, which have adopted a complex level of AMT projects were found to significantly invest in TLP and were classified as a world class TLP. It was obvious that whenever managers wished to increase their level of AMT projects, they should initially raise the practice level of TLP.

Subsequently, the practice of TLP was found to significantly influence the success of AMT implementation. Based on the statistical tests applied for both the firms (i.e. successfully implementing AMT projects and the firms unsuccessful in implementing AMT projects), it was evident that where the unsuccessful group that had paid very low attention to TLP, the TLP was heavily practiced in the successful group. This finding stressed that the organisations that paid great attention to TLP and provided resources and efforts to promote TLP are very likely to succeed in managing the process of AMT implementation. Based on the first and second hypotheses, it was evident that the practice of TLP had a positive significant influence on the adoption of AMT projects and also on implementation of AMT projects.

Beside its significant impact on the adoption and installation of AMT projects, TLP was also found to have significant influence on the manufacturing operations performance. Based on the statistical results obtained from testing both groups (i.e. the firms that had experienced substantial decline in performance and the firms that have achieved substantial improvement in performance), it was obvious that the exploitation of TLP within the firms, which have experienced substantial declined in performance, was almost absent. As shown in section 5.5.3, out of all parameters (46) included in the four levels of TLP, only five parameters were practiced. Several researchers had warned firms from underestimation of TLP. For instance, Carlson, L. W (2004) [249] explained that

neglecting to implement TLP would greatly reduce overall organisation performance and effectively inhibit the ability to articulate the results and actions recommended to the business decision-makers. Conversely, the organisations that have achieved substantial improvement in performance had been identified as world class TLP. In order to be world class TLP, a firm had to practice all (46) parameters included in all four level of TLP starting from basic level through average level and advanced level to world-class level. Many scholars argued that competitive success is influenced by the firm's ability to engage in TLP. For instance, Spender, (1996) [250], and Gulati, (1999) [139], argued that TLP was very important to a firm seeking to create competitive advantage and improve overall organisation performance. Hitt et al (2000) [134] also stressed that in this exciting competitive era, TLP played a vital role in the firm's competitive success. As a consequence, the finding of this study had not only approved the third hypothesis but also supported the contentions debated by several authors.

Since the three previous hypotheses were accepted, it can be concluded that the consideration and commitment to the set of TLP parameters (the forty-six parameters of the four levels) would not only lead to successful management of AMT projects but also to improvements in the performance of manufacturing operations.

Based on the statistical tests performed to measure whether organisation size has any influence on the implementation of TLP, it was found that small size firms were appeared to pay very poor attention to TLP, where the large size organisation had significantly positively invested in TLP and were rated as a world class TLP. The lack of TLP in small firms could be referred to many reasons. For instance, lack of resources, lack of competences and skills, and undervaluation of importance of such process may likely to be used to explain abandonment of small firms to TLP. On the contrary, the large size organisations pay a great attention and allocate considerable resources and efforts to the TLP. The attention of large firms to TLP could not only be seen from launching projects of limited duration, but also from establishing units or/and departments which were interested only in learning and managing trends and developments of new technologies. As a result, the fourth hypothesis which assumed that organisation size had an influence on the initiation of TLP was accepted.

After 1990s, there was considerable improvement in Irish manufacture sector in particular and significant growth in Irish economy as a whole. As a result, this research had investigated the extent to which early and late adopters of AMT had considered the implementation of TLP. However, there was evidence that the early adopters of AMT projects were neither convinced to devote any resources to TLP, nor used any learning activities to manage their advanced technologies. The focus was on basic and simple parameters that costed neither money nor efforts. The underestimation of TLP in early adopters of AMT projects may have referred to several factors. For instance, lack of financial resource, lack of skills and specialists in TLP, difficulty to communicate with others (i.e. lack of information technologies), origination structure, lack of competition environment, etc. Conversely, by using all the parameters involved in levels (i.e. basic, average, advanced, and world class levels), the later adopters of AMT projects have obviously expressed their great appreciation to implementation of TLP. The capability of later adopters to perform a world class TLP indicated that the changes, which had happened to the Irish manufacturing sector in particular and/or Irish economy as a whole had significant impact on the strategies and policies made to manage new businesses in Republic of Ireland. Thus, the finding that the implementation of TLP was very poor in early adopters, while it was significantly practiced by late adopters, has approved the fifth hypothesis of this study, which assumed that Irish manufacturers who had adopted AMT projects after 1990s were more likely to invest in TLP more than those who had adopted AMT before 1990s.

Based on foregoing discussion, for manufacturing organisations to cope with the rapid changes/developments of advanced technologies and also to achieve competitive advantage of investment in such technologies, intensive consideration and commitment must be devoted to the TLP. Early exploration and availability of needed information, which were performed by TLP, could have assisted managers to predict future requirements of the new technologies and may have avoided several unforeseen problems during implementation of the new systems.

#### 5.5.7.1 Further Observations

Many authors demonstrate that organisations were often found to invest in advanced technologies on the basis of limited information. Therefore, it was not surprising to find many experienced human and technical problems once the new system was installed. Lack of TLP often produces unsatisfactory results [85 and 74]. Based on the significant role of TLP in increasing the success level of adoption and implementation of AMT projects and improving the performance of manufacturing operations, this research further observed several other issues rated to TLP. The additional issues observed by this research were the factors that may encourage managers to initiate TLP, the factors that may dissuade managers from investing in TLP, and identifying members who are responsible for TLP.

Wolff, M.F (2000) [251] explained that TLP was driven by the quest for a competitive edge and the need to adapt to change. The empirical study reported in this research identified number of factors that were believed to be very important in encouraging managers to initiate TLP. These factors in order of importance were 'problems during production', 'introduction of new product', 'shifting customer demand', 'intensive competition with foreign competitors', and 'available capital'. On the contrary, fascination for new technologies was found insignificant to influence the implementation of TLP.

The statistical results had also demonstrated that there is a consensus among the participants about the factors that restricted them from investing in TLP. The participants of this study emphasised that all the factors listed were very significant impediments that discouraged them from initiating TLP in their own organisations. These factors in order of importance included 'lack of financial and human resources', 'deficiencies in experienced and skilled people', 'time-consuming', 'limited Information Technologies/Systems (IT/IS)', 'regulatory constraints in your industry', 'cost-intensive', 'training budget priorities', and 'lack of communication routines'. To verify the degree of agreement among the respondents about the importance of these factors, factor analysis was conducted. The results of this test explained that all above factors were found to have a high factor loading ranging from 0.51 to 0.87. Interestingly, 'limited Information Technologies/Systems (IT/IS)', and 'lack of communication routines' were found to score very high loading 0.87 and 0.85 respectively. The importance of these

factors was also confirmed by several researchers. For instance, Wolff, (2000) [251] stressed that TLP was powered by Information Technology (IT).

TLP was characterised by its cross-functional impact. Wolff, (2000) [251] demonstrates that more than half of technology companies involved in technology intelligence (i.e. TLP) now have a group of experts dedicated to collecting, analysing, and apply the output of TLP for the parent company, its units or divisions. Successful practice of TLP appeared less likely to occur when relevant functions or skills were missing from TLP members. A successful team was likely to have active members from all over the organisation. The scope of these members of TLP was broadly encompassed for instance, 'strategic alliances', 'acquisition of technologies developed externally', 'partnering with key customers', 'risk analysis for new technologies', 'early identification of market gaps', 'networks and databases', 'archiving of related business and technical data', and 'competitor patent analysis'. As TLP members were given several functions including scrutiny, identification, evaluation, and recommendation, this study however identified the people who are responsible for practicing TLP. Based on the statistical results, members of top management, engineers, and members of middle management were found to heavily involve in practicing functions of TLP. Therefore, the members of TLP should have been from a variety of functional departments across the organisation. This mix of members would have facilitated the tasks of the team in assigning the responsibilities for various activities and identifying needed permissions and resources.

