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The Impact of Knowledge Management Practices on NPP Organizational Performance — Results of a Global Survey

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THE IMPACT OF KNOWLEDGE MANAGEMENT PRACTICES ON NPP ORGANIZATIONAL PERFORMANCE — RESULTS OF A GLOBAL SURVEY

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For further information on this publication, please contact:

Nuclear Knowledge Management Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
Email: Official.Mail@iaea.org

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FOREWORD

The IAEA has been asked by Member States in the 2012 General Conference Resolutions to "further increase the level of awareness of efforts in managing nuclear knowledge" and to continue "to further develop and disseminate guidance and methodologies for planning, designing, and implementing nuclear knowledge management programs". The present report summarizes the results of empirical research on the relationship between KM practices in nuclear power plants, their impact on the quality of organizational knowledge processes and the resulting effects on the organizational effectiveness of nuclear power plants. It presents the basic findings of the "IAEA Global Nuclear Power Plant Survey: Investigating the Link Between Knowledge Management Practices and Organizational Performance", which was conducted in 2010.

This benchmark survey of KM practices in nuclear power plants was developed using a standard research methodology. The survey was made available on a global basis to all nuclear power plant sites. Senior operations managers were asked to complete the survey with input, as required, from their plant management team. Data from individual survey responses were treated as confidential, and only aggregate findings were reported. A total of 124 station 'site organizations' participated in the survey, representing a response rate of approximately 60%.

The findings provide empirical evidence of the importance of KM practices in improving the organizational effectiveness of nuclear power plants. They provide information about the current state of the industry with respect to KM practices, illustrating the direct and tangible benefits of implementing such practices and justifying continued or further efforts to ensure that KM programmes and systems are strategically planned and implemented in operating nuclear power plants. The research provides insights into the mechanisms by which KM practices have an impact on organizational effectiveness and provides a basis for further research. It is expected that the survey instrument and measures developed will be used for future IAEA KM studies to measure and track this important issue on an ongoing basis. The assessment methodology and data also provide a measurement basis for nuclear power plant benchmarking and improvement.

This report was prepared primarily for managers of nuclear power plants and other KM practitioners and stakeholders in nuclear operating facilities. It may also be useful to other nuclear facility owners and operators, nuclear design and support organizations, nuclear R&D organizations, nuclear regulators, academia and government policy makers.

The IAEA would like to express its appreciation to all those who participated in the survey. The IAEA is grateful to J. de Grosbois (Canada), who was the author of this report. The IAEA officers responsible for this publication were Y. Yanev, A. Kosilov and Z. Pasztory of the Department of Nuclear Energy.

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

Nuclear power plant (NPP) organizations have been dealing with knowledge management (KM) related issues and knowledge processes from the outset. However, while some NPPs have adopted KM practices and have been proactive in implementing strategic company-wide KM programmes, many other NPPs do not view or manage these activities from a strategic KM perspective, nor yet see any need to do so. While the concepts of KM are beginning to be understood in the nuclear industry, they have yet to be widely applied and the benefits are difficult to measure. There has been little prior research on KM in NPP organizations.

1.2. OBJECTIVES

The objective of this report is to summarize the findings of research that was conducted as a thesis to explore the link between KM practices and their impact on NPP organizational performance. In general, the issue has not been extensively researched and is not well understood. Little or no prior empirical research has been done on this topic in the specific context of NPP operations. The report also summarizes the findings from the research on the importance of a supportive organizational culture, how it is influenced by KM practices, and how it impacts organizational knowledge processes and performance. Finally, the report summarizes the research findings on what specific knowledge management practices have proven effective in NPPs and what benefits have been achieved in terms of organizational effectiveness.

1.3. SCOPE

This report summarizes the results of empirical research that directly investigated the relationship between KM practices in NPPs, their impact on the quality of organizational knowledge processes, and the resulting effects on NPP organizational effectiveness. It presents the basic findings of the IAEA Global KM Survey of NPPs conducted in 2010.

1.4. STRUCTURE

Section 2 is a brief introduction to the knowledge management context and provides some theoretical perspective. Section 3 discusses some of the unique characteristics of the nuclear industry that present additional challenges to knowledge management with respect to nuclear power plants. Section 4 discusses nuclear power plant organizations from a knowledge management perspective and provides additional context for the research. Section 5 describes the research approach taken including the research questions, research model, and key constructs used. Section 6 describes the survey distribution method and response. Section 7 provides descriptive statistics. Section 8 summarizes the results of the statistical data analysis. Section 9 summarizes the study limitations. Section 10 provides the conclusions of the report. In addition, the Appendices I–VII provide (respectively) the survey instrument, a list of participating NPPs, descriptive data for each of the construct variables, bivariate scatterplots for constructs, descriptive data for each indicator measure in the study, demographic data, and the detailed results of the multiple regression analysis. Appendix VIII summarises several recommended revisions to improve the survey instrument for use in future.

1.5. TARGET AUDIENCE

This report was prepared primarily for NPP managers and other KM practitioners and stakeholders in nuclear operating facilities. It may also be useful to other nuclear facility owners and operators, nuclear design and support organizations, nuclear R&D organizations, nuclear regulators, academia, and government policy makers.

2. KNOWLEDGE MANAGEMENT CONTEXT

Knowledge exists in different forms and at different levels in an organization. Tacit knowledge is experiential knowledge or 'know how' in the minds of individuals that typically cannot easily be easily expressed, captured or transferred. An example of tacit knowledge would be the know-how of an experienced maintenance engineer that allows him/her to arrive at a rapid and accurate diagnosis of problems with complex plant equipment such as a turbine. Explicit knowledge is knowledge that has been recorded or codified in some form such as manuals, procedures, databases, or electronic media.

It is important to recognize knowledge in organizations exists at an individual level, at a group level, at a department level, and at an organizational level. Further, the level of abstraction and form of knowledge may range from detailed facts, to organized information, to interpretations and analysis, to conceptualizations, to theoretical models, or even wisdom. Knowledge can be considered a resource (i.e. an input), it may be embedded in work methods (i.e. part of a process) or it can be a product (i.e. an output). Knowledge may often be time dependent or contextual, and must be maintained and renewed.

In the literature, authors such as N.T. Pham and F.W. Swierczek [1] describe the mechanisms by which knowledge is accumulated, disseminated and stored in organizations and many refer to these as knowledge processes. There are many different definitions of knowledge processes used in the literature. This research classified the more widely used and accepted definitions into one of five primary knowledge processes, shown below in Figure 1. The primary knowledge processes are defined as [2]:

(1) Knowledge acquisition and adoption;
(2) Knowledge generation and validation;
(3) Knowledge sharing and transfer;
(4) Knowledge retention and storage; and
(5) Knowledge utilization and application.

Knowledge processes can be viewed as the means by which organizations build, maintain and apply the tacit and explicit knowledge in all its various forms.

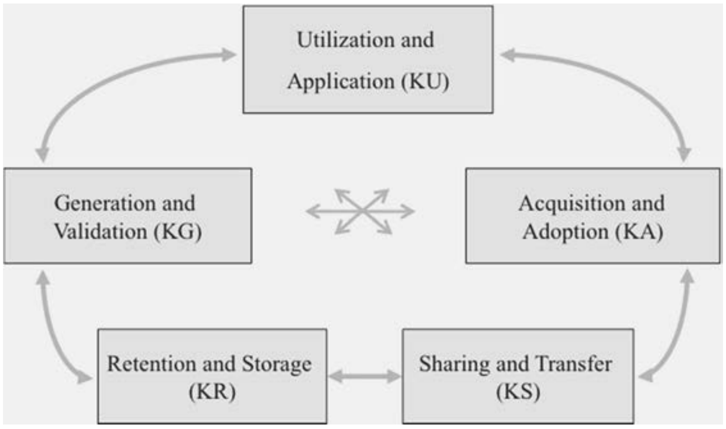


FIG. 1. The primary knowledge processes (see Ref. [2]).

Knowledge management has been described by leading authors such as G.F. Hedlund [3] and D. Andriessen [4] as those practices (i.e. activities, initiatives or actions initiated or supported by management) that can influence and improve organizational knowledge processes. The goals of KM cited in the literature by authors like A. Jantunen [5], D. Carluccii and G. Schiuma [6], and J. Darroch [7] are to improve organizational learning, to build and maintain an effective organizational knowledge base, and to enable effective knowledge utilization. All of these goals are argued to help achieve organizational objectives. Authors like Y. Malhotra [8], J.M. Firestone and M.W. McElroy [9], S.G. Chang and J.H. Ahn [10], and G.F. Hedlund (see Ref. [3]) all contend that organizations having quality knowledge processes (i.e. they are aligned with business needs and priorities, and are efficient and effective) will be higher performing organizations.

3. KNOWLEDGE MANAGEMENT CHALLENGES IN AN NPP

NPPs operate in a highly regulated environment with stringent requirements. Effective management systems must be in place to ensure compliance with a number of regulatory and operating licence requirements including, for example: nuclear safety, environmental controls, equipment reliability and qualification, nuclear quality assurance, nuclear security, nuclear waste management and safeguards, radiation protection and monitoring, operating experience feedback and corrective action programmes, work management and control, outage planning and management, and design basis configuration management. All of these are knowledge intensive processes that involve knowledge management considerations.

Knowledge management in the NPP context presents many challenges and issues and these stem from many factors such as:

— A complex technology base and infrastructure;
— Lengthy technology and plant life-cycles;
— Highly capital-intensive plant assets;
— A reliance on multi-disciplinary technologies and expertise;
— Competing operational objectives (i.e. safety, economics, and production);
— Potentially high hazards that must be systematically managed to demonstrably low tolerable risks; and
— An organization that is a complex socio-technical system.

There is an on-going need in NPPs for coordination and alignment of often inter-dependent knowledge processes. There is also a frequent need for risk-informed technical decision making, both from a design basis management perspective and from an operations and maintenance perspective. Nuclear plant organizations are heavily knowledge-dependent and their operational needs demand a high level of expertise and knowledge-based infrastructure. Knowledge is embedded in humans, the underlying plant technology, and work processes and methodologies. The terms ‘knowledge-worker’ and ‘knowledge organization’ are all the more relevant to the multi-disciplinary environment of NPP organizations. For these reasons, NPP managers are interested in understanding and influencing the factors that affect not only the building and retention of the corporate knowledge base, but its effective utilization. The KM issues and priorities will vary in each NPP organization and this will depend on both internal organizational factors, and factors such as the national industry and infrastructure issues.

Many NPPs have started to manage knowledge and knowledge processes on a corporate-wide level as part of an integrated strategic KM programme. There are many reasons for this trend. For example, as existing plants have aged, there have been many hard lessons learned about the need for accurate maintenance of plant design basis information to ensure the continued safe and economic operation of each NPP (i.e. this information must be kept up to date, accurate and correct). Another reason is that many NPPs are under pressure to achieve improvements in economics, and this is driven by factors such as ownership consolidation and fleet management, deregulation and competition, rising operating costs, and opportunities arising from new technology. As a result, some plants are reducing staff by outsourcing more maintenance and design services, and this creates additional risks and dependencies on outside firms to maintain essential knowledge.

There are also several reasons why KM issues may become a priority in nuclear organizations. For example, in some Member States, the nuclear industry is a maturing industry and NPPs are experiencing high attrition rates due to retirements. This has highlighted their vulnerability to the loss of experts and their highly specialized and (difficult to replace) knowledge. In other Member States, there are aggressive plans underway for new builds and critical skills shortages have become a problem. Some Member States are experiencing both problems simultaneously, and further, need to staff upcoming refurbishment or decommissioning projects. Finally, there is concern in the industry over the ‘pipeline’ of adequately skilled new graduates due to the lack of university level nuclear engineering and science programmes. It takes typically months of formal in-house training and many more years of on-the-job training to build up the competencies and experience needed for many specialized NPP staff roles. Any of these factors may contribute to a shortage of critical technical competencies in nuclear organizations and may have a direct impact on safety, production, and economics. Pro-active measures aimed at knowledge building, retention and transfer have been needed.

4. KNOWLEDGE MANAGEMENT VIEW OF AN NPP ORGANIZATION

Basic management theory suggests that organizations, in order to be effective, must fulfil the goals of core business processes (i.e. work processes, procedures and methods), using plant and equipment (i.e. base technology), people (i.e. human competencies), and information technology infrastructure (i.e. supporting technology). All of these factors, it is generally recognized, need to be aligned to organizational objectives (and in NPPs, that means the safe and reliable production of electricity) to achieve organizational performance. Organizational theory further predicts that organizational performance will be enhanced by a supportive culture that promotes organizational learning. Figure 2 illustrates these relationships and they are assumed to apply in the context of any NPP organization.

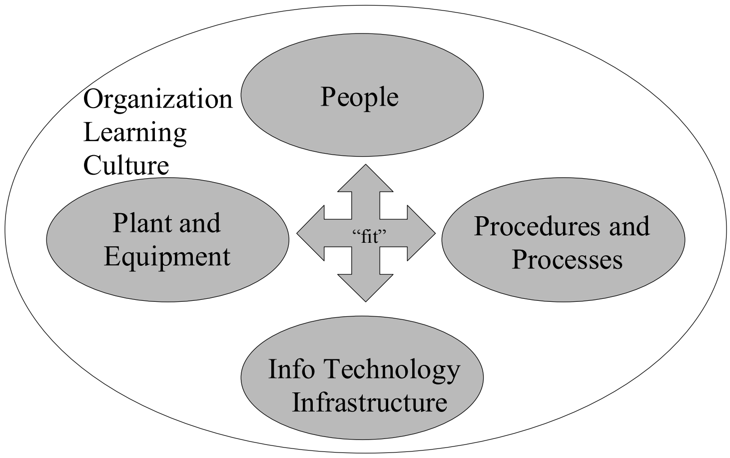


FIG. 2. Aligning to organizational objectives (see Ref. [2]).

From the literature, it is predicted that KM may play a significant role in achieving this alignment and in improving organizational performance. However, there is little consensus in the literature as to just how and why this may occur. This research hypothesizes that KM practices, by creating and enabling quality knowledge processes, help achieve and support this synergistic alignment, thus enabling and enhancing organizational effectiveness and ultimately performance. It is argued that quality knowledge processes promote the building and maintenance of a more integrated and shared organizational knowledge base, enhance organizational learning, and result in better knowledge-based decisions and action. The literature (e.g. [11]) suggests that a supportive organizational culture will also play an important role in these relationships, in that it promotes excellence in actions and decisions by motivating employees to be pro-active and to strive for continuous improvement. The net effect is hypothesized to be greater organizational effectiveness that will in turn improve overall operations, maintenance and administration (OM&A) of the organization. Figure 3 illustrates these relationships.

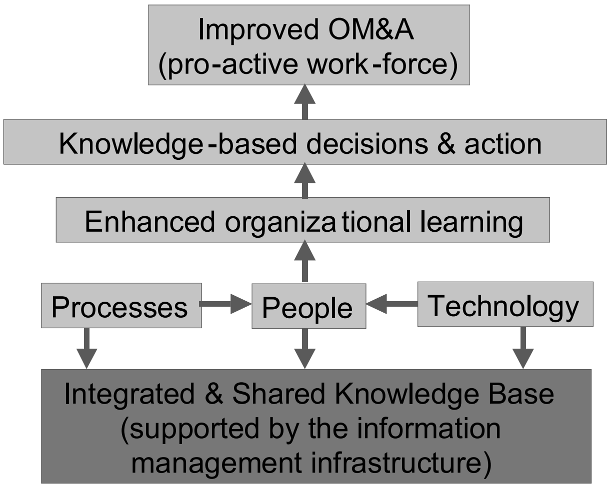


FIG. 3. KM links to improved operations, maintenance and administration (see Ref. [2]).

Many NPP organizations have invested heavily in information technology infrastructure as a way to improve efficiency and achieve cost reduction. In most operating NPPs, the information technology infrastructure is quite complex. There are typically a large number of systems. Figure 4 illustrates some of the more typical information systems and technology (IST) and operational support system (OSS) found in NPPs. The figure helps to convey the concept of an integrated and shared organizational knowledge-base (K-base) supported by these systems. Examples of these systems include computer aided design (CAD) models and drawings, operations and maintenance (O&M) history databases, outage planning systems, equipment reliability systems, and others.

Basic information systems theory predicts that collectively, these systems (if properly implemented) should support work and effective decision processes. This in turn, it is argued, should enable the tacit knowledge of plant staff to be leveraged and fully utilized in the day-to-day operation of the facility. The predicted end result being the more effective implementation of organizational policy, practices, and procedures, to achieve the objectives of the organization's OM&A strategies (see Fig. 4). Information systems technology support then, it is argued, when viewed from a KM perspective, is essentially another, though perhaps quite distinct, way to enhance the quality of knowledge processes.

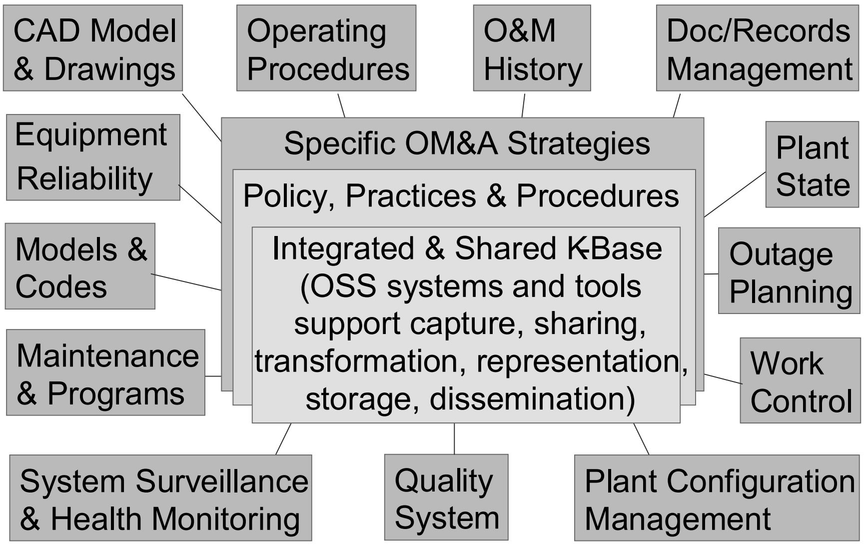


FIG. 4. Typical information systems & technology infrastructure in NPPs [12].

In summary, it is hypothesized that effective KM practices will have a direct impact on the quality of knowledge processes, and these in turn should improve overall NPP organizational effectiveness. The information technology infrastructure of the organization is also expected to play an important role by enabling and supporting these quality knowledge processes. Finally it is expected that the extent of KM practices and the effectiveness of the IT infrastructure will both have a positive impact on the level of supportive organizational culture, and all these factors will have a positive effect on the quality of knowledge processes. Finally, it is believed that quality knowledge processes and a supportive organizational culture will directly and positively impact organizational effectiveness.

5. RESEARCH QUESTIONS AND APPROACH

The preceding discussion provides some useful insights into the hypothesized role and influence of knowledge management practices, knowledge processes, and the knowledge base in NPP organizations, and specifically with respect to work-processes and organizational learning. However, although there is an abundance of literature that conceptually supports knowledge management practices as important and beneficial, very little empirical research has been done to back up these claims. It is difficult for managers to know what KM practices are being applied in NPPs today, whether or not they are beneficial, and to what extent. Many factors in an organization will impact performance, and KM practices may be just one of them. Basic questions such as whether NPP organizations that implement KM practices realize any real measurable performance benefits remain unanswered. To address these questions, an empirical survey of the total global population of NPPs was conducted to explore and investigate these issues further in detail. The main research questions which drove the design of the survey were (see Ref. [2]):

— To what extent do NPPs have specific knowledge management practices supported and in use by managers?
— To what extent do NPPs have a supportive organizational culture?
— To what extent do NPPs have quality knowledge processes?
— To what extent do NPP organizations consider themselves effective?

— To what extent does support for knowledge management practices impact on and help create a supportive organization culture?
— To what extent does support for knowledge management practices impact the quality of knowledge processes?
— To what extent does the level of technology support (i.e. in terms of the effectiveness of information systems and information technologies) impact the quality of knowledge processes?
— To what extent does the quality of knowledge processes impact organizational effectiveness?
— To what extent does the degree of supportive organizational culture impact the quality of knowledge processes?
— To what extent does the degree of supportive organizational culture impact the organizational effectiveness?
— To what extent does the quality of knowledge processes impact organizational effectiveness?

The answers to these questions are of interest to NPP owners and operators. Little if any management research has been done on nuclear plant organizations in general, and none on this specific issue, perhaps due to their being less accessible to researchers. Figure 5 illustrates the basic elements of the conceptual model used in the research (adapted from Ref. [2]).

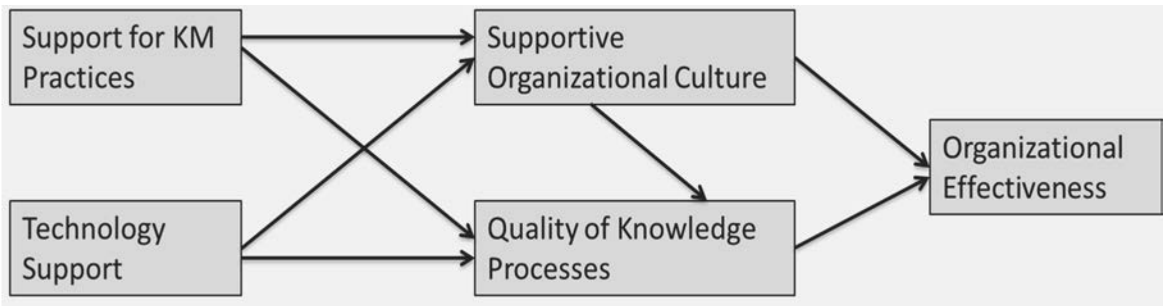


FIG. 5. The 'KM Performance Model' relationships (adapted from Ref. [2]).

The elements of the research model include five main factors (i.e. theoretical construct variables):
— *Support for knowledge management practices* (i.e. degree to which management is supporting those practices that are known to influence employee behaviour and action to positively affect knowledge processes), (independent variable);
— *Level of organizational technology support,* (independent variable);
— *The quality of knowledge processes* (i.e. the extent to which knowledge processes effectively meet the requirements of the organization's business processes), (an intermediate variable);
— *The degree of supportive organizational culture* (an intermediate variable); and
— *Organizational effectiveness* (i.e. the degree to which the organizational goals, including production and safety, are achieved), (dependent variable).

As with any social sciences, organizational studies research requires careful consideration and design of a meaningful measurement model. This should be based on prior theory and established measures where possible. Three of the main constructs in the research model were defined with well-defined sub-constructs. Measures were developed (in the form of survey questions) for each of the constructs (and sub-constructs) and included in the NPP survey. The basis for each of the construct measures is summarized below, and this includes the sub-constructs identified.

The first construct, '*support for KM practices'*, measures the extent of perceived organizational support for KM, where KM is assumed to be the collective set of actions/practices implemented by management to influence the quality of knowledge processes and represents the upper part of the left-hand side of the research model. The IAEA KM Guidelines [13, 14] provide a useful categorization of KM practices that have been adapted for use in the survey:

— KM strategy and planning — the extent to which corporate wide KM policy and strategy has been established and the planning to implement it has been put in place;
— Support for organizational learning — the extent to which management provides sufficient resources and enables various mechanisms for individual, group, or institutional level learning;
— Process management practices — the extent to which management establishes and maintains effective knowledge-based business processes (e.g. process-oriented KM practices);
— Information management practices — the extent to which effective information management practices have been implemented (i.e. that support knowledge processes);
— Organizational performance management practices — the extent to which knowledge-based performance management practices have been put in place;
— Training related practices — the extent to which best practices for training have been put in place and address KM related issues of training;
— Human resource (HR) related practices — the extent to which HR related KM practices such as competency development and knowledge retention have been put in place.

The second construct, '*technology support'* measures the level of organizational support for the effective use of information systems and technology, including advanced operational (decision) support systems. It is comprised of two sub-constructs: one measuring conventional application of information systems and technology (IST) (i.e. the effectiveness of the enterprise IS and IT); and the other measuring support for advanced operational support systems (OSS) (i.e., measures how effectively advanced NPP-specific decision support systems are utilized). Together, these sub-constructs represent the information management infrastructure supporting the organization's integrated and shared knowledge base as shown in Figures 3 and 4.

Operational support systems might include, for example: advanced decision support systems such as refuelling software; probabilistic 'production risk' models for equipment reliability (used for maintenance and outage planning); real-time probabilistic 'safety risk' models for operator evaluation and awareness of plant safety (i.e. 'safety monitors'); system health monitors (e.g. predictive maintenance tools such as vibration, acoustic, thermal, or other monitors); advanced model-based monitoring and diagnostics (e.g. physics, chemistry, boiler, feed water and thermal hydraulics models); advanced information exchange (e.g. hand-held computers, plant-wide equipment status monitoring, wireless communications); electronic (i.e. graphical) road-maps of business and decision processes or work-flows (e.g. operational flow-sheets with links to supporting procedures or related resource documents); and automated field data collection (i.e. smart instruments, field-bus, radio frequency identification (RFID) tagging, data logging, equipment monitors).

The third construct, quality of knowledge processes, is based on five key knowledge processes. Several authors agree that the accumulation and use of knowledge and core competencies in organizations are enabled by effective knowledge processes (e.g. S.I. Tannembaum and G.V. Alliger [15]; P.N. Rastogi [16]; and G. Probst [17]). Authors use different terms and definitions to describe knowledge processes; however, they can be summarized as five basic knowledge processes that are found frequently in the literature, and for the purposes of this research were defined as follows (see Ref [2]):

- *Quality of knowledge acquisition and adoption processes (KA)* — the process of obtaining and adopting new external knowledge (whether tacit or explicit) into the organization. This is interpreted to include knowledge identification and selection processes for the purpose of acquisition;
- *Quality of knowledge sharing and transfer processes (KS)* — the exchange of knowledge within the organization (directly or indirectly) and including processes of knowledge conveyance and distribution;
- *Quality of knowledge generation and validation processes (KG)* — the creation of new knowledge, typically by incremental knowledge development, and its validation within the organization. It may also include knowledge identification and selection processes associated with internal knowledge generation processes;
- *Quality of knowledge retention and storage processes (KR)* — the process of keeping knowledge (whether tacit or explicit) within the organization and maintaining its availability and relevance for future use. It incorporates the related concepts of knowledge capture, preservation, storage, retrieval, accessibility, identification and protection in the context of internal organizational knowledge retention;
- *Quality of knowledge utilization and application processes (KU)* — the concept of internal organizational knowledge use (whether tacit or explicit) and including the process of adapting or interpreting it in a problem context.

Much of the literature on organizational culture, safety culture, and knowledge sharing culture describes similar factors of trust, leadership, rewards, shared vision and goals, personal responsibility, support for learning, a questioning attitude, and communication (see Ref [2]). In the context of KM, an organizational culture that promotes effective knowledge processes and thus supports and enables organizational learning is seen as playing an important role in organizational effectiveness and overall performance. The research model posits that from a knowledge management practice and knowledge process perspective, a 'supportive organizational culture' (SOC) enhances the effect of KM practices on the quality of knowledge processes in an organization. It is also expected to enhance the subsequent effect that the quality of knowledge processes will have on organizational effectiveness and performance. Thus Figure 5 includes the construct 'supportive organizational culture' as part of the model to indicate its important influence. Measures for SOC were adapted from prior research on organizational culture (there are many established measures in the literature) and included existing measures of safety culture as an important component of organizational culture in an NPP context.

Finally, there is a significant body of literature on the topic of organizational effectiveness, the construct on the right hand side of the model, and the dependent variable. The study focused specifically on relevant measures from the nuclear industry related to NPPs, and adapted them as appropriate. Measures for the construct 'organizational effectiveness' were based on three general areas: well-accepted top level management objectives for NPPs; prior research on the fundamentals of NPP operational excellence (including operations, engineering, maintenance, radiological protection, chemistry, and training); and high-level organizational effectiveness measures that focus specifically on NPP operational effectiveness. The exact measures used in the survey can be found in Appendix I. Additional explanation of the research methodology can be found in Ref. [2].

6. SURVEY DISTRIBUTION AND RESPONSE

The NPP KM survey was distributed and responses collected between April and September 2010. E-mail invitations were sent to NPP site interface officers asking their station senior operations manager(s) to participate by completing the survey with input as required from members of the plant management team. Surveys were downloadable from the IAEA web-site in four languages: English, Chinese, Russian, and French. In cases where contacts with senior NPP operations managers were established, direct invitations to participate were e-mailed to the identified individuals.

A total of 118 individual survey responses were received. Three of these could not be used, therefore 115 completed responses were considered. The respondents identified in many cases that the response represented multiple reactor units. In a few cases the response was a 'fleet' response reporting on multiple stations, all of which were claimed to have similar 'standardized' management practices. This resulted in a total of 124 station 'site organizations' (i.e. slightly higher than the total number of survey responses) being represented out of a total of 204 organizations in the total global population, or 60.8%.

NPP stations range from single unit to eight unit stations. On average there are two units per station. In a few cases, there were multiple stations at a single site. When considering the total number of units at each participating site, the responses represented a total of 253 reactor units or 57.9% of all 437 operating reactors. A total of 50 different operating organizations were represented in the response. The following sections provide a summary and analysis of the survey findings (for additional detail, see Ref. [2]). Survey response data was treated as confidential and only aggregate findings are reported.

7. DESCRIPTIVE STATISTICS

This section summarizes basic descriptive data to characterize the total population of NPPs, followed by a summary of the basic demographics of survey response data. Table 1 summarizes the number of plants by reactor type in each country for the entire global population of NPPs at the time of the survey. The various plant reactor types include:

— AGR — advanced gas reactor;
— BWR — boiling water reactor;
— FBR — fast breeder reactor;
— GCR — gas cooled reactor;
— LWCGR — light water cooled gas reactor;
— PHWR — pressurized heavy water reactor;
— PWR — pressurized water reactor;

TABLE 1. SUMMARY OF ALL NPPs BY COUNTRY AND REACTOR TYPE (see Ref. [2])

Country	Reactor type							
	AGR	BWR	FBR	GCR	LWCGR	PHWR	PWR	Total
Armenia	0	0	0	0	0	0	1	1
Belgium	0	0	0	0	0	0	7	7
Brazil	0	0	0	0	0	0	2	2
Bulgaria	0	0	0	0	0	0	2	2
Canada	0	0	0	0	0	18	0	18
China	0	0	0	0	0	2	9	11
Czech Republic	0	2	0	0	0	0	6	8
Finland	0	2	0	0	0	0	2	4
France	0	0	0	0	0	0	58	58
Germany	0	6	0	0	0	0	11	17
Hungary	0	0	0	0	0	0	4	4
India	0	2	0	0	0	16	0	18
Japan	0	30	0	0	0	0	24	54
South Korea	0	0	0	0	0	4	16	20
Lithuania	0	0	0	0	1	0	0	1
Netherlands	0	0	0	0	0	0	1	1
Romania	0	0	0	0	0	3	1	4
Russian Federation	0	0	1	0	15	0	15	31
Slovakia	0	0	0	0	0	0	4	4
Slovenia	0	0	0	0	0	0	1	1
South Africa	0	0	0	0	0	0	2	2
Spain	0	2	0	0	0	0	6	8
Sweden	0	7	0	0	0	2	3	12
Switzerland	0	2	0	0	0	0	3	5
Taiwan, China	0	4	0	0	0	0	2	6
United Kingdom	14	0	0	4	0	0	1	19
Ukraine	0	0	0	0	0	0	15	15
USA	0	35	0	0	0	0	69	104
Total	14	92	1	4	16	45	265	437

Table 2 summarizes the response data by country with respect to the total NPP population and the NPPs included in the set of responding stations.

TABLE 2. RESPONDING NPPs BY PERCENT OF POPULATION AND COUNTRY (see Ref. [2])

Country	Total NPP population		NPPs in sample response			
	Frequency	Percent	Frequency	Percent of total NPPs in survey response	Percent country NPP population	Percent of global NPP population
Armenia	1	0.2	0	0	0	0
Belgium	7	1.6	7	2.8	39.5	1.6
Brazil	2	0.5	2	0.8	39.5	0.5
Bulgaria	2	0.5	2	0.8	39.5	0.5
Canada	18	4.1	17	6.7	37.3	3.9
China	11	2.5	9	3.6	32.3	2.1
Czech Republic	8	1.8	2	0.8	9.9	0.5
Finland	4	0.9	4	1.6	39.5	0.9
France	58	13.3	18	7.1	12.3	4.1
Germany	17	3.9	10	4.0	23.3	2.3
Hungary	4	0.9	4	1.6	39.5	0.9
India	18	4.1	2	0.8	4.4	0.5
Japan	54	12.4	20	7.9	14.6	4.6
South Korea	20	4.6	18	7.1	35.6	4.1
Lithuania	1	0.2	1	0.4	39.5	0.2
Netherlands	1	0.2	1	0.4	39.5	0.2
Romania	4	0.9	2	0.8	19.8	0.5
Russian Federation	31	7.1	3	1.2	3.8	0.7
Slovakia	4	0.9	4	1.6	39.5	0.9
Slovenia	1	0.2	1	0.4	39.5	0.2
South Africa	2	0.5	2	0.8	39.5	0.5
Spain	8	1.8	7	2.8	34.6	1.6
Sweden	12	2.7	7	2.8	23.1	1.6
Switzerland	5	1.1	5	2.0	39.5	1.1
Taiwan, China	6	1.4	6	2.4	39.5	1.4
United Kingdom	19	4.3	19	7.5	39.5	4.3
Ukraine	15	3.4	9	3.6	23.7	2.1
USA	104	23.8	71	28.1	27.0	16.2
Total	437	100	253	100	n/a	57.9

USA had a high count of NPPs represented[1]. Figure 6 shows NPP units by output (in MWe).

[1] To check for non-response bias, an independent samples t-test comparison of respondents versus non-respondents was done to see if there was any difference in NPP operational performance using 3-year unit Capacity Factor (CF) (see Ref [2]). There was a significant (i.e. to $P < 0.005$ level) difference in means between the two groups with responding units having a 3.79% higher mean 3-year Unit Capacity Factor (UCF). The number of US responses in the study may have contributed to this difference. Although not large in magnitude, this difference does indicate a bias in the response towards higher performing plants.

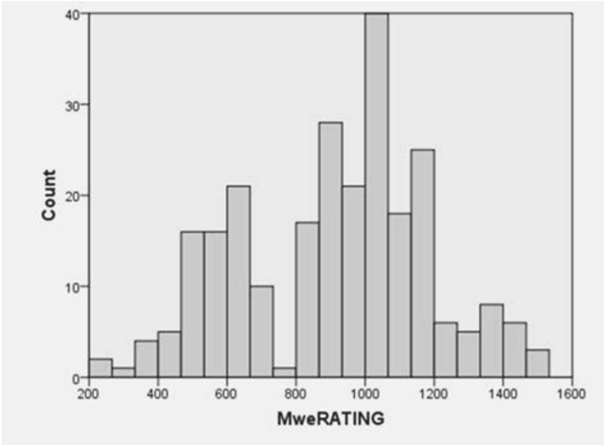


FIG. 6. Breakdown of responding NPPs by plant output rating (see Ref. [2]).

Table 3 summarizes the responses by country and reactor type for stations responding.

TABLE 3. RESPONDING NPPs BY COUNTRY AND REACTOR TYPE (see Ref. [2])

Country	Count by reactor type						
	AGR	BWR	GCR	LWCGR	PHWR	PWR	Total
Belgium	0	0	0	0	0	7	7
Brazil	0	0	0	0	0	2	2
Bulgaria	0	0	0	0	0	2	2
Canada	0	0	0	0	17	0	17
China	0	0	0	0	2	7	9
Czech Republic	0	0	0	0	0	2	2
Finland	0	2	0	0	0	2	4
France	0	0	0	0	0	18	18
Germany	0	4	0	0	0	6	10
Hungary	0	0	0	0	0	4	4
India	0	0	0	0	2	0	2
Japan	0	13	0	0	0	7	20
South Korea	0	0	0	0	4	14	18
Lithuania	0	0	0	1	0	0	1
Netherlands	0	0	0	0	0	1	1
Romania	0	0	0	0	2	0	2
Russian Federation	0	0	0	0	0	3	3
Slovakia	0	0	0	0	0	4	4
Slovenia	0	0	0	0	0	1	1
South Africa	0	0	0	0	0	2	2
Spain	0	1	0	0	0	6	7
Sweden	0	4	0	0	0	3	7
Switzerland	0	2	0	0	0	3	5
Taiwan, China	0	4	0	0	0	2	6
United Kingdom	14	0	4	0	0	1	19
Ukraine	0	0	0	0	0	9	9
USA	0	26	0	0	0	45	71
Total	14	56	4	1	27	151	253

Figure 7 shows the number of units by each responding operator within the sample (with operator identification numbers being assigned alphabetically).

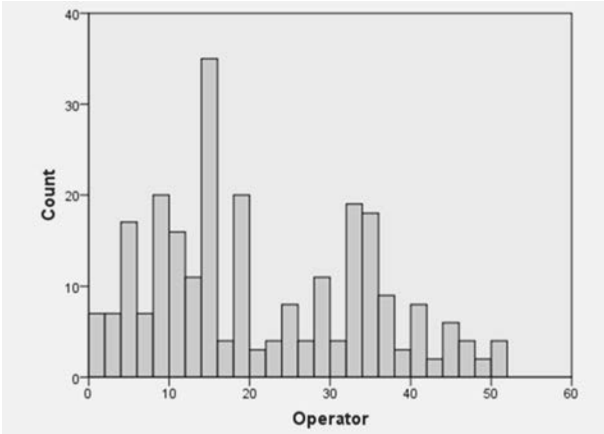


FIG. 7. Number of responding NPPs by operator (see Ref. [2]).

For readers that are interested in more detailed descriptive statistics of the response data, please refer to Appendices III–V. Detailed descriptive data (figures and tables) are provided that can be used as benchmark data. The data specifically answers the following basic research questions:

— To what extent are KM practices supported and in use by managers in operating NPPs?
— To what extent do NPP organizations have a supportive organizational culture?
— To what extent do NPP organizations have quality knowledge processes?
— To what extent do NPP organizations consider themselves to be effective?