Out of 25 problems challenging managers during the implementation of new technologies, 10 problems were found to significantly occur during the implementation of AMT projects. These 10 problems were 'Lack of integration of Manufacturing Information Systems', 'Lack of integration across functions', 'Problems with interconnection of equipment', 'Obsolescence of technology', 'Underestimation of on-going support of the information services department', 'Inadequate communication networking among system components', 'AMT skill deficiencies', 'Failure to recognise the resources needed to maintain the system (i.e. engineers etc)', 'Disruptions during implementation', and 'A conflict between short-time production requirements and long-term goals'. An interesting finding was that several major problems challenging implementation of AMT

were related to TLP. For instance, the respondents who complained from the lack of integration of Manufacturing Information Systems are basically complaining from the lack of TLP. The information technologies were a backbone for TLP (i.e. collecting and distributing information internal and/or external the origination). The same was also applied on the respondents who were complaining of 'underestimation of on-going support of the information services department' and 'inadequate communication networking among system components'. These functions were very important activities in promoting TLP.

One of the most important finding of Table 5.9 was that almost three quarters (73.5%) of the respondents held a senior manager position in their organisations. Many authors stressed that senior managers and top management as a whole were the ones who are charged with the decisions to implement TLP activities and/or invest in AMT projects. Therefore, this finding was a confirmation that the respondents of this study were aware of TLP and AMT implementation and therefore a high credibility for the responses was obtained.

In order to assess the importance of the research's subject for participants and also to measure the credibility and reliability of the answers provided by the respondents, this research had posed two questions including 'would you like to receive the study findings?', and 'would you like to be contacted again?'. Of course any respondents who are interested in this study will score 'Yes' and look forward to receive the study findings. In relation to the credibility and reliability of the information provided, respondents who would provide credible information would not be hesitated to contacted again and would score 'Yes' to contacted again. Obviously, the statistical results showed that almost all (%76) participants were interested in this research and wished if they can receive a copy of the results of this study. Furthermore, two thirds (%60) of the participants were willing to be contacted again which is evident that the respondents knew what they were doing and what they were answering.

## 5.6 EVALUATE THE CURRENT RESEARCH

If a measuring instrument was developed or found in the literature, how did we assess its quality for use in research? For this question, according to Punch,

(1998), [163] there were two main technical criteria of validity and reliability, which were sometimes called psychometric characteristics of an instrument.

### 5.6.1 Validity

First central concept in measurement was validity. One view of its meaning was the question: "how do we know that this instrument measures what we think (or wish) it measures?" In this view, measurement validity meant the extent to which instruments measured what it is claimed to measure; an indicator was valid to the extent that it empirically represents the concept it was supposed to measure [163]. Among the various approaches to the validation of instruments, three of the main ones were content validity, criterion-related validity and construct validity [163].

Content validity focuses on whether the full content of a conceptual description was represented in the measure. Neuman, (1994) [252] explained that a conceptual description was a space, holdings ideas and concepts, and the indicators in a measure should have sampled all ideas in the description. In this research, to access content validity, pre-test and pilot studies were conducted. Initially, during the pre-test study, 15 people were contacted and requested to evaluate the contents of both research strategies (i.e. case study and survey research). These 15 people were from different background. Where 7 people were specialists and from industry sector (i.e. pharmaceutical and chemical companies), the remaining 8 people were from academic sector including 4 from Dublin Institute of Technology (DIT) in Dublin and 4 academic people from Liverpool University in UK. Two academic people and three senior managers had expressed their eagerness to participate in the assessment process. Subsequently, the pilot study particularly for empirical research was also carried out. During this stage of the research, a copy of the questionnaire approved by the pre-test stage was sent to 20 Irish pharmaceutical and chemical firms. These firms were requested to answer and assess the contents of the enclosed questionnaire. Based on their feedback, the final version of the questionnaire was sent to the participants.

In criterion-related validity, an indicator was compared with another measure of the same construct in which the research had confidence. The third approach was to construct validity which focused on how well a measure conforms to theoretical expectations. Any measure existed in some theoretical

context, and should therefore have showed relationship with other constructs which could be predicted within that context [163]. The construct validity for each element measured in this study was evaluated by factor analysing using SPSS Data Reduction and Factor Analysis procedure [240]. The steps used in performing this analysis were performed using the guidelines provided by Saraph et al (1989) [241].

Following this procedure, the items assigned to each elements were submitted to principal component factor analysis to determine the number of factors and factor loading extracted by the Kaiser criterion (with Eigenvalue greater that one). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was used to assess the suitability of the sample. The high values of KMO (close to 1.0) generally indicated that a factor analysis may be useful with the data. If the value was less than 0.50, the results of the factor analysis probably would not be very useful [240 and 242].

In general all the KMO values found were considered acceptable. All elements accounted for more than 0.50 of the variance. This suggested that on overall the survey instrument was valid and had high internal consistency.

### 5.6.2 Reliability

Reliability was a central concept in measurement, and it basically meant consistency. There were two main aspects to this consistency [163]. First, consistency over time meant the stability of measurement over time, and it was usually expressed in the question: if the same instrument was given to the same people, under the same circumstances, but at a different time, to what extent would they get the same score? To the extent that they would obtain the same score, the measuring instrument would be reliable, otherwise would be unreliable.

Second, internal consistency reliability is related to the concept-indicator idea of measurement. Since multiple items are used, the question concerns the extent to which the items were consistent with each other, or all working in the same direction. This was the internal consistency of a measuring instrument. Various ways had been devised to assess the internal consistency. The best known are the Cronbach's coefficient alpha, the Kuder-Richardston formulas and split-half techniques [163].

In this research study, an internal consistency reliability analysis was performed for the elements by using the SPSS Scale Reliability analysis procedure.

Reliability tests on the survey instruments were performed using the guidelines provided by Saraph et al (1989) [241]. *Cronbach's alpha* (α) was one of the most commonly used reliability coefficients, which ranged in value from 0 to 1 to estimate the value of internal consistency [253 and 254]. Alpha was measured on the same scale as a correlation coefficient. The closer the alpha was to 1.00, the greater the internal consistency of items in the instrument being assessed [281].

The *alpha* (α) value could be calculated from any subset of the elements and it could provide the best illustration as regard to internal consistency. The coefficient α was calculated for each elements. Cronbach (1951), Nunnally (1967) and Scott (1981) as quoted by Saraph et al (1989) [241] held the same view that an α value of 0.7 and above are considered to be adequate for testing the reliability of the elements. Thus, it could be concluded that on overall the survey instrument had high internal consistency and reliable.

In the present research, the reliability coefficient α ranged from 0.85 to 0.94 which were more than 0.7. Appendixes from D.1 to D.4 showed in detail the results of reliability analysis for all items used in this research. Thus, it could be concluded that on overall the survey instrument was reliable and it had high internal consistency.

# CHAPTER 6

## 6. CONCLUSIONS AND FUTURE WORK

### 6.1 INTRODUCTION

The purpose of this chapter is to summarise the work presented in the thesis and to draw some final conclusions. The original research questions and propositions are addressed in terms of a summary of the empirical findings. This chapter explains the limitation rise during this research. Future work concludes the chapter and the thesis.

### 6.2 RESEARCH CONCLUSIONS

The following conclusions are derived from the case study approach:

- Development of a new model that describes the lifecycle of TLP and revision of conventional model of the process of implementation of AMTs

This study had contributed to the literature in several ways. In terms of knowledge management literature, this study had contributed to this field by a development of new model that describes the lifecycle of TLP. In relation to technological change management literature, this study had revised the traditional model of implementation of new technologies by suggesting TLP model as a first phase that must be conducted before beginning with traditional three phases namely: adoption phase, installation phase and post-installation phase. Obviously, the development of such model is very important contribution that constructs the initial ground where new researchers could stand on to conduct more deepening studies about this process and its effects to businesses as a whole.

- Applying the Measurement of TLP on all Pharmaceutical and Chemical firms in Ireland

The measurement of TLP developed by this study is applied on all the pharmaceutical and chemical firms in Ireland. It is found that the practice level of TLP in the pharmaceutical and chemical firms in Ireland is advanced level. This

meant that pharmaceutical and chemical firms in Ireland are paying very significant attention and effort to TLP, and they are not lagging behind their European counterparts in this field.

The following conclusions, relating to the five hypotheses, are drawn from the analysis of the survey research approach:

- The practice of TLP has a positive and significant influence on the adoption phase of AMT implementation process.

- The practice of TLP has a positive significant influence on the installation phase of AMT implementation process.

- The practice of TLP has a positive and significant influence on the performance of manufacturing operations.

- The organisation size has a significant influence on the practice of TLP.

- Irish late adopters of new technologies pay significant attention to the practice of TLP, more so than Irish early adopters of AMT projects.

The following conclusions are drawn from consideration of the results of entire research activity:

- The practice level of TLP in Irish manufacturing organisations is found as an advanced level. Furthermore, there is a consensus among respondents that all parameters involved in the TLP are very important particularly the parameters represented by world class level of TLP:

Based on the importance-practice grid methodology (refer to chapter 5, section 5.4.4), this research concludes that on one hand, the practice level of TLP in manufacturing firms in Ireland is assessed and found as an advanced level which is very significant level among levels of TLP.

- The factors that encouraged managers to initiate TLP are identified:

The empirical study reported in this research identifies a number of factors that are believed to be very important in encouraging managers to initiate TLP. These factors in order of importance are 'problems during production', 'introduction of new product', 'shifting customer demand', 'intensive competition with foreign competitors', and 'available capital'. On the contrary, fascination for new technologies was found insignificant to influence the implementation of TLP.

- The factors that discouraged managers from establishing TLP are determined:

The statistical results had also demonstrated that there is a consensus among the participants about the factors that restricted them from investing in TLP. The participants of this study emphasised that all the factors listed are very significant impediments that discouraged them from initiating TLP in their own organisations. These factors in order their importance include 'lack of financial and human resources', 'deficiencies in experienced and skilled people', 'time-consuming', 'limited Information Technologies/Systems (IT/IS)', 'regulatory constraints in your industry', 'cost-intensive', 'training budget priorities', and 'lack of communication routines'. To verify the degree of agreement among the respondents about the importance of these factors, factor analysis was conducted. The results of this test explain that all above factors are found to have a high factor loading. Interestingly, 'limited Information Technologies/Systems (IT/IS)', and 'lack of communication routines' are found to score very high loading 0.87 and 0.85 respectively.

- This study identifies people involved in the management of TLP

As TLP members were given several functions including scrutiny, identification, evaluation, and recommendation, this study however identifies the people who are responsible for practicing TLP. Based on the statistical results, members of top management, engineers, and members of middle management are found to heavily be involved in practicing functions of TLP. Therefore, the members of TLP should have been from a variety of functional departments across the organisation. This mix of members would have facilitated the tasks of the team in assigning the

responsibilities for various activities and identifying needed permissions and resources.

- This research explains the execution plan that is used to introduce new technology observed by TLP

This study explains the plan that was usually followed whenever managers agreed to adopt and install a new technology. In addition, the background and number of people who are responsible for installing the new technology are also identified. Moreover, essential information companies frequently sought when investing in AMT had been identified. Describing the nature of required information is important especially for companies that had neglected or underestimated the role of early information gathering. Insufficient and inefficient information is often a major contributor to the failure of investment in AMT projects.

- This research identifies significant problems and barriers that challenge AMT implementation

Out of 25 problems challenging managers during the implementation of new technologies, 10 problems are found to significantly occur during the implementation of AMT projects. These 10 problems are 'Lack of integration of Manufacturing Information Systems', 'Lack of integration across functions', 'Problems with interconnection of equipment', 'Obsolescence of technology', 'Underestimation of on-going support of the information services department', 'Inadequate communication networking among system components', 'AMT skill deficiencies', 'Failure to recognise the resources needed to maintain the system (i.e. engineers etc)', 'Disruptions during implementation', and 'A conflict between short-time production requirements and long-term goals'. An interesting finding is that several major problems challenging implementation of AMT are related to TLP. For instance, the respondents who complained from the lack of integration of Manufacturing Information Systems are basically complaining from the lack of TLP. The information technologies are a backbone for TLP (i.e. collecting and distributing information internal and/or external the origination). The same is also applied on the respondents who were complaining of 'underestimation of on-going support of the information services department' and

'inadequate communication networking among system components'. These functions are very important activities in promoting TLP.

### 6.2.1 Further Observations

- It is observed that majority of the participants to this empirical study are senior managers

Almost three quarters (73.5%) of the respondents held a senior manager position in their organisations (refer to Table 5.9). Many authors stressed that senior managers and top management as a whole were the ones who were charged with the decisions to implement TLP activities and/or invest in AMT projects. Therefore, this finding is a confirmation that the respondents of this study are aware of TLP and AMT implementation and therefore it gave a high credibility for the responses.

- It is also observed that participants are very interested in the issues studied by this research

In order to assess the importance of the research's subject for participants and also to measure the credibility and reliability of the answers provided by the respondents, this research had posed two questions including 'would you like to receive the study findings?', and 'would you like to be contacted again?'. Of course any respondents who were interested in this study would score 'Yes' and look forward to receive the study findings. In relation to the credibility and reliability of the information provided, respondents who would provide credible information would not be hesitated to be contacted again and would score 'Yes' to contacted again. Obviously, the statistical results show that almost all (%76) participants are interested in this research and wish if they could receive a copy of the results of this study. Furthermore, two thirds (%60) of the participants are willing to be contacted again which is evident that the respondents knew what they are doing and what they are answering.

This study represents a first step to explore the issues related to the assessment of the TLP implementation in the Republic of Ireland. Also, the understanding on the

effects that TLP could exert on several functions is expanded such as technological change management and operations management in manufacturing organisations both domestically and over the world.

## 6.3 LIMITATIONS OF THIS RESEARCH

In the case-study approach, a single case had limitations in terms of its research capabilities including replication and reliability of research. In other cases, there may have been different behaviour orientations and awareness for the same TLP because of the different organisational cultures and social norms influencing decision makers. Therefore, because the knowledge derived from this research was embedded in contextual settings, researchers suggested investigating the TLP in other contexts and fields.

In the survey research approach, all participants in this study were pharmaceutical and chemical industrial members. No perspective of other Irish industries was included in this empirical study. It was likely that other industries perspectives could provide different points of views and remarkable notions of conflict management in Irish organisations. Therefore, comparison between different industries (i.e. Pharmaceutical & Chemical, Electrical & Electronic, Plastic & Rubber, Food & Beverages, Textile etc) or/and different sectors (Manufacturing, Service and Trade sectors) would be needed. In summary, the respondents used in this study are not representatives of the broad variety of Irish manufacture sector population to make a generalisation of the results possible. It was suggested that in future studies a representative sample of all industries in manufacture sector should be surveyed.

Time and budget constraints limited the case-study analysis to only one firm; the firm chosen was thought to be good representative of the industry at large and provided a good basis for examination. These constraints also prevented researchers from posting and sending the questionnaire to wide and varied population. The list of items included in the questionnaires was too long, which may have discouraged some managers from participating in the study.

To address some of the limitations and recommendations raised here a number of perspectives of future research were discussed in the following section.

## 6.4 FUTURE WORK

While the results documented in the current study were unique and significant and provided insights regarding the implementation of TLP and the management of AMT projects, they also served to present some issues as potential questions of further research.

1. As this study focused on Pharmaceutical and Chemical industry, further research is needed to study the practice levels of TLP in different industries and examine the relationship between the TLP and adoption of new technologies in manufacturing organisations,
2. To examine the impact of organisation structure on the implementation of TLP in manufacturing organisations,
3. How can governments help to promote TLP within manufacturing organisations and to what extent this help serves to support the degree of success in these new technologies? and
4. As the results of this study are concerned with all of pharmaceutical and chemical firms in Ireland, further analysis of the survey data should be carried out to separately identify the level of TLP in Irish-owned organisations, EU-owned organisations and American-owned organisations and then make a comparison between the three groups (i.e. Irish, European and American organisations) in order to gain insights on impact of cultural aspect of organisations on their practice of TLP.

Some questions arose through the interview sessions that may be worthy of further research. In relation to technological change management, interviewees as senior managers did not hide their concern about some matters such as how an operator would react to a new system, how many people would loose their jobs due to implementation of a new system, and how much motivation and/or moral drops as people may get redeployed. Future studies particularly in the Republic of Ireland should seek good answers to these questions in order to push the wheel of Advanced Manufacturing Technology (AMT) forward.

From a survey of the literature, several issues regarding the inability of traditional justification techniques to justify AMT projects arose. The challenge to traditional justification techniques was incrementally raised and thus, researchers and practitioners urged to find new techniques that are able to effectively adapt to these changes. Thus, to help investors, developers, and implementers of AMT projects address issues surrounding the management of AMT implementation more effectively; more research was needed to address the following questions:

- Research was needed to develop a conceptual model to describe and understand the economics of AMT projects.
- There was a need to develop techniques and metrics with which to quantify the impact of such techniques upon the business as a whole.
- A methodology needed to be developed to enable industry to use these new concepts, techniques and metrics to provide a rational basis for the selection of, investment in and management of the components that would come together to make the "factories of the future".