Appendix III provides descriptive data and histograms for each of the construct variables in the study. Appendix IV provides individual bivariate scatterplots between each the construct and sub-construct variables (all possible combinations) in the study. A simple bivariate scatterplot allows the visualization of the relationship (or lack thereof) between the various constructs and sub-constructs in the research model. Appendix V summarizes descriptive data for individual indicator measures used for each construct or sub-construct in the study, in the form of histograms. Appendix VI provides additional descriptive data from Section G (Demographic Data) of the survey (see Appendix I).

Appropriate procedures for data entry and preparation, data quality and screening (including removal of outliers), handling of missing data, missing value analysis, and reliability screening of measures (construct reliability analysis) were followed and are described in Ref. [2]. The study was based on the use of constructs and sub-constructs, each comprised of several Likert-scale measures. Construct values for each respondent were calculated based on simple averaging of the construct's measures. Construct reliability analysis was performed to ensure the integrity of each construct. The measures considered unreliable were removed from the data set and statistical analysis (see Appendix VII). Improvements to these measures are planned for future versions of the survey and these are summarized in Appendix VIII.

8. SUMMARY OF REGRESSIONS AND FINDINGS

This chapter summarizes the results of the statistical analysis that was done to address the following basic research questions:

— To what extent do knowledge management practices impact on and help create a supportive organization culture?

- To what extent do knowledge management practices impact the quality of knowledge processes?
- To what extent does the level of technology support (i.e. in terms of effective information systems technologies or operational support systems) impact the quality of knowledge processes?
- To what extent does a supportive organizational culture impact on quality of knowledge processes?
- To what extent does a supportive organizational culture impact on organizational effectiveness?
- To what extent does the quality of knowledge processes impact on organizational effectiveness?

One of the challenges of this type of organizational study is that both theory and prior research predict that all of our variables (the constructs and sub-constructs), though independent, will have some degree of covariance. Of interest is the relative effect size and the amount of variance explained by these relationships when they are considered together in each many-to-one relationship (i.e. to determine which sub-construct covariates are explaining the variance of the dependent variable in each case). Thus in order to discriminate, we ideally need a method to examine their effects simultaneously.

As an initial investigation of these relationships, a statistical analysis based on a series of independent multiple regressions was performed. A summary of the findings is provided in this section. Detailed results of each of the regressions are summarized in Appendix VII. For readers interested in a more advanced analysis, please see Ref. [2] for a full description of a statistical analysis using Path Analysis methodology. In terms of the significant relationships identified, the results of the two analyses are quite similar, with two exceptions: the first being the link between organizational performance management (OPM) related KM practices and the quality of knowledge generation and validation processes (KG); the second being the link between supportive organizational culture (SOC) and the quality of knowledge sharing and transfer (KS). Both these relationships were not found to be significant in the path analysis (see Ref. [2]). The differences may be due to simultaneous effects, indirect effects, the possible effects of collinearity, or possible limitations in the measures used. Only the results of the multiple regressions are reported here for simplicity.

Multiple regressions can help to explore and understand the nature and strength of the dominant relationships between the various constructs. This section summarises the results of a systematic piece-wise multiple regression analysis to examine what significant associations exist between the constructs and sub-constructs. It is important to recognize that this approach is limited in that it does not account for simultaneous or indirect interactions among all the factors in a full model analysis. However, as there is no prior empirical research to draw upon, it does provide a useful method to identify the more important relationships and forms a basis for further analysis or research. Note that when a variable is eliminated from a multiple regression model, it does not necessarily mean it has no effect whatsoever, rather, it should be interpreted that the variable is not explaining much of the variance of the dependent variable in the presence of the other independent variables in the model.

A backward elimination multiple regression procedure was used to explore all possible direct main-effect relationships between constructs (i.e. specific knowledge management practices, organizational technology support, quality of knowledge processes, supportive organizational culture, and organizational effectiveness). This was done to the sub-construct level. Significance levels of 0.05 were used as a cut-off. Significance results of interest are discussed in the interpretations. Appendix VII provides the results of each detailed regression model.

In a backwards elimination regression procedure, all the independent variables included in the model are regressed on the dependent variable. If any variables are not statistically significant, the one making the smallest contribution is dropped. Then the remaining variables are regressed on the dependent variable, and again if any variables are not statistically significant, the one making the smallest contribution is dropped. The procedure continues until all remaining variables are statistically significant.

Recall that in multiple regression, the objective is to determine whether the coefficients (slopes) of the independent variables are different from zero (i.e. if they are having a real effect on the dependent variable), or if different from zero, they are not just due to random chance. The null hypothesis is that each independent variable has no effect (i.e. $B = 0$) and evidence is needed to reject this hypothesis. The criteria, is that the *P-value*, the probability that the observed result occurred randomly, is lower than the predetermined cut-off (i.e. the significance level). See Appendix VII for further explanations.

In multiple regression, the size of the coefficient (i.e. *B)* for each independent variable is the size of the effect that variable has on the dependent variable, and the sign on the coefficient (positive or negative) is the direction of the effect. The coefficient (i.e. *B)* tells you how much a given dependent variable is expected to increase when the corresponding independent variable increases by one unit, holding all the other independent variables constant. The findings are summarized below. All findings reported were statistically significant results at the $P < 0.05$ level or better.

The first finding from the piece-wise regressions is that specific knowledge management practices and technology support sub-constructs positively impacted specific knowledge processes. The following sets of relationships (see Sections VII.2–VII.6) were found to be significant:

— Organizational performance management related KM practices (OPM, $B = 0.415$), human resource related KM practices (HRP, $B = 0.29$), and advanced operational support systems (OSS, $B = 0.207$) have a positive direct influence on the quality of knowledge acquisition and adoption processes (KA);

— Human resource related KM practices (HRP, $B = 0.295$), information management related KM practices (IMP, $B = 0.418$), and support for organizational learning related KM practices (SOL, $B = 0.404$) all have a positive and direct impact on the quality of knowledge sharing and transfer processes (KS);

— Human resource related KM practices (HRP, $B = 0.355$) and training related KM practices (TRP, $B = 0.409$) have a positive and direct impact on the quality of knowledge retention and storage processes (KR);

— Operational performance management related KM practices (OPM, $B = 0.571$) and knowledge management strategy and planning related practices (KMS, $B = 0.255$) all have a positive and direct impact on quality of knowledge generation and validation processes (KG); and

— Information management related KM practices (IMP, $B = 0.419$), human resource related KM practices (HRP, $B = 0.235$), and information systems and technology support (IST, $B = 0.224$) all have a positive and direct impact on the quality of knowledge utilization and application processes (KU).

The second finding from the piece-wise regressions is that specific knowledge management practices and technology support sub-constructs positively impacted the construct supportive organizational culture (SOC). The following sets of relationships (see Section VII.7) were found to be significant:

— Information management related KM practices (IMP, $B = 0.168$), human resource related KM practices (HRP, $B = 0.156$), effective use of information systems and technology (IST, B = 0.097), support for organizational learning related KM practices (SOL, B = 0.405), and support for KM strategy and planning (KMS, B = 0.169) all have a positive and direct impact on the supportive organizational culture (SOC).

Although training related practices and operational support systems were expected to play a role, this was not supported by the data.

The third finding from the piece-wise regressions is that a supportive organizational culture has a strong, direct, and significant effect on all of the quality of knowledge processes. The following specific relationships (see Section VII.8) were significant:

- Supportive organizational culture (SOC, B = 0.628) had a positive and direct impact on the quality of knowledge acquisition and adoption processes (KA);
- Supportive organizational culture (SOC, B = 0.572) had a positive and direct impact on the quality of knowledge generation and validation processes (KG);
- Supportive organizational culture (SOC, B = 0.753) had a positive and direct impact on the quality of knowledge sharing and transfer processes (KS);
- Supportive organizational culture (SOC, B = 0.538) had a positive and direct impact on the quality of knowledge utilization and application processes (KU); and
- Supportive organizational culture (SOC, B = 0.616) had a positive and direct impact on the quality of knowledge retention and storage processes (KR).

The fourth finding from the piece-wise regressions (see Section VII.9) is that:

- Supportive organizational culture (SOC, B = 0.60) has a strong, direct, and significant effect on organizational effectiveness (OE).

The fifth finding from the piece-wise regressions is that there are several important inter-relationships among the quality of knowledge processes. Using piece-wise regression, each of the quality of knowledge processes was regressed against the other remaining four quality of knowledge process constructs. As discussed earlier, the causal direction of these relationships has not been determined or assumed. The following specific relationships (see Sections VII.10.1–VII.10.5) were found to be significant:

- The quality of knowledge generation and validation processes (KG, B = 0.672) and the quality of knowledge sharing and transfer processes (KS, B = 0.239) had a positive and direct impact on quality knowledge acquisition and adoption processes (KA);
- The quality of knowledge generation and validation processes (KG, B = 0.312), the quality of knowledge retention and storage processes (KR, B = 0.502) and the quality of knowledge acquisition and adoption processes (KA, B = 0.262), had a positive and direct impact on the quality of knowledge sharing and transfer processes (KS);
- The quality of knowledge utilization and application processes (KU, B = 0.316) and the quality of knowledge sharing and transfer processes (KS, B = 0.452) had a positive and direct impact on the quality of knowledge retention and storage processes (KR);
- The quality of knowledge utilization and application processes (KU, B = 0.212), the quality of knowledge acquisition and adoption processes (KA, B = 0.428), and the quality of knowledge sharing and transfer processes (KS, B = 0.181) had a positive and direct impact on the quality of knowledge generation and validation processes (KG); and
- The quality of knowledge retention and storage processes (KR, B = 0.328) and the quality of knowledge generation and validation processes (KG, B = 0.341) had a positive and direct impact on the quality of knowledge utilization and application processes (KU).

The sixth finding from the piece-wise regressions is that there are important findings on the relationships between the quality of knowledge management processes and organizational effectiveness. Using piece-wise regression, all of the quality of knowledge process constructs were regressed against organizational effectiveness. The following specific relationships (see Section VII.11) were found to be significant:

— The quality of knowledge retention and storage processes (KR, B = 0.361) and the quality of knowledge utilization and application processes (KU, B = 0.385) have a positive and direct impact on organizational effectiveness (OE).

Figure 8 illustrates the relationships among the quality of knowledge processes constructs and organizational effectiveness. They are an important finding in that they establish the knowledge process mechanisms by which organizational effectiveness is impacted. Multiple regression does not prove a causal relationship (i.e. the direction must be interpreted based on theory and more advanced statistical methods) and the literature is not conclusive on the direction of these inter-relationships. For this reason they are shown with a 'dotted line' link to indicate the causal nature of the relationship is not determined and it could be causal in either direction. However, these relationships help to understand that significant inter-relationships do exist, and when combined with theory, guide the selection of feasible causal path links for further research. The links KU → OE and KR → OE have been established empirically in the literature by authors such as A. Jantunen (see Ref. [5]) and J.D. McKeen et al. [18] respectively and therefore are shown as unidirectional 'solid lines' to indicate they are assumed to be causal in nature. The path analysis (not described in this report, see Ref. [2]) confirmed these relationships and established causality among most of the quality of knowledge process constructs.

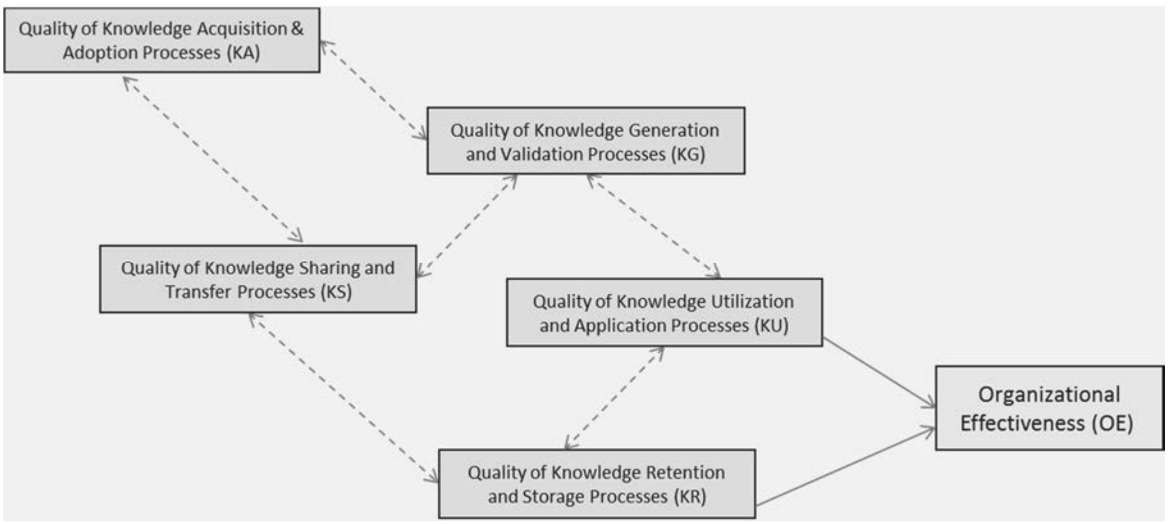


FIG. 8. Links among knowledge processes and to organizational effectiveness (adapted from Ref. [2]).

The seventh finding from the piece-wise regressions was obtained from the regression of all possible sub-constructs (i.e., the full model, which included all the knowledge management practices, both organizational technology support sub-constructs, supportive organizational culture, and all the quality of knowledge process sub-constructs) on organizational effectiveness. This test was to examine whether any direct relationships were more significant than the hypothesized KMPM relationships. The following set of relationships (see Section VII.12.) were found to be significant:

— The quality of knowledge utilization and application (KU, $B = 0.367$), KM strategy and planning (KMS, $B = 0.083$), supportive organizational culture (SOC, $B = 0.215$), and quality of knowledge retention and storage (KR, $B = 0.193$) were found significant with OE at 0.05 level.

All other constructs dropped out of the model as not significant. Although KM strategy and planning (KMS) had a significant direct relationship with organizational effectiveness (OE), the effect size is small. The findings agree with the other regression findings and support the hypothesized KMPM relationships. They show clearly that the mechanism by which the KM practices influence organizational effectiveness is not direct and is primarily through their effect on a supportive organizational culture and on the quality knowledge processes.

Figure 9 shows the combined results from all of the regressions in Appendix VII. Only the statistically significant relationships (i.e. the arrows) are shown, and these represent the links found by the multiple regressions between the factors. The links between the quality of knowledge process constructs are shown as two-way arrows to indicate the causal direction is not determined by regression and cannot be assumed. The link from KM strategy and planning (KMS) to organizational effectiveness (OE) is shown as a dotted line to emphasize it is the only significant (though small in effect size) direct link found between the KM practices or organizational technology support sub-constructs and OE. The link between organizational performance management practices (OPM) and quality of knowledge generation and validation (KG) and the link between supportive organizational culture (SOC) and quality of knowledge sharing and transfer (KS) are also shown as dotted lines to indicate these links were significant in the multiple regressions but were not supported in the path analysis (see Ref. [2]). All the remaining links were found to be significant positive direct relationships.

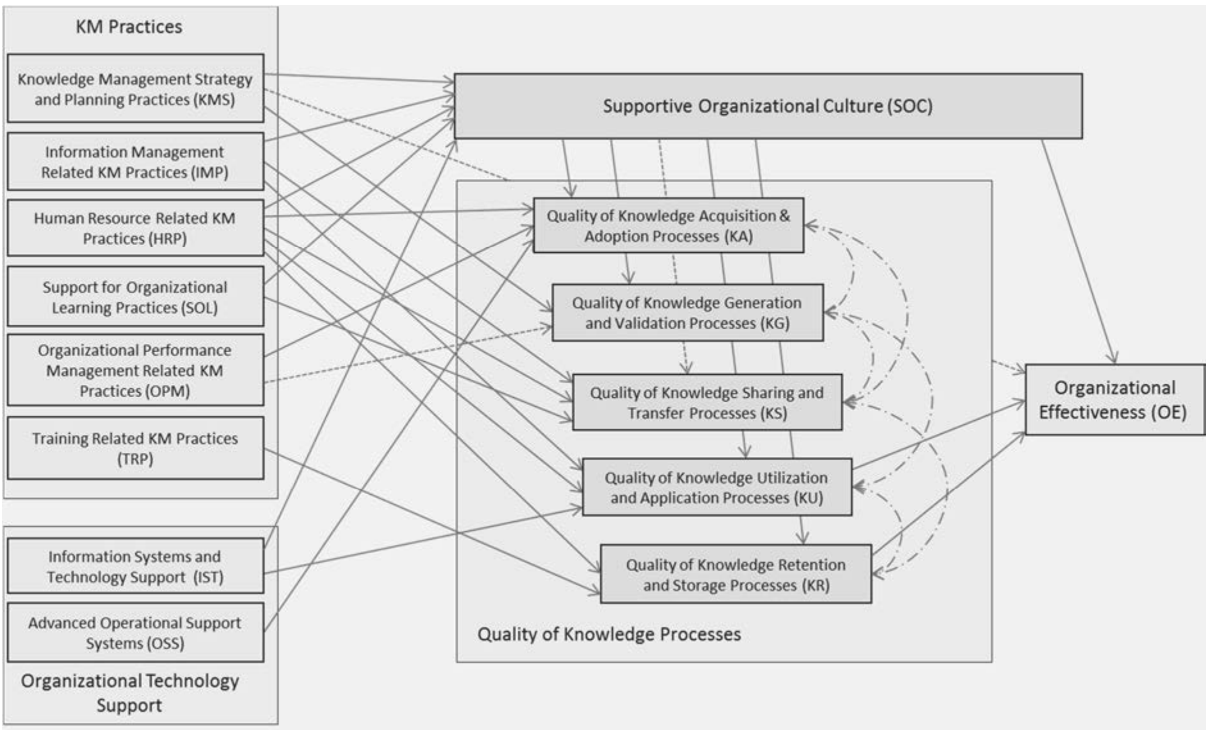


FIG. 9. Significant links between all constructs and sub-constructs (adapted from Ref. [2]).

In summary, the findings from the linear regressions substantially agree with the findings of the path analysis and support the Knowledge Management Performance Model (KMPM), see Ref. [2]). They provide evidence of specific and meaningful direct effect relationships, all to a significance of P = 0.05 or better. Standard multiple linear regression techniques allow many-to-one relationships to be examined and provide valuable insights into the data, however, the findings must be interpreted with appropriate care. Some of the limitations of the study are discussed in the following section.

9. STUDY LIMITATIONS

A challenge of organizational studies research is the validation of developed theory with empirical results. Latent construct research models, which are essentially abstract conceptual frameworks that represent and help to explain organizational factors (i.e. influences, processes, behaviours or phenomena) in a theoretical context, must be supported by meaningful measures that can be applied to obtain reliable data. In many such studies, the researcher must try to identify and contend with many practical limitations. As with any such study, there are several sources of potential error. Independent multiple regressions can help identify the significant variables that may explain the variance in the dependent variable in each model but they cannot simultaneously consider the whole set of variables as system. Indirect and simultaneous effects cannot be evaluated. Careful consideration of this limitation when interpreting the results is necessary.

Another limitation may occur when there is collinearity between two independent variables in a model. Linear regression is sensitive to the effects of high collinearity and unreliable findings may be produced in some cases, such as negative coefficients occurring when all correlations are positive. Although tests for collinearity and multi-collinearity were performed and levels considered reasonable, it is possible that collinearity is influencing some regression findings.

In addition, there is always a question of possible weaknesses in the measures used. For instance, unexpected links that were found to be significant may be legitimate, but may also be related to measurement limitations. As an example, the link between operational support systems and quality of knowledge acquisition and adoption processes was not expected and should be interpreted with caution. It may be due to the perception by managers of recent acquisitions of these systems themselves as a knowledge (i.e. technology) acquisition process, which was not the intent of the measure.

Another potential weakness in the study is bias. Self-report bias, individual response bias and non-response bias are common problems in empirical social sciences research. To minimize self-report bias, reverse coding of some questions was used. To minimize individual bias, cases where multiple responses were received were averaged. To check for non-response bias, an independent samples t-test comparison of respondents versus non-respondents was performed and results indicated a slight bias in the response towards higher performing plants (see Ref. [2]).

A further limitation of the study is small sample size. Although a high percentage of the total population responded, it was not possible to obtain an adequate model fit using Structural Equation Model (SEM) techniques with a sample size of only 124 station organizations. If the study is repeated in future and a higher response is achieved, SEM methods would be recommended. A small sample size also makes the study more vulnerable to influence of outliers, reliability issues, etc.

Finally, it should be noted that the results of the path analysis (see Ref. [2]) were similar and reconfirmed the regression findings. The strength (effect size) of specific relationships vary somewhat in the path analysis but this is expected as the method is able to analyse all the modelled relationships as a system of linear equations, and indirect and simultaneous effects are considered. However, the same significant relationships were observed, with the two exceptions (discussed in Section 8). In these cases, simultaneous or indirect effects, possible effects of collinearity, and/or the possible effects of weaknesses in the construct measures may be a factor and should be considered in future research.

10. CONCLUSIONS

The research represents the first comprehensive empirical study of NPP organizations on the topic of KM and its links to organizational effectiveness. The findings show the levels to which KM practices have been applied in NPPs and provide clear evidence NPPs that have implemented KM practices obtain significant measurable benefits. The research provides new insights for managers on how and why KM practices are effective at improving organizational effectiveness, and explains the mechanisms by which this occurs. The findings will hopefully help NPP managers to better understand and achieve the benefits of KM practices in future.

KM practices are well recognized in the literature as important enablers of organizational performance. The empirical findings of this study strongly support this and reconfirm other research showing a link between knowledge processes (that enable organizational learning) and firm performance. The findings help understand why KM is an important strategic issue for NPPs. However, KM remains difficult and challenging and NPP managers often have difficulty assessing the benefits realized from their efforts. In this respect, the findings also provide useful justification for allocating resources to implement KM programmes and practices. This research clearly shows that management support for KM practices is an important determinant of organizational effectiveness in the context of NPPs.

In general, the findings show that NPP organizations with higher levels of support for KM practices have higher levels of organizational effectiveness (measured across a range of performance measures that include safety, economic, operations, and maintenance indicators). The research findings were statistically significant and strongly support the relationships hypothesized in the Knowledge Management Performance Model (KMPM). These relationships are of interest to NPP managers and include:

(1) KM practices and organizational technology support have a strong collective positive effect on the extent of supportive organizational culture in NPPs;
(2) KM practices and organizational technology support have a strong collective and positive effect on the quality of knowledge processes;
(3) The five quality of knowledge process constructs have a strong collective and positive effect on organizational effectiveness. This effect happens ultimately through the quality of knowledge utilization and application construct and the quality of knowledge retention and storage construct (but it occurs via a specific mechanism, i.e. pattern of interactions, among the other quality of knowledge processes); and
(4) The extent of a supportive organizational culture has a strong positive effect on the quality of knowledge processes and organizational effectiveness.

When the full model (i.e. all the sub-constructs) was regressed simultaneously on organizational effectiveness, only the following three relationships were found to be significant and have a meaningful (i.e. large) effect size: supportive organizational culture, the quality of knowledge utilization and application, and the quality of knowledge retention and storage. Although KM strategy and planning was found to be significant, it had a relatively small effect size (B = 0.083). This finding further supports the validity of the KMPM model as explaining the nature and mechanics of the relationships among the sub-constructs. The findings clearly support the main research hypothesis, i.e. that the mechanism by which the seven KM practice constructs and the two extent of technology support constructs influence organizational effectiveness is not direct: it is primarily through their effect on the intermediate variables of a supportive organizational culture and the five quality of knowledge process constructs.

Finally, the data from the study and the subsequent analysis findings provides a useful industry benchmark. This may help to better understand where and how NPPs may improve current KM practices and programmes and realize additional benefits. As the study represents the first of its kind, further research is recommended in this area and it is hoped will build on these findings. The IAEA Global NPP KM Survey may be repeated by the IAEA in future and if so, the data can be used to see important trends and develop measures for improvement at an industry level.

Appendix I

SURVEY INSTRUMENT

IAEA GLOBAL NUCLEAR POWER PLANT SURVEY: 'INVESTIGATING THE LINK BETWEEN KNOWLEDGE MANAGEMENT PRACTICES AND ORGANIZATIONAL PERFORMANCE'

PART A: KNOWLEDGE MANAGEMENT PRACTICES

Please indicate your level of agreement with each of the following statements about your station organization, according to the following rankings:

1 — Strongly disagree;
2 — Somewhat disagree;
3 — Neither agree nor disagree (neutral);
4 — Somewhat agree;
5 — Strongly agree.

1. Knowledge management strategy and plan	**Strongly disagree 1**	**2**	**3**	**4**	**Strongly agree 5**	**Unable to rate**
a. The organization has clear, documented high level knowledge management plan and goals	☐	☐	☐	☐	☐	☐
b. Implementation of the knowledge management strategy and plan is openly and actively supported by management	☐	☐	☐	☐	☐	☐
c. Knowledge management roles and responsibilities are clearly defined and understood by managers and employees	☐	☐	☐	☐	☐	☐
d. Other management strategies (e.g. human resources, information systems, operations, communications and maintenance plans) are closely aligned with the knowledge management strategy and plan	☐	☐	☐	☐	☐	☐
e. The needs and gaps in the organizational knowledge base are periodically reviewed and the knowledge management strategy and plan is revised to address them	☐	☐	☐	☐	☐	☐

2. Support for organizational learning	**Strongly disagree 1**	**2**	**3**	**4**	**Strongly agree 5**	**Unable to rate**
a. Knowledge creation and application (e.g., finding better methods, technology innovation) is encouraged, recognized and rewarded	☐	☐	☐	☐	☐	☐
b. Sharing of knowledge is promoted and rewarded (e.g., experts are encouraged and rewarded to coach or mentor other employees)	☐	☐	☐	☐	☐	☐
c. Open communication and a no-blame approach to reporting problems and sharing lessons learned are promoted (e.g., regular communication is encouraged between maintenance and operations personnel)	☐	☐	☐	☐	☐	☐
d. Learning opportunities are encouraged (e.g., joining specialist groups or attending training seminars)	☐	☐	☐	☐	☐	☐

3. Process management practices	**Strongly disagree 1**	**2**	**3**	**4**	**Strongly agree 5**	**Unable to rate**
a. For all processes and procedures, priority is placed on ensuring the requirements, methods, inputs, outputs, interfaces, responsibilities, and workflow are documented correctly and maintained up to date	☐	☐	☐	☐	☐	☐
b. Consideration of hazards and risk is built into all work and decision processes to ensure safety is not adversely impacted.	☐	☐	☐	☐	☐	☐
c. Procedures are aligned to knowledge and information requirements of both work tasks and decision processes	☐	☐	☐	☐	☐	☐
d. A process to measure and improve the quality and control of all business, work, and decision processes is defined and followed.	☐	☐	☐	☐	☐	☐
e. Comprehensive knowledge management procedures (e.g. for knowledge loss risk assessment) are documented and in use	☐	☐	☐	☐	☐	☐
f. Knowledge management processes and procedures are extended to suppliers and technical support organizations	☐	☐	☐	☐	☐	☐

4. Information management practices	**Strongly disagree 1**	**2**	**3**	**4**	**Strongly agree 5**	**Unable to rate**
a. Licensing documents, design basis documents, procedures, specifications, drawings, and training materials are updated promptly to address plant changes and are maintained under configuration management	☐	☐	☐	☐	☐	☐
b. Records, data, and logs are required to be complete, meaningful, accurate and accessible (e.g., logs, minutes, test results)	☐	☐	☐	☐	☐	☐
c. Data standards, metadata, document codes, subject indexes and filing systems are widely used to enable efficient information correlation, storage and retrieval	☐	☐	☐	☐	☐	☐
d. Procedures ensure the needs for data and information safety, security, maintainability, accessibility, quality and preservation	☐	☐	☐	☐	☐	☐

5. Organizational performance management practices	**Strongly disagree 1**	**2**	**3**	**4**	**Strongly agree 5**	**Unable to rate**
a. Independent external peer review assessments are conducted regularly (e.g. WANO, INPO, or IAEA-OSART reviews)	☐	☐	☐	☐	☐	☐
b. Self-assessments are widely used to stimulate learning and improve performance (e.g. benchmarking against best practices)	☐	☐	☐	☐	☐	☐
c. Performance objectives are established and monitored for all levels and areas of the organization (including for knowledge processes)	☐	☐	☐	☐	☐	☐
d. Performance objectives for operations, maintenance, and safety are based on objectives established by industry best practice	☐	☐	☐	☐	☐	☐
e. The effectiveness of the management system (including knowledge management aspects) is regularly reviewed	☐	☐	☐	☐	☐	☐
f. On-going processes for operational experience capture, review, analysis and corrective action are defined and followed	☐	☐	☐	☐	☐	☐

6. Training related practices	**Strongly disagree 1**	**2**	**3**	**4**	**Strongly agree 5**	**Unable to rate**
a. The organization incorporates principles of the 'systematic approach to training' (SAT) in training programmes	☐	☐	☐	☐	☐	☐
b. Sufficient training is provided to achieve and maintain the required level of competence for all job positions	☐	☐	☐	☐	☐	☐
c. Training material is reviewed to ensure it reflects lessons learned from operating experience and agrees with plant documentation	☐	☐	☐	☐	☐	☐
d. Collaboration with universities and colleges ensures an appropriate supply of new graduates.	☐	☐	☐	☐	☐	☐
e. Other techniques are used for training (e.g. story-telling, concept mapping, pre-job briefings, informal seminars, mentoring programmes etc.). Please specify: ______________ ____	☐	☐	☐	☐	☐	☐

7. Human resource related practices	**Strongly disagree 1**	**2**	**3**	**4**	**Strongly agree 5**	**Unable to rate**
a. Expected retirements and unexpected departures are regularly tracked and the resulting need for and availability of critical knowledge and job skills is acted upon	☐	☐	☐	☐	☐	☐
b. New hiring is done long before experts depart to facilitate knowledge transfer and ensure the competency of replacements is developed in time	☐	☐	☐	☐	☐	☐
c. Interviews with departing employees are routinely carried out well in advance to identify critical knowledge and experience and to facilitate knowledge capture and transfer	☐	☐	☐	☐	☐	☐
d. Competency, training and knowledge sharing or transfer goals are identified, evaluated and rewarded in employee performance assessment	☐	☐	☐	☐	☐	☐
e. Work assignments promote learning (e.g., job-rotations, team selections and staff assignments consider learning opportunities)	☐	☐	☐	☐	☐	☐

PART B: TECHNOLOGY SUPPORT

*Please indicate how **effectively** each of the following technologies is used in your station organization according to the following rankings:*

1 — Very effectively;
2 — Effectively;
3 — Somewhat effectively;
4 — Not effectively;
5 — Not used (at all).

1. Information systems and technology support	**Very effectively 1**	**2**	**3**	**4**	**Not used 5**	**Unable to rate**
a. Three dimensional (3D) virtual reality environments for training	☐	☐	☐	☐	☐	☐
b. Computer and/or web-based training	☐	☐	☐	☐	☐	☐
c. Desktop (e.g. plant) training simulators	☐	☐	☐	☐	☐	☐
d. Full scope main control room training simulators	☐	☐	☐	☐	☐	☐
e. Electronic archives and databases (e.g. for document management, event reporting, maintenance records, etc.)	☐	☐	☐	☐	☐	☐
f. Enterprise application software (e.g. for financials, procurement, parts inventory management, work and outage management, etc.)	☐	☐	☐	☐	☐	☐
g. Intranet web portal with search/retrieval access to frequently used resources (e.g. documents, bulletins, contact lists, etc.)	☐	☐	☐	☐	☐	☐
h. Three-dimensional (3D) computer aided design (CAD) plant models and editable electronic drawings	☐	☐	☐	☐	☐	☐

2. Advanced operational support systems	**Very effectively 1**	**2**	**3**	**4**	**Not used 5**	**Unable to rate**
a. Operational decision support systems (e.g. refuelling software)	☐	☐	☐	☐	☐	☐
b. Regularly updated (i.e. 'living') probabilistic risk models of equipment reliability for maintenance and outage planning	☐	☐	☐	☐	☐	☐
c. Real-time probabilistic risk models for operator evaluation and awareness of plant safety (i.e. 'a safety monitor')	☐	☐	☐	☐	☐	☐
d. System health monitors (e.g. predictive maintenance tools such as vibration, acoustic, thermal, or other monitors)	☐	☐	☐	☐	☐	☐
e. Advanced model-based monitoring and diagnostics (e.g. physics, chemistry, boiler, feed water and thermal hydraulics models)	☐	☐	☐	☐	☐	☐
f. Advanced information exchange (e.g. hand-held computers, plant-wide equipment status monitoring, wireless communications)	☐	☐	☐	☐	☐	☐
g. Electronic (i.e. graphical) road-maps of business and decision processes or work-flows (e.g. operational flow-sheets) with links to supporting procedures, related resources or documents	☐	☐	☐	☐	☐	☐
h. Automated field data collection (i.e., smart instruments, field-bus, radio frequency identification (RFID) tagging, data logging, equipment monitors)	☐	☐	☐	☐	☐	☐
i. Other (please specify): ________________________________	☐	☐	☐	☐	☐	☐

PART C: QUALITY OF KNOWLEDGE PROCESSES

Please indicate your level of agreement with each of the following statements about your station organization, according to the following rankings:

1 — Strongly disagree;
2 — Somewhat disagree;
3 — Neither agree nor disagree (neutral);
4 — Somewhat agree;
5 — Strongly agree.

1. Knowledge acquisition	**Strongly disagree 1**	**2**	**3**	**4**	**Strongly agree 5**	**Unable to rate**
a. The organization has difficulty finding and hiring appropriately qualified graduates	☐	☐	☐	☐	☐	☐
b. The organization excels at identifying and acquiring external technical information needed to operate and maintain the plant	☐	☐	☐	☐	☐	☐
c. External information acquired is often not organized or stored in a maintainable and accessible way to facilitate use and re-use	☐	☐	☐	☐	☐	☐
d. The organization is effective at acquiring knowledge from external (e.g. peer-plant) operating experiences	☐	☐	☐	☐	☐	☐
e. The organization is highly effective at adopting external best practices	☐	☐	☐	☐	☐	☐
f. The organization is good at capturing technical know-how and relevant design information related to services or products received from outside organizations	☐	☐	☐	☐	☐	☐

2. Knowledge creation	**Strongly disagree 1**	**2**	**3**	**4**	**Strongly agree 5**	**Unable to rate**
a. NPP staff learn from operating experience and new and better ways of running the plant are seldom overlooked	☐	☐	☐	☐	☐	☐
b. Independent review processes are effective at validating proposed operational or design changes that may impact safety or production	☐	☐	☐	☐	☐	☐
c. Employees lack the questioning attitude needed to challenge assumptions and investigate anomalies or uncertainties	☐	☐	☐	☐	☐	☐
d. Employees regularly create innovative solutions by combining or adapting existing and/or acquired knowledge	☐	☐	☐	☐	☐	☐
e. The organization excels at generating, transforming, and presenting plant data as meaningful information	☐	☐	☐	☐	☐	☐
f. Engineers have to spend too much time gathering and compiling data from many sources	☐	☐	☐	☐	☐	☐

3. **Knowledge transfer**	**Strongly disagree 1**	**2**	**3**	**4**	**Strongly agree 5**	**Unable to rate**
a. Findings, information, data, reports, or files generated in one area of the company are readily accessible to other areas	☐	☐	☐	☐	☐	☐
b. Employees often do not know where in the organization to find specialized knowledge and information	☐	☐	☐	☐	☐	☐
c. The problem of hoarding (keeping) knowledge does not exist and employees willingly share their knowledge with co-workers	☐	☐	☐	☐	☐	☐
d. Expertise and skills are not effectively transferred to junior staff from more experienced employees	☐	☐	☐	☐	☐	☐
e. Employees routinely and voluntarily share relevant information with other parts of the organization where it may be needed	☐	☐	☐	☐	☐	☐

4. **Knowledge utilization**	**Strongly disagree 1**	**2**	**3**	**4**	**Strongly agree 5**	**Unable to rate**
a. Lessons learned from operating experience are incorporated in work practices, manuals, procedures and decision-making	☐	☐	☐	☐	☐	☐
b. The organization is often not able to apply its knowledge effectively to solve difficult technical problems	☐	☐	☐	☐	☐	☐
c. Employees are consistently able to make important technical decisions correctly	☐	☐	☐	☐	☐	☐
d. Employees are not always aware of and do not always make effective use of each other's skills and expertise	☐	☐	☐	☐	☐	☐
e. Equipment replacement and design change decisions are based on a risk-informed decision process	☐	☐	☐	☐	☐	☐

5. **Knowledge retention**	**Strongly disagree 1**	**2**	**3**	**4**	**Strongly agree 5**	**Unable to rate**
a. Employees often lack an appropriate knowledge of the reactor and power plant fundamentals	☐	☐	☐	☐	☐	☐
b. Employees have adequate knowledge/understanding of work processes (e.g. industrial and radiation safety work practices)	☐	☐	☐	☐	☐	☐
c. There is often a shortage of critical skills and experience due to unexpected departures and retirements	☐	☐	☐	☐	☐	☐
d. Plant design basis documents are easily located and are up-to-date and accurate	☐	☐	☐	☐	☐	☐
e. Maintenance, operations, or technical support specialists lack adequate knowledge of specific systems and technologies to enable them to work effectively and safely	☐	☐	☐	☐	☐	☐

PART D: ORGANIZATIONAL CULTURE

Please indicate your level of agreement with each of the following statements about your station organization, according to the following rankings:

1 — Strongly disagree;
2 — Somewhat disagree;
3 — Neither agree nor disagree (neutral);
4 — Somewhat agree;
5 — Strongly agree.