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# APPENDIXES

## APPENDIX A: THE INTERVIEW SCRIPT

## A.1: AN INVITATION TO ASSIST IN A STUDY

### DEVELOPING UNIQUE MEASUREMENT TO EVALUATE TECHNOLOGICAL LEARNING PROCESS (TLP)

**WHAT THIS STUDY IS ABOUT?**

In scientific literatures and management practice, there are a considerable agreement about the importance of an accurate and early anticipation of future needs and technological developments/trends. Many studies believe that the effectiveness of technology management is fundamentally influenced by observations made about current and future technology developments. Therefore, this study attempts to investigate the role of Technology Learning Process (TLP) in technology management. Noteworthy, there is no commonly used term for Technology Learning Process (TLP) in companies. Expressions such as technology monitoring, technology forecasting, technology scouting, technology foresight, and technology intelligence show the broad variety of expressions/definitions and include different activities in each firm.

In the narrow scope, TLP is defined as prediction of future characteristics of machines, procedures, or techniques. The definition of TLP can be extended to continuous monitoring of new/existing technology developments in order to discover promising future applications and includes an evaluation/validation of their potentials. The goal of TLP is then to exploit potential opportunities and to defend against potential threats, through prompt delivery of relevant information about technological trends in the environment of the company. According to this definition, TLP includes the monitoring and analysis of individual competitors as well as activities in universities and start-up companies.

**OBJECTIVE OF THE STUDY**

The aims of this study are to investigate how and why TLP practices are implemented and to examine potential impact of the use of TLP on the technological change management.

**WHO ARE WE INTEND TO SEEK ASSISTANCE FROM**

- Specialist of Technology Learning Unit: a person who is/was responsible for scanning and monitoring the trends and developments of new technologies,
- Specialist of Technology Acquisition Learning Unit: a person who is/was involved in discovering and acquiring competitive technology for the company,

- Manager or Member of information management,
- Manager or Member of Research and Development (R&D) department,
- Manager or Member of Middle Management,
- Heads of Technology Planning/Strategy Group or Department,
- Champion and/or Project Manager: a person who is an enthusiastic promoter of a technology and is sufficiently senior to influence management decisions with regard to that technology.

**CONFIDENTIALITY**

All information will be confidential. Answers will be strictly non-attributable to the interviewees on a personal level, or to their companies. Only aggregate figures will be published.

**SUPPORT**

If you have any questions regarding the interview questions, objective of the interview, time of the interview or any other clarification for the phrases used in the attached interview script, please send email to mohamed.dabnoon2@mail.dcu.ie or suzanne.dockery@dcu.ie

## A.2: INVITATION LETTER

Dear Sir/Madam

Dublin City University is conducting research, which involves study of Technology Learning Process (TLP) and its impact on the technological change management and also on operation management. This study attempts not only to trace and document how and why TLP practices are implemented but also to examine potential impact of the practice of TLP on the management of AMT projects. As part of this research, interviews are being held with senior managers in Irish manufacturing companies.

To this end I would be grateful for an appointment with you for about 30 minutes of informed meeting at your earliest convenience.

The information provided will be treated as strictly confidential.

Thank you for your cooperation

Yours Sincerely

Mohamed Dabnoon
PhD Research Student

School of Mechanical & Manufacturing Engineering,
Dublin City University,
Glassnevin, Dublin 9

# A.3: QUESTION SCRIPT FOR THE TLP IMPLEMENTATION INTERVIEWS

## THE INTERVIEW SCRIPT (IS)

QUESTIONS SCRIPT FOR THE TECHNOLOGICAL LEARNING PROCESS (TLP) INTERVIEWS

### 1. INTRODUCTION

The uncertainty, dynamism, and volatility of new technologies are altering the fundamental nature of competition as the 21st century begins. In this exciting competitive era, Technological Learning Process (TLP) plays a vital role in the firm's competitive success. Remarkably, there is no commonly used term for Technological Learning Process (TLP) in companies. Expressions such as technology monitoring, technology forecasting, technology scouting, technology foresight, and technology intelligence show the broad variety of expressions/definitions and include different activities in each firm.

### 2. BUSINESS/PRODUCT CHARACTERISTICS

### 3. TECHNOLOGICAL LEARNING PROCESS

3.1. First of all, how did you get to this level of success? In other words, how did you acquire your advanced technologies and how did you initially know that there are competitive technologies out there and they fit in your existing systems?

3.2. What is the process/approach that you use to assess the threat and opportunities for your company?

3.3. How do you organise and structure the learning process that you use?

3.4. Would you please describe the core tasks of your learning process activities and how do you coordinate these tasks of the learning process in your company?

3.5 Technology learning process comprises of many aspects such as technological aspects and non-technological aspects. What aspects does your learning process focus on?

3.6. Do you think that your success in adopting and implementing advanced technologies is due to the use of learning process?

- If yes, why do you think so?
- If no, what is the primary factor?

3.7. How do you measure your own learning process practices? In other words, what method do you use to assess your current learning process practices? If

you don't have one, based on your own experience, could you suggest a method that you think is useful to assess practice levels of technological learning process?

3.8 What information sources do you use to research or gather information as part of your learning process?

3.9. What did you do to improve your learning process capabilities?

3.10. How long have you been involved in the learning process?

3.11. What level of resources have you invested towards learning process as part of company strategy and how large is your investment in R&D as a whole?

3.12. What kind of expertise is involved in the learning process?

3.13. Do you think that the scope of the learning process is confined within the country or at international level?

3.14. If You Don't Have Learning Process, when managing the implementation of advanced technologies, does your organisation follow a specific model or method to investigate new technologies and their developments? Please provide brief description of model or reference for model if published

3.15. What constraints discourage you from establishing learning process?

**4 WRAP UP**

Are there any other things we haven't asked you that you think we should know about?

We reassure that all information will be confidential. Answers will be strictly non-attributable to the interviewees on a personal level, or to their companies. Only aggregate figures will be published.

*Thank you for your patience and*
*Your kind cooperation is very much appreciated*

## A.4: REVIEW AND APPROVAL LETTER

School of Mech & Mfg Eng,
Dublin City University (DCU),
Glassnevin, Dublin 9

Dear Sir/Madam

First of all I would like to take this opportunity to express my sincere appreciation for valuable information about the implementation of TLP that you provided during the interview session. However, we are still very much in need of your assistance and expertise.

The enclosed document contains a set of parameters for TLP implementation that we have developed based on information provided by you. We would appreciate it if you could review the document and send us any comments you might have. In particular, if you feel that we have neglected any critical activities or overemphasised any activities we would appreciate receiving such information from you.

Your assistance to date and review of this document will greatly advance the progress of my research and I greatly appreciate all your effort.

Warmest Regards and Sincerest Thanks,

Yours Sincerely

Mohammad Dabnoon

# APPENDIX B: POSTAL QUESTIONNAIRE

## B.1: PRE-TEST AND PILOT STUDIES

**Dublin City University (DCU)**
**School of Mech & Mfg Eng**
Dublin 9, Ireland
Prof M.S.J. Hashmi PhD DSc FIMechE FIEI MASME
Head of School

Dear Mr. A. M

Dublin City University is conducting research, which involves study of Technology Learning Process (TLP) and its impact on Irish manufacturers who have successfully implemented sophisticated level of Advanced Manufacturing Technologies (AMTs). Based on several discussions with senior managers in Irish organisations, we have developed several parameters that enable us to measure the sophistication level of TLP. To test these parameters and examine their impact on the success level of the process of AMT implementation, a survey questionnaire was designed which consists of several closed-end questions.

Prior to dispatching this questionnaire, we decided to conduct a pre-test and a pilot study to test several issues linked to the questionnaire design process such as underestimation or overestimation of the developed parameters of TLP, length of the survey, degree of understandability, simplicity of answering the questions and provided scales.

Dear Mr. A. M, as you have great experience with such studies, Prof Hashmi, Dr Geraghty and I decided to contact and invite you to participate in this pilot study. We kindly ask you to review our questionnaire attached to this e-mail, answer all the questions, and put your comments and concerns regarding any issues that you think are 'important' in the space provided under each question.

To make it much easier for you, a website (http://www.student.dcu.ie/~dabnoom2/TLP.html) has been developed through which you can check and answer our questionnaire, and send your comments and concerns that will help us to develop the final version of our questionnaire.