Organizational culture	**Strongly disagree 1**	**2**	**3**	**4**	**Strongly agree 5**	**Unable to rate**
a. Managers and employees often do not see learning, innovation, and improvement as a part of their jobs	☐	☐	☐	☐	☐	☐
b. Employees who innovate-feel recognized and rewarded	☐	☐	☐	☐	☐	☐
c. There is a prevailing attitude and commitment to follow defined processes and fully comply with procedures	☐	☐	☐	☐	☐	☐
d. Employees often do not feel empowered to make decisions appropriate to their job duties	☐	☐	☐	☐	☐	☐
e. There is shared vision, purpose, and expectations among employees and they see all their problems as mutual	☐	☐	☐	☐	☐	☐
f. People are seen as the organisation's most valued asset	☐	☐	☐	☐	☐	☐
g. Employees and managers are open-minded and respect each other's opinions and contributions	☐	☐	☐	☐	☐	☐
h. There is a team-oriented approach throughout the station (e.g., employees trust, cooperate, and help each other)	☐	☐	☐	☐	☐	☐
i. Employees often do not feel responsible for plant performance and fail to demonstrate their commitment to it	☐	☐	☐	☐	☐	☐
j. Consideration of safety is clearly evident in employee and management actions and decisions	☐	☐	☐	☐	☐	☐
k. Improvements are mostly driven by externally imposed requirements (e.g. regulatory rulings, owner influences).	☐	☐	☐	☐	☐	☐
l. A questioning attitude is cultivated (i.e. information, approaches and decisions are carefully scrutinized)	☐	☐	☐	☐	☐	☐
m. The organization is focused primarily on short-term goals	☐	☐	☐	☐	☐	☐

PART E: ORGANIZATIONAL EFFECTIVENESS

Please indicate your level of agreement with each of the following statements about your station-organization, according to the following rankings:

1 — Strongly disagree;
2 — Somewhat disagree;
3 — Neither agree nor disagree (neutral);
4 — Somewhat agree;
5 — Strongly agree.

Organizational effectiveness	**Strongly disagree 1**	**2**	**3**	**4**	**Strongly agree 5**	**Unable to rate**
a. The organization has difficulty making operational changes smoothly and in a timely manner	☐	☐	☐	☐	☐	☐
b. Maintenance technicians consistently conduct high-quality corrective and preventive maintenance	☐	☐	☐	☐	☐	☐
c. The ratio of corrective to preventive maintenance is high relative to best performing NPPs of similar design	☐	☐	☐	☐	☐	☐
d. The plant chemistry programme ensures the plant consistently operates within the chemistry specifications	☐	☐	☐	☐	☐	☐
e. Projects involving multiple departments are typically behind schedule, over-budget, and not well coordinated	☐	☐	☐	☐	☐	☐
f. Safety objectives are consistently met or exceeded	☐	☐	☐	☐	☐	☐
g. System and/or performance analysis engineers are not effective at resolving problems that affect plant safety or performance	☐	☐	☐	☐	☐	☐
h. Radiological conditions are effectively controlled (i.e. field levels are as low as reasonably achievable and dose control is effective)	☐	☐	☐	☐	☐	☐
i. Quality of documentation (i.e. design, work-process and procedural documentation) needs to improve	☐	☐	☐	☐	☐	☐
j. Operators effectively act on changing plant conditions to ensure on-going safe and reliable plant operation	☐	☐	☐	☐	☐	☐
k. Weekly operations objectives are regularly not met	☐	☐	☐	☐	☐	☐
l. Work planning and management is effective (e.g. planned work-scope is stable, little time is wasted waiting on approvals or parts)	☐	☐	☐	☐	☐	☐
m. The average number of critical component failures per year is low relative to other similar plants	☐	☐	☐	☐	☐	☐
n. Recurrence of known and avoidable operational problems is not always prevented	☐	☐	☐	☐	☐	☐
o. The organization is effective at managing its external interfaces (i.e. the regulator, public, suppliers, contractors)	☐	☐	☐	☐	☐	☐
p. Environmental objectives are sometimes not met	☐	☐	☐	☐	☐	☐
q. Maintenance objectives (e.g. level of corrective and preventive maintenance backlog) based on industry best practice are consistently met or exceeded	☐	☐	☐	☐	☐	☐
r. Financial objectives are often not me.	☐	☐	☐	☐	☐	☐
s. Regulatory objectives are consistently met or exceeded	☐	☐	☐	☐	☐	☐
t. System health improvement initiatives are effective	☐	☐	☐	☐	☐	☐
u. Corrective and preventive maintenance and outage work is completed on schedule and in a timely manner	☐	☐	☐	☐	☐	☐
v. Financial resources (budgets) are adequate and allocated wisely	☐	☐	☐	☐	☐	☐

PART F: OPERATIONAL PERFORMANCE

If you provide the name of your station (optional), the operational performance indicator ratings data for your station will be taken from available industry sources for correlation with the survey data and future research. Your responses will remain confidential and only aggregate findings will be reported.

Name of your station (optional): ____

PART G: DEMOGRAPHIC AND OTHER DATA

(1) Please indicate the number of employees (excluding contractors) at your station: ______________
(2) Please indicate the typical number of full-time equivalent contractors during outages: ____________
(3) Please indicate the typical number of full-time equivalent contractors while at power: ____________
(4) Please indicate the percentage of employees with university degrees at your station: ____________
(5) Please indicate the country your station is located in: ______________________________
(6) Please indicate the number of operational units (i.e. power reactors) at your station: ____________
(7) Please indicate the type of reactor (e.g. PWR, BWR, PHWR, LWCGR, or GCR etc.): ____________
(8) Please indicate the plant model (i.e. product) name (e.g. EPR, AP1000, WWER 440, etc.): _________
(9) Please check the appropriate row to indicate the approximate age of each unit at your station (measured in years from completion of construction) (ignore columns for any non-existent units):

Age (years)	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8
1–10	☐	☐	☐	☐	☐	☐	☐	☐
11–20	☐	☐	☐	☐	☐	☐	☐	☐
21–30	☐	☐	☐	☐	☐	☐	☐	☐
31–40	☐	☐	☐	☐	☐	☐	☐	☐
41+	☐	☐	☐	☐	☐	☐	☐	☐

(10) Please indicate which communities of practice (COP) your station organization participates in and whether regular self-assessment is done against the performance indicators or benchmarks from that COP group.

Name or topic of COP Work Group	**Indicate if a regular participant**	**Indicate if doing benchmarking**
Equipment Reliability	☐	☐
Materials and Services (supply chain)	☐	☐
Information Technology	☐	☐
Business Services/Nuclear Asset Management	☐	☐
Information Management	☐	☐
Licensing/Regulatory Issues	☐	☐
Human Resources	☐	☐
Radiation Protection	☐	☐
Nuclear Fuel	☐	☐
Performance Monitoring/Improvement	☐	☐
Plant Operations	☐	☐
Chemistry Management	☐	☐
Work Management	☐	☐
Simulators	☐	☐
Training	☐	☐
Cost Estimation and Management	☐	☐
Configuration Management	☐	☐
Fire Protection	☐	☐
Other (specify: ______________________________)	☐	☐

Please also indicate whether COP participations above include: local (e.g. national) ☐, regional (e.g. European) ☐, international (e.g. IAEA, EPRI, INPO or NEI) ☐, or Owner's Group based COPs ☐.

(11) Please indicate the number of operations managers who helped complete this survey response: __________

(12) Please make any additional comments on, or clarifications of your responses in the space provided below:

____

____

____

(13) If you wish to have an electronic copy of the report summarizing the findings of this study once it is available, please provide your name, title and e-mail address (optional).

Name: ____

Title: ____

E-mail address: ____

Thank you for your valuable time in completing this questionnaire!

Appendix II

SUMMARY OF PARTICIPATING STATIONS

Table II.1 provides a summary list of all of the NPPs that participated in the survey.

TABLE II.1. SUMMARY OF PARTICIPATING REACTOR UNITS (see Ref. [2])

NPP name	Country	Reactor type	In-service	MWe rating
Almaraz Unit 1	Spain	PWR	1983	1050
Almaraz Unit 2	Spain	PWR	1984	983
Angra NPP 1- Unit 1	Brazil	PWR	1985	640
Angra NPP 2- Unit 1	Brazil	PWR	2000	1350
ANO Unit 1	USA	PWR	1974	845
ANO Unit 2	USA	PWR	1980	1012
Asco NPP 1	Spain	PWR	1984	1033
Asco NPP 2	Spain	PWR	1985	1027
Beznau Unit 1	Switzerland	PWR	1969	380
Beznau Unit 2	Switzerland	PWR	1972	380
Biblis NPP A	Germany	PWR	1975	1225
Biblis NPP B	Germany	PWR	1977	1300
Bohunice Unit 3	Slovakia	PWR	1984	436
Bohunice Unit 4	Slovakia	PWR	1985	436
Borssele Unit 1	Netherlands	PWR	1973	478
Braidwood Unit 1	USA	PWR	1988	1194
Braidwood Unit 2	USA	PWR	1988	1166
Brokdorf Unit 1	Germany	PWR	1986	1440
Bruce Nuclear A, Unit 3	Canada	PHWR	1978	825
Bruce Nuclear A, Unit 4	Canada	PHWR	1979	825
Bruce Nuclear B, Unit 5	Canada	PHWR	1985	840
Bruce Nuclear B, Unit 6	Canada	PHWR	1984	866
Bruce Nuclear B, Unit 7	Canada	PHWR	1986	840
Bruce Nuclear B, Unit 8	Canada	PHWR	1987	840
Brunsbuettel Unit 1	Germany	BWR	1976	806
Bugey Unit 2	France	PWR	1979	920
Bugey Unit 3	France	PWR	1979	920
Bugey Unit 4	France	PWR	1979	880
Bugey Unit 5	France	PWR	1980	880
Byron Unit 1	USA	PWR	1985	1183
Byron Unit 2	USA	PWR	1987	1153
Callaway Unit 1	USA	PWR	1985	1284
Catawba Unit 1	USA	PWR	1985	1153
Catawba Unit 2	USA	PWR	1986	1305
Cernavoda Unit 1	Romania	PHWR	1996	706
Cernavoda Unit 2	Romania	PHWR	2007	704
Chinshan Unit 1	Taiwan, China	BWR	1978	629
Chinshan Unit 2	Taiwan, China	BWR	1979	629
Civaux Unit 1	France	PWR	2002	1495
Civaux Unit 2	France	PWR	2002	1495
Clinton Unit 1	USA	BWR	1987	1067
Comanche Peak Unit 1	USA	PWR	1990	1166
Comanche Peak Unit 2	USA	PWR	1993	1166
Cook Unit 1	USA	PWR	1975	1056
Cook Unit 2	USA	PWR	1978	1133
Cooper Unit 1	USA	BWR	1974	787
Cruas Unit 1	France	PWR	1984	880
Cruas Unit 2	France	PWR	1985	915

TABLE II.1 (cont.). SUMMARY OF PARTICIPATING REACTOR UNITS (see Ref. [2])

NPP name	Country	Reactor type	In-service	MWe rating
Cruas Unit 3	France	PWR	1984	915
Cruas Unit 4	France	PWR	1985	880
Darlington Unit 1	Canada	PHWR	1992	934
Darlington Unit 2	Canada	PHWR	1990	934
Darlington Unit 3	Canada	PHWR	1993	934
Darlington Unit 4	Canada	PHWR	1993	934
Daya Bay Unit 1	China	PWR	1994	984
Daya Bay Unit 2	China	PWR	1994	984
Diablo Canyon Unit 1	USA	PWR	1985	1153
Diablo Canyon Unit 2	USA	PWR	1986	1149
Doel Unit 1	Belgium	PWR	1975	392
Doel Unit 2	Belgium	PWR	1975	433
Doel Unit 3	Belgium	PWR	1982	1006
Doel Unit 4	Belgium	PWR	1985	1008
Dresden Unit 2	USA	BWR	1970	869
Dresden Unit 3	USA	BWR	1971	871
Duane Arnold Unit 1	USA	BWR	1975	647
Dungeness B Unit 3	UK	AGR	1985	555
Dungeness B Unit 4	UK	AGR	1985	555
Farley Unit 1	USA	PWR	1977	851
Farley Unit 2	USA	PWR	1981	860
Fermi Unit 2	USA	BWR	1988	1179
FitzPatrick Unit 1	USA	BWR	1975	862
Fort Calhoun Unit 1	USA	PWR	1973	499
Fukushima Daini Unit 1	Japan	BWR	1982	1100
Fukushima Daini Unit 2	Japan	BWR	1984	1100
Fukushima Daini Unit 3	Japan	BWR	1985	1100
Fukushima Daini Unit 4	Japan	BWR	1987	1100
Ginna Unit 1	USA	PWR	1970	602
Goesgen Unit 1	Switzerland	PWR	1979	1035
Golfech Unit 1	France	PWR	1991	1345
Golfech Unit 2	France	PWR	1994	1345
Grafenrheinfeld Unit 1	Germany	PWR	1982	1345
Grand Gulf Unit 1	USA	BWR	1985	1288
Gravelines B Unit 1	France	PWR	1980	910
Gravelines B Unit 2	France	PWR	1980	910
Gravelines B Unit 3	France	PWR	1981	910
Gravelines B Unit 4	France	PWR	1981	910
Gravelines C Unit 5	France	PWR	1985	910
Gravelines C Unit 6	France	PWR	1985	910
Grohnde NPP 1	Germany	PWR	1985	1430
Gundremmingen NPP B	Germany	BWR	1984	1344
Gundremmingen NPP C	Germany	BWR	1985	1344
Hartlepool Unit 1	UK	AGR	1983	605
Hartlepool Unit 2	UK	AGR	1984	605
Hatch Unit 1	USA	BWR	1976	876
Hatch Unit 2	USA	BWR	1979	883
Heysham A Unit 1	UK	AGR	1983	575
Heysham A Unit 2	UK	AGR	1983	575
Heysham B Unit 1	UK	AGR	1988	625
Heysham B Unit 2	UK	AGR	1988	625
Hinkley Point B Unit 1	UK	AGR	1978	610
Hinkley Point B Unit 2	UK	AGR	1976	610
Hunterston B Unit 1	UK	AGR	1976	595

TABLE II.1 (cont.). SUMMARY OF PARTICIPATING REACTOR UNITS (see Ref. [2])

NPP name	Country	Reactor type	In-service	MWe rating
Hunterston B Unit 2	UK	AGR	1977	595
Ignalina Unit 2	Lithuania	LWCGR	1987	1500
Indian Point Unit 2	USA	PWR	1974	1062
Indian Point Unit 3	USA	PWR	1976	1079
Isar 1 Unit 1	Germany	BWR	1979	912
Un-named Unit 1	Russian Federation	PWR	Not available	Not available
Un-named Unit 2	Russian Federation	PWR	Not available	Not available
Un-named Unit 3	Russian Federation	PWR	Not available	Not available
Kashiwazaki Kariwa Unit 1	Japan	BWR	1985	1100
Kashiwazaki Kariwa Unit 2	Japan	BWR	1990	1100
Kashiwazaki Kariwa Unit 3	Japan	BWR	1993	1100
Kashiwazaki Kariwa Unit 4	Japan	BWR	1994	1100
Kashiwazaki Kariwa Unit 5	Japan	BWR	1990	1100
Kashiwazaki Kariwa Unit 6	Japan	BWR	1996	1356
Kashiwazaki Kariwa Unit 7	Japan	BWR	1997	1356
Koeberg Unit 1	South Africa	PWR	1984	900
Koeberg Unit 2	South Africa	PWR	1985	900
Kori A Unit 1	South Korea	PWR	1978	603
Kori A Unit 2	South Korea	PWR	1983	675
Kori B Unit 3	South Korea	PWR	1986	1035
Kori B Unit 4	South Korea	PWR	1986	1035
Kozloduy Unit 5	Bulgaria	PWR	1988	1000
Kozloduy Unit 6	Bulgaria	PWR	1993	1039
Krsko Unit 1	Slovenia	PWR	1983	666
Kuosheng Unit 1	Taiwan, China	BWR	1981	950
Kuosheng Unit 2	Taiwan, China	BWR	1983	970
LaSalle Unit 1	USA	BWR	1984	1138
LaSalle Unit 2	USA	BWR	1985	1150
Leibstadt Unit 1	Switzerland	BWR	1984	1220
Limerick Unit 1	USA	BWR	1986	1199
Limerick Unit 2	USA	BWR	1990	1204
Lingao Unit 1	China	PWR	2002	990
Lingao Unit 2	China	PWR	2003	990
Loviisa Unit 1	Finland	PWR	1977	510
Loviisa Unit 2	Finland	PWR	1981	510
Maanshan Unit 1	Taiwan, China	PWR	1984	936
Maanshan Unit 2	Taiwan, China	PWR	1985	936
McGuire Unit 1	USA	PWR	1981	1140
McGuire Unit 2	USA	PWR	1984	1149
Mochovce Unit 1	Slovakia	PWR	1998	470
Mochovce Unit 2	Slovakia	PWR	2000	470
Muehleberg Unit 1	Switzerland	BWR	1972	372
Nine Mile Point Unit 1	USA	BWR	1969	628
Nine Mile Point Unit 2	USA	BWR	1988	1163
Oconee Unit 1	USA	PWR	1973	934
Oconee Unit 2	USA	PWR	1974	934
Oconee Unit 3	USA	PWR	1974	934
OHI Unit 1	Japan	PWR	1979	1175
OHI Unit 2	Japan	PWR	1979	1175
OHI Unit 3	Japan	PWR	1991	1180
OHI Unit 4	Japan	PWR	1993	1180
Oldbury Unit 1	UK	GCR	1967	217
Oldbury Unit 2	UK	GCR	1968	217
Olkiluoto Unit 1	Finland	BWR	1979	878
Olkiluoto Unit 2	Finland	BWR	1982	878

TABLE II.1 (cont.). SUMMARY OF PARTICIPATING REACTOR UNITS (see Ref. [2])

NPP name	Country	Reactor type	In-service	MWe rating
Oskarshamn Unit 1	Sweden	BWR	1972	487
Oskarshamn Unit 2	Sweden	BWR	1975	623
Oskarshamn Unit 3	Sweden	BWR	1985	1197
Oyster Creek Unit 1	USA	BWR	1969	650
Paks Unit 1	Hungary	PWR	1983	500
Paks Unit 2	Hungary	PWR	1984	500
Paks Unit 3	Hungary	PWR	1986	500
Paks Unit 4	Hungary	PWR	1987	500
Palisades Unit 1	USA	PWR	1971	842
Palo Verde Unit 1	USA	PWR	1986	1402
Palo Verde Unit 2	USA	PWR	1986	1406
Palo Verde Unit 3	USA	PWR	1988	1405
Peach Bottom Unit 2	USA	BWR	1974	1172
Peach Bottom Unit 3	USA	BWR	1974	1172
Pickering A Unit 1	Canada	PHWR	1971	542
Pickering A Unit 4	Canada	PHWR	1973	542
Pickering B Unit 5	Canada	PHWR	1983	540
Pickering B Unit 6	Canada	PHWR	1984	540
Pickering B Unit 7	Canada	PHWR	1985	540
Pickering B Unit 8	Canada	PHWR	1986	540
Pilgrim Unit 1	USA	BWR	1972	711
Point Beach Unit 1	USA	PWR	1970	524
Point Beach Unit 2	USA	PWR	1972	524
Point Lepreau Unit 1	Canada	PHWR	1983	638
Qinshan 1- Unit 1	China	PWR	1994	310
Qinshan 3- Unit 1	China	PHWR	2002	650
Qinshan 3- Unit 2	China	PHWR	2003	700
Quad Cities Unit 1	USA	BWR	1973	866
Quad Cities Unit 2	USA	BWR	1973	871
Ringhals Unit 1	Sweden	BWR	1976	848
Ringhals Unit 2	Sweden	PWR	1975	875
Ringhals Unit 3	Sweden	PWR	1981	1045
Ringhals Unit 4	Sweden	PWR	1983	913
River Bend Unit 1	USA	BWR	1986	1055
San Onofre Unit 2	USA	PWR	1983	1127
San Onofre Unit 3	USA	PWR	1984	1127
Santa Maria De Garona Unit 1	Spain	BWR	1971	466
Seabrook Unit 1	USA	PWR	1990	1296
Shimane Unit 1	Japan	BWR	1974	460
Shimane Unit 2	Japan	BWR	1989	820
Sizewell B Unit 1	UK	PWR	1995	1188
South Ukraine Unit 1	Ukraine	PWR	1982	1000
South Ukraine Unit 2	Ukraine	PWR	1985	1000
South Ukraine Unit 3	Ukraine	PWR	1989	1000
St. Lucie Unit 1	USA	PWR	1976	839
St. Lucie Unit 2	USA	PWR	1983	839
Susquehanna Unit 1	USA	BWR	1983	1199
Susquehanna Unit 2	USA	BWR	1985	1204
Tarapur Unit 3	India	PHWR	2006	540
Tarapur Unit 4	India	PHWR	2005	540
Temelin Unit 1	Czech Republic	PWR	2002	1000
Temelin Unit 2	Czech Republic	PWR	2003	1000
Three Mile Island Unit 1	USA	PWR	1974	890
Tianwan Unit 1	China	PWR	2007	1000
Tianwan Unit 2	China	PWR	2007	1000

TABLE II.1 (cont.). SUMMARY OF PARTICIPATING REACTOR UNITS (see Ref. [2])

NPP name	Country	Reactor type	In-service	MWe rating
Tihange Unit 1	Belgium	PWR	1975	962
Tihange Unit 2	Belgium	PWR	1983	1008
Tihange Unit 3	Belgium	PWR	1985	1054
Tomari Unit 1	Japan	PWR	1989	579
Tomari Unit 2	Japan	PWR	1991	579
Tomari Unit 3	Japan	PWR	2009	912
Torness Unit 1	UK	AGR	1988	625
Torness Unit 2	UK	AGR	1989	625
Trillo Unit 1	Spain	PWR	1988	1066
Turkey Point Unit 3	USA	PWR	1972	693
Turkey Point Unit 4	USA	PWR	1973	693
Ulchin A Unit 1	South Korea	PWR	1988	985
Ulchin A Unit 2	South Korea	PWR	1989	984
Ulchin C Unit 5	South Korea	PWR	2004	1048
Ulchin C Unit 6	South Korea	PWR	2005	1048
Unterweser Unit 1	Germany	PWR	1979	1410
Vandellos NPP 2	Spain	PWR	1988	1087
Vermont Yankee Unit 1	USA	BWR	1972	515
Vogtle Unit 1	USA	PWR	1987	1109
Vogtle Unit 2	USA	PWR	1989	1127
Waterford Unit 3	USA	PWR	1985	1075
Watts Bar Unit 1	USA	PWR	1996	1202
Wolf Creek Unit 1	USA	PWR	1985	1226
Wolsong A Unit 1	South Korea	PHWR	1983	622
Wolsong A Unit 2	South Korea	PHWR	1997	730
Wolsong B Unit 3	South Korea	PHWR	1998	729
Wolsong B Unit 4	South Korea	PHWR	1999	730
Wylfa Unit 1	UK	GCR	1971	475
Wylfa Unit 2	UK	GCR	1972	475
Yonggwang A Unit 1	South Korea	PWR	1986	985
Yonggwang A Unit 2	South Korea	PWR	1987	978
Yonggwang B Unit 3	South Korea	PWR	1995	1039
Yonggwang B Unit 4	South Korea	PWR	1996	1039
Yonggwang C Unit 5	South Korea	PWR	2002	1046
Yonggwang C Unit 6	South Korea	PWR	2002	1050
Zaporozhye Unit 1	Ukraine	PWR	1984	1000
Zaporozhye Unit 2	Ukraine	PWR	1985	1000
Zaporozhye Unit 3	Ukraine	PWR	1986	1000
Zaporozhye Unit 4	Ukraine	PWR	1987	1000
Zaporozhye Unit 5	Ukraine	PWR	1989	1000
Zaporozhye Unit 6	Ukraine	PWR	1995	1000

Appendix III

DESCRIPTIVE DATA FOR CONSTRUCT VARIABLES

This appendix summarizes the data from the global NPP survey on each of the construct and sub-construct variables. The detailed descriptive data (figures and tables) provided can be used as benchmark data. This data specifically answers the following basic research questions:

— To what extent are knowledge management practices currently supported and in use by managers in operating NPPs?
— To what extent do NPP organizations consider themselves to have a supportive organizational culture?
— To what extent do NPP organizations consider themselves to have quality knowledge processes?
— To what extent do NPP organizations consider themselves to be effective?

The construct or sub-construct value for each response case was calculated as a simple average response based on the sum of all the response values for of the set of measures that comprised that construct or sub-construct, and divided by the number of measures. For the purposes of reporting of descriptive data in this section, intermediate scale values were binned to the closest integer scale value for histogram plotting.

The exact wordings of measures used in the survey instrument (see Appendix I) are provided in the sub-sections below. For descriptive statistics on individual measures, see Appendix V. Note that the histogram for each construct shows the frequency in raw counts on the y-axis and the Likert scale value on the x-axis. For example, in Figure III.1 below, approximately 2 NPP responses rated that KMS as 1, approximately 12 NPP responses rated that KMS as 2, approximately 48 responses rated that KMS as 3, approximately 42 NPP responses rated that KMS as 4, and approximately 18 NPP responses rated that KMS as 5. A best fit normal distribution curve is provided in each plot as a useful reference to better visualize how normal the response data was in each case.

III.1. KM STRATEGY AND PLANNING RELATED KM PRACTICES

Table III.1 and Figure III.1 are the descriptive statistics and histogram respectively for the construct KMS, ‘Knowledge Management Strategy and Plan’, which includes the following measures:

— Measure KMSa: ‘The organization has clear, documented high level knowledge management plan and goals’;
— Measure KMSb: ‘Implementation of the knowledge management strategy and plan is openly and actively supported by management’;
— Measure KMSc: ‘Knowledge management roles and responsibilities are clearly defined and understood by managers and employees’;
— Measure KMSd: ‘Other management strategies (e.g. human resources, information systems, operations, communications and maintenance plans) are closely aligned with the knowledge management strategy and plan’;
— Measure KMSe: ‘The needs and gaps in the organizational knowledge base are periodically reviewed and the knowledge management strategy and plan is revised to address them’.

The scale values used were: strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), and strongly agree (5).

TABLE III.1. SUMMARY STATISTICS FOR KMS — KNOWLEDGE MANAGEMENT STRATEGY & PLAN

N	Valid	123
	Missing	6
Mean		3.512
Standard error of mean		0.0827
Median		3.0
Standard deviation		0.9176
Variance		0.842
Range		4.0

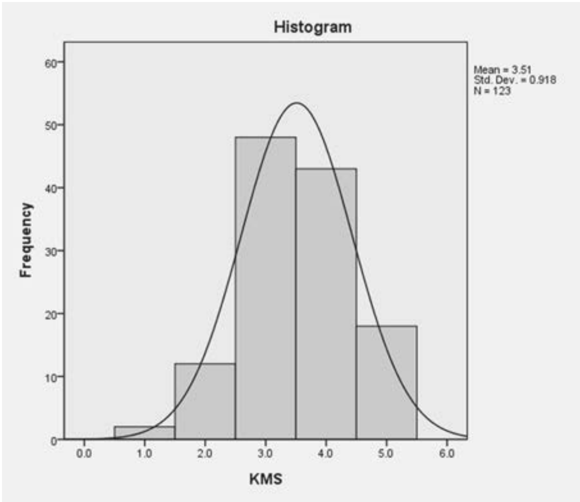


FIG. III.1. Histogram for KMS — knowledge management strategy & plan.

III.2. SUPPORT FOR ORGANIZATIONAL LEARNING RELATED KM PRACTICES

Table III.2 and Figure III.2 are the descriptive statistics and histogram respectively for the construct SOL, 'Support for organizational learning', which includes the following measures:

— Measure SOLa: 'Knowledge creation and application (e.g., finding better methods, technology innovation) is encouraged, recognized and rewarded';
— Measure SOLb: 'Sharing of knowledge is promoted and rewarded (e.g., experts are encouraged and rewarded to coach or mentor other employees)';
— Measure SOLc: 'Open communication and a no-blame approach to reporting problems and sharing lessons learned are promoted (e.g., regular communication is encouraged between maintenance and operations personnel)';
— Measure SOLd: 'Learning opportunities are encouraged (e.g., joining specialist groups or attending training seminars)'.

The scale values used were: strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), and strongly agree (5).

TABLE III.2. SUMMARY STATISTICS FOR SOL — SUPPORT FOR ORGANIZATIONAL LEARNING

N	Valid	124
	Missing	5
Mean		4.0
Standard error of mean		0.0648
Median		4.0
Standard deviation		0.7213
Variance		0.52
Range		3.0

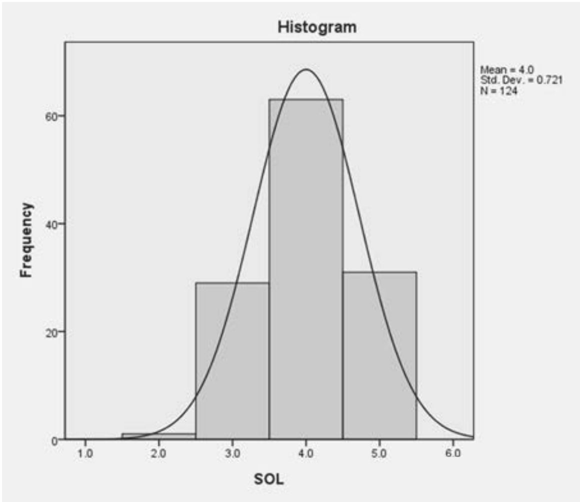


FIG. III.2. Histogram for SOL — support for organizational learning.

III.3. PROCESS MANAGEMENT RELATED KM PRACTICES

Table III.3 and Figure III.3 are the descriptive statistics and histogram respectively for the construct PMP, 'Process management related KM practices', which includes the following measures:

— Measure PMPa: 'For all processes and procedures, priority is placed on ensuring the requirements, methods, inputs, outputs, interfaces, responsibilities, and workflow are documented correctly and maintained up to date';
— Measure PMPb: 'Consideration of hazards and risk is built into all work and decision processes to ensure safety is not adversely impacted';
— Measure PMPc: 'Procedures are aligned to knowledge and information requirements of both work tasks and decision processes';
— Measure PMPd: 'A process to measure and improve the quality and control of all business, work, and decision processes is defined and followed';
— Measure PMPe: 'Comprehensive knowledge management procedures (e.g. for knowledge loss risk assessment) are documented and in use';
— Measure PMPf: 'Knowledge management processes and procedures are extended to suppliers and technical support organizations'.

The scale values used were: strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), and strongly agree (5).

TABLE III.3. SUMMARY STATISTICS FOR PMP — PROCESS MANAGEMENT PRACTICES

N	Valid	124
	Missing	5
Mean		3.661
Standard error of mean		0.0657
Median		4.0
Standard deviation		0.7313
Variance		0.535
Range		3.0

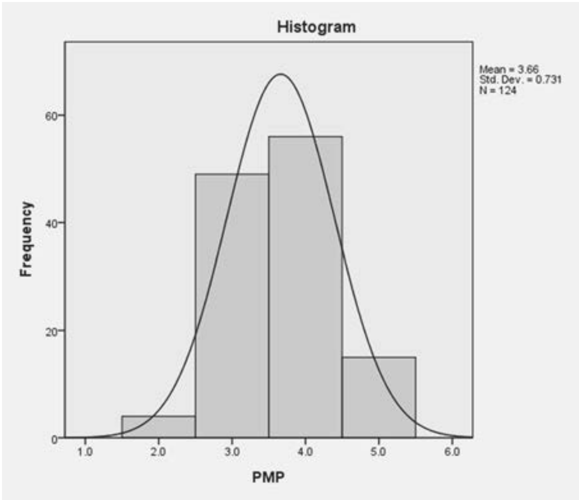


FIG. III.3. Histogram for PMP — process management practices.

III.4. INFORMATION MANAGEMENT RELATED KM PRACTICES

Table III.4 and Figure III.4 are the descriptive statistics and histogram respectively for the construct IMP: 'Information management related KM practices', which includes the following measures:

- Measure IMPa: 'Licensing documents, design basis documents, procedures, specifications, drawings, and training materials are updated promptly to address plant changes and are maintained under configuration management';
- Measure IMPb: 'Records, data, and logs are required to be complete, meaningful, accurate and accessible (e.g., logs, minutes, test results)';
- Measure IMPc: 'Data standards, metadata, document codes, subject indexes and filing systems are widely used to enable efficient information correlation, storage and retrieval';

Measure IMPd: 'Procedures ensure the needs for data and information safety, security, maintainability, accessibility, quality and preservation'. The scale values used were: strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), and strongly agree (5).

TABLE III.4. SUMMARY STATISTICS FOR IMP — INFORMATION MANAGEMENT PRACTICES

N	Valid	124
	Missing	5
Mean		4.274
Standard error of mean		0.0529
Median		4.0
Standard deviation		0.589
Variance		0.347
Range		3.0

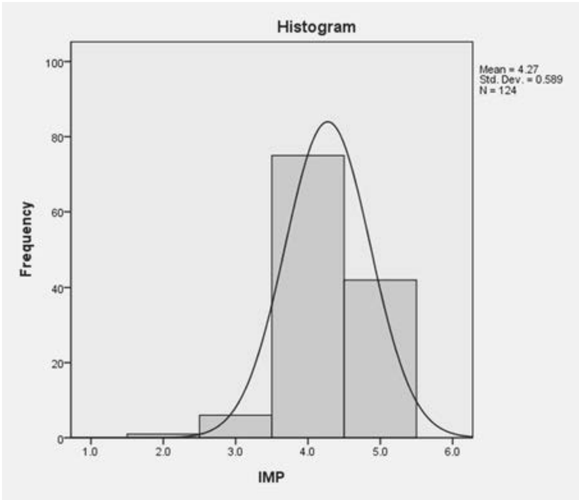


FIG. III.4. Histogram for IMP — information management practices.

III.5. ORGANIZATIONAL PERFORMANCE MANAGEMENT RELATED KM PRACTICES

Table III.5 and Figure III.5 are the descriptive statistics and histogram respectively for the construct OPM: ‘Operational performance management’ related KM practices, which includes the following measures:

— Measure OPMa: ‘Independent external peer review assessments are conducted regularly (e.g. WANO, INPO, or IAEA-OSART reviews)’;
— Measure OPMb: ‘Self-assessments are widely used to stimulate learning and improve performance (e.g. benchmarking against best practices)’;
— Measure OPMc: ‘Performance objectives are established and monitored for all levels and areas of the organization (including for knowledge processes)’;
— Measure OPMd: ‘Performance objectives for operations, maintenance, and safety are based on objectives established by industry best practice’;
— Measure OPMe: ‘The effectiveness of the management system (including knowledge management aspects) is regularly reviewed’;
— Measure OPMf: ‘On-going processes for operational experience capture, review, analysis and corrective action are defined and followed’.

The scale values used were: strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), and strongly agree (5).

TABLE III.5. SUMMARY STATISTICS FOR OPM — ORGANIZATIONAL PERFORMANCE MANAGEMENT PRACTICES

N	Valid	124
	Missing	5
Mean		4.242
Standard error of mean		0.0463
Median		4.0
Standard deviation		0.5159
Variance		0.266
Range		2.0

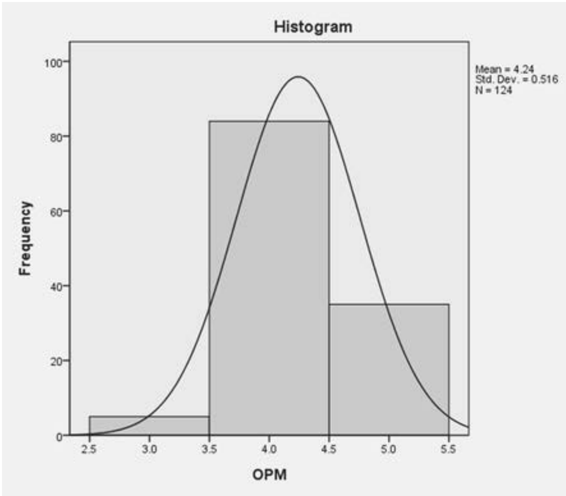


FIG. III.5. Histogram for OPM — organizational performance management practices.

III.6. TRAINING RELATED KM PRACTICES

Table III-6 and Figure III-6 are the descriptive statistics and histogram respectively for the construct TRP: 'Training related practices', which includes the following measures:

- Measure TRPa: 'The organization incorporates principles of the 'systematic approach to training' (SAT) in training programmes';
- Measure TRPb: 'Sufficient training is provided to achieve and maintain the required level of competence for all job positions';
- Measure TRPc: 'Training material is reviewed to ensure it reflects lessons learned from operating experience and agrees with plant documentation';
- Measure TRPd: 'Collaboration with universities and colleges ensures an appropriate supply of new graduates';
- Measure TRPe: 'Other techniques are used for training (e.g. story-telling, concept mapping, pre-job briefings, informal seminars, mentoring programmes etc.)'.

The scale values used were: strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), and strongly agree (5).

TABLE III.6. SUMMARY STATISTICS FOR TRP — TRAINING RELATED PRACTICES

N	Valid	124
	Missing	5
Mean		4.161
Standard error of mean		0.0477
Median		4.0
Standard deviation		0.5317
Variance		0.283
Range		2.0

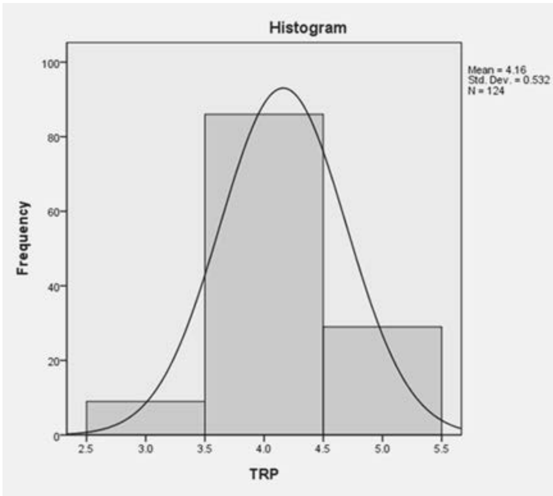


FIG. III.6. Histogram for TRP — training related practices.

III.7. HUMAN RESOURCE RELATED KM PRACTICES

Table III.7 and Figure III.7 are the descriptive statistics and histogram respectively for the construct HRP: ‘Human resource related practices’, which includes the following measures:

— Measure HRPa: ‘Expected retirements and unexpected departures are regularly tracked and the resulting need for and availability of critical knowledge and job skills is acted upon’;
— Measure HRPb: ‘New hiring is done long before experts depart to facilitate knowledge transfer and ensure the competency of replacements is developed in time’;
— Measure HRPc: ‘Interviews with departing employees are routinely carried out well in advance to identify critical knowledge and experience and to facilitate knowledge capture and transfer’;
— Measure HRPd: ‘Competency, training and knowledge sharing or transfer goals are identified, evaluated and rewarded in employee performance assessment’;
— Measure HRPe: ‘Work assignments promote learning (e.g., job-rotations, team selections and staff assignments consider learning opportunities)’.

The scale values used were: strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), and strongly agree (5).

TABLE III.7. SUMMARY STATISTICS FOR HRP — HUMAN RESOURCE PRACTICES

N	Valid	124
	Missing	5
Mean		3.282
Standard error of mean		0.0814
Median		3.0
Standard deviation		0.9067
Variance		0.822
Range		3.0

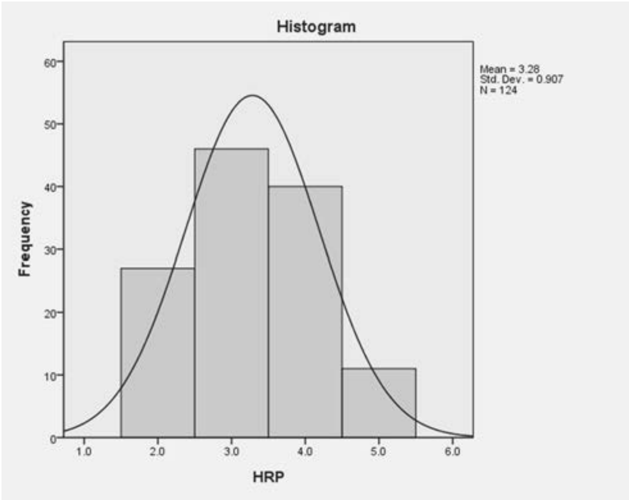


FIG. III.7. Histogram for HRP — human resource practices.

III.8. INFORMATION SYSTEMS AND TECHNOLOGY EFFECTIVENESS

Table III.8 and Figure III.8 are the descriptive statistics and histogram respectively for the construct IST: 'Information systems and technology support', which includes the following measures:

— Measure ISTa: 'Three dimensional (3D) virtual reality environments for training';
— Measure ISTb: 'Computer and/or web-based training';
— Measure ISTc: 'Desktop (e.g. plant) training simulators';
— Measure ISTd: 'Full scope main control room training simulators';
— Measure ISTe: 'Electronic archives and databases (e.g. for document management, event reporting, maintenance records, etc.)';
— Measure ISTf: 'Enterprise application software (e.g. for financials, procurement, parts inventory management, work and outage management, etc.)';
— Measure ISTg: 'Intranet web portal with search/retrieval access to frequently used resources (e.g. documents, bulletins, contact lists, etc.)';
— Measure ISTh: 'Three-dimensional (3D) computer aided design (CAD) plant models and editable electronic drawings'.

The scale values used were: very effectively (1), effectively (2), somewhat effectively (3), not effectively (4), not used at all (5).

TABLE III.8. SUMMARY STATISTICS FOR IST — INFORMATION SYSTEMS & TECHNOLOGY

N	Valid	123
	Missing	6
Mean		3.512
Standard error of mean		0.0687
Median		4.0
Standard deviation		0.7614
Variance		0.58
Range		4.0

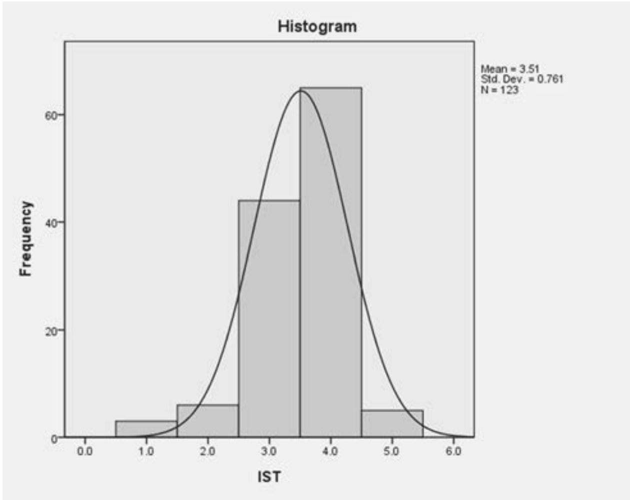


FIG. III.8. Histogram for IST — information systems & technology.

III.9. OPERATIONAL DECISION SUPPORT SYSTEM EFFECTIVENESS

Table III.9 and Figure III.9 are the descriptive statistics and histogram respectively for the construct OSS: ‘Advanced operational support systems’, which includes the following measures:

— Measure OSSa: ‘Operational decision support systems (e.g. refuelling software)’;
— Measure OSSb: ‘Regularly updated (i.e. ‘living’) probabilistic risk models of equipment reliability for maintenance and outage planning’;
— Measure OSSc: ‘Real-time probabilistic risk models for operator evaluation and awareness of plant safety (i.e. ‘a safety monitor’)’;
— Measure OSSd: ‘System health monitors (e.g. predictive maintenance tools such as vibration, acoustic, thermal, or other monitors)’;
— Measure OSSe: ‘Advanced model-based monitoring and diagnostics (e.g. physics, chemistry, boiler, feed water and thermal hydraulics models)’;
— Measure OSSf: ‘Advanced information exchange (e.g. hand-held computers, plant-wide equipment status monitoring, wireless communications)’;
— Measure OSSg: ‘Electronic (i.e. graphical) road-maps of business and decision processes or work-flows (e.g. operational flow-sheets) with links to supporting procedures, related resources or documents’;
— Measure OSSh: ‘Automated field data collection (i.e., smart instruments, field-bus, radio frequency identification (RFID) tagging, data logging, equipment monitors)’;
— Measure OSSi: ‘Other’.

The scale values used were: very effectively (1), effectively (2), somewhat effectively (3), not effectively (4), not used at all (5).

TABLE III.9. SUMMARY STATISTICS FOR OSS — OPERATIONAL SUPPORT SYSTEMS

N	Valid	120
	Missing	9
Mean		3.225
Standard error of mean		0.0841
Median		3.0
Standard deviation		0.9209
Variance		0.848
Range		4.0

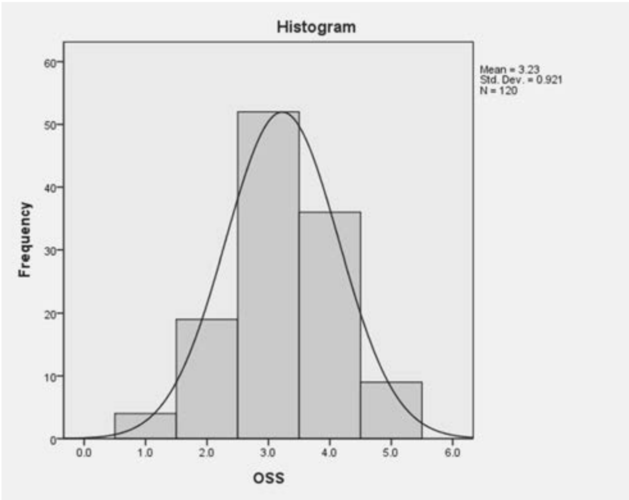


FIG. III.9. Histogram for OSS — operational support systems.

III.10. QUALITY OF KNOWLEDGE ACQUISITION AND ADOPTION PROCESSES

Table III.10 and Figure III.10 are the descriptive statistics and histogram respectively for the construct KA: 'Knowledge acquisition and adoption', which includes the following measures:

— Measure KAa: 'The organization has difficulty finding and hiring appropriately qualified graduates'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
— Measure KAb: 'The organization excels at identifying and acquiring external technical information needed to operate and maintain the plant';
— Measure KAc: 'External information acquired is often not organized or stored in a maintainable and accessible way to facilitate use and re-use'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
— Measure KAd: 'The organization is effective at acquiring knowledge from external (e.g. peer-plant) operating experiences';
— Measure KAe: 'The organization is highly effective at adopting external best practices';
— Measure KAf: 'The organization is good at capturing technical know-how and relevant design information related to services or products received from outside organizations'.

The scale values used were: strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), and strongly agree (5).

TABLE III.10. SUMMARY STATISTICS FOR KA
— KNOWLEDGE ACQUISITION & ADOPTION

N	Valid	124
	Missing	5
Mean		3.5
Standard error of mean		0.0601
Median		3.0
Standard deviation		0.6687
Variance		0.447
Range		3.0

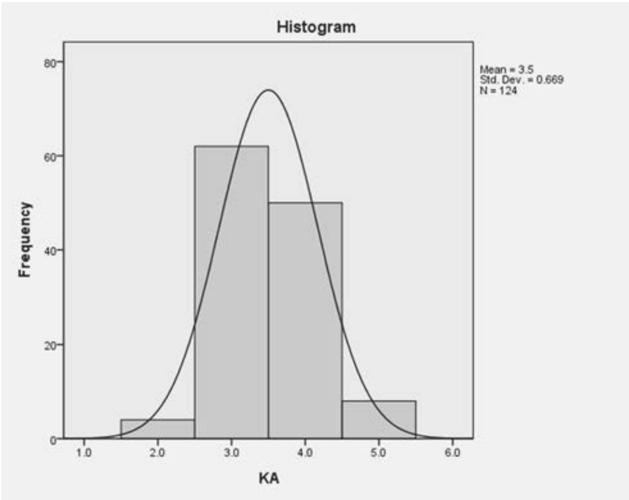


FIG. III.10. Histogram for KA — knowledge acquisition & adoption.

III.11. QUALITY OF KNOWLEDGE GENERATION AND VALIDATION PROCESSES

Table III.11 and Figure III.11 are the descriptive statistics and histogram respectively for the construct KG, ‘Knowledge generation and validation’, which includes the following measures:

— Measure KGa: ‘NPP staff learn from operating experience and new and better ways of running the plant are seldom overlooked’;
— Measure KGb: ‘Independent review processes are effective at validating proposed operational or design changes that may impact safety or production’;
— Measure KGc: ‘Employees lack the questioning attitude needed to challenge assumptions and investigate anomalies or uncertainties’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
— Measure KGd: ‘Employees regularly create innovative solutions by combining or adapting existing and/or acquired knowledge’;
— Measure KGe: ‘The organization excels at generating, transforming, and presenting plant data as meaningful information’;
— Measure KGf: ‘Engineers have to spend too much time gathering and compiling data from many sources’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

The scale values used were: strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), and strongly agree (5).

TABLE III.11. SUMMARY STATISTICS FOR KG
— KNOWLEDGE GENERATION & VALIDATION

N	Valid	123
	Missing	6
Mean		3.553
Standard error of mean		0.0613
Median		4.0
Standard deviation		0.68
Variance		0.462
Range		3.0

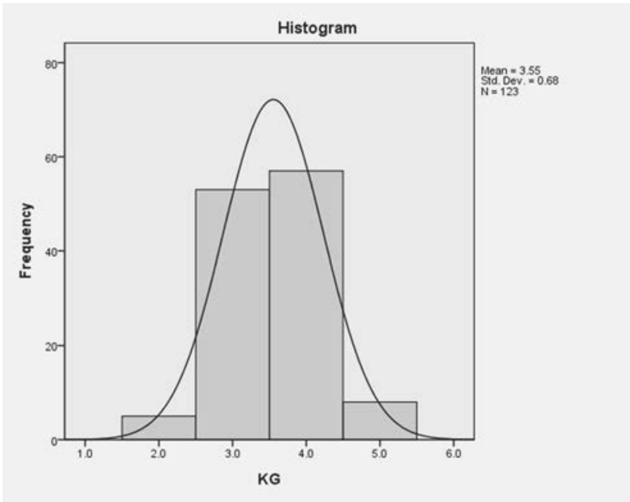


FIG. III.11. Histogram for KG — knowledge generation & validation.

III.12. QUALITY OF KNOWLEDGE SHARING AND TRANSFER PROCESSES

Table III.12 and Figure III.12 are the descriptive statistics and histogram respectively for the construct KS: 'Knowledge sharing and transfer', which includes the following measures:

— Measure KSa: 'Findings, information, data, reports, or files generated in one area of the company are readily accessible to other areas';
— Measure KSb: 'Employees often do not know where in the organization to find specialized knowledge and information'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
— Measure KSc: 'The problem of hoarding (keeping) knowledge does not exist and employees willingly share their knowledge with co-workers';
— Measure KSd: 'Expertise and skills are not effectively transferred to junior staff from more experienced employees'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
— Measure KSe: 'Employees routinely and voluntarily share relevant information with other parts of the organization where it may be needed'.

The scale values used were: strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), and strongly agree (5).

TABLE III.12. SUMMARY STATISTICS FOR
KS — KNOWLEDGE SHARING & TRANSFER

N	Valid	123
	Missing	6
Mean		3.61
Standard error of mean		0.067
Median		4.0
Standard deviation		0.7425
Variance		0.551
Range		3.0

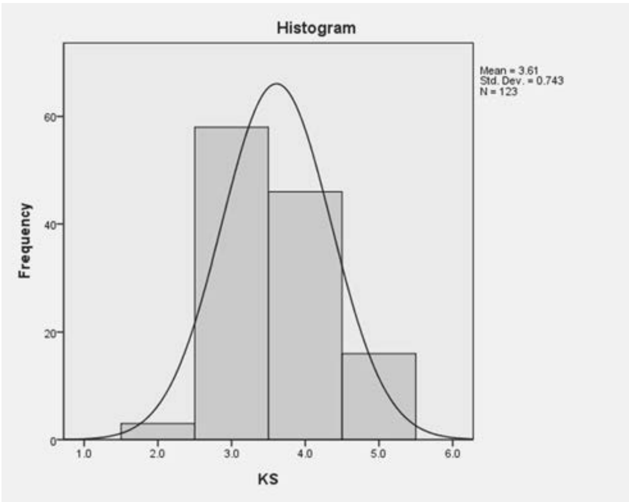


FIG. III.12. Histogram for KS — knowledge sharing & transfer.

III.13. QUALITY OF KNOWLEDGE UTILIZATION AND APPLICATION PROCESSES

Table III.13 and Figure III.13 are the descriptive statistics and histogram respectively for the construct KU: 'Knowledge utilization and application', which includes the following measures:

— Measure KUa: 'Lessons learned from operating experience are incorporated in work practices, manuals, procedures and decision-making';
— Measure KUb: 'The organization is often not able to apply its knowledge effectively to solve difficult technical problems'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
— Measure KUc: 'Employees are consistently able to make important technical decisions correctly';
— Measure KUd: 'Employees are not always aware of and do not always make effective use of each other's skills and expertise'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
— Measure KUe: 'Equipment replacement and design change decisions are based on a risk-informed decision processes'.

The scale values used were: strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), and strongly agree (5).

TABLE III.13. SUMMARY STATISTICS FOR KU
— KNOWLEDGE UTILIZATION & APPLICATION

N	Valid	124
	Missing	5
Mean		3.847
Standard error of mean		0.0606
Median		4.0
Standard deviation		0.6753
Variance		0.456
Range		2.0

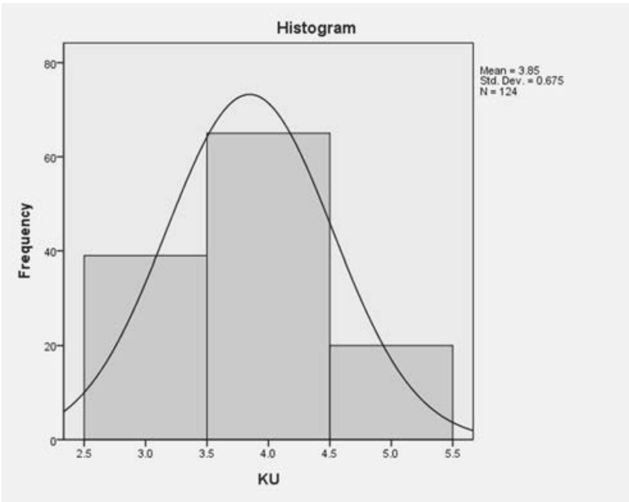


FIG. III.13. Histogram for KU — knowledge utilization & application.

III.14. QUALITY OF KNOWLEDGE RETENTION AND STORAGE PROCESSES

Table III.14 and Figure III.14 are the descriptive statistics and histogram respectively for the construct KR: 'Knowledge retention and storage', which includes the following measures:

— Measure KRa: 'Employees often lack an appropriate knowledge of the reactor and power plant fundamentals'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
— Measure KRb: 'Employees have adequate knowledge/understanding of work processes (e.g. industrial and radiation safety work practices)';
— Measure KRc: 'There is often a shortage of critical skills and experience due to unexpected departures and retirements'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
— Measure KRd: 'Plant design basis documents are easily located and are up-to-date and accurate';
— Measure KRe: 'Maintenance, operations, or technical support specialists lack adequate knowledge of specific systems and technologies to enable them to work effectively and safely'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

The scale values used were: strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), and strongly agree (5).

TABLE III.14. SUMMARY STATISTICS FOR KR
— KNOWLEDGE RETENTION & STORAGE

N	Valid	123
	Missing	6
Mean		4.0
Standard error of mean		0.06
Median		4.0
Standard deviation		0.6653
Variance		0.443
Range		3.0

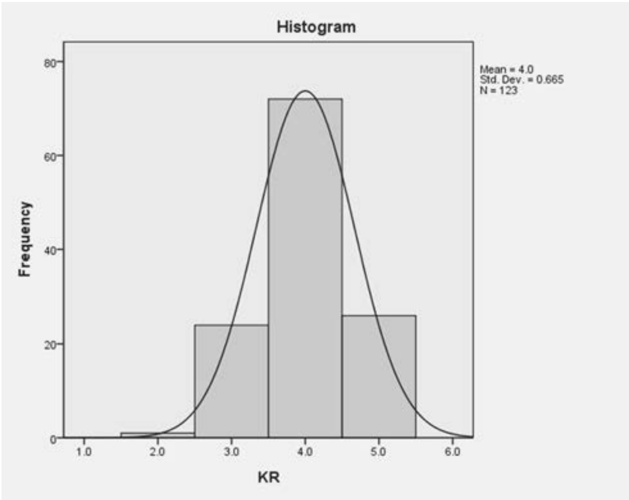


FIG. III.14. Histogram for KR — knowledge retention & storage.

III.15. SUPPORTIVE ORGANIZATIONAL CULTURE

Table III.15 and Figure III.15 are the descriptive statistics and histogram respectively for the construct SOC: ‘Supportive organizational culture’, which includes the following measures:

— Measure SOCa: ‘Managers and employees often do not see learning, innovation, and improvement as a part of their jobs’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
— Measure SOCb: ‘Employees who innovate-feel recognized and rewarded’;
— Measure SOCc: ‘There is a prevailing attitude and commitment to follow defined processes and fully comply with procedures’;
— Measure SOCd: ‘Employees often do not feel empowered to make decisions appropriate to their job duties’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
— Measure SOCe: ‘There is shared vision, purpose, and expectations among employees and they see all their problems as mutual’;
— Measure SOCf: ‘People are seen as the organisation’s most valued asset’;
— Measure SOCg: ‘Employees and managers are open-minded and respect each other’s opinions and contributions’;
— Measure SOCh: ‘There is a team-oriented approach throughout the station (e.g., employees trust, cooperate, and help each other)’;
— Measure SOCi: ‘Employees often do not feel responsible for plant performance and fail to demonstrate their commitment to it’. Note the data was reverse coding corrected to

support statistical analysis and should be interpreted as the results for the equivalent positively worded question;

— Measure SOCj: ‘Consideration of safety is clearly evident in employee and management actions and decisions’;
— Measure SOCk: ‘Improvements are mostly driven by externally imposed requirements (e.g. regulatory rulings, owner influences)’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question (i.e. in this case, ‘mostly driven by internally imposed requirements’);
— Measure SOCl: ‘A questioning attitude is cultivated (i.e. information, approaches and decisions are carefully scrutinized)’;
— Measure SOCm: ‘The organization is focused primarily on short-term goals’.

The scale values used were: strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), and strongly agree (5).

TABLE III.15. SUMMARY STATISTICS FOR SOC — SUPPORTIVE ORGANIZATIONAL CULTURE

N	Valid	124
	Missing	5
Mean		3.847
Standard error of mean		0.0584
Median		4.0
Standard deviation		0.6508
Variance		0.423
Range		3.0

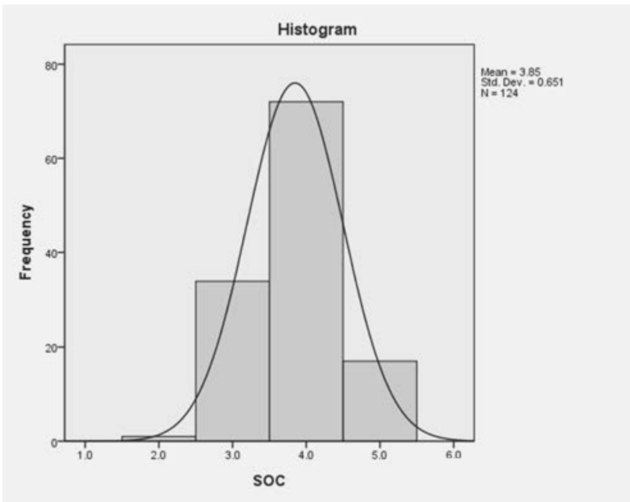


FIG. III.15. Histogram for SOC — supportive organizational culture.

III.16. ORGANIZATIONAL EFFECTIVENESS

Table III.16 and Figure III.16 are the descriptive statistics and histogram respectively for the construct OE: ‘Organizational effectiveness’, which includes the following measures:

- Measure OEa: ‘The organization has difficulty making operational changes smoothly and in a timely manner’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
- Measure OEb: ‘Maintenance technicians consistently conduct high-quality corrective and preventive maintenance’;
- Measure OEc: ‘The ratio of corrective to preventive maintenance is high relative to best performing NPPs of similar design’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question (i.e., in this case, interpreted as ‘the ratio of corrective to preventive maintenance is similar to best performing NPPs of similar design’);
- Measure OEd: ‘The plant chemistry programme ensures the plant consistently operates within the chemistry specifications’;
- Measure OEe: ‘Projects involving multiple departments are typically behind schedule, over-budget, and not well coordinated’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question (i.e. in this case, ‘on schedule, on budget, and well-coordinated’);
- Measure OEf: ‘Safety objectives are consistently met or exceeded’;
- Measure OEg: ‘System and/or performance analysis engineers are not effective at resolving problems that affect plant safety or performance’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
- Measure OEh: ‘Radiological conditions are effectively controlled (i.e. field levels are as low as reasonably achievable and dose control is effective)’;
- Measure OEi: ‘Quality of documentation (i.e. design, work-process and procedural documentation) needs to improve’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question (i.e. in this case interpreted as: ‘quality of documentation is adequate and does not need to improve’);
- Measure OEj: ‘Operators effectively act on changing plant conditions to ensure on-going safe and reliable plant operation’;
- Measure OEk: ‘Weekly operations objectives are regularly not met’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
- Measure OEl: ‘Work planning and management is effective (e.g. planned work-scope is stable, little time is wasted waiting on approvals or parts)’;
- Measure OEm: ‘The average number of critical component failures per year is low relative to other similar plants’;
- Measure OEn: ‘Recurrence of known and avoidable operational problems is not always prevented’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
- Measure OEo: ‘The organization is effective at managing its external interfaces (i.e. the regulator, public, suppliers, contractors);

— Measure OEp: ‘Environmental objectives are sometimes not met’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
— Measure OEq: ‘Maintenance objectives (e.g. level of corrective and preventive maintenance backlog) based on industry best practice are consistently met or exceeded’;
— Measure OEr: ‘Financial objectives are often not met’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question;
— Measure OEs: ‘Regulatory objectives are consistently met or exceeded’;
— Measure OEt: ‘System health improvement initiatives are effective’;
— Measure OEu: ‘Corrective and preventive maintenance and outage work is completed on schedule and in a timely manner’;
— Measure OEv: ‘Financial resources (budgets) are adequate and allocated wisely’.

The scale values used were: strongly disagree (1), somewhat disagree (2), neither agree nor disagree (3), somewhat agree (4), and strongly agree (5).

TABLE III.16. SUMMARY STATISTICS FOR OE — ORGANIZATIONAL EFFECTIVENESS

N	Valid	124
	Missing	5
Mean		3.887
Standard error of mean		0.054
Median		4.0
Standard deviation		0.6009
Variance		0.361
Range		2.0

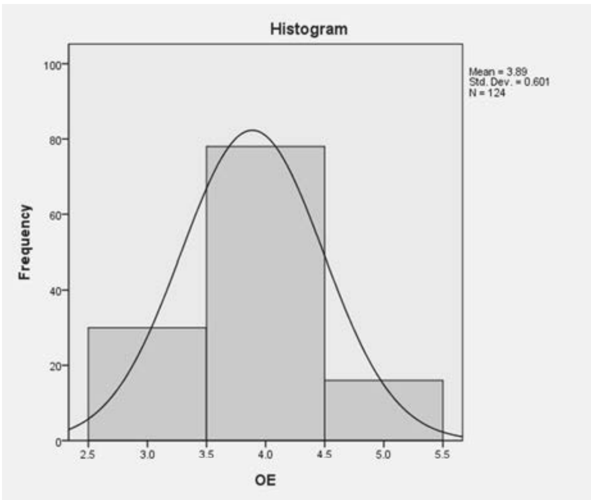


FIG. III.16. Histogram for OE — organizational effectiveness.

Appendix IV

BIVARIATE SCATTERPLOTS FOR CONSTRUCTS

A simple bivariate scatterplot is a useful method of visualizing the basic relationship between the various constructs and sub-constructs in the model. This Appendix provides this plot for each of these relationships (adapted from Ref. [2]). Note that the darker points in the scatterplots indicate coincidental (i.e. one or more) points are plotted. Table IV.1 is a legend to the construct and sub-construct variable names used on the scatterplots.

The scatterplots in this appendix are provided so NPP managers have a visual presentation of the main effects relationships data. Readers who are interested in specific two-way relationships may use this appendix to better visualize the nature of the correlations of interest.

A scatterplot that has a somewhat random pattern indicates the relationship between the constructs plotted is likely very weak or non-existent. The first scatterplot in Section IV.1.1 — Knowledge Acquisition and Adoption (KA) versus Knowledge Management Strategy and Plan (KMS) is such an example. Alternatively a scatterplot that exhibits an obvious trend in the data likely indicates a linear relationship exists. The third scatterplot in Section IV.1.1 — Knowledge Generation and Validation (KG) versus Knowledge Management Strategy and Plan (KMS) is such an example. The slope of the trend (assuming it is linear) indicates the sign (positive or negative) and the nature (i.e. rate of change) in the relationship. The closer the points are to a true linear trend line, the more statistically significant the relationship will be.

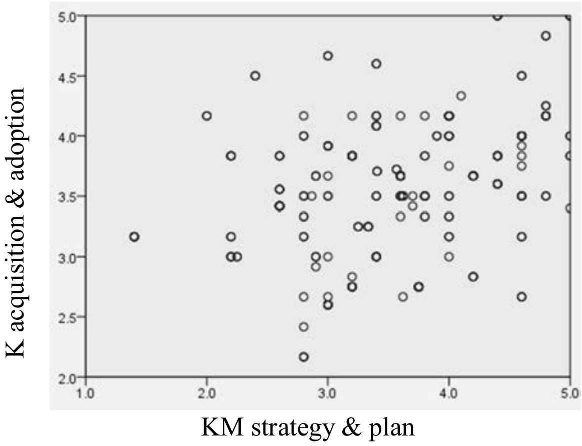
TABLE IV.1. LIST OF CONSTRUCT NAMES AND INDICATOR MEASURES (see Ref. [2])

No	Construct variable	Description of indicator measures (i.e. individual survey questions) included in each construct (or sub-construct)
1	KMS	KM strategy and planning — average response from questions A1 a–e
2	SOL	Support for organizational learning — average response from questions A2 a–d
3	PMP	Process management related KM practices — average response questions A3 a–f
4	IMP	Information management practices — average response from questions A4 a–d
5	OPM	Organizational performance management related KM practices — average response from questions A5 a–f
6	TRP	Training related practices — average response from questions A6 a–e
7	HRP	Human resource related KM practices — average response from questions A7 a–e
8	IST	Information systems and technology support — average response from questions B1 a–h
9	OSS	Advanced operational support systems — average response from questions B2 a–i
10	KA	Quality of knowledge acquisition and adoption processes – average response from questions C1 a–f
11	KG	Quality of knowledge generation & validation processes — average response from questions C2 a–f
12	KS	Quality of knowledge sharing and transfer processes — average response from questions C3 a–e
13	KU	Quality of knowledge utilization and application processes — average response from questions C4 a–e
14	KR	Quality of knowledge retention and storage processes — average response from questions C5 a–e
15	SOC	Supportive organizational culture — average response from questions D1 a–m
16	OE	Organizational effectiveness — average response from questions E1 a–v
17	OTS	Organizational Technology Support — the combination of IST and OSS together

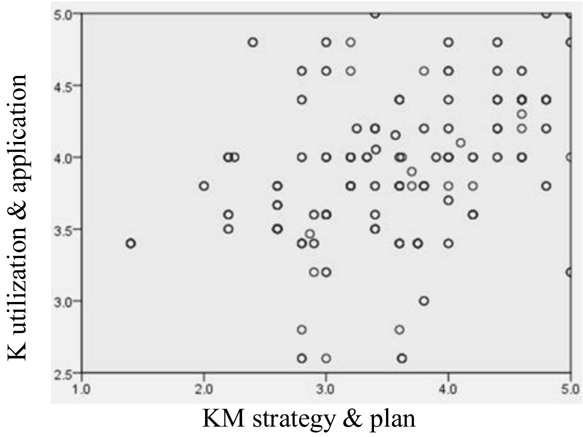
Note: the following measures were considered unreliable from the construct reliability analysis and were removed from the data set and statistical analysis: TRPd, ISTa, OSSi, KAa, SOCc, and OEc. Improvements to these measures are planned for future versions of the survey and these are summarized in Appendix VIII.

IV.1. SCATTERPLOTS OF KNOWLEDGE PROCESSES vs. KNOWLEDGE MANAGEMENT PRACTICES

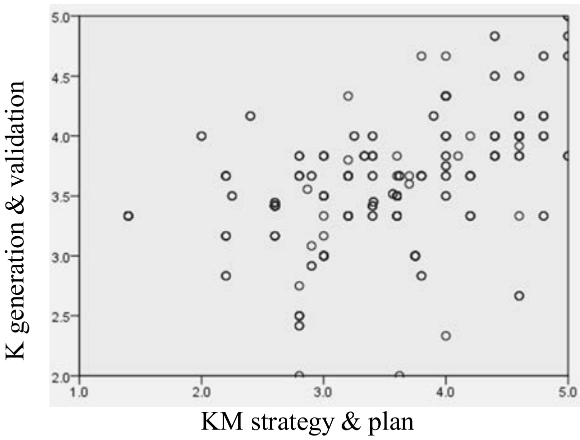
IV.1.1. Quality of knowledge processes vs. KM strategy and plan



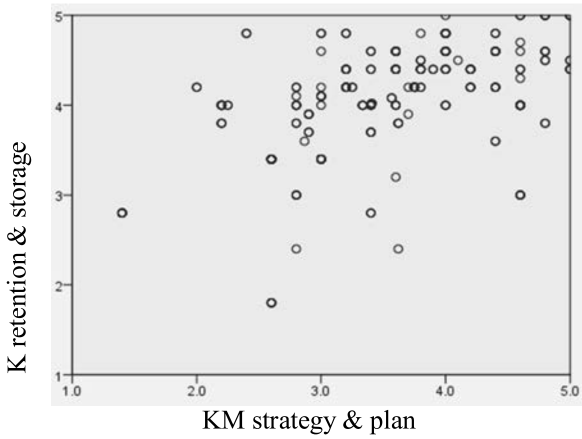
Scatterplot of KA vs. KMS



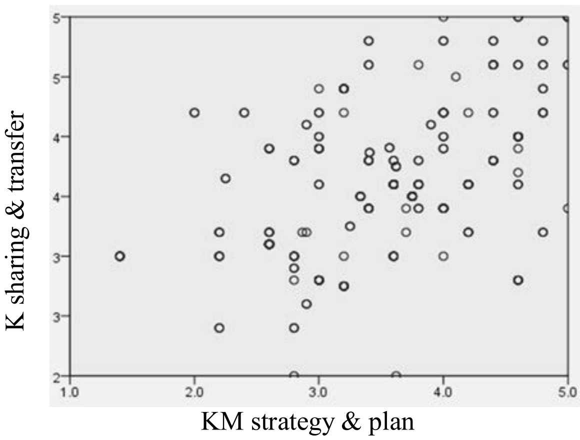
Scatterplot of KU vs. KMS



Scatterplot of KG vs. KMS



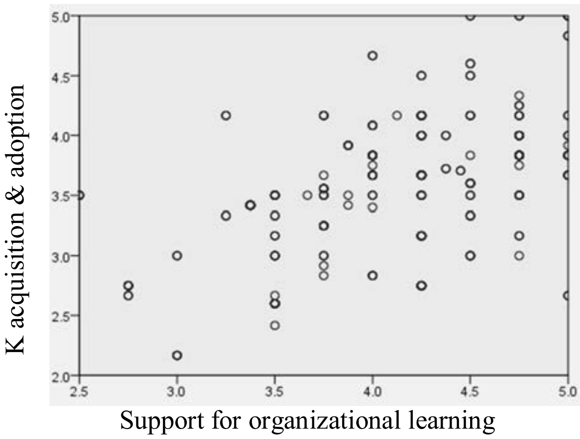
Scatterplot of KR vs. KMS



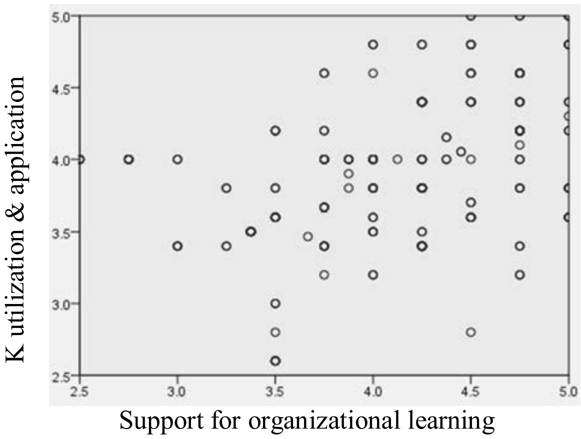
Scatterplot of KS vs. KMS

FIG. IV.1. Scatterplots of quality of knowledge processes vs. KM strategy & plan.

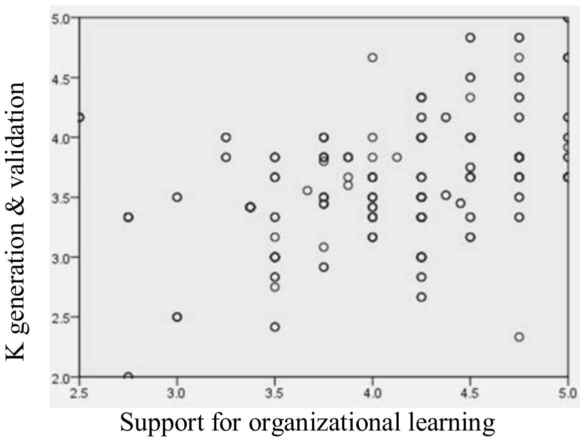
IV.1.2. Quality of knowledge processes vs. support for organizational learning



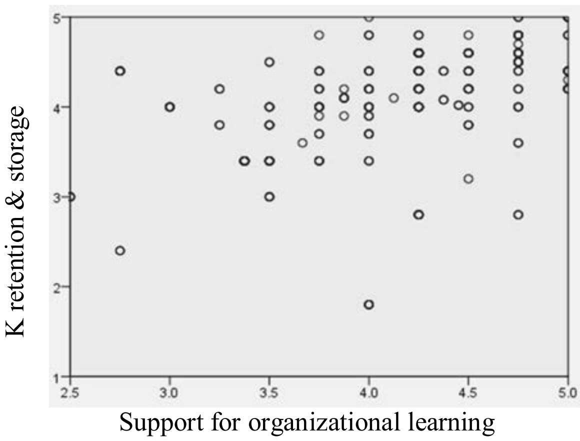
Scatterplot of KA vs. SOL



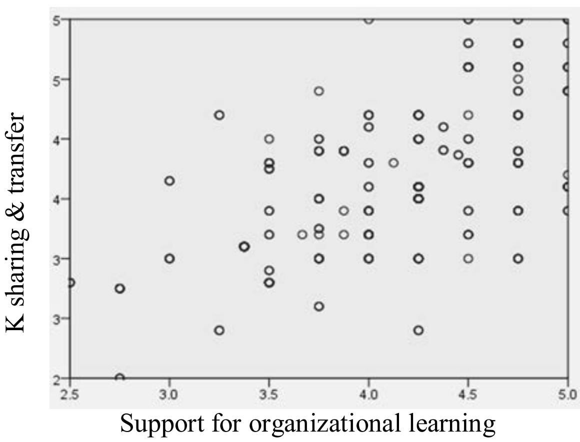
Scatterplot of KU vs. SOL



Scatterplot of KG vs. SOL



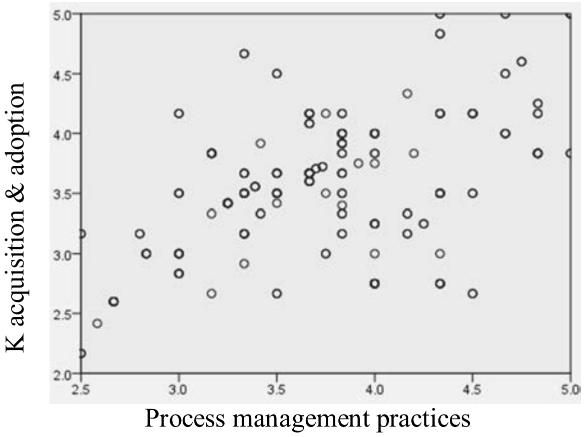
Scatterplot of KR vs. SOL



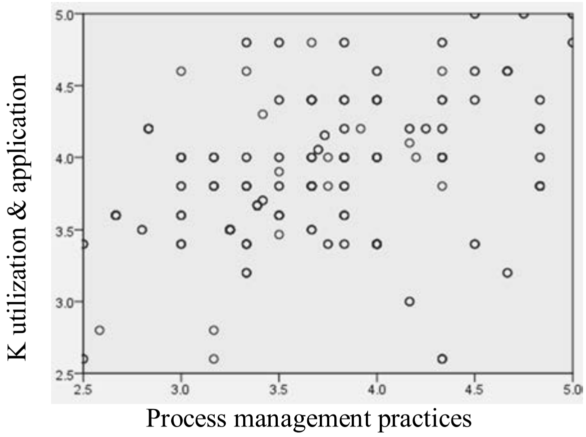
Scatterplot of KS vs. SOL

FIG. IV.2. Scatterplots of quality of knowledge processes vs. support for organizational learning.