Warmest Regards and Sincerest Thanks

Yours Sincerely

Mohamed Dabnoon

## B.2: INVITATION LETTER

Equipments

Dear Sir/Madam

Dublin City University (DCU) is conducting research, which involves study of Technology Learning Process (TLP) and its impact on manufacturing organisations that have successfully implemented sophisticated level of Advanced Manufacturing Technologies (AMTs). Based on several discussions with senior managers in Irish organisations, we have developed several parameters that enable us to measure the sophistication level of TLP. To test these parameters and examine their impact on the success level of the process of AMT implementation, a survey questionnaire consisting of several closed-end questions is being distributed to Irish and UK manufacturing companies.

The data provided will be treated as confidential. It would be appreciated if you could complete the enclosed questionnaire and return it in the envelope provided. Alternatively you can access the same questionnaire and respond via e-mail. This is found at the following website address:

http://www.student.dcu.ie/~dabnoom2/TLP.htm

All the information received will be treated as confidential whether you identify yourself or not. However, in order to encourage respondents to reply, those who decide to give their names and addresses/contact number will be entered into a draw for the following prizes:

2GB MP3/MP4 Player, FM Radio and Carrying Case
1GB MP3/MP4 Player, FM Radio and Carrying Case
256MB MP3

Warmest Regards and Sincerest Thanks

Yours Sincerely

M. Dabnoon

## B.3: INSTRUCTIONS FOR THE QUESTIONNAIRE SURVEY

We encourage more than one person from an organisation to complete the questionnaire. In this way we hope to obtain views about the application and utilization of TLP and the process of AMT implementation as seen by people with roles such as developers, managers, researchers, champion etc. To this end, feel free to duplicate the questionnaire, or request additional copies from Ms Suzanne Dockery or Dabnoon Mohamed (see Support below).

CONFIDENTIALITY

Please answer the questions on the following sheets as honestly as you can. Your answers will be strictly non-attributable to you on a personal level, or to your company. Only aggregate figures will be published.

COMPLETING THE QUESTIONNAIRE

There are no right or wrong answers to these questions; we are attempting to identify the unique standards that correlate with the effective implement of AMTs, not to 'score' an organisation's capability. However, there are several important points that should be noted and clarified:

- While there are many questions to answer, they are all multiple choice, and we estimate that it will take you about 20 to 25 minutes to complete the questionnaire. When you have filled it out, please return it in the pre-addressed envelope provided, or to the research organisation (M & MEng in DCU) that distributed it to you,
- If you can't answer all the questions below, don't be concerned. We expect this will be the case with many respondents, in part because not everyone will have been involved in all aspects of the utilization process of TLP and the process of AMT implementation, and in part because not all activities/tasks mentioned might align with what you have done. If you feel that you don't know the answer to a question, or it is not applicable in your situation, just check the (DK) box,
- The questionnaire is written in a manner that assumes you are involved in both AMT implementation process and TLP application process. If you have been experienced in only one process, your responses should reflect the process with which you have been involved in,
- You can expand on any of your answers on the last sheet of the questionnaire,
- Some of the terms in the questionnaire have specific meanings. In order to minimize ambiguities, we have included a section called Simplification of Terms in the Questionnaire (STQ), and
- Please check the boxes in the questionnaire as unambiguously as possible.

**SUPPORT**

If you have any questions regarding the survey or the questionnaire, please send email to "mohamed.dabnoon2@mail.dcu.ie" or "suzanne.dockery@dcu.ie"

## B.4: SIMPLIFICATION OF TERMS IN THE QUESTIONNAIRE

There are several terms used in the questionnaire that have specific meaning in the context of the questionnaire. These terms are defined below:

**Section B:**
**Question.B1:** Advanced Manufacturing Technologies (AMTs) are new technologies, which are used directly by companies in the production of a product. Basically, AMT is an umbrella encompassing a number of computer-aided technologies such the ones that are listed down in the Section B of the questionnaire. In Question B1, most of AMTs that are used in manufacturing companies are shown and participants to this study are requested to tick 'Yes' or 'No' to AMTs that they use in their own companies.

**Section C:**
**Question.C1:** The process of implementation of AMT goes through several phases including Adoption Phase and Installation Phase. **The Adoption Phase** is concerned with conducting several processes/activities to adopt the required AMT. Some of these activities/processes that are performed during this phase are selection, justification and acquisition of AMT. Whereas the **Installation Phase** is concerned with installing, operating, and monitoring adopted AMT projects. This phase requires also organisations to modify and/or set several managerial and technical activities.

To this end, **Question.C1** seeks to determine the degree of success that the participants had achieved when they implemented AMT projects in their own companies. A five-point scale ranging from failure to very successful is provided. The Failure-point scale, which means the AMT was not even compatible, is equal to 1. Whereas, the Very Successful-point scale which means the AMT was adopted and implemented %100 successfully, is equal to 5.

**Question.C2:**
**Issues challenging Implementation of AMT Projects:** To determine the difficulties manufacturers faced during the process of implementation of AMT projects, participants in this study are provided with most of the problems that several manufacturing companies often faced when implemented AMT projects. The list provided under **Question.C2** is comprised of a variety of issues namely: technological, organisational, and human issues. Therefore, **Question.C2** seeks to understand the problems that manufacturers face when they adopted and implemented AMT projects. Thus, participants are requested to rate the importance of the problems on a five-point scale ranging from Not a Problem to Very Major Problem. Where Not a Problem is equal to 1, Very Major Problem is equal to 5.

**Section D:**
**Technology Learning Process (TLP)** is defined as an organisational process for the prediction of future characteristics of machines, procedures, or techniques. The definition of TLP can be extended to continuous monitoring of new/existing technology developments in order to discover promising future applications and includes an evaluation/validation of their potentials. The goal of TLP is then to

exploit potential opportunities and to defend against potential threats, through prompt delivery of relevant information about technological trends in the environment of the organisation. According to this definition, TLP includes the scrutinizing, monitoring, collection, analysis, validation and dissemination of technological and non-technological information, which is obtained mainly from individual competitors as well as activities in universities and start-up companies

**Question.D1:**
**Practiced Level of TLP:**
Participants in this study are provided with a list of 46 TLP activities, which should be conducted to ensure an organisation is up-to-date with and has a good awareness of trends and developments of existing/new technologies. To determine practice level for these 46 activities, participants are provided with a five-point scale ranging from Not Practiced through to Regularly Practiced. Where Not Practice is equal to 1, Regularly Practiced is equal to 5. Basically, TLP consists of several levels starting from Basic Level through to World-Class Level. Therefore, **Question.D1** is very important for this study. Because, based on the answers provided by the participants, we will be able to classify the level of TLP practice of an organisation.

**Question.D2:**
**Importance Degree in using TLP activities in a company:** The participants in this study are requested to determine the importance degree of TLP activities whether or not they are implemented.

Where as in **Question.D1** the researchers of this study will decided which level of TLP practice the participants are in, **Question.D2** provides a chance for participants to decide themselves which activity is more important than others. Regardless to whether the participants have practiced or not practiced these activities, a five-point scale is again used to let the participants determine the impotence level of the TLP activities. The five-point scale ranges from Not Important, through to Very Important.

**Section E:**
**Question.E1:**
**Performance Measures** are measures used to identify the improvements that occurred due to compliance with the methods a company used to implement any type of AMT. In this study, participants are provided with a list, which consists of fifteen performance measures. These measures represent four dimensions including quality improvements, flexibility improvements, cost reductions, and time-based operational and product developments. The researchers of this study are requesting participants to describe the changes in manufacturing performance that participants believe happened as a result of implementation of new technologies. To measure the changes that occurred on manufacturing performance, this study provides a five-point scale ranging from Substantial-Decline-In-Performance through to Substantial-Improvement-In-Performance.