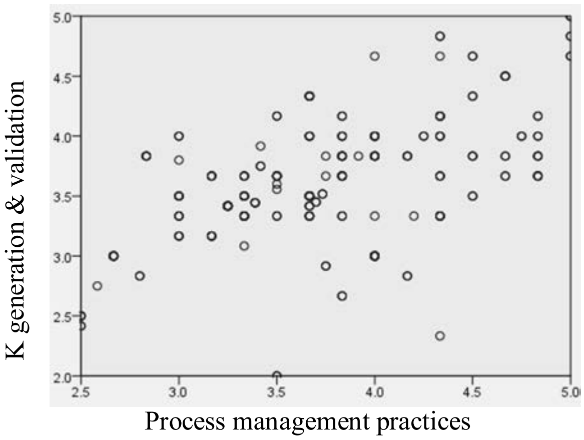
IV.1.3. Quality of knowledge processes vs. process management related KM practices



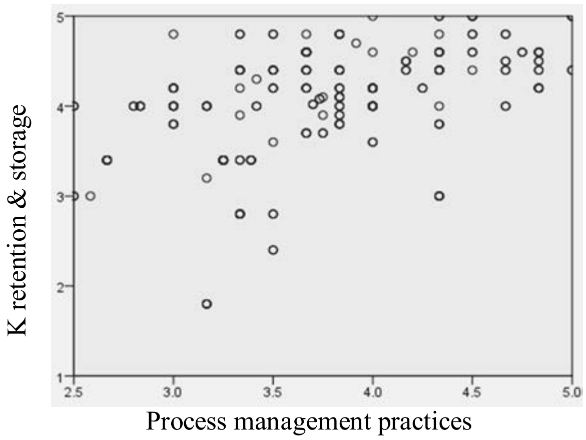
Scatterplot of KA vs. PMP



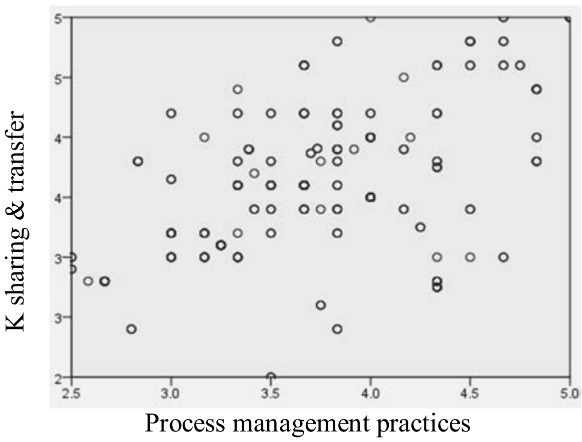
Scatterplot of KU vs. PMP



Scatterplot of KG vs. PMP



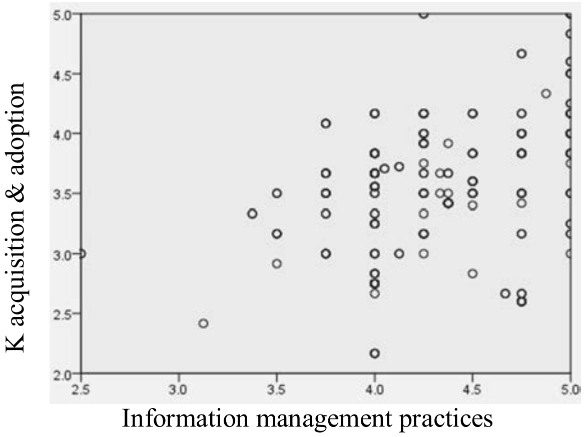
Scatterplot of KR vs. PMP



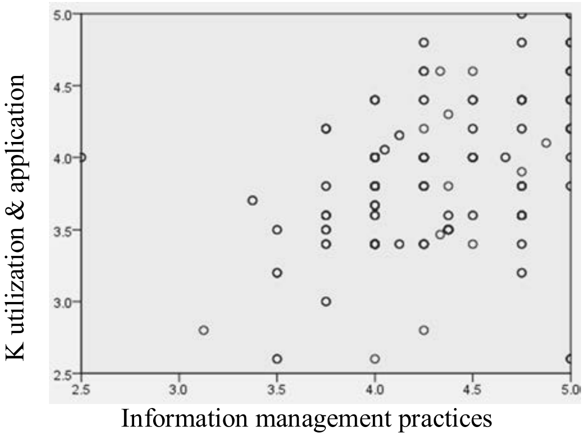
Scatterplot of KS vs. PMP

FIG. IV.3. Scatterplots of quality of knowledge processes vs. process management practices.

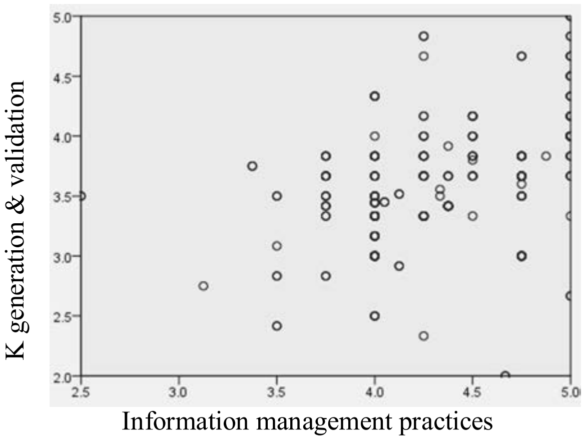
IV.1.4. Quality of knowledge processes vs. information management related KM practices



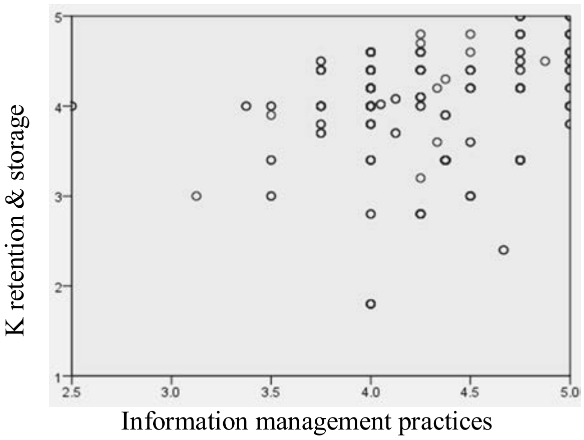
Scatterplot of KA vs. IMP



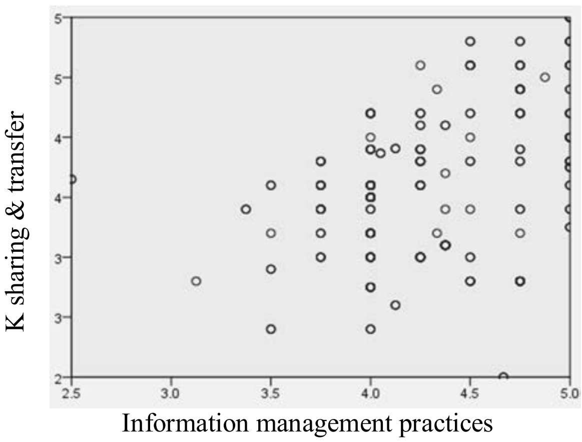
Scatterplot of KU vs. IMP



Scatterplot of KG vs. IMP



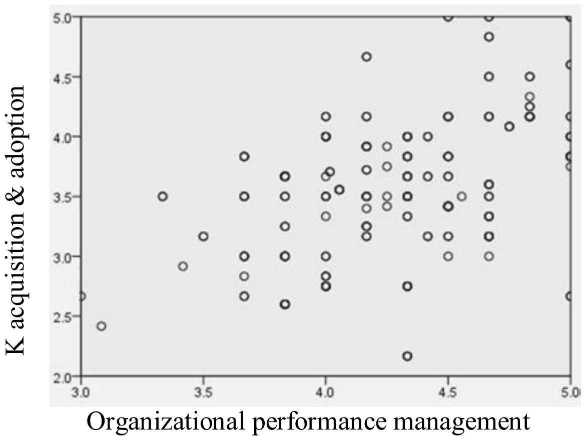
Scatterplot of KR vs. IMP



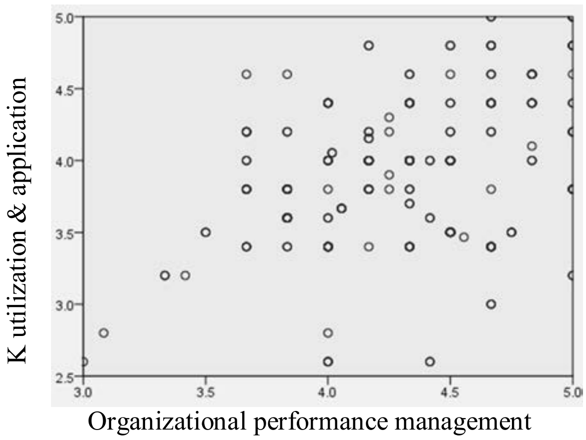
Scatterplot of KS vs. IMP

FIG. IV.4. Scatterplots of quality of knowledge processes vs. information management practices.

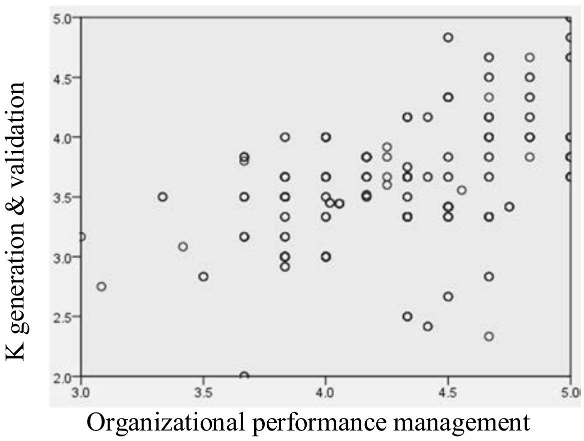
IV.1.5. Quality of knowledge processes vs. organizational performance management related KM practices



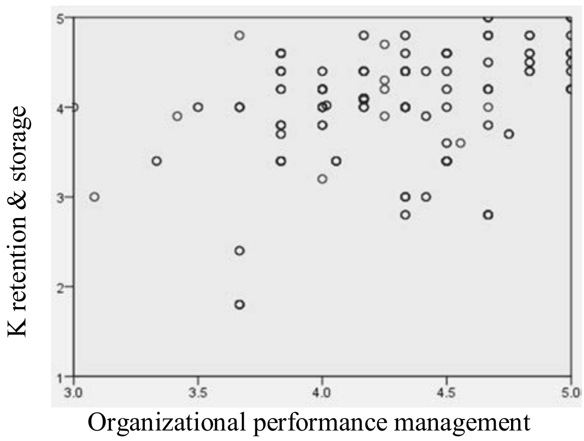
Scatterplot of KA vs. OPM



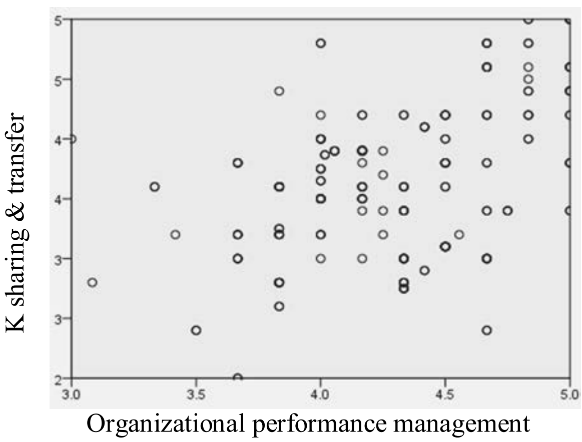
Scatterplot of KU vs. OPM



Scatterplot of KG vs. OPM



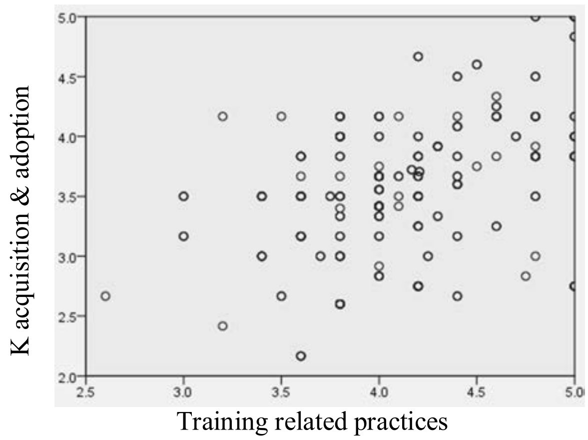
Scatterplot of KR vs. OPM



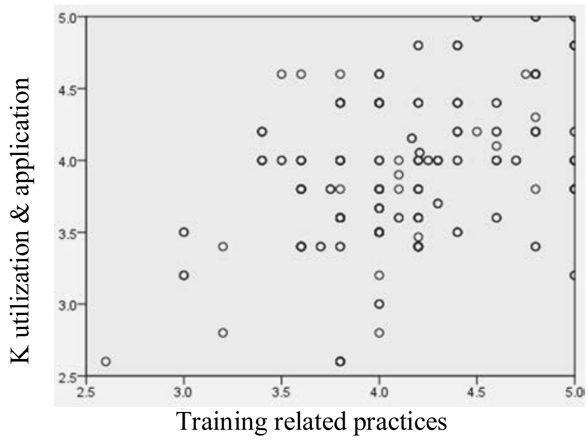
Scatterplot of KS vs. OPM

FIG. IV.5. Scatterplots of quality of knowledge processes vs. organizational performance management.

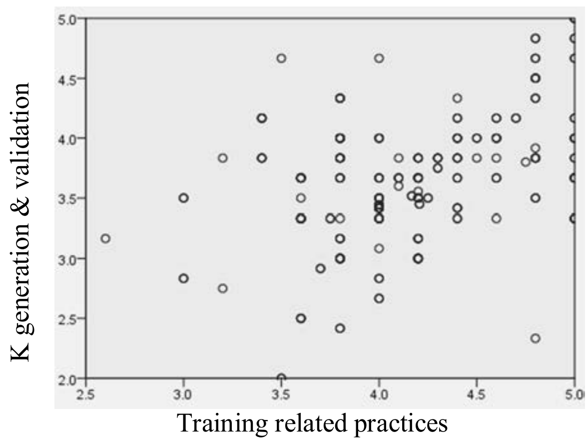
IV.1.6. Quality of knowledge processes vs. training related KM practices



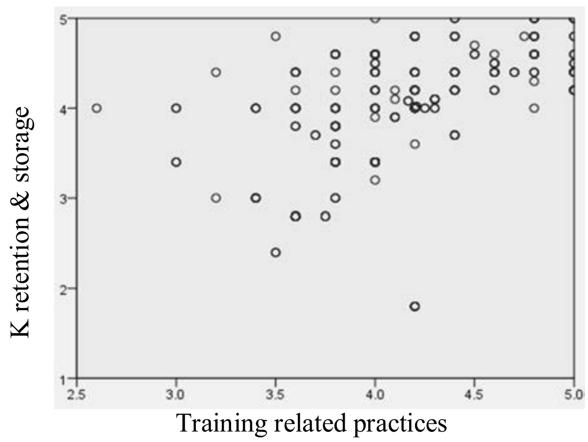
Scatterplot of KA vs. TRP



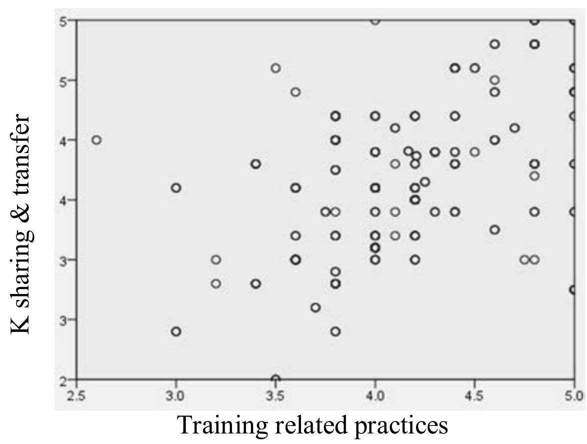
Scatterplot of KU vs. TRP



Scatterplot of KG vs. TRP



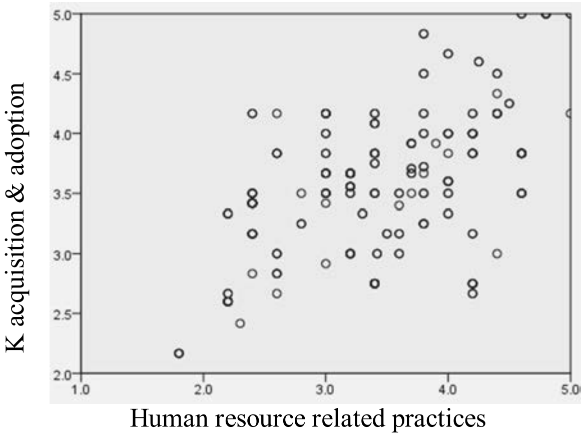
Scatterplot of KR vs. TRP



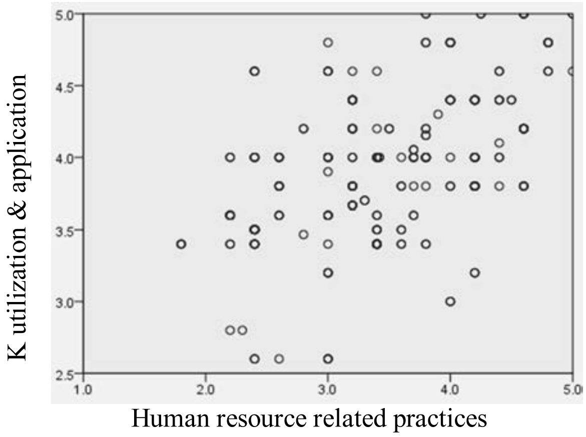
Scatterplot of KS vs. TRP

FIG. IV.6. Scatterplots of quality of knowledge processes vs. training related practices.

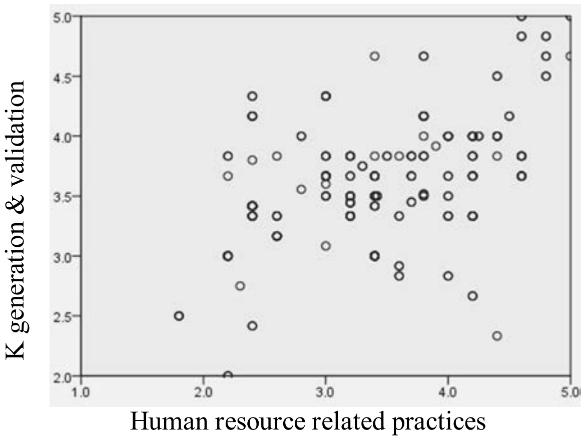
IV.1.7. Quality of knowledge processes vs. human resource related KM practices



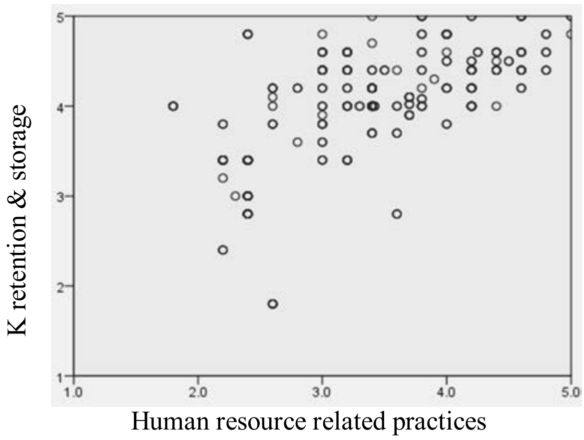
Scatterplot of KA vs. HRP



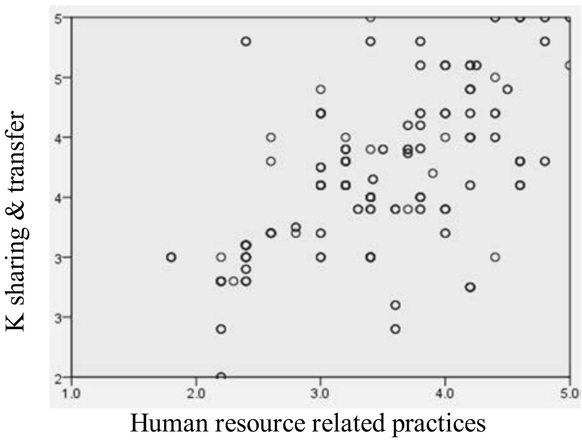
Scatterplot of KU vs. HRP



Scatterplot of KG vs. HRP



Scatterplot of KR vs. HRP

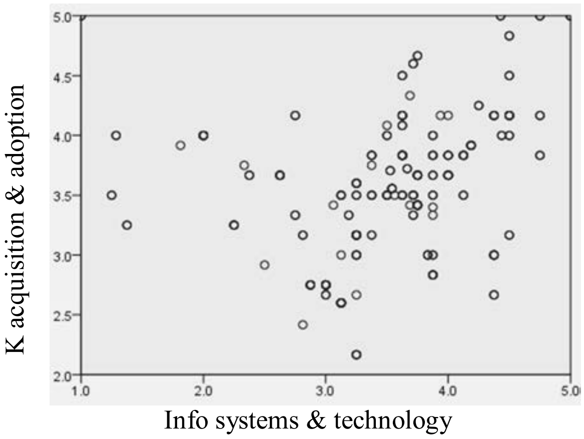


Scatterplot of KS vs. HRP

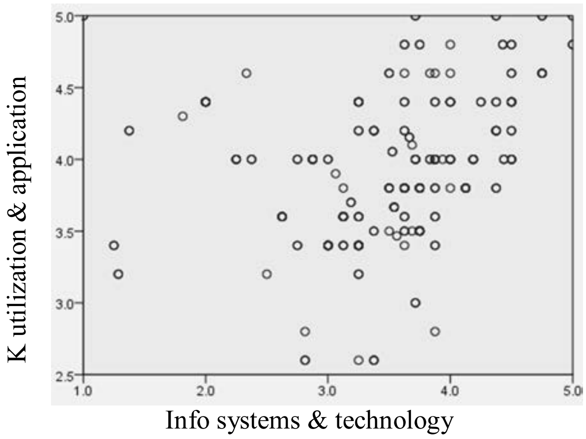
FIG. IV.7. Scatterplots of quality of knowledge processes vs. human resource practices.

IV.2. SCATTERPLOTS OF KNOWLEDGE PROCESSES vs. ORGANIZATIONAL TECHNOLOGY SUPPORT CONSTRUCTS

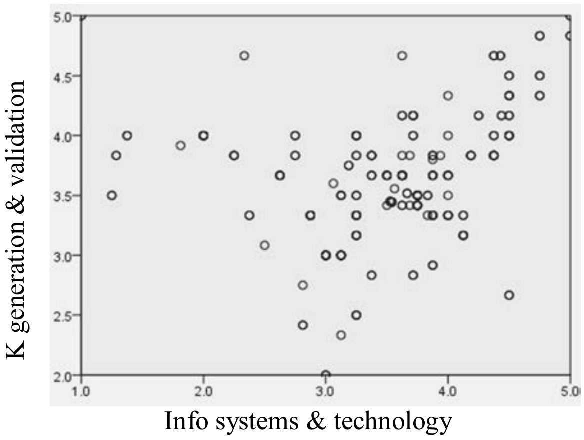
IV.2.1. Quality of knowledge processes vs. information systems & technology



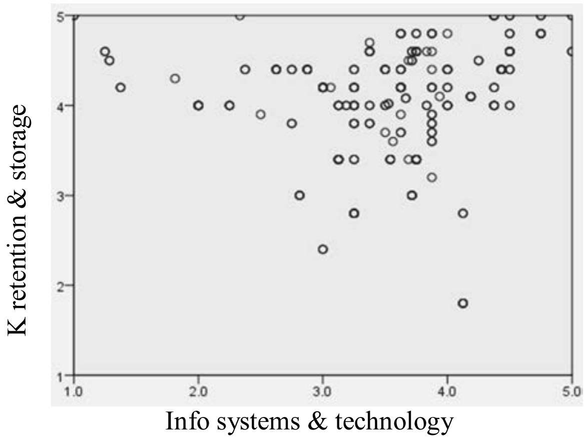
Scatterplot of KA vs. IST



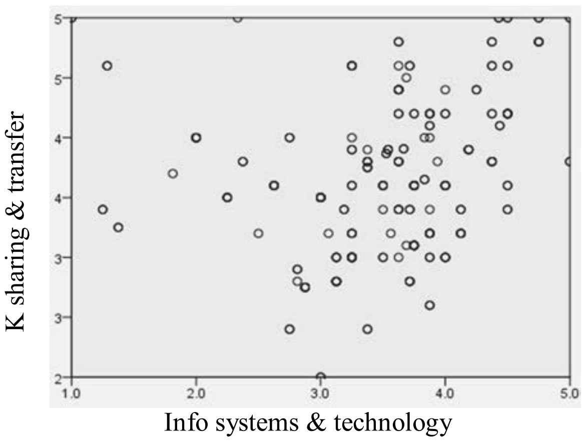
Scatterplot of KU vs. IST



Scatterplot of KG vs. IST



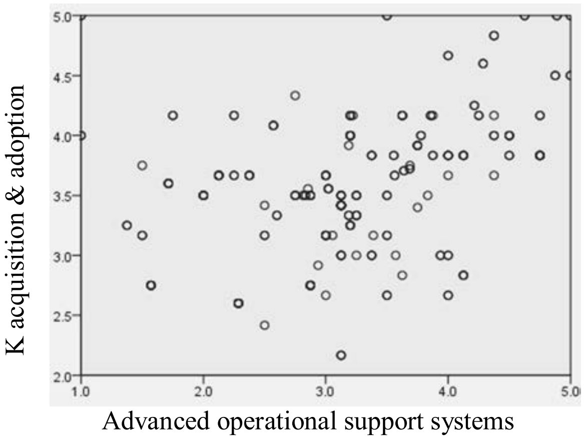
Scatterplot of KR vs. IST



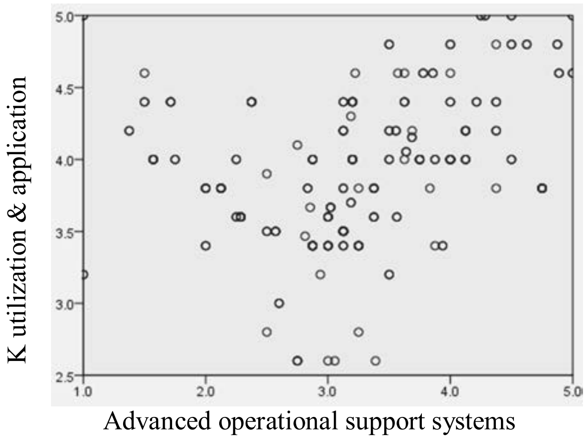
Scatterplot of KS vs. IST

FIG. IV.8. Scatterplots of quality of knowledge processes vs. information systems & technology.

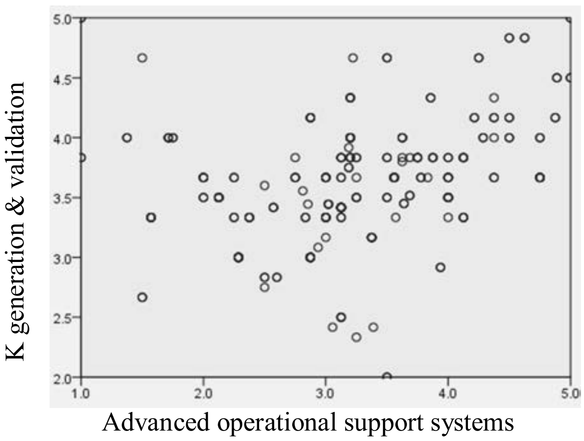
IV.2.2. Quality of knowledge processes vs. advanced operational support systems



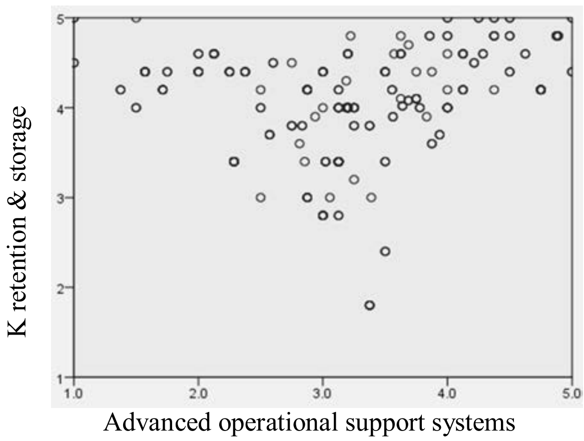
Scatterplot of KA vs. OSS



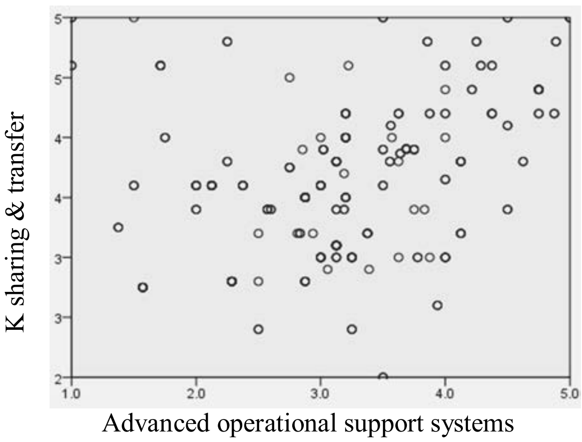
Scatterplot of KU vs. OSS



Scatterplot of KG vs. OSS



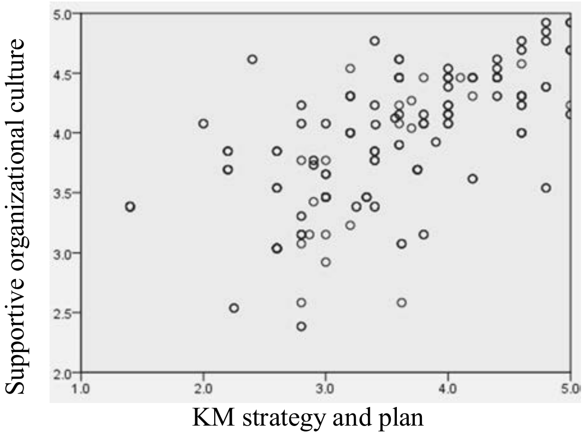
Scatterplot of KR vs. OSS



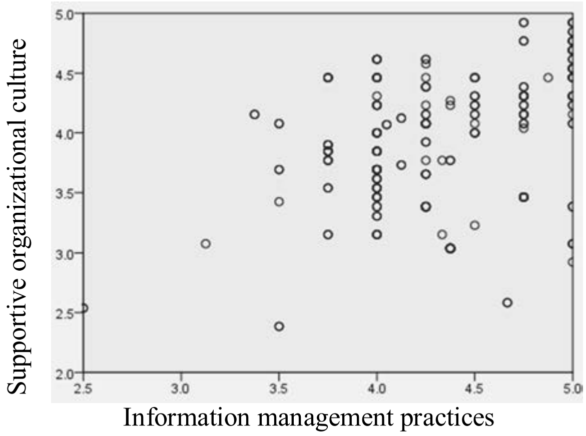
Scatterplot of KS vs. OSS

FIG. IV.9. Scatterplots of quality of knowledge processes vs. advanced operational support systems.

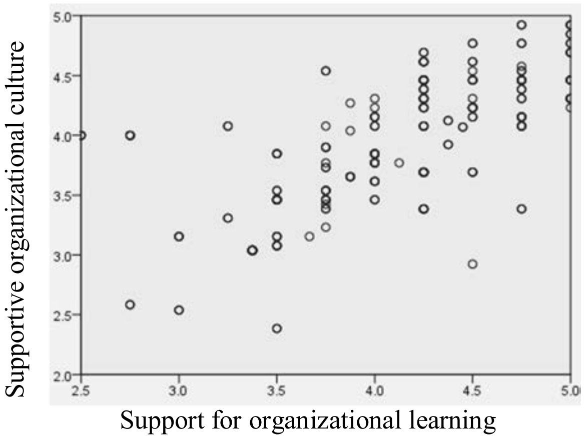
IV.3. SCATTERPLOTS OF SUPPORTIVE ORGANIZATIIONAL CULTURE vs. KNOWLEDGE MANAGEMENT PRACTICES



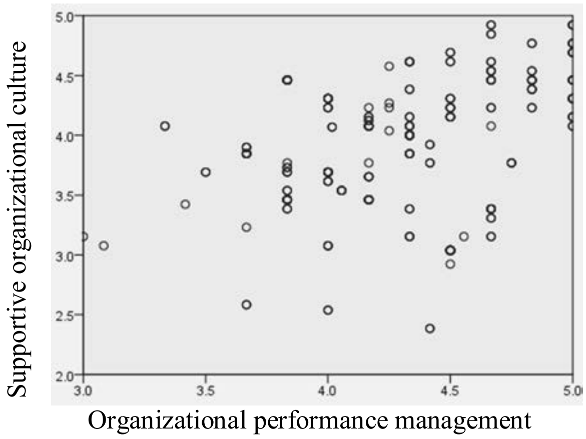
Scatterplot of SOC vs. KMS



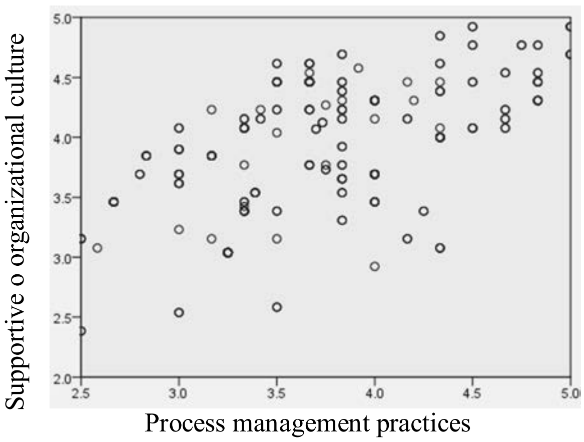
Scatterplot of SOC vs. IMP



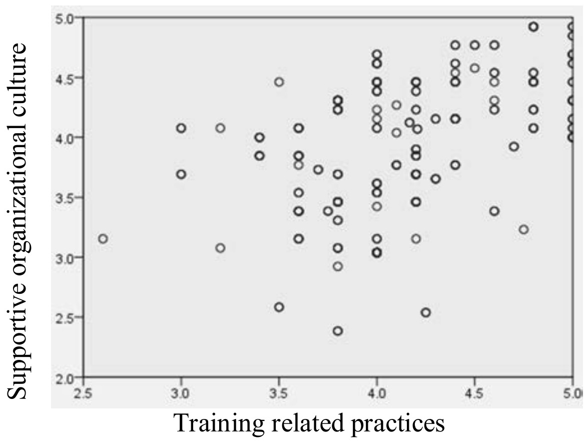
Scatterplot of SOC vs. SOL



Scatterplot of SOC vs. OPM

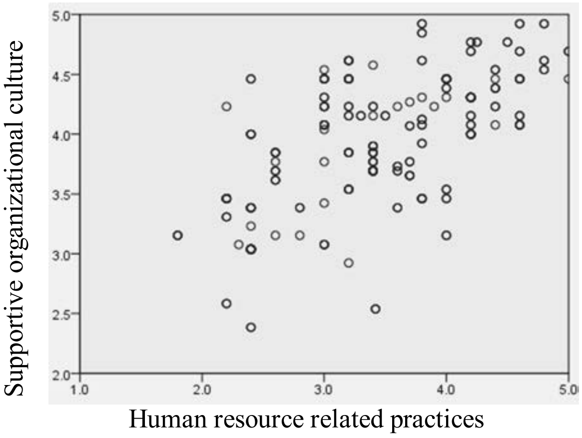


Scatterplot of SOC vs. PMP

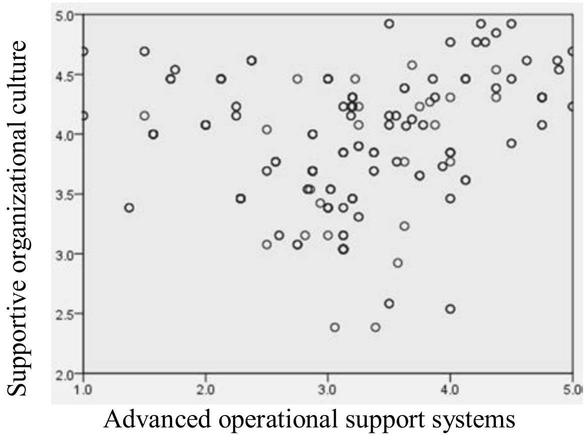


Scatterplot of SOC vs. TRP

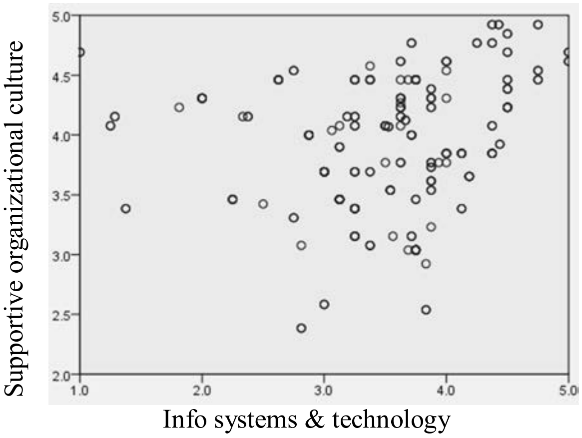
FIG. IV.10(a). Scatterplots of supportive organizational culture vs. KM practices.



Scatterplot of SOC vs. HRP



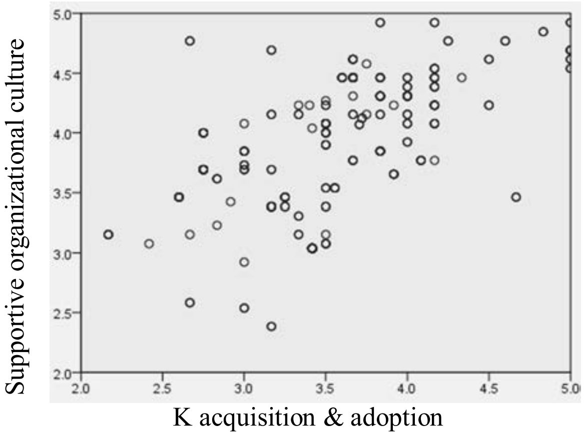
Scatterplot of SOC vs. OSS



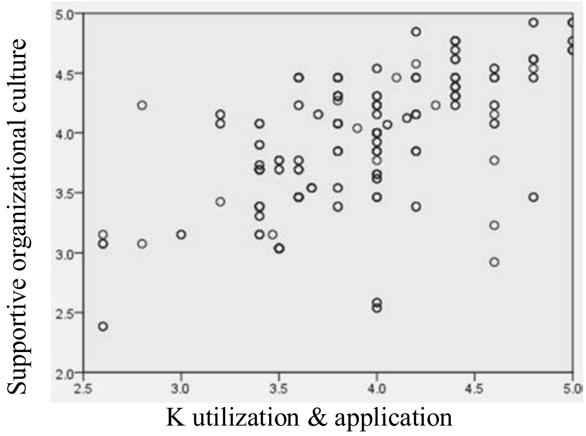
Scatterplot of SOC vs. IST

FIG. IV.10(b). Scatterplots of supportive organizational culture vs. human resource practices and organizational technology support.

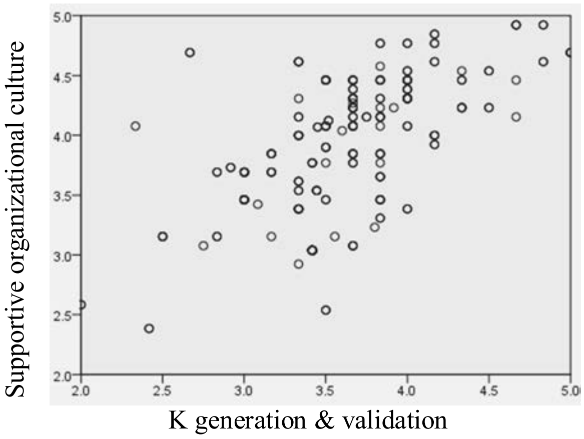
IV.4. SCATTERPLOTS OF SUPPORTIVE ORGANIZATIONAL CULTURE vs. QUALITY OF KNOWLEDGE PROCESSES



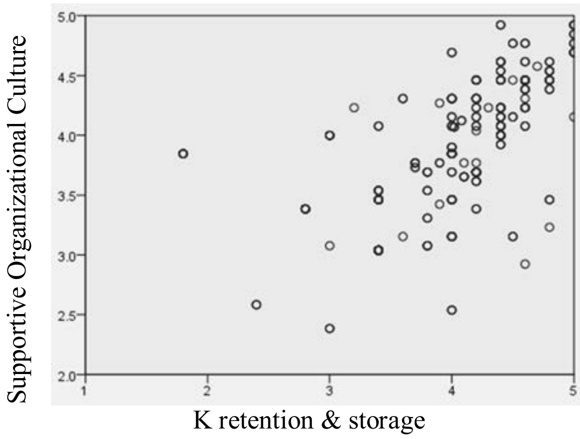
Scatterplot of SOC vs. KA



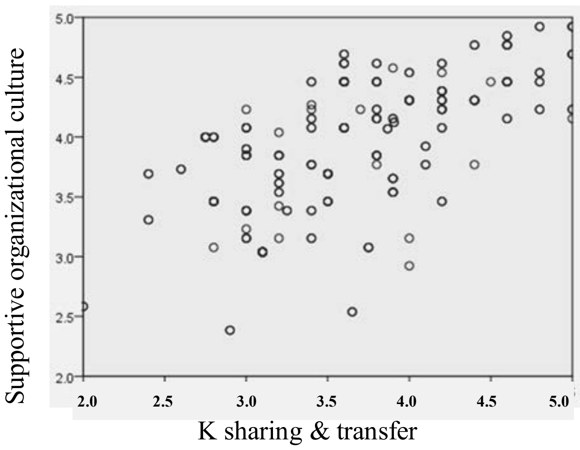
Scatterplot of SOC vs. KU



Scatterplot of SOC vs. KG



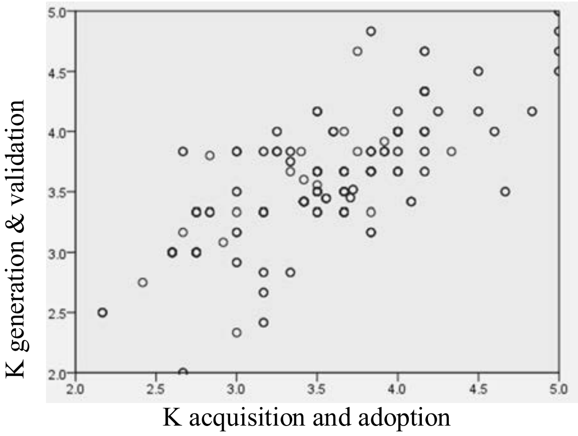
Scatterplot of SOC vs. KR



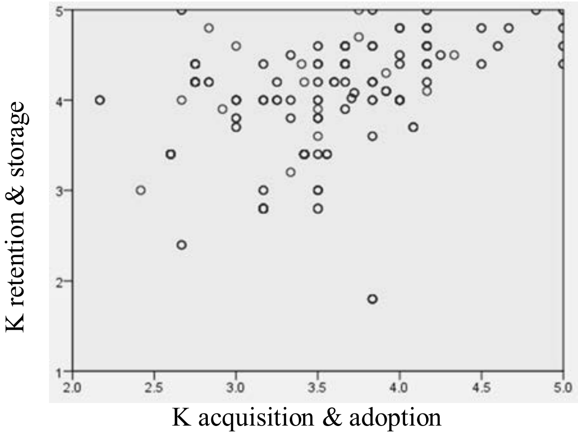
Scatterplot of SOC vs. KS

FIG. IV.11. Scatterplots of supportive organizational culture vs. quality of knowledge processes.

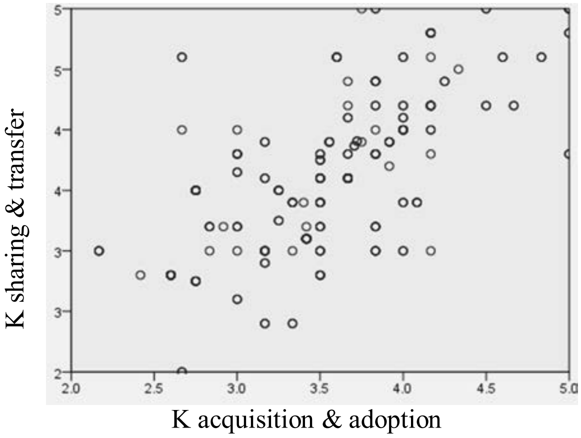
IV.5. SCATTERPLOTS OF THE INTER-RELATIONSHIPS BETWEEN THE QUALITY OF KNOWLEDGE PROCESS CONSTRUCTS



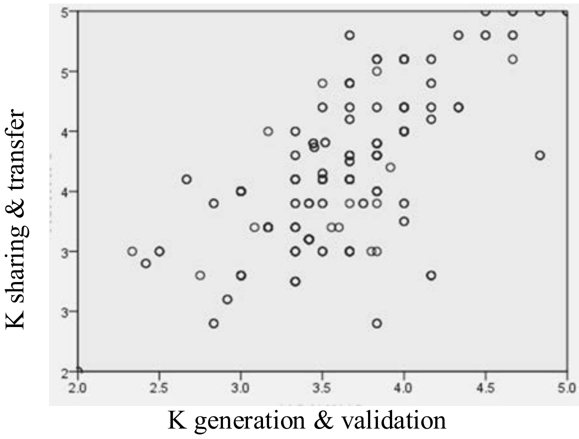
Scatterplot of KG vs. KA



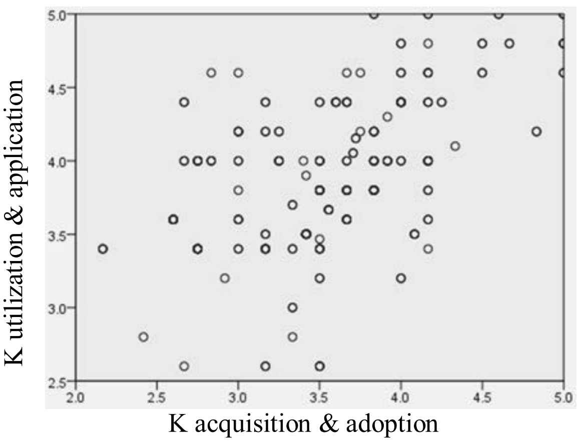
Scatterplot of KR vs. KA



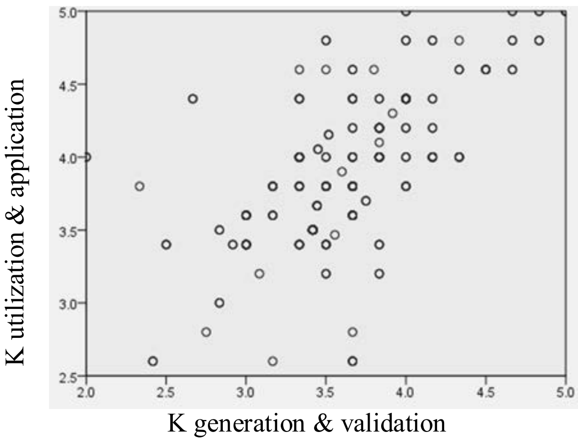
Scatterplot of KS vs. KA



Scatterplot of KS vs. KG

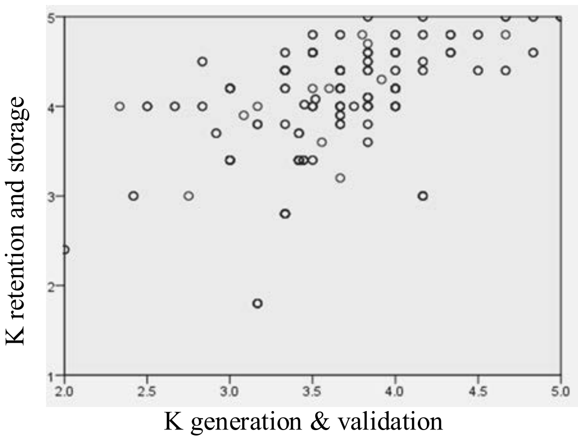


Scatterplot of KU vs. KA

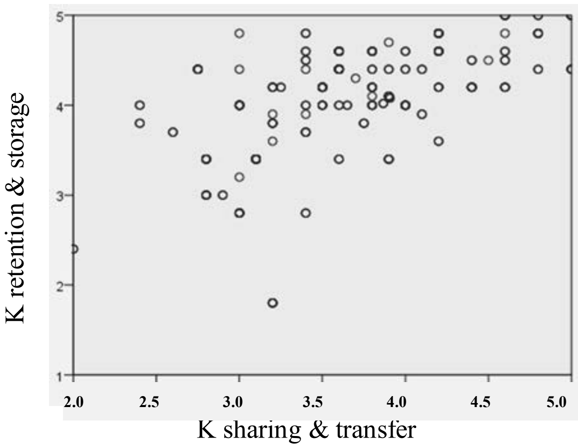


Scatterplot of KU vs. KG

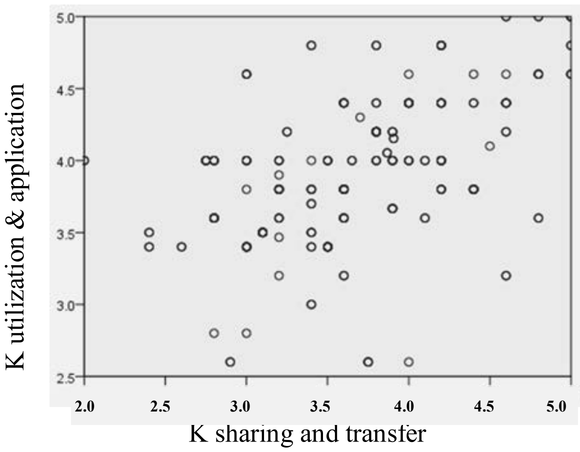
FIG. IV.12(a). Scatterplots between qualities of knowledge process constructs.



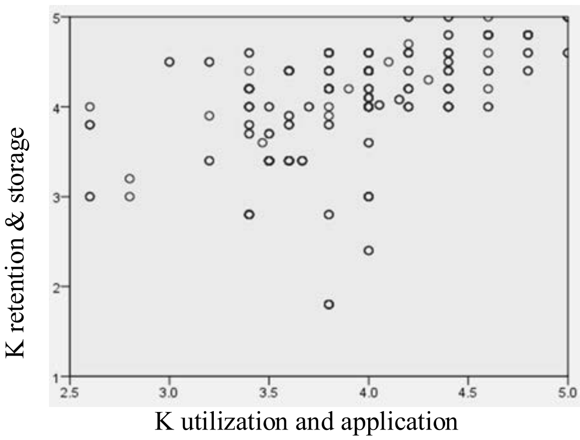
Scatterplot of KR vs. KG



Scatterplot of KR vs. KS



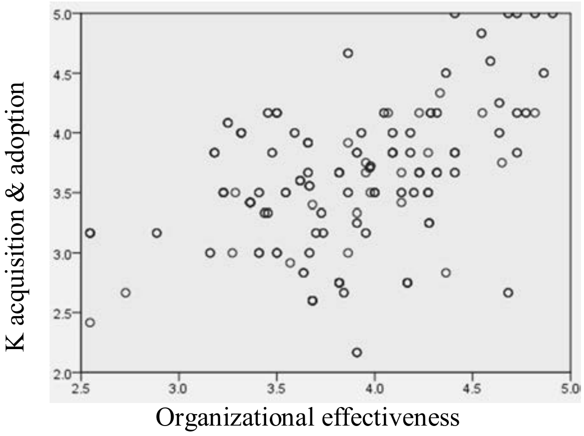
Scatterplot of KU vs. KS



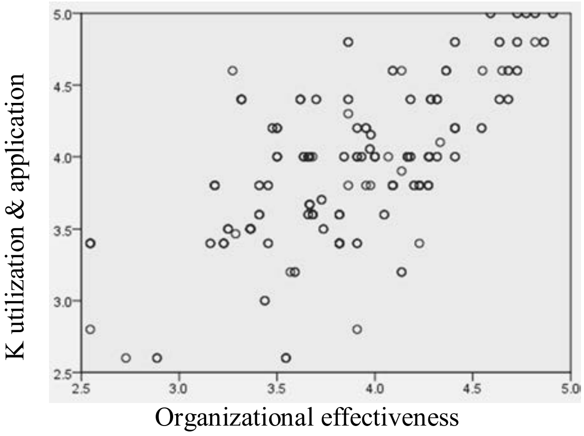
Scatterplot of KR vs. KU

FIG. IV.12(b). Scatterplots between quality of knowledge processes.

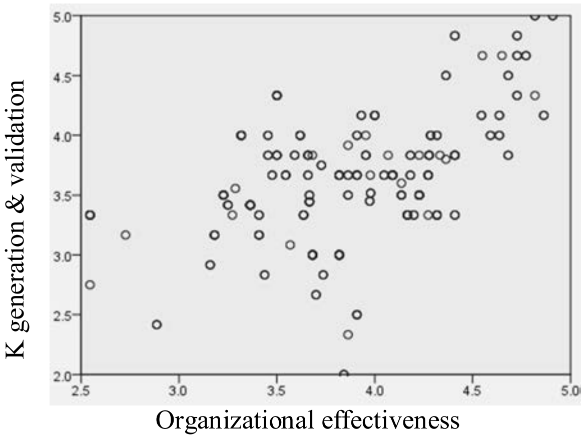
IV.6. SCATTERPLOTS OF THE QUALITY OF KNOWLEDGE PROCESS CONSTRUCTS VS. ORGANIZATIONAL EFFECTIVENESS



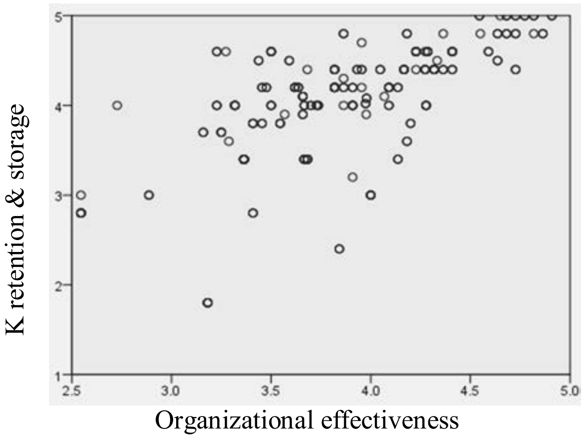
Scatterplot of KA vs. OE



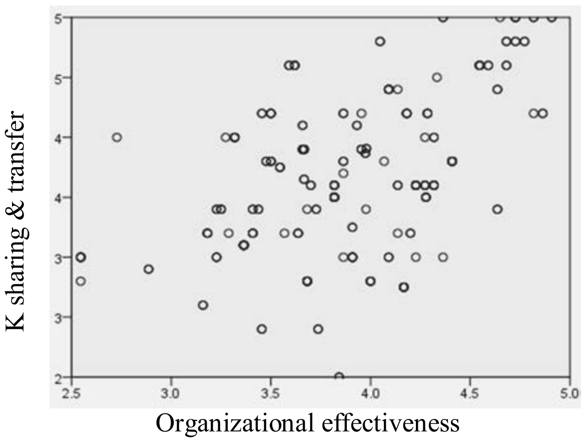
Scatterplot of KU vs. OE



Scatterplot of KG vs. OE



Scatterplot of KR vs. OE



Scatterplot of KS vs. OE

FIG. IV.13. Scatterplots of quality of knowledge processes vs. organizational effectiveness.

IV.7. SCATTERPLOTS OF SUPPORTIVE ORGANIZATIONAL CULTURE VS. ORGANIZATIONAL EFFECTIVENESS

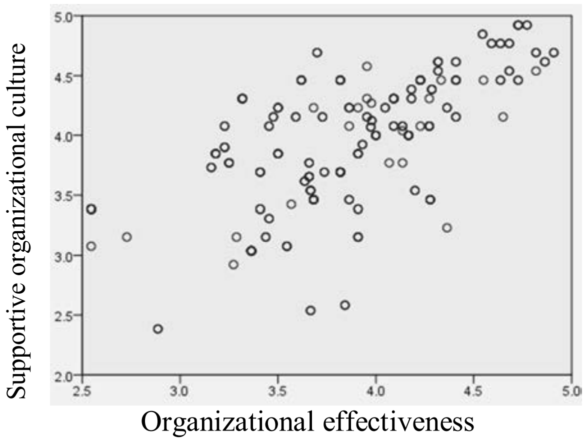


FIG. IV.14. Scatterplot of supportive organization culture vs. organizational effectiveness.

Appendix V

DESCRIPTIVE DATA FOR INDIVIDUAL MEASURES

This appendix summarizes the response data from the global NPP survey on each of the measured variables in the form of a histogram. A best fit normal distribution curve is provided in each plot as a useful reference to better visualize how normal the response data was in each case. These results can be used as benchmark data. The data helps to answer the following basic research questions at a measurement level:

— To what extent are knowledge management practices currently supported and in use by managers in operating NPPs (i.e. for each measure)?
— To what extent do NPP organizations consider themselves to have a supportive organizational culture?
— To what extent do NPP organizations consider themselves to have quality knowledge processes?
— To what extent do NPP organizations consider themselves to be effective?

For the purposes of reporting of descriptive data in this section, intermediate scale values were binned to the closest integer scale value for histogram plotting. The exact wording of measures used in the survey instrument (see Appendix I) are provided in the sub-sections below for easy reference.

V.1. KM STRATEGY AND PLANING RELATED KM PRACTICES

Measure KMSa: ‘The organization has clear, documented high level knowledge management plan and goals’.

Measure KMSb: ‘Implementation of the knowledge management strategy and plan is openly and actively supported by management’.

Measure KMSc: ‘Knowledge management roles and responsibilities are clearly defined and understood by managers and employees’.

Measure KMSd ‘Other management strategies (e.g. human resources, information systems, operations, communications and maintenance plans) are closely aligned with the knowledge management strategy and plan’.

Measure KMSe: ‘The needs and gaps in the organizational knowledge base are periodically reviewed and the knowledge management strategy and plan is revised to address them’.

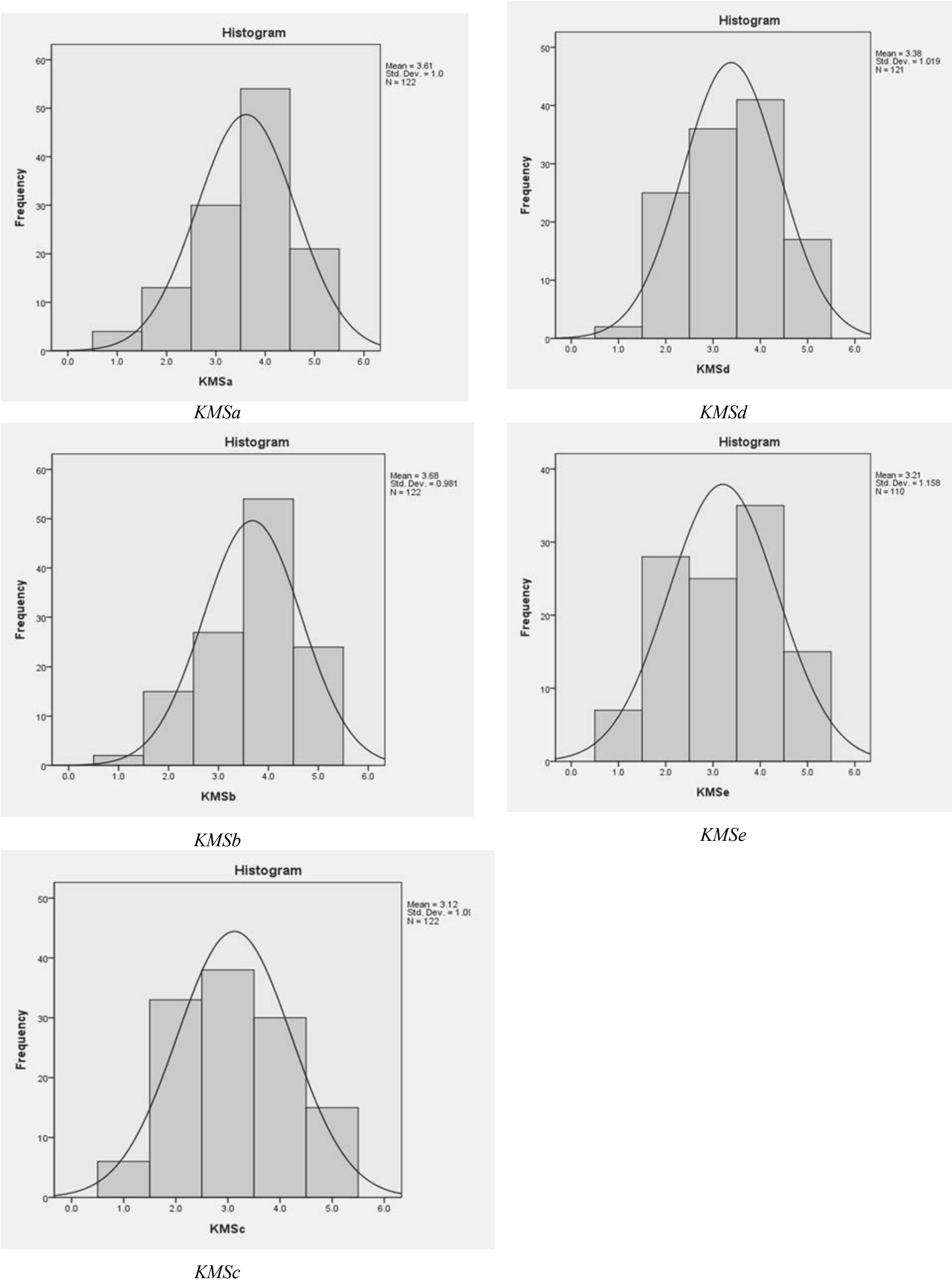


FIG. V.1. Histograms for measures of KM strategy & plan (KMS a, b, c, d and e).

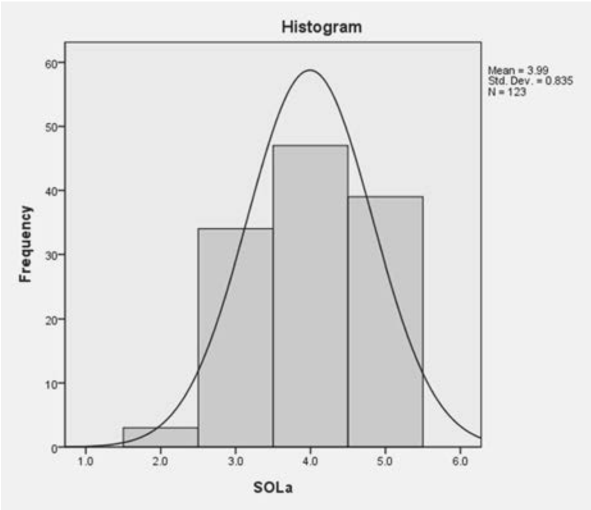
V.2. SUPPORT FOR ORGANIZATIONAL LEARNING RELATED KM PRACTICES

Measure SOLa: 'Knowledge creation and application (e.g., finding better methods, technology innovation) is encouraged, recognized and rewarded'.

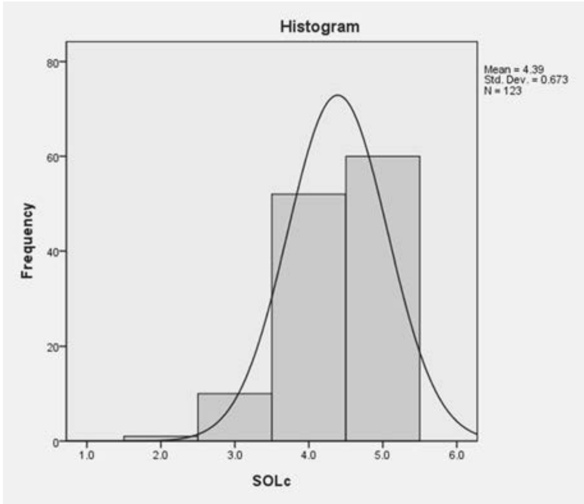
Measure SOLb: ‘Sharing of knowledge is promoted and rewarded (e.g., experts are encouraged and rewarded to coach or mentor other employees)’.

Measure SOLc: ‘Open communication and a no-blame approach to reporting problems and sharing lessons learned are promoted (e.g., regular communication is encouraged between maintenance and operations personnel)’.

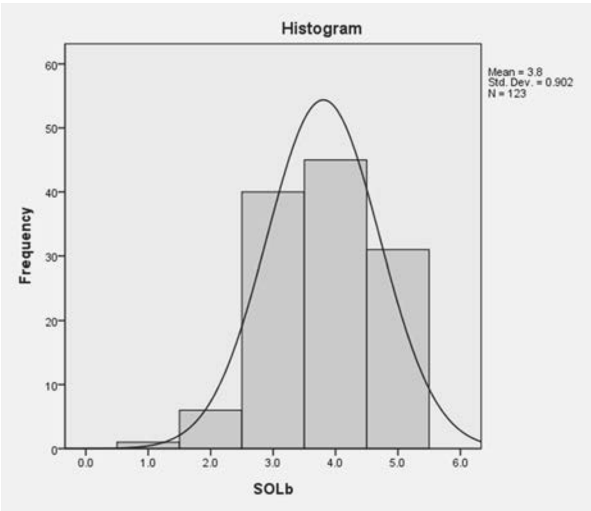
Measure SOLd: ‘Learning opportunities are encouraged (e.g., joining specialist groups or attending training seminars)’.



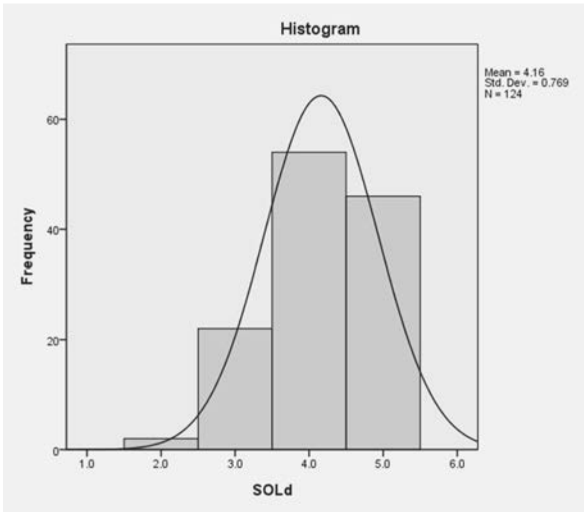
Measure SOLa



Measure SOLc



Measure SOLb



Measure SOLd

FIG. V.2. Histograms for measures of support for organizational learning (SOL a, b, c and d).

V.3. PROCESS MANAGEMENT RELATED KM PRACTICES

Measure PMPa: ‘For all processes and procedures, priority is placed on ensuring the requirements, methods, inputs, outputs, interfaces, responsibilities, and workflow are documented correctly and maintained up to date’.

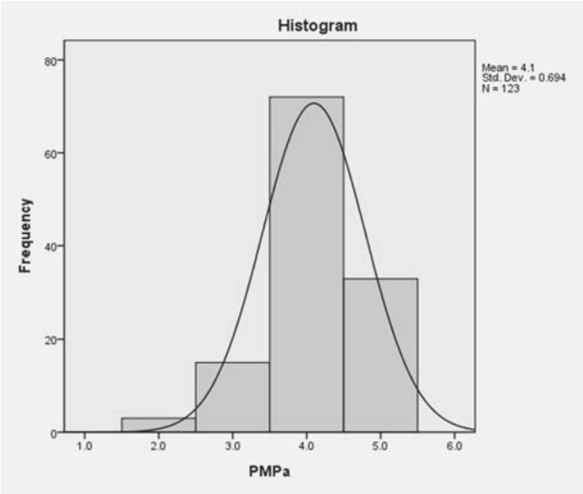
Measure PMPb: ‘Consideration of hazards and risk is built into all work and decision processes to ensure safety is not adversely impacted’.

Measure PMPc: ‘Procedures are aligned to knowledge and information requirements of both work tasks and decision processes’.

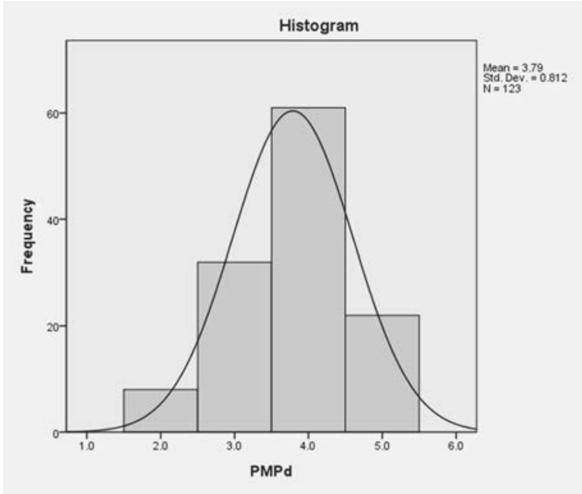
Measure PMPd: ‘A process to measure and improve the quality and control of all business, work, and decision processes is defined and followed’.

Measure PMPe: ‘Comprehensive knowledge management procedures (e.g. for knowledge loss risk assessment) are documented and in use’.

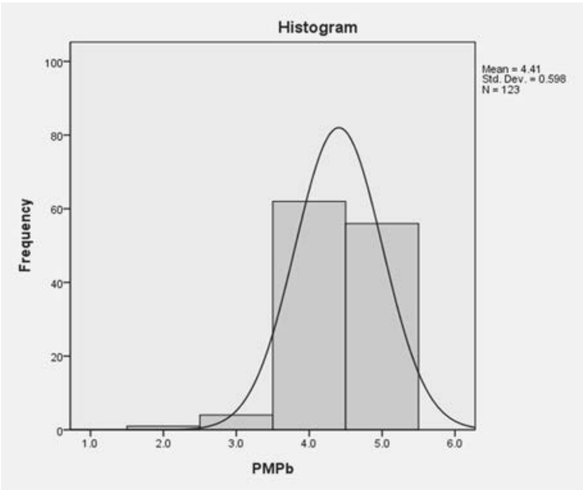
Measure PMPf: ‘Knowledge management processes and procedures are extended to suppliers and technical support organizations’.



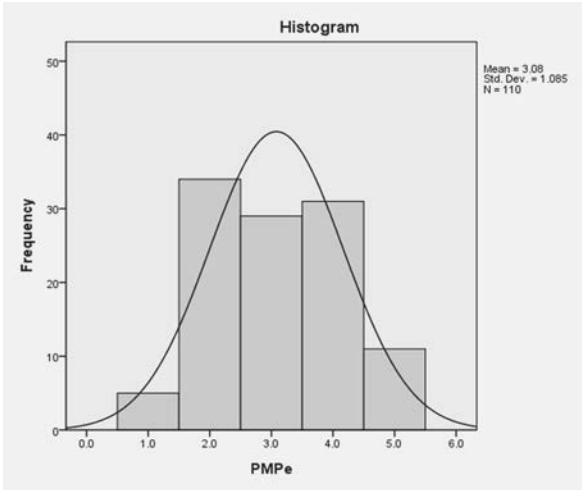
PMPa



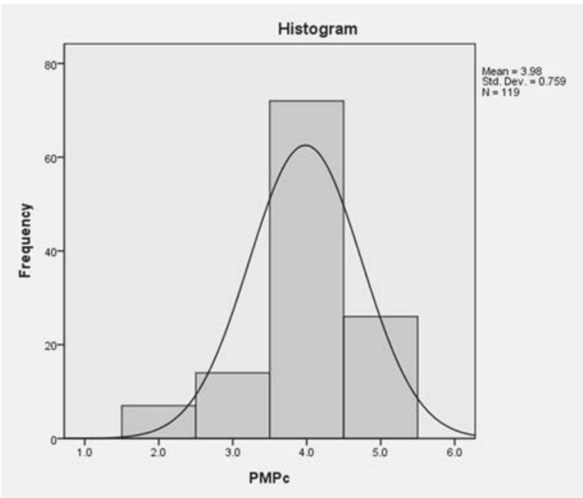
PMPd



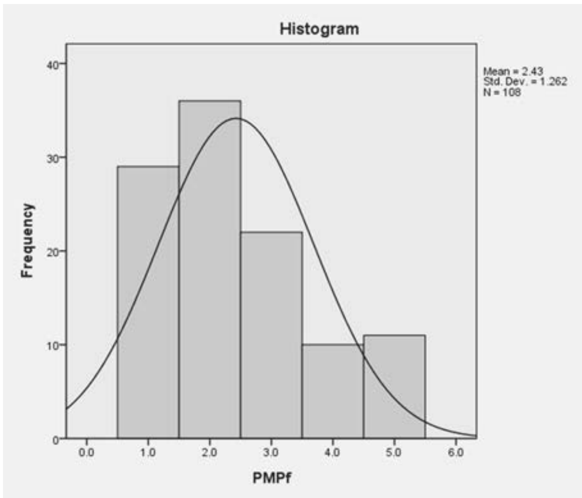
PMPb



PMPe



PMPc



PMPf

FIG. V.3. Histograms for measures of process management practices (PMP a, b, c, d, e and f).

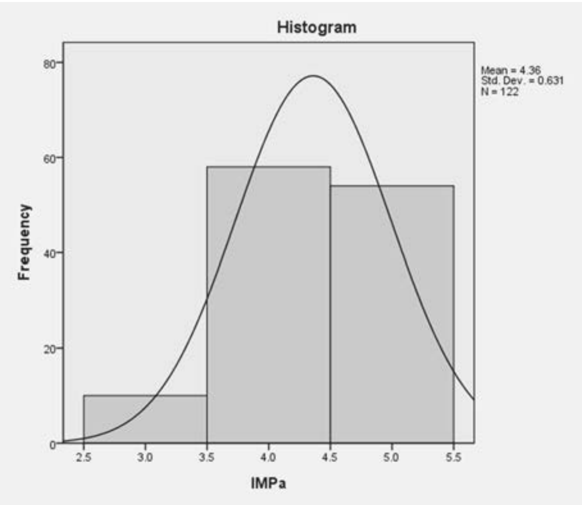
V.4. INFORMATION MANAGEMENT RELATED KM PRACTICES

Measure IMPa: ‘Licensing documents, design basis documents, procedures, specifications, drawings, and training materials are updated promptly to address plant changes and are maintained under configuration management’.