## Definition for Several Terms Used in This Questionnaire

**Listening Posts:**

Listening Posts are a comprehensive system for listening to partners' needs and customers' needs. They are specifically designed to understand partners' needs and specifically designed to listen to customers' needs. There are also some listening posts that support both partner and customer contacts. These listening posts capture both quantitative and qualitative data. Organisations, which use these listening posts, correlate information from their various listening posts to validate their findings and to provide evidence that they are improving their processes and adding value to their partners and customers. The listening posts are reviewed at least annually and revised as appropriate to align with a business strategy. Some examples of these listening posts are:

Understand Needs Through Listening Posts:

| | | |
|---|---|---|
| 1. Branch telephone survey | 5. Customer telephone Survey | 9. Strategic Studies |
| 2. Partnership scorecards | 6. Customer Advisory Council | 10. Voice of the Customer |
| 3. Win/loss analysis | 7. In-box Surveys | 11. Market Research |
| 4. Partnership Surveys | 8. Quality Function Deployment | 12. New Tech/Product Release Survey |

**Scorecards:**
Scorecards are developed jointly with the partner and define partnership goals, measures and targets. Regular partnership meetings review the progress toward goal achievement, with the first meeting being a "year in review" session for strategic planning. Subsequent Partnership Scorecard reviews drive action plans for both the company and its partner.

**Watch List:**
Watch list is a list of securities being monitored closely by a brokerage or exchange in order to spot irregularities. Firms on the watch list might be suspected of regulatory violations, (i.e. about to issue new securities), attracting unusually heavy volume, etc.

**Organisation** is a set of projects or business groups that share those same basic corporate and technical cultures. They may or may not work in the same product line, but probably share the same values, use similar technologies and have open lines of communication.

**Process** is a sequence of interdependent activities whose execution leads to a goal. Often (but not always) a process is initiated by a decision to take action (perhaps by a manager), and is completed when a product is generated

**Senior Manager** is a manager who is responsible for a number of projects or business groups and has financial responsibility for and control over these projects or groups,

**Champion** is a person who is an enthusiastic promoter of a technology and is sufficiently senior to influence management decisions with regard to that technology,

# B.5: POSTAL QUESTIONNAIRE SURVEY

SN NO: | | | | | |

Dublin City University
Ollscoil Chathair Bhaile Átha Cliath

**SURVEY QUESTIONNAIRE** **2007**

**DUBLIN CITY UNIVERSITY (DCU), IRELAND**

**Study of the link between**

**THE TECHNOLOGY LEARNING PROCESS (TLP)**

**And**

**THE PROCESS OF IMPLEMENTATION OF NEW TECHNOLOGIES**

**Among Irish Manufacturers**

The School of Mechanical and Manufacturing Engineering of Dublin City University is studying utilisation of Technology Learning Process (TLP) and its impact on the process of implementation of Advanced Manufacturing Technologies (AMTs) in Irish manufacturing organisations. As part of this study we would appreciate if you could take time to complete this questionnaire. Thank you in advance for your kind cooperation

**Please circle, tick or fill in the blanks provided. Please answer ALL questions.**

This questionnaire is divided into 5 sections:

Section A: General Information
Section B: Advanced Manufacturing Technologies (AMT)
Section C: Process of Implementation of Advanced Manufacturing Technologies (AMTs)
Section D: Application and Utilisation of Technology Learning Process (TLP)
Section E: Organisation Performance Measures

**ALL INFORMATION WILL BE TREATED <u>STRICTLY CONFIDENTIALLY</u>**

Name: _____
Company Name: _____
Company Address: _____
_____
Telephone No: _____Fax No: _____
Email Address: _____

Findings of this study will be made available to all respondents who request them:
Do you want to receive the study findings? □ Yes □ No

**Section A**: General Information

| **A1:** What type of Industrial/Manufacturing group best describes your organisation? (*Please Tick One*) | |
|---|---|
| □ Electrical and Electronic | □ Stationery, Paper & printing |
| □ Plastics & Rubber | □ Industrial equipment |
| □ Metal & Mech. Engineering | □ Automotive & Transportation |
| □ Chemical & Allied Products | □ Textile, Clothing & Footwear |
| □ Food, Tobacco & Beverages | □ Clay & Building Ind. Products |
| □ Wood and Furniture | □ Others (Specify) _____ |

| **A2:** Ownership: | □ Irish □ EU □ USA □ Mix □ Other |
|---|---|

| **A3:** Foundation Year? | □ Before 1970s | □ 1970s | □ 1980s |
|---|---|---|---|
| | | □ 1990s | □ 2000s |

| **A4:** Number of employees (*Please Tick One*)? | □ Less than 25 | □ 101 to 250 |
|---|---|---|
| | □ 25 to 50 | □ 251 to 500 |
| | □ 51 to 100 | □ More than 500 |

| **A5:** Job title of person answering the survey questionnaire (*Please Tick One*): | | |
|---|---|---|
| □ Owner | □ Manager/Head of Department | □ Champion |
| □ Engineer/Executive | □ Supervisor | □ |
| Others_____ | | |

**Section B:** Advanced Manufacturing Technologies (AMTs)

| **B1:** Which of the following AMTs do you use in your organisation? | **Usage** | |
|---|---|---|
| | **Yes** | **NO** |
| Computer Aided Design (CAD) | | |
| Computer Aided Manufacturing (CAM) | | |
| Numerical Control (NC) Machines | | |
| Computer Numerical Control (CNC) Machines | | |
| Direct Numerical Control (DNC) Machines | | |
| Automated Material Handling Systems (AMHS) | | |
| Computer-Aided Engineering (CAE) | | |
| Robotics (Ro) | | |
| Automated Guided Vehicles (AGV) | | |
| Automated Storage and Retrieval System (AS/RS) | | |
| Flexible Manufacturing System (FMS) | | |
| Computer-Integrated Manufacturing (CIM) | | |
| Material Requirement Planning (MRP) | | |
| Manufacturing Resource Planning (MRP II) | | |
| Enterprise Resource Planning (ERP) | | |
| Total Quality Management (TQM) | | |
| Just-In-Time Manufacturing (JIT) | | |
| **Others Please Specify:** _____ | | |

| **B2:** When did you introduce first time any of above technologies to your organisation? | □ Before 1970s | □ 1970s | □ 1980s |
|---|---|---|---|
| | | □ 1990s | □ 2000s |

**Section C**: Process of Implementation of Advanced Manufacturing Technologies (AMTs)

| **C1:** Please specify degree of success in the phases of AMT implementation: | Level of Success | | | | |
|---|---|---|---|---|---|
| | Failure | Unsuccessful | Somewhat Successful | Successful | Very Success |
| Adoption Phase (i.e. Selection, Justification, and Acquisition of required AMTs) | | | | | |
| Implementation Phase (i.e. installing, operating, and monitoring of adopted AMTs) | | | | | |

| **C2:** Please rate the degree of difficulty that your organisation faced during Adoption and Implementation phases of AMT projects? | **Degree of Difficulty** | | | | |
|---|---|---|---|---|---|
| | Not Problem | Minor | Somewhat Problematic | Major | Very Major |
| Problems with interconnection of equipment | | | | | |
| Lack of integration of Manufacturing Information Systems | | | | | |
| Lack of integration across functions | | | | | |
| Obsolescence of technology | | | | | |
| Lack of the necessary discipline on the shop-floor | | | | | |
| Failure to remove organisational barriers between functional areas | | | | | |
| Inadequate communication networking among system components | | | | | |

| **C2:** Please rate the degree of difficulty that your organisation faced during Adoption and Implementation phases of AMT projects? | **Degree of Difficulty** | | | | |
|---|---|---|---|---|---|
| | Not Problem | Minor | Somewhat Problematic | Major | Very Major |
| Discouragement and initial hesitation of senior management to provide full support | | | | | |
| Underestimation of on-going support of the information services department | | | | | |
| Poor communication between senior management and other departments | | | | | |
| Production management skill deficiencies | | | | | |
| AMT skill deficiencies | | | | | |
| Problems with outside SW development consultants | | | | | |
| Adverse effect on workflow | | | | | |
| Opposition by workforce and/or staff/management | | | | | |
| Lack of effective training programs of support personnel and production staff | | | | | |
| Uncertainty and disagreement of engineers about the required changes | | | | | |
| Failure to recognise the resources needed to maintain the system (i.e. engineers etc) | | | | | |
| Failure to adapt to and plan for continuous change over time | | | | | |
| Disruptions during implementation | | | | | |
| Changing priorities in manufacturing function | | | | | |
| Lack of co-ordination with the company's strategic plan | | | | | |
| Implementation without an appropriate manufacturing strategy | | | | | |
| Failure to achieve financial targets | | | | | |
| Changes in the marketplace during the implementation process | | | | | |
| A conflict between short-time production requirements and long-term goals | | | | | |