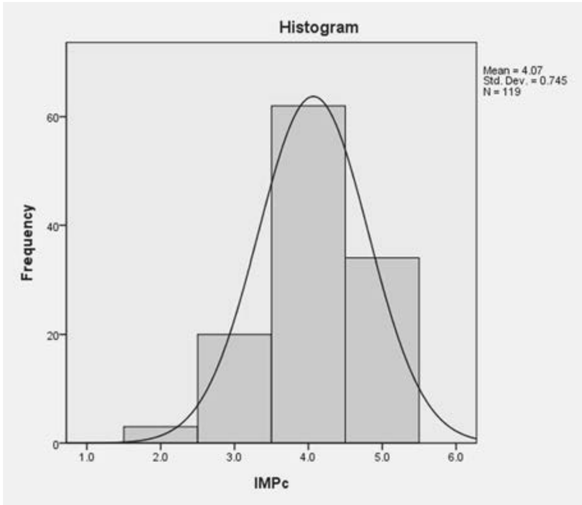
Measure IMPb: ‘Records, data, and logs are required to be completed, meaningful, accurate and accessible (e.g., logs, minutes, test results)’.

Measure IMPc: ‘Data standards, metadata, document codes, subject indexes and filing systems are widely used to enable efficient information correlation, storage and retrieval’.

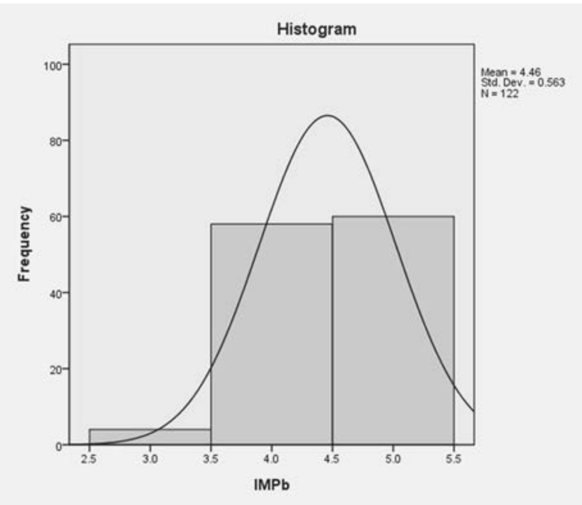
Measure IMPd: ‘Procedures ensure the needs for data and information safety, security, maintainability, accessibility, quality and preservation’.



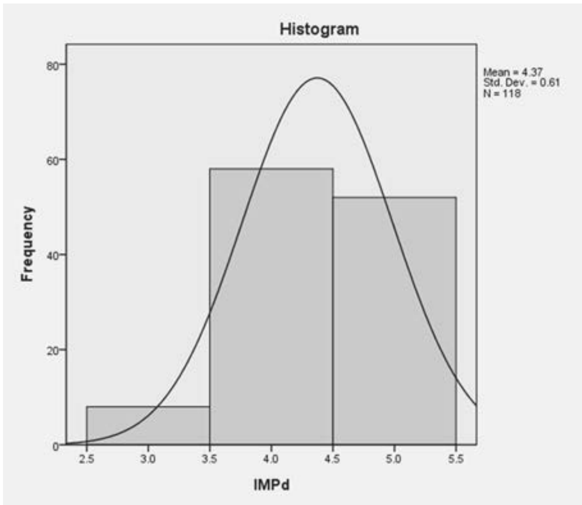
IMPa



IMPc



IMPb



IMPd

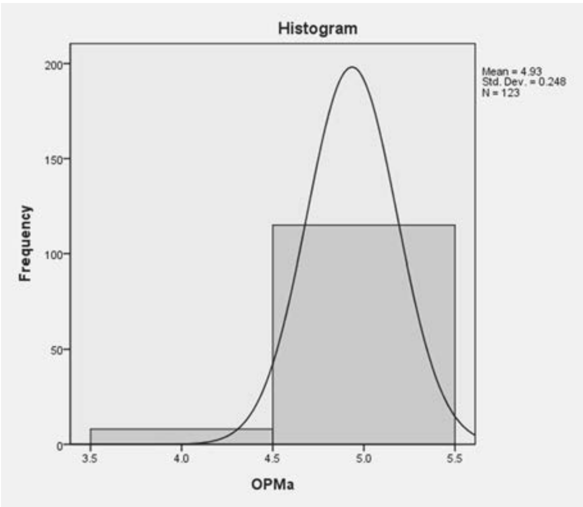
FIG. V.4. Histograms for measures of information management practices (IMP a, b, c and d).

V.5. ORGANIZATIONAL PERFORMANCE MANAGEMENT RELATED KM PRACTICES

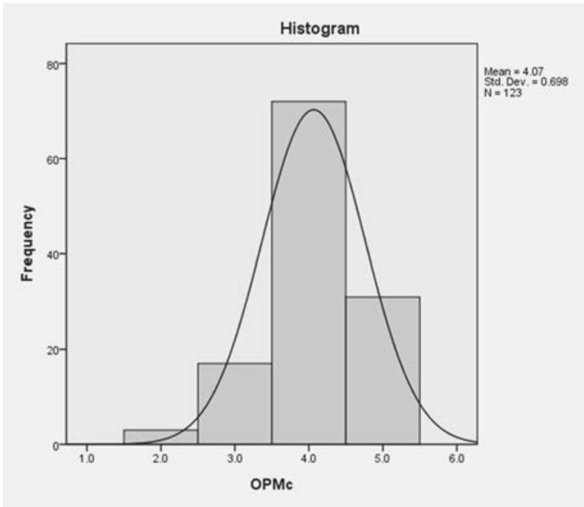
Measure OPMa: ‘Independent external peer review assessments are conducted regularly (e.g. WANO, INPO, or IAEA-OSART reviews)’.

Measure OPMb: ‘Self-assessments are widely used to stimulate learning and improve performance (e.g. benchmarking against best practices)’.

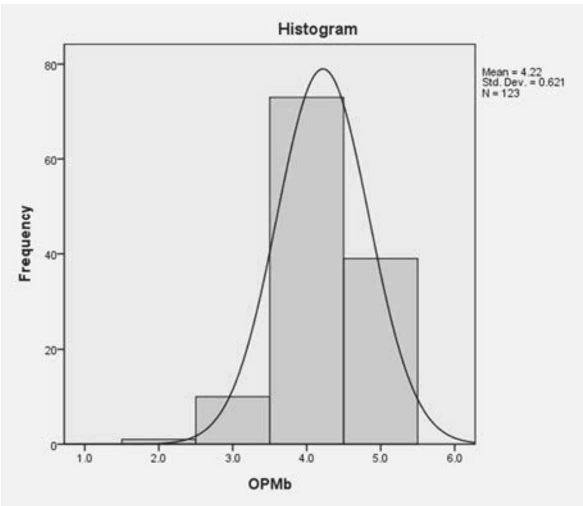
Measure OPMc:	‘Performance objectives are established and monitored for all levels and areas of the organization (including for knowledge processes)’.
Measure OPMd:	‘Performance objectives for operations, maintenance, and safety are based on objectives established by industry best practice’.
Measure OPMe:	‘The effectiveness of the management system (including knowledge management aspects) is regularly reviewed’.
Measure OPMf:	‘On-going processes for operational experience capture, review, analysis and corrective action are defined and followed’.



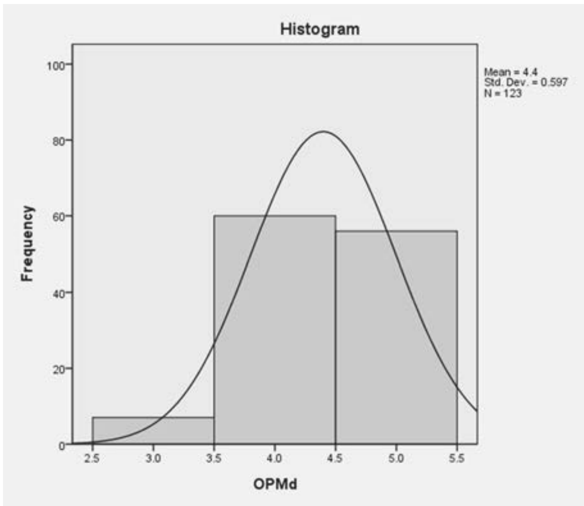
OPMa



OPMc

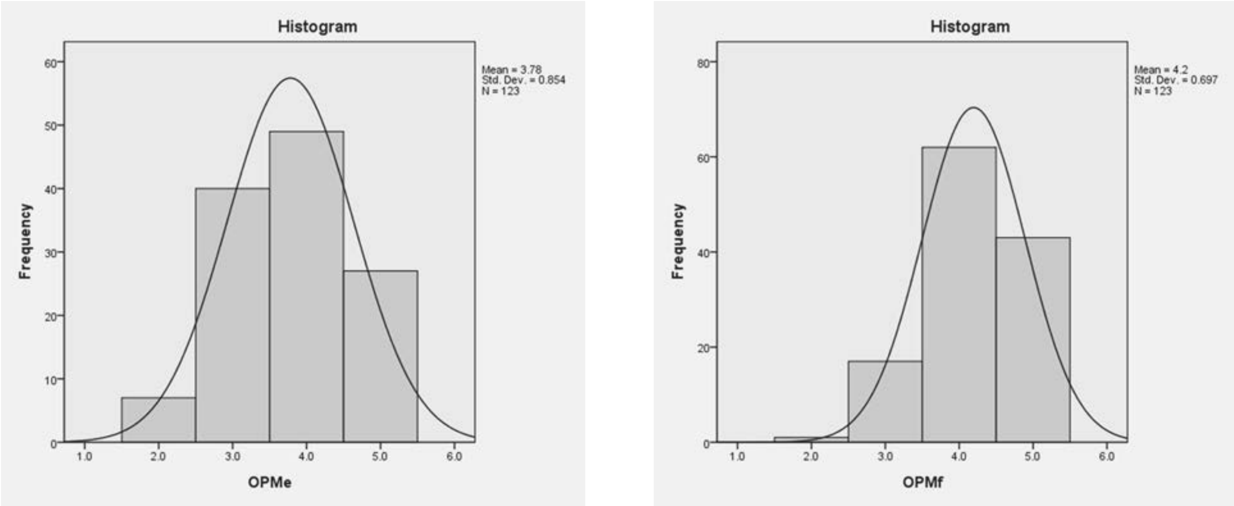


OPMb



OPMd

FIG. V.5(a). Histograms for measures of organizational performance management (OPM a, b, c and d).



OPMe *OPMf*

FIG. V.5(b). Histograms for measures of organizational performance management (OPM e and f).

V.6. TRAINING RELATED KM PRACTICES

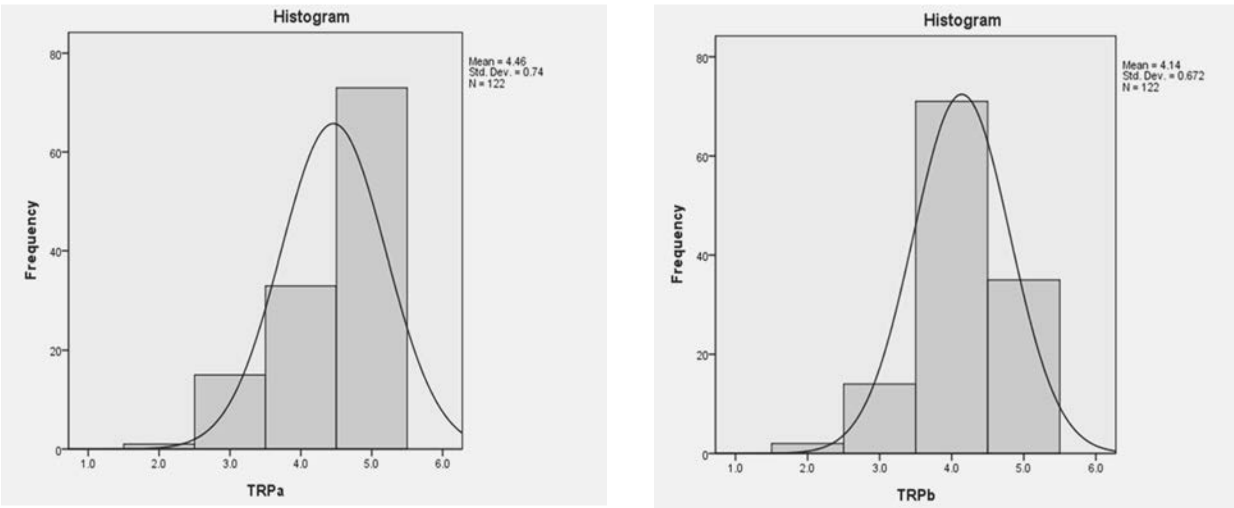
Measure TRPa: ‘The organization incorporates principles of the ‘systematic approach to training’ (SAT) in training programmes’.

Measure TRPb: ‘Sufficient training is provided to achieve and maintain the required level of competence for all job positions’.

Measure TRPc: ‘Training material is reviewed to ensure it reflects lessons learned from operating experience and agrees with plant documentation’.

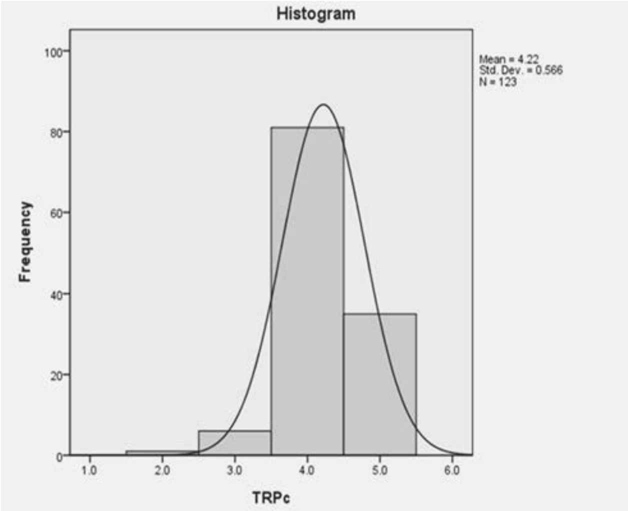
Measure TRPd: ‘Collaboration with universities and colleges ensures an appropriate supply of new graduates’.

Measure TRPe: ‘Other techniques are used for training (e.g. story-telling, concept mapping, pre-job briefings, informal seminars, mentoring programmes etc.)’.

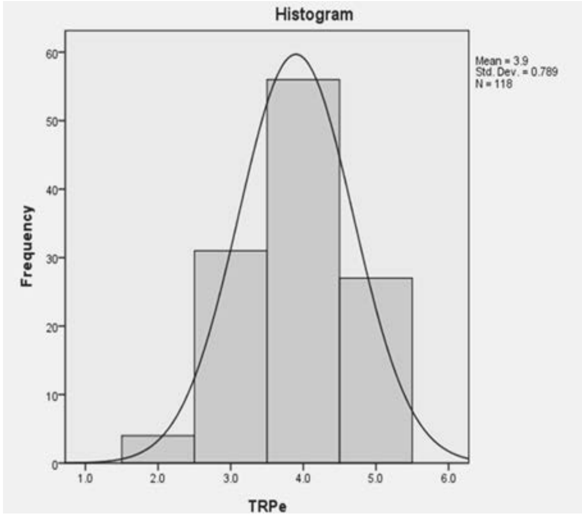


TRPa *TRPb*

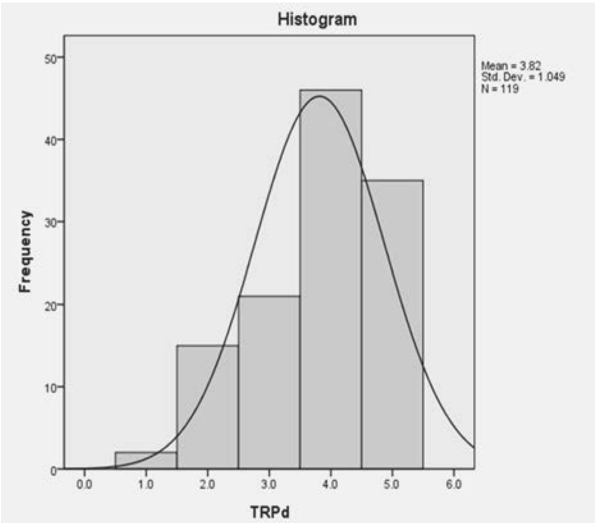
FIG. V.6(a). Histograms for measures of training related practices (TRP a and b).



TRPc



TRPe



TRPd

FIG. V.6(b). Histograms for measures of training related practices (TRP c, d and e).

V.7. HUMAN RESOURCE RELATED KM PRACTICES

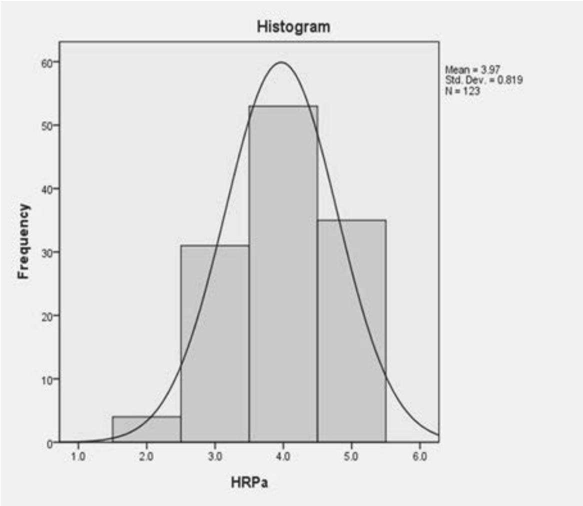
Measure HRPa: ‘Expected retirements and unexpected departures are regularly tracked and the resulting need for and availability of critical knowledge and job skills is acted upon’.

Measure HRPb: ‘New hiring is done long before experts depart to facilitate knowledge transfer and ensure the competency of replacements is developed in time’.

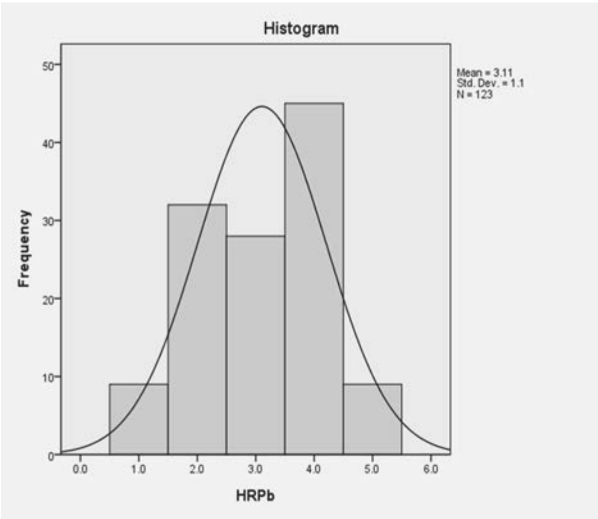
Measure HRPc: ‘Interviews with departing employees are routinely carried out well in advance to identify critical knowledge and experience and to facilitate knowledge capture and transfer’.

Measure HRPd: ‘Competency, training and knowledge sharing or transfer goals are identified, evaluated and rewarded in employee performance assessment’.

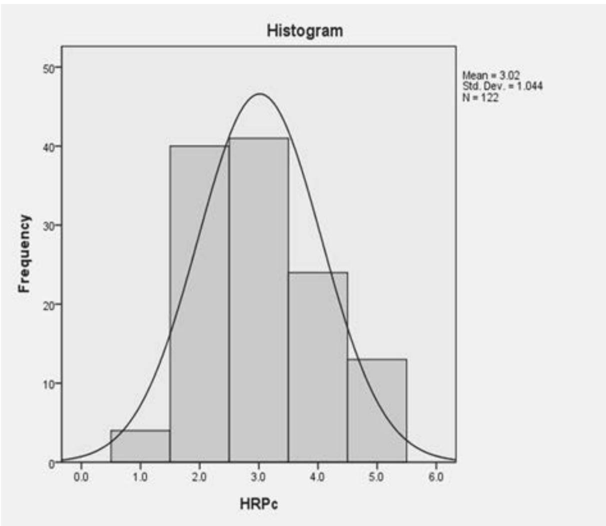
Measure HRPe: ‘Work assignments promote learning (e.g., job-rotations, team selections and staff assignments consider learning opportunities)’.



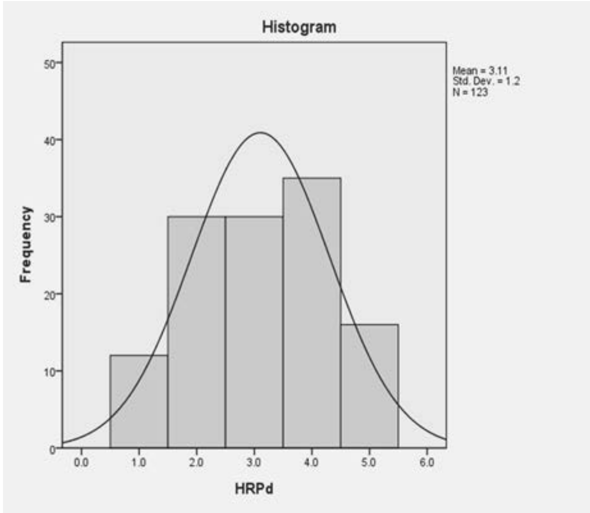
HRPa



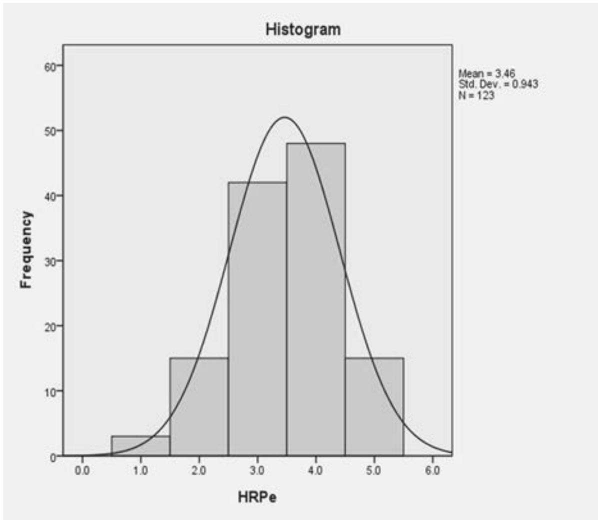
HRPb



HRPc



HRPd

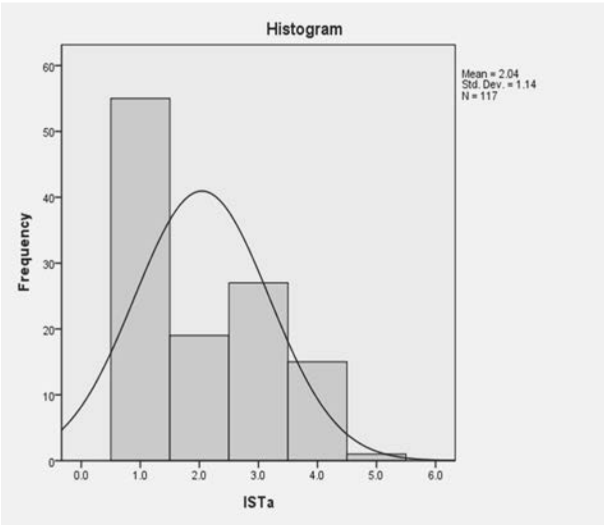


HRPe

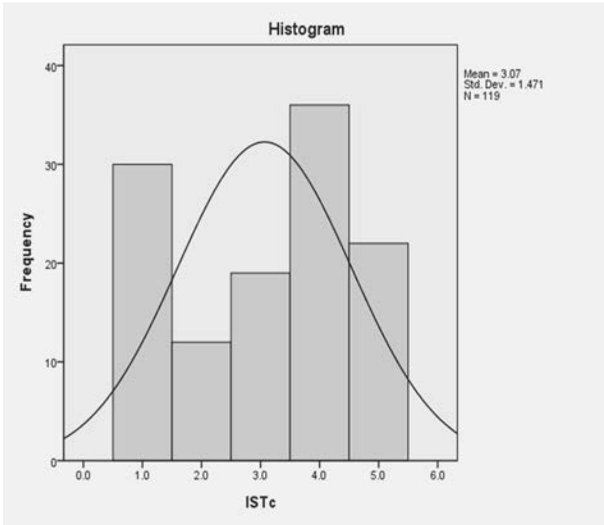
FIG. V.7. Histograms for measures of human resource practices (HRP a, b, c, d and e).

V.8. INFORMATION SYSTEMS AND TECHNOLOGY EFFECTIVENESS

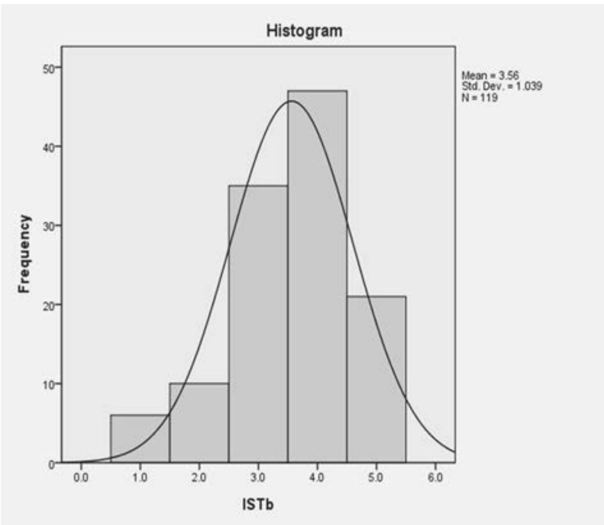
Measure ISTa: ‘Three dimensional (3D) virtual reality environments for training’.
Measure ISTb: ‘Computer and/or web-based training’.
Measure ISTc: ‘Desktop (e.g. plant) training simulators’.
Measure ISTd: ‘Full scope main control room training simulators’.
Measure ISTe: ‘Electronic archives and databases (e.g. for document management, event reporting, maintenance records, etc.)’.
Measure ISTf: ‘Enterprise application software (e.g. for financials, procurement, parts inventory management, work and outage management, etc.)’.
Measure ISTg: ‘Intranet web portal with search/retrieval access to frequently used resources (e.g. documents, bulletins, contact lists, etc.)’.
Measure ISTh: ‘Three-dimensional (3D) computer aided design (CAD) plant models and editable electronic drawings’.



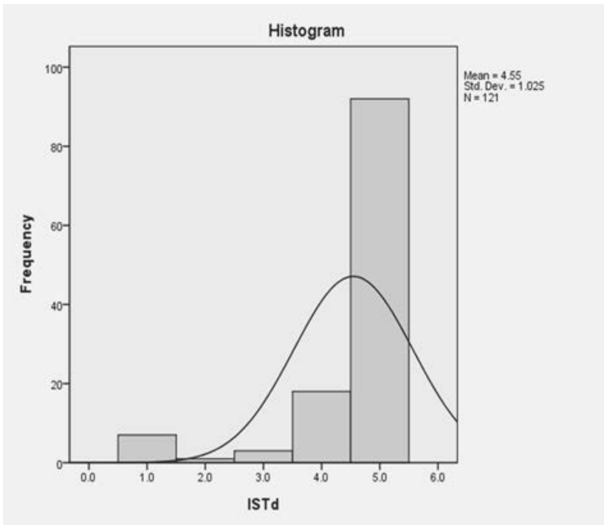
ISTa



ISTc

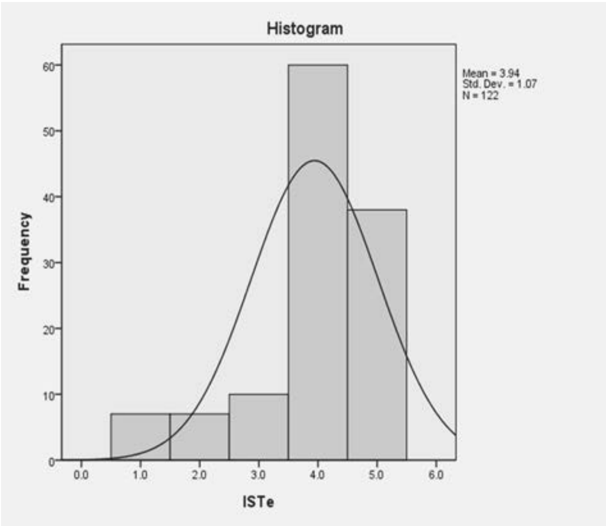


ISTb

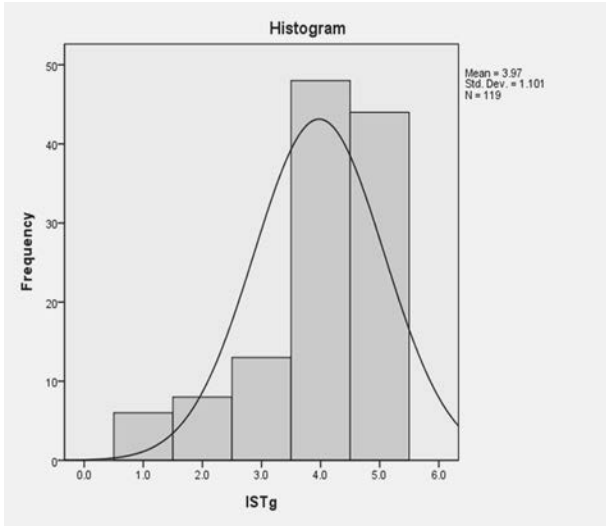


ISTd

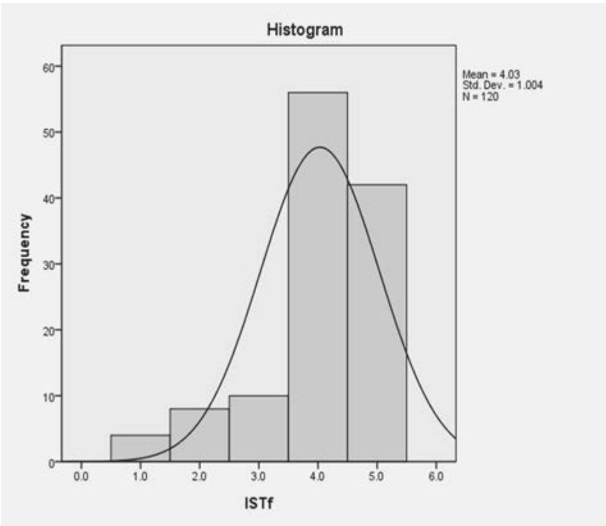
FIG. V.8(a). Histograms for measures of information systems & technology (IST a, b, c and d).



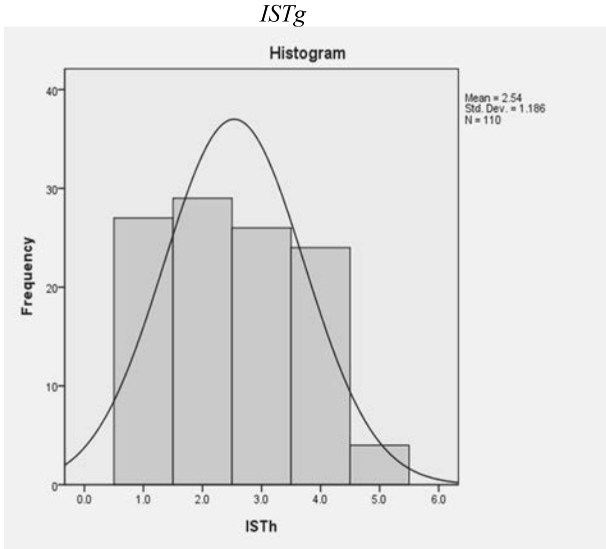
ISTe



ISTg



ISTf

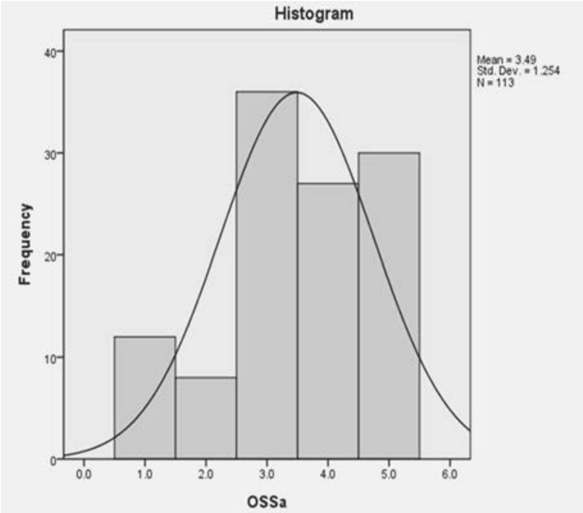


ISTh

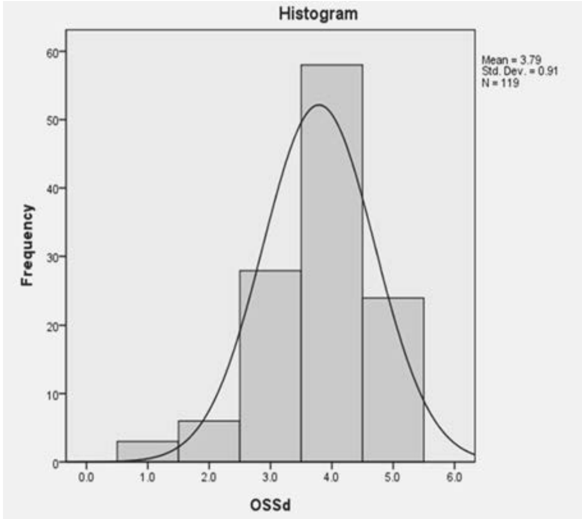
FIG. V.8(b). Histograms for measures of information systems & technology (IST e, f, g and h).

V.9. OPERATIONAL DECISION SUPPORT SYSTEM EFFECTIVENESS

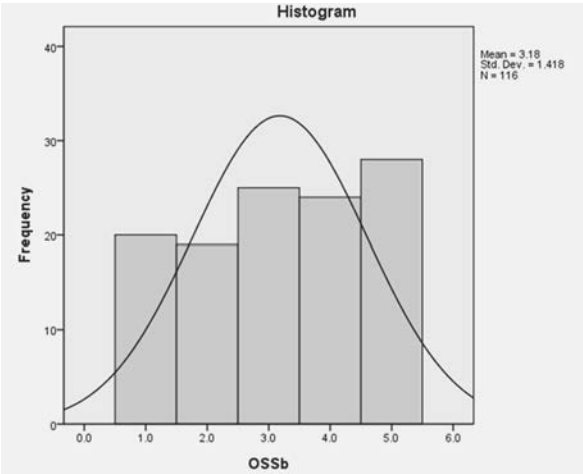
Measure OSSa: ‘Operational decision support systems (e.g. refuelling software)’.
Measure OSSb: ‘Regularly updated (i.e. ‘living’) probabilistic risk models of equipment reliability for maintenance and outage planning’.
Measure OSSc: ‘Real-time probabilistic risk models for operator evaluation and awareness of plant safety (i.e. ‘a safety monitor’)’.
Measure OSSd: ‘System health monitors (e.g. predictive maintenance tools such as vibration, acoustic, thermal, or other monitors)’.
Measure OSSe: ‘Advanced model-based monitoring and diagnostics (e.g. physics, chemistry, boiler, feed water and thermal hydraulics models)’.
Measure OSSf: ‘Advanced information exchange (e.g. hand-held computers, plant-wide equipment status monitoring, wireless communications)’.
Measure OSSg: ‘Electronic (i.e. graphical) road-maps of business and decision processes or work-flows (e.g. operational flow-sheets) with links to supporting procedures, related resources or documents’.
Measure OSSh: ‘Automated field data collection (i.e., smart instruments, field-bus, radio frequency identification (RFID) tagging, data logging, equipment monitors)’.
Measure OSSi: ‘Other’.