**Section D**: Importance and Practice Level of Technological Learning Process (TLP)

| **D2** | | | | | **D1: On the right hand:** Please determine which of the following activities you practice to learn and track trends and developments in advanced technologies?<br>---<br>**D2: On the left hand:** Please Specify the importance of the same activities? | **D1** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Very Important | Important | Moderate | Somewhat | Not Important | | Not Practice | Hardly Practice | Occasionally | Fairly Practice | Regularly Practice |
| | | | | | Cooperate with suppliers that offer a valuable information | | | | | |
| | | | | | Cooperate with customers/users | | | | | |
| | | | | | Check government sources that detail information on foreign & domestic investments | | | | | |
| | | | | | Participate in activities of professional associations | | | | | |
| | | | | | Participate in activities of trade associations | | | | | |
| | | | | | Scrutinize business literature and variety of periodicals | | | | | |
| | | | | | Join local chambers of commerce | | | | | |
| | | | | | Subscribe to the local press and check the local newspaper | | | | | |
| | | | | | Subscribe and review trade press | | | | | |
| | | | | | Collaborate with stockbrokers who made deeply studies of a competitor | | | | | |
| | | | | | Keep track of the prospectus that reveals the major stockholders along with financial and organisational details | | | | | |
| | | | | | Contact and visit the investment banks | | | | | |
| | | | | | Participation of employees in the company's strategy (e.g. innovation need) through informal searching and learning activities | | | | | |
| | | | | | Use IT such as Bulletin Board System and E-mails | | | | | |
| | | | | | Accessibility to the Internet | | | | | |
| | | | | | Create informal discussion networks through intranet discussion platforms | | | | | |
| | | | | | Rotate jobs among employees in order to strengthen the informal technological learning networks in your organisation | | | | | |
| | | | | | Clearly establish communication routines to pass on the | | | | | |

| D2 | | | | | D1: On the right hand: Please determine which of the following activities you practice to learn and track trends and developments in advanced technologies?<br>---<br>D2: On the left hand: Please Specify the importance of the same activities? | D1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Very Important | Important | Moderate | Somewhat | Not Important | | Not Practice | Hardly Practice | Occasionally | Fairly Practice | Regularly Practice |
| | | | | | trends and developments of new technologies to top management | | | | | |
| | | | | | Provide your members with extra travel budget to update your company with the latest developments of its technology | | | | | |
| | | | | | Use Technology Roadmaps as a tool to learn and/or anticipate future tends of the new technologies | | | | | |
| | | | | | Use a Balanced Scorecard to improve critical areas such as technology, product, process, and market development | | | | | |
| | | | | | Use Listening Posts to get some feedback from customers & partners | | | | | |
| | | | | | Use a Watch List to spot irregularities in the environment of your firm | | | | | |
| | | | | | Benchmark key competitors | | | | | |
| | | | | | Conduct a sensitivity/risk analysis | | | | | |
| | | | | | Launch projects of limited duration specifically dedicated to learn specific technological problems and developments | | | | | |
| | | | | | Appoint a gatekeeper (i.e. someone frequently in contact with people from outside the organisation to sustain the flow of information across company boundaries) | | | | | |
| | | | | | Use venture capital funds as a tool to get access to new technological trends and solutions at a very early stage | | | | | |
| | | | | | Send technology envoys throughout the world in order to build up a network with institutions, universities and start-up companies | | | | | |
| | | | | | Organize technology colloquia to assess different technological developments and/or possible research directions | | | | | |
| | | | | | Arrange innovation workshops | | | | | |
| | | | | | Proactively collaborate with universities and research institutes | | | | | |
| | | | | | Collaborate with start-ups and leading companies | | | | | |
| | | | | | Establish centralized and/or decentralized units dedicated to learn developments and trends of new technologies, in which the tasks are hierarchically divided within the positions and departments | | | | | |
| | | | | | Establish a suitable pyramidal structure of R&D personnel | | | | | |
| | | | | | Build a reliable and accessible database as a result of your yearly accumulation of R&D documents | | | | | |
| | | | | | Use R&D documents in comparison to other documents | | | | | |
| | | | | | Acquire up-to-date R&D tools | | | | | |
| | | | | | Share knowledge, whether formal or informal, within the R&D dept | | | | | |
| | | | | | Share information among departments (i.e. formal and informal knowledge sharing among R&D, production, and marketing Depts) | | | | | |
| | | | | | Gain support and commitment of top management to anticipate technological breakthrough and global changes | | | | | |
| | | | | | Keep a constant balance between human resource planning and learning strategy in your organisation | | | | | |
| | | | | | Recruit high levels of education, skills, and experience among employees to manage technological learning | | | | | |
| | | | | | Provide training programmes for your employees to improve technological learning | | | | | |
| | | | | | Provide incentive systems suitable for technological learning and effective in stimulating the bottom-up flow of technological trends | | | | | |
| | | | | | Provide researchers with financial resources to follow their own research interest | | | | | |

**D3.** Who is responsible for TLP in your organisation?

| | |
|---|---|
| □ Members of Top Management | □ Researchers |
| □ TLP Specialists | □ Engineers |
| □ Technology Agents | □ Members of Middle Management |

**D4:** How important are the following factors to initiate TLP in your organisation?
*Where: **1**= Not Important; **2**= Somewhat Important; **3**=Moderate Important; **4**=Important; and **5**= Very Important*

| | | | | | |
|---|---|---|---|---|---|
| Problems during Production | 1□ | 2□ | 3□ | 4□ | 5□ |
| Intensive Competition with Foreign Competitors | 1□ | 2□ | 3□ | 4□ | 5□ |
| Shifting customer demand | 1□ | 2□ | 3□ | 4□ | 5□ |
| Fascination for New Technologies | 1□ | 2□ | 3□ | 4□ | 5□ |
| Available Capital | 1□ | 2□ | 3□ | 4□ | 5□ |
| New Product Introduction | 1□ | 2□ | 3□ | 4□ | 5□ |

**Please specify any other criteria that you think are essential in initiation of TLP in your organisation:**

_____

_____

**D5:** How significant are the following constraints to discourage organisations from establishing TLP?
*Where: **1**= No Important; **2**= Somewhat Important; **3**=Moderate Important; **4**=Important; and **5**= Very Important*

| | | | | | |
|---|---|---|---|---|---|
| Lack of financial and human resources | 1□ | 2□ | 3□ | 4□ | 5□ |
| Deficiencies in experienced and skilled people | 1□ | 2□ | 3□ | 4□ | 5□ |
| Limited Information Technologies/Systems (IT/IS) | 1□ | 2□ | 3□ | 4□ | 5□ |
| Lack of communication routines | 1□ | 2□ | 3□ | 4□ | 5□ |
| Regulatory Constraints in your Industry | 1□ | 2□ | 3□ | 4□ | 5□ |
| Training Budget Priorities | 1□ | 2□ | 3□ | 4□ | 5□ |
| Cost-intensive | 1□ | 2□ | 3□ | 4□ | 5□ |
| Time-consuming | 1□ | 2□ | 3□ | 4□ | 5□ |

**Please specify any other constraints that you think are critical in discouraging companies from establishing TLP:**

_____

_____

**Section E**: Organisation Performance Measures

| **E1:** Please assess the changes in manufacturing performance that you consider are attributable to the adoption of new technologies | **Organisation Performance Measures** | | | | |
|---|---|---|---|---|---|
| | **Actual level of achievement** | | | | |
| | Substantial Decline in Performance | Decline in Performance | No Change in Performance | Improvement in Performance | Substantial Improvement in Performance |
| Product Quality | | | | | |
| Scrap and Rework | | | | | |
| Variety of Products Manufactured | | | | | |
| Ability to change production lot sizes | | | | | |
| Number of operators | | | | | |
| Average labour cost | | | | | |
| Operator output rates | | | | | |
| Average numbers of tasks per operator | | | | | |
| Delivery lead-times | | | | | |
| Setup times | | | | | |
| Changeover times | | | | | |
| Manufacturing lead-times | | | | | |
| Engineering/design lead-times | | | | | |
| Time-to-markets | | | | | |
| Time for a major design change in an existing product | | | | | |

*Thank you for your patience. Your kind cooperation is very much appreciated*

**CONTACT:**

In case we need some further information on this study, would you be willing to be contacted again? □ Yes □ No

If **YES**, please specify your preferred mode for further communication (*circle as applicable*):

□ Through email
□ Through questionnaire
□ Through interview (by prior appointment at your premises)

**Please return** (using the pre-addressed and stamped envelope) **to:**

Professor: Hashmi
Head of School,
School of Mechanical and Manufacturing Engineering,
Dublin City University, Dublin 9,
REPUBLIC OF IRELAND

# B.6: REMINDER LETTER FOR POSTAL QUESTIONNAIRE

School of Mech & Mfg Eng,
Dublin City University,
(DCU)
Dublin 9
2007

Dear Mr.

This is just to remind you that a questionnaire was sent to you few weeks ago and to date I have not received any response/feedback. May be the post did not reach you or due to pressure of work you did not have time to check the attached document.

Whatever is the reason, I would like to request you to kindly spare few minutes to complete the questionnaire enclosed. For your convenience, the following linkage provides you with our online questionnaire. To start completing the Online Questionnaire, please click on the following linkage:

http://www.student.dcu.ie/~dabnoom2/TLP.htm

If you face any difficulty to understand terms used in this questionnaire, please refer to a simplification letter enclosed.

I would like to emphasise that this is a very important project we have undertaken and its success will depend on getting a good response from you.

All the information received will be treated as strictly confidential whether you identify yourself or not. However, in order to encourage respondents to reply, those who decide to give their names and addresses/contact number will be entered into a draw for the following prizes:

2GB MP3/MP4 Player, FM Radio and Carrying Case
1GB MP3/MP4 Player, FM Radio and Carrying Case
256MB MP3/MP4 Player, FM Radio and Carrying Case

Warmest Regards and Sincerest Thanks

Yours Sincerely

Head of Mechanical & Manufacturing Engineering School
Professor M.S.J. Hashmi PhD DSc FIMechE FIEI MASME

# APPENDIX C: ONLINE QUESTIONNAIRE SURVEY

## C.1: INVITATION E-MAILS FOR ONLINE QUESTIONNAIRE

School of Mech & Mfg Eng
Dublin City University (DCU)
Glassnevin, Dublin 9

Dear Mr.

We are conducting a survey in order to find out the practice level of TLP in your organisation and the effects that TLP exerts on the technological change management and also on operation management. This research attempts to identify the parameter that measure the practice level of TLP and document their influence on several functions within manufacturing organisations.

If you could take 5 minutes to complete our questionnaire we would be extremely grateful. All replies to the survey will be entered into a prize draw for €150 cash.

If you would like to be entered into the prize draw, just fill in your contact details at the end of the survey.

To begin the survey, just click on the linkage below. All your answers will be kept strictly confidential.

http://www.student.dcu.ie/~dabnoom2/TLP.htm

Warmest Regards and Sincerest Thanks

Yours truly

Mohamed Dabnoon

## C. 2: REMINDER LETTER FOR ONLINE QUESTIONNAIRE

**********
**

**Attention:** The Research Team will be extremely grateful if you forward this e-mail also to Mr.
This E-mail is from the Research Team: Professor. Hashmi (Head of the School), Dr. John Geraghty (Head of the Research), Mr. M. Dabnoon (Member of the Research Team), and Ms. Suzanne Dockery (Member of the Research Team).
**********
**

Dear Mr.

This is just to remind you that a questionnaire was sent to you few weeks ago and to date I have not received any response/feedback. May be the post did not reach you or due to pressure of work you did not have time to check the attached document.

Whatever is the reason, I would like to request you to kindly spare few minutes to complete the survey attached. For your convenience, the following linkage provides you with our online survey questionnaire. To start completing the Online Questionnaire, please click on the following linkage:

http://www.student.dcu.ie/~dabnoom2/TLP.htm

If you face any difficulty to understand terms used in this questionnaire, please refer to a simplification letter attached to this e-mail.

I would like to emphasise that this is a very important project we have undertaken and its success will depend on getting a good response from you.

All the information received will be treated as strictly confidential whether you identify yourself or not. However, in order to encourage respondents to reply, those who decide to give their names and addresses/contact number will be entered into a draw for the following prizes:

2GB MP3/MP4 Player, FM Radio and Carrying Case
1GB MP3/MP4 Player, FM Radio and Carrying Case
256MB MP3/MP4 Player, FM Radio and Carrying Case

Warmest Regards and Sincerest Thanks

Yours Sincerely

Head of Mechanical & Manufacturing Engineering School
Professor M.S.J. Hashmi PhD DSc FIMechE FIEI MASME

# APPENDIX D: RELIABILITY ANALYSIS

## D.1: SCALE OF PROBLEMS CHALLENEGE MANAGEMENT OF AMT IMPLEMENTATION

Scale of all (26) variables involved in challenging AMT implementation

Case Processing Summary

| | | N | % |
|---|---|---|---|
| Cases | Valid | 65 | 95.6 |
| | Excluded(a) | 3 | 4.4 |
| | Total | 68 | 100.0 |

A Listwise deletion based on all variables in the procedure.

Reliability Statistics

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .929 | .928 | 26 |

## D.2: SCALE OF PRACTICE LEVEL OF DEVELOPED PARAMTERS OF TLP

Scale of all (46) variables of TLP involved in measure practice level of TLP

Case Processing Summary

| | | N | % |
|---|---|---|---|
| Cases | Valid | 68 | 100.0 |
| | Excluded(a) | 0 | .0 |
| | Total | 68 | 100.0 |

A Listwise deletion based on all variables in the procedure.

Reliability Statistics

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .940 | .939 | 46 |

## D.3: SCALE OF IMPORTANCE DEGREE OF DEVELOPED PARAMTERS OF TLP

Scale of ALL (46) variables used to assess the importance degree of the developed parameters of TLP

Case Processing Summary

| | | N | % |
|---|---|---|---|
| Cases | Valid | 67 | 98.5 |
| | Excluded(a) | 1 | 1.5 |
| | Total | 68 | 100.0 |

A Listwise deletion based on all variables in the procedure.

Reliability Statistics

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .941 | .940 | 46 |

## D.4: SCALE OF MANUFACTURING PERFORMANCE MEASURES

Case Processing Summary

| | | N | % |
|---|---|---|---|
| Cases | Valid | 66 | 97.1 |
| | Excluded(a) | 2 | 2.9 |
| | Total | 68 | 100.0 |

A Listwise deletion based on all variables in the procedure.

Reliability Statistics

| Cronbach’s Alpha | Cronbach’s Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .845 | .845 | 15 |

Item Statistics

| Manufacturing Operations Performance Measures | Mean | Std. Dev | N |
|---|---|---|---|
| Product Quality | 4.21 | .71285 | 66 |
| Scrap and Rework | 4.06 | .72066 | 66 |
| Variety of Products Manufactured | 3.73 | .90376 | 66 |
| Ability to change production lot sizes | 3.61 | .92618 | 66 |
| Number of operators | 3.74 | .88249 | 66 |
| Average labour cost | 3.77 | .89090 | 66 |
| Operator output rates | 4.11 | .70446 | 66 |
| Average numbers of tasks per operator | 3.83 | .83359 | 66 |
| Delivery lead-times | 4.00 | .70165 | 66 |
| Setup times | 3.71 | .89038 | 66 |
| Changeover times | 3.73 | .88657 | 66 |
| Manufacturing lead-times | 3.89 | .78699 | 66 |
| Engineering/design lead-times | 3.59 | .84083 | 66 |
| Time-to-markets | 3.80 | .80803 | 66 |
| Time for a major design change in an existing product | 3.50 | .809 | 66 |

# APPENDIX E: JOURNAL PUBLICATIONS IN PREPARATION

- Dabnoon, M., Geraghty, J., Leavy, B., and Hashmi, M.S.J., " Implementation of Technological Learning Process (TLP): Primary Elements/Stages of TLP", Journal of Engineering and Technology Management, 2008

- Dabnoon, M., Geraghty, J., Leavy, B., and Hashmi, M.S.J., "Measurement of Technological Learning Process (TLP): Activities involved in the management of TLP implementation", Journal of Engineering and Technology Management, 2008

- Dabnoon, M., Geraghty, J., Leavy, B., and Hashmi, M.S.J., " Determine the practice level of Technological Learning Process (TLP) in Irish Pharmaceutical and Chemical Industry", Journal of Engineering and Technology Management, 2008

- Dabnoon, M., Geraghty, J., Leavy, B., and Hashmi, M.S.J., " Study the links between the Technological Learning Process (TLP) and both technological change management and operations management", Journal of Engineering and Technology Management, 2008