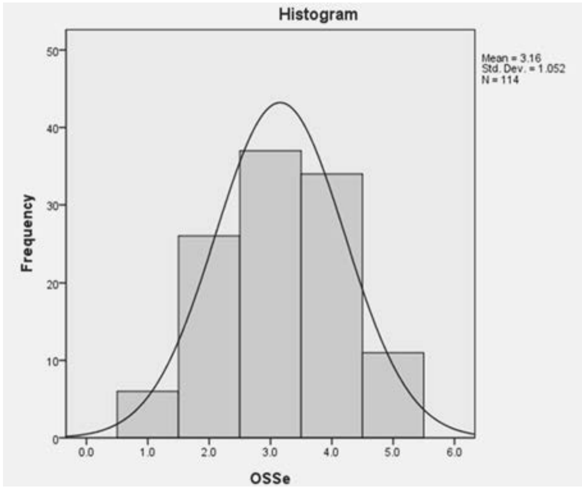
OSSa



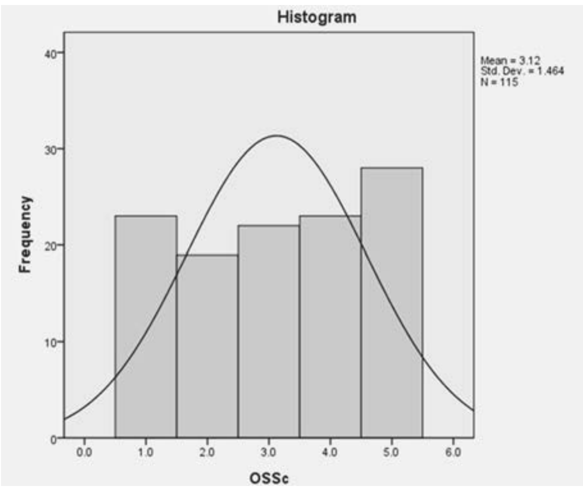
OSSd



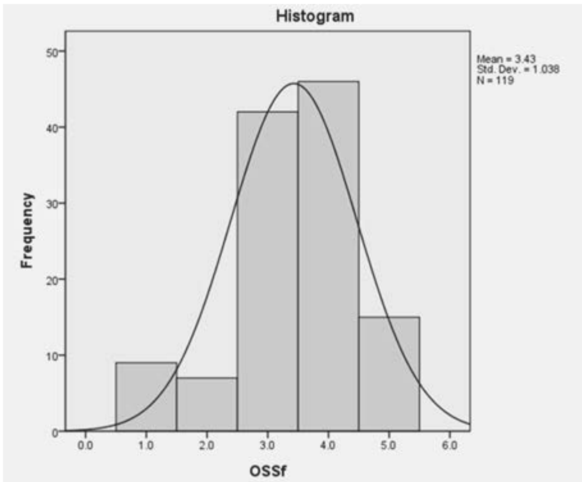
OSSb



OSSe

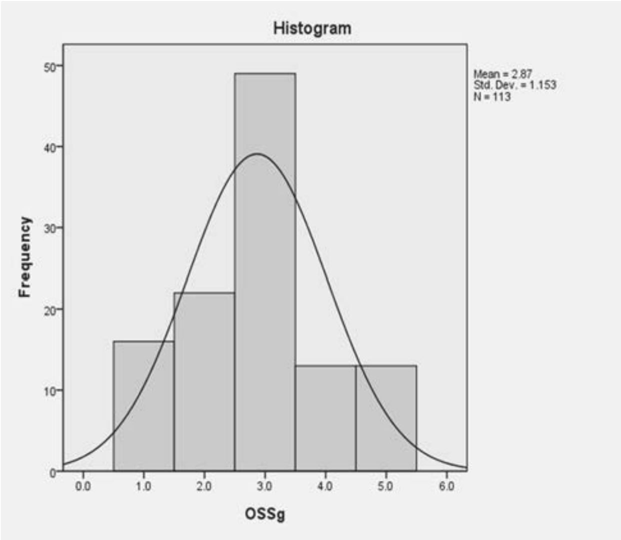


OSSc

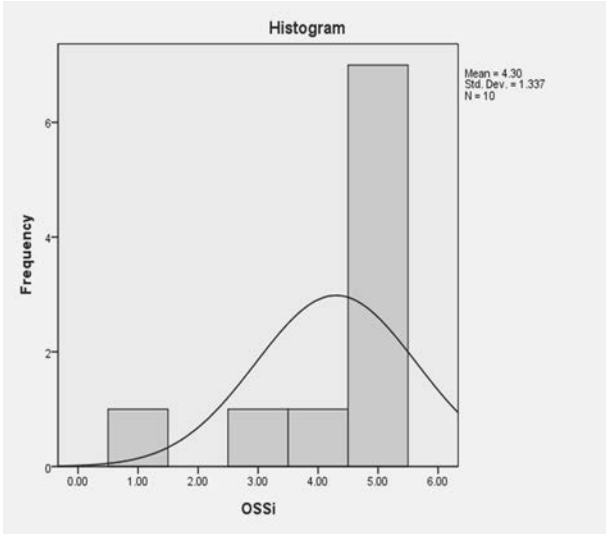


OSSf

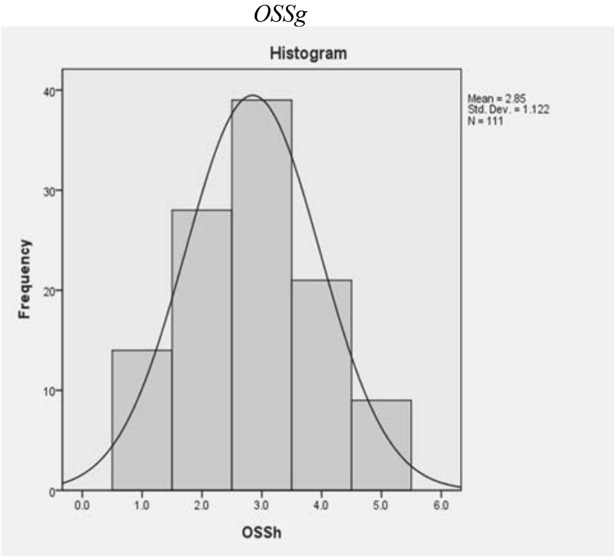
FIG. V.9(a). Histograms for measures of advanced operational support systems (OSS a, b, c, d, e and f).



OSSg



OSSi



OSSh

FIG. V.9(b). Histograms for measures of advanced operational support systems (OSS g, h and i).

V.10. QUALITY OF KNOWLEDGE ACQUISITION AND ADOPTION PROCESSES

Measure KAa: ‘The organization has difficulty finding and hiring appropriately qualified graduates’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

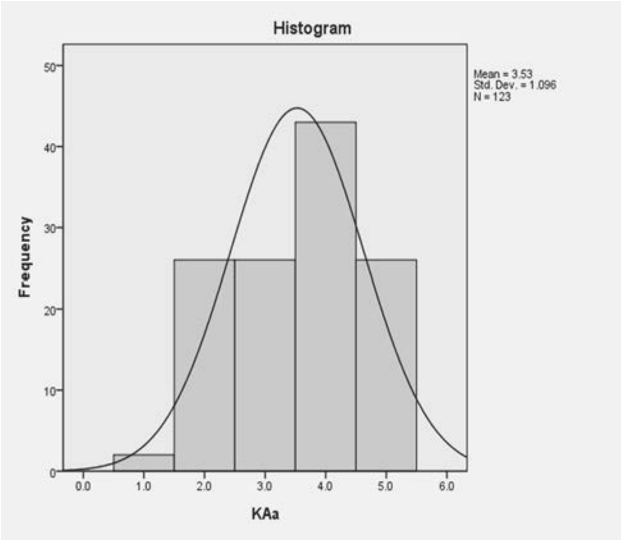
Measure KAb: ‘The organization excels at identifying and acquiring external technical information needed to operate and maintain the plant’.

Measure KAc: ‘External information acquired is often not organized or stored in a maintainable and accessible way to facilitate use and re-use’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

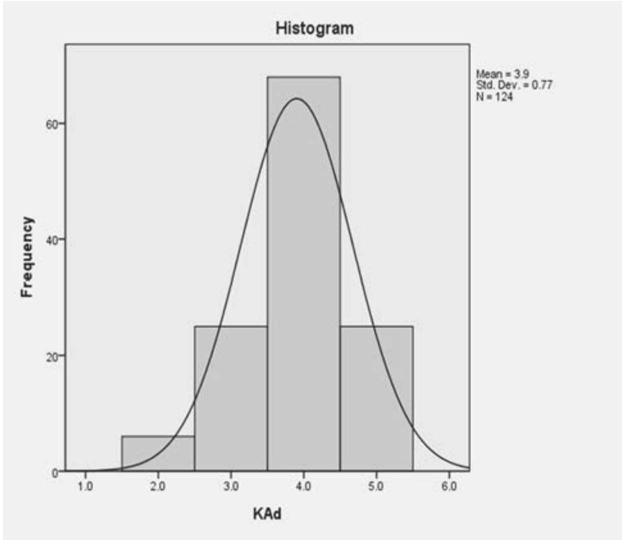
Measure KAd: ‘The organization is effective at acquiring knowledge from external (e.g. peer-plant) operating experiences’.

Measure KAe: ‘The organization is highly effective at adopting external best practices’.

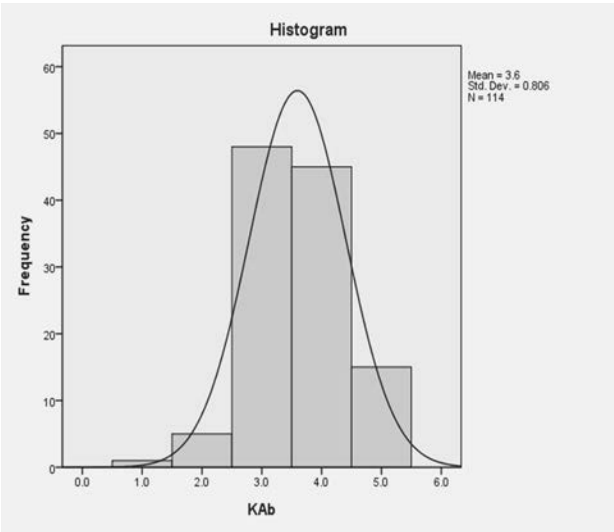
Measure KAf: ‘The organization is good at capturing technical know-how and relevant design information related to services or products received from outside organizations’.



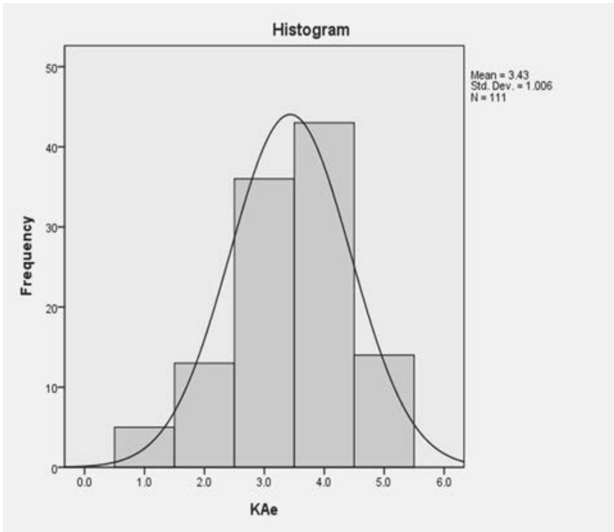
KAa



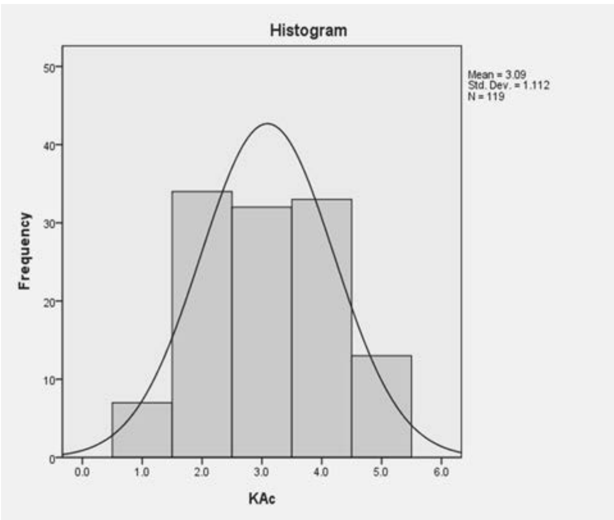
KAd



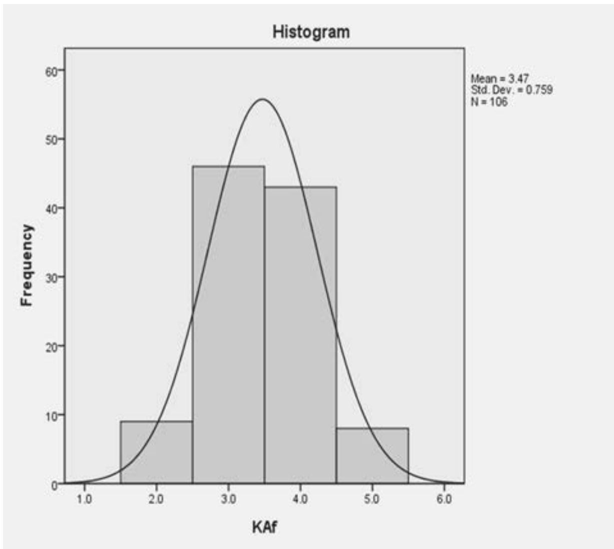
KAb



KAe



KAc



KAf

FIG. V.10. Histograms for measures of quality of knowledge acquisition & adoption (KA a, b, c, d, e and f).

V.11. QUALITY OF KNOWLEDGE GENERATION AND VALIDATION PROCESSES

Measure KGa: 'NPP staff learn from operating experience and new and better ways of running the plant are seldom overlooked'.

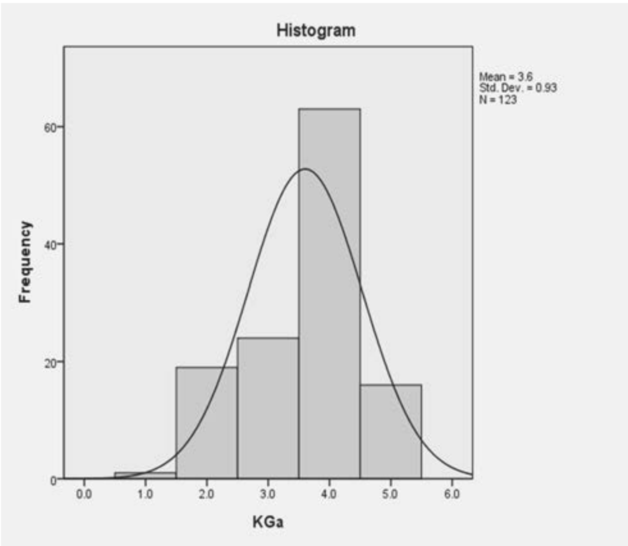
Measure KGb: 'Independent review processes are effective at validating proposed operational or design changes that may impact safety or production'.

Measure KGc: 'Employees lack the questioning attitude needed to challenge assumptions and investigate anomalies or uncertainties'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

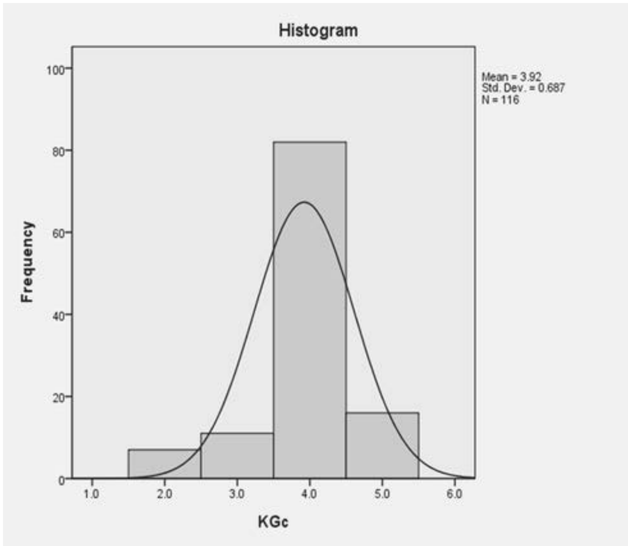
Measure KGd: 'Employees regularly create innovative solutions by combining or adapting existing and/or acquired knowledge'.

Measure KGe: 'The organization excels at generating, transforming, and presenting plant data as meaningful information'.

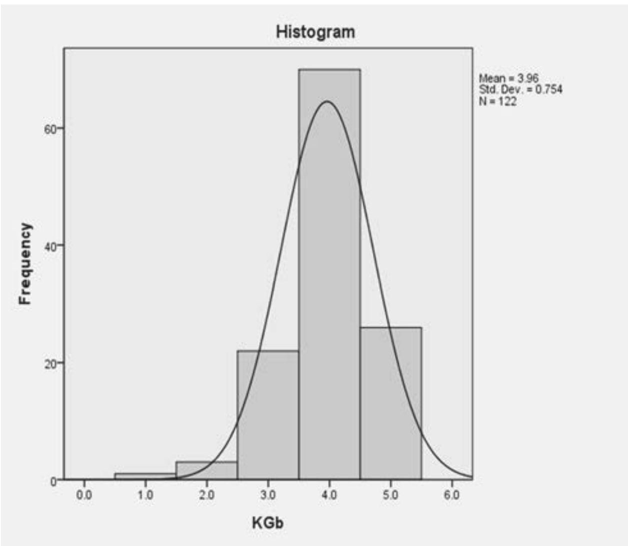
Measure KGf: 'Engineers have to spend too much time gathering and compiling data from many sources'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.



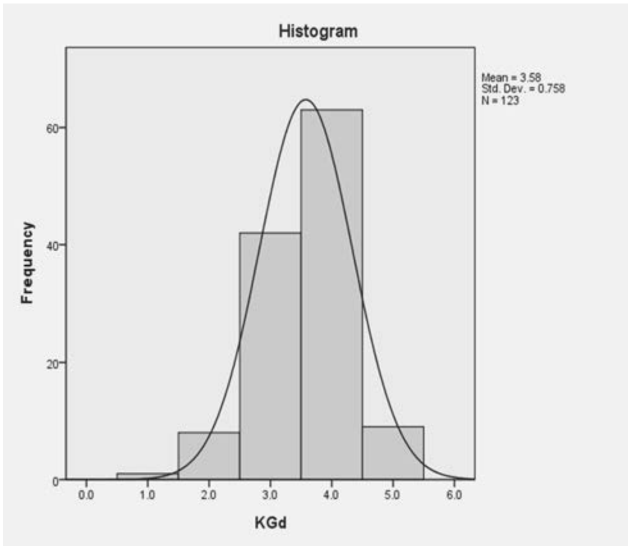
KGa



KGc

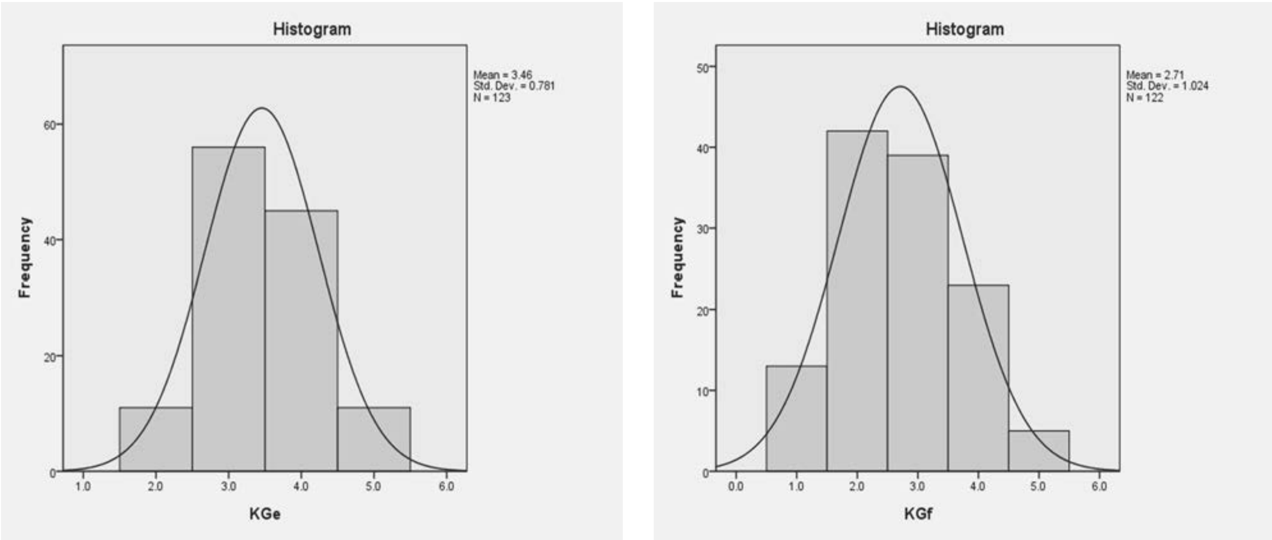


KGb



KGd

FIG. V.11(a). Histograms for measures of quality of knowledge generation & validation (KG a, b, c and d).



KGe *KGf*

FIG. V.11(b). Histograms for measures of quality of knowledge generation & validation (KG e and f).

V.12. QUALITY OF KNOWLEDGE SHARING AND TRANSFER PROCESSES

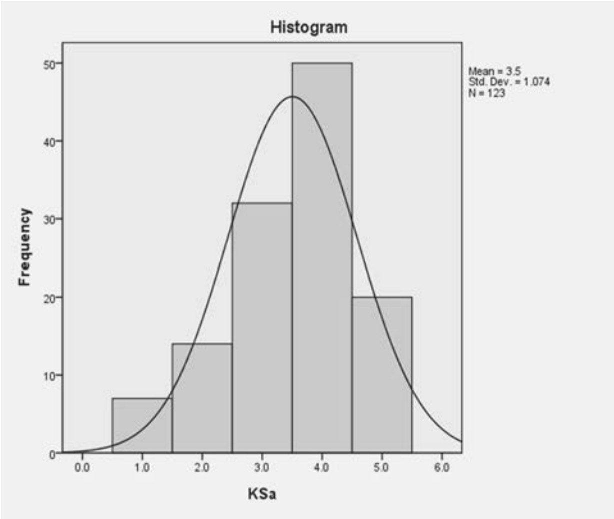
Measure KSa: ‘Findings, information, data, reports, or files generated in one area of the company are readily accessible to other areas’.

Measure KSb: ‘Employees often do not know where in the organization to find specialized knowledge and information’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

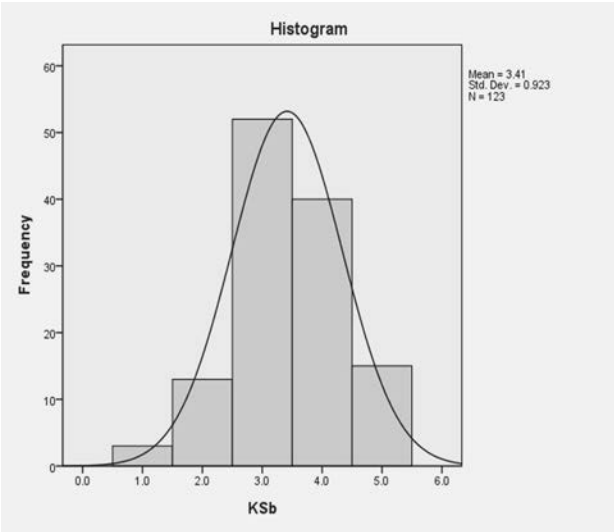
Measure KSc: ‘The problem of hoarding (keeping) knowledge does not exist and employees willingly share their knowledge with co-workers’.

Measure KSd: ‘Expertise and skills are not effectively transferred to junior staff from more experienced employees’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

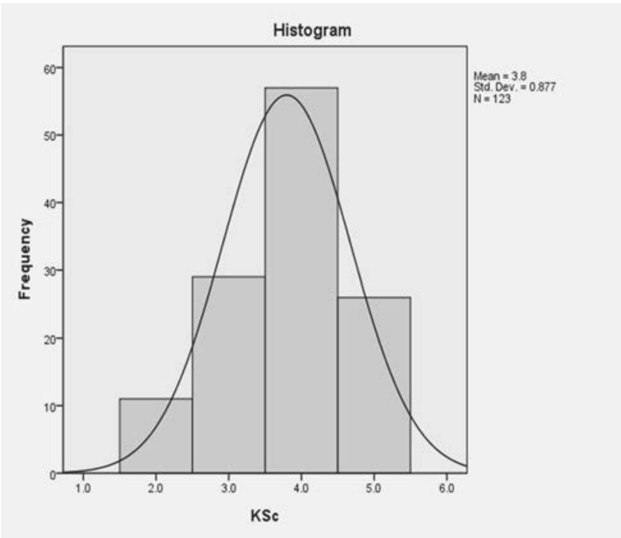
Measure KSe: ‘Employees routinely and voluntarily share relevant information with other parts of the organization where it may be needed’.



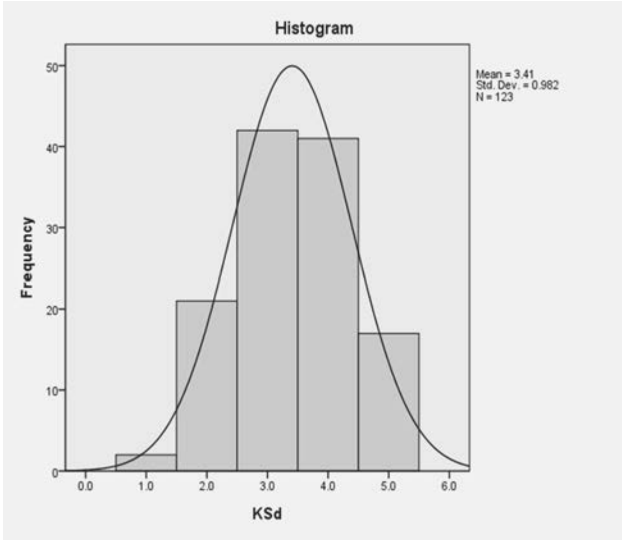
KSa



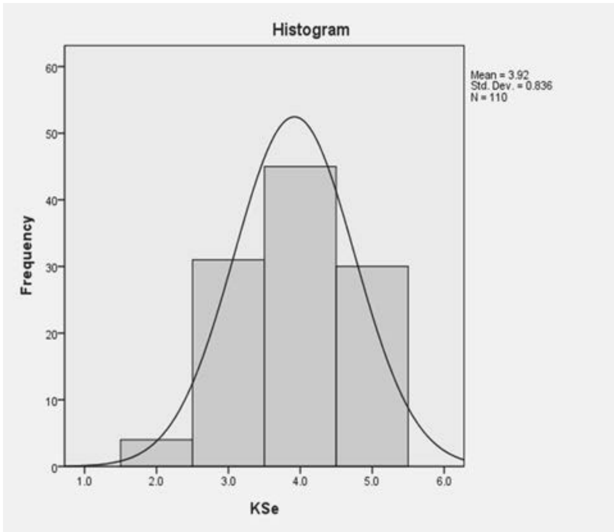
KSb



KSc



KSd



KSe

FIG. V.12. Histograms for measures of quality of knowledge sharing and transfer (KS a, b, c, d and e).

V.13. QUALITY OF KNOWLEDGE UTILIZATION AND APPLICATION PROCESSES

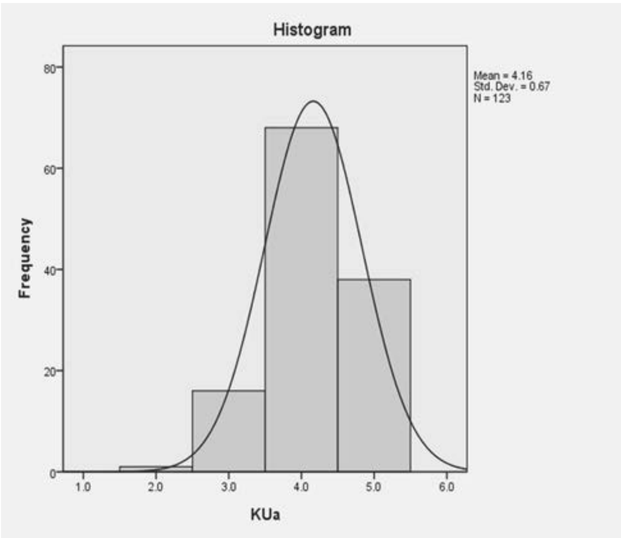
Measure KUa: ‘Lessons learned from operating experience are incorporated in work practices, manuals, procedures and decision-making’.

Measure KUb: ‘The organization is often not able to apply its knowledge effectively to solve difficult technical problems’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

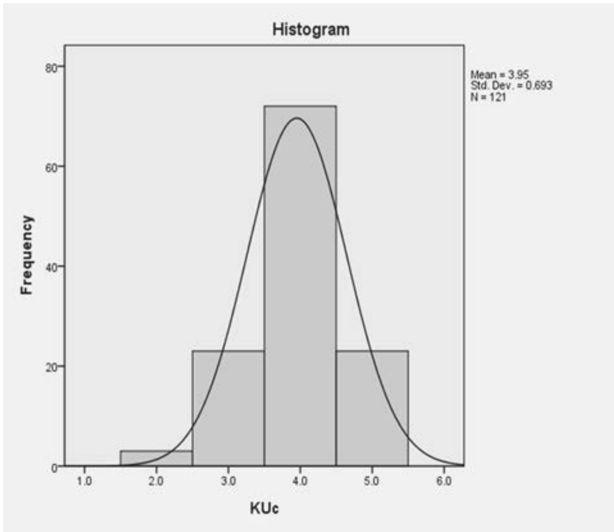
Measure KUc: ‘Employees are consistently able to make important technical decisions correctly’.

Measure KUd: ‘Employees are not always aware of and do not always make effective use of each other’s skills and expertise’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

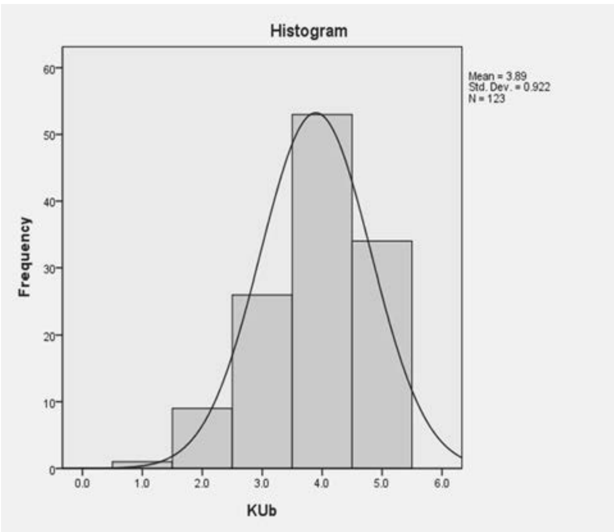
Measure KUe: ‘Equipment replacement and design change decisions are based on a risk-informed decision processes.



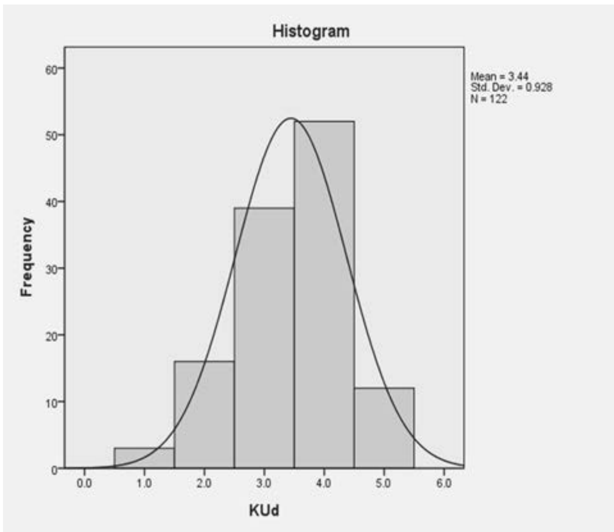
KUa



KUc

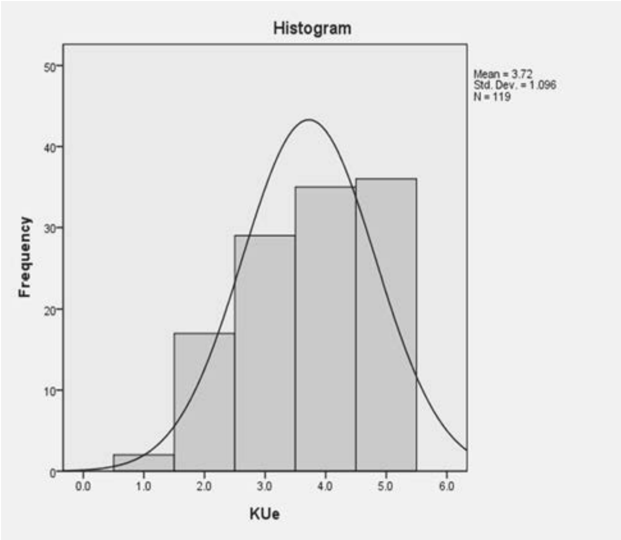


KUb



KUd

FIG. V.13(a). Histograms for measures of quality of knowledge utilization & application (KU a, b, c and d).



KUe

FIG. V.13(b). Histograms for measures of quality of knowledge utilization & application (KUe).

V.14. QUALITY OF KNOWLEDGE RETENTION AND STORAGE PROCESSES

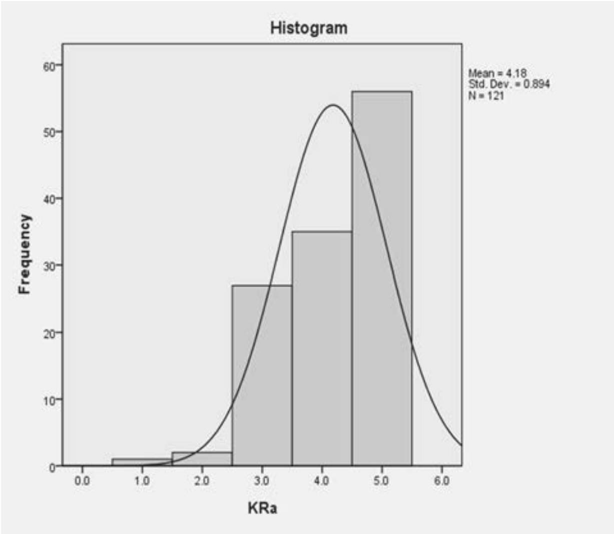
Measure KRa: ‘Employees often lack an appropriate knowledge of the reactor and power plant fundamentals’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

Measure KRb: ‘Employees have adequate knowledge/understanding of work processes (e.g. industrial and radiation safety work practices)’.

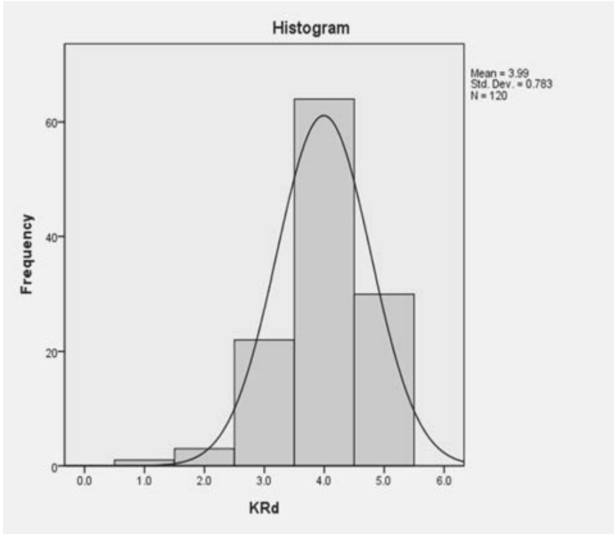
Measure KRc: ‘There is often a shortage of critical skills and experience due to unexpected departures and retirements’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

Measure KRd: ‘Plant design basis documents are easily located and are up-to-date and accurate’.

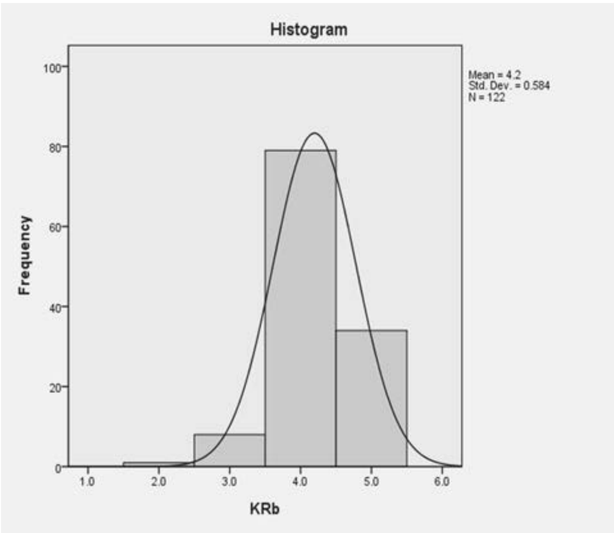
Measure KRe: ‘Maintenance, operations, or technical support specialists lack adequate knowledge of specific systems and technologies to enable them to work effectively and safely’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.



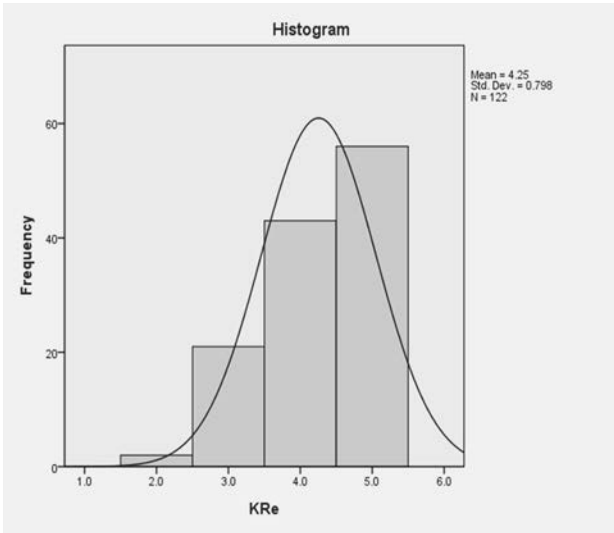
KRa



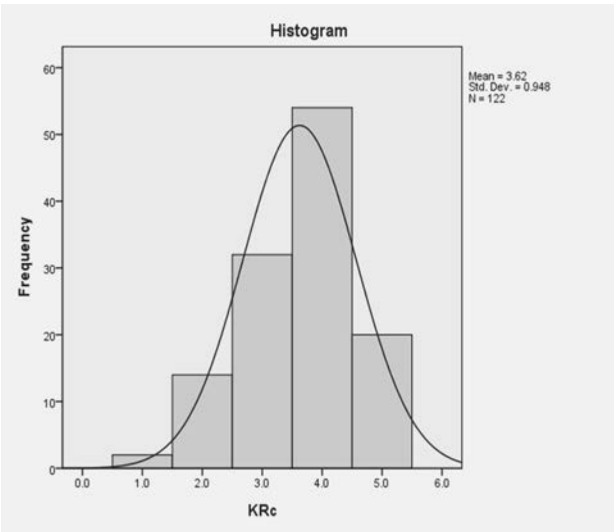
KRd



KRb



KRe



KRc

FIG. V.14. Histograms for measures of quality of knowledge retention & storage (KR a, b, c, d and e).

V.15. SUPPORTIVE ORGANIZATINAL CULTURE

Measure SOCa: ‘Managers and employees often do not see learning, innovation, and improvement as a part of their jobs’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

Measure SOCb: ‘Employees who innovate feel recognized and rewarded’.

Measure SOCc: ‘There is a prevailing attitude and commitment to follow defined processes and fully comply with procedures’.

Measure SOCd: ‘Employees often do not feel empowered to make decisions appropriate to their job duties’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

Measure SOCe: ‘There is shared vision, purpose, and expectations among employees and they see all their problems as mutual’.

Measure SOCf: ‘People are seen as the organisation’s most valued asset’.

Measure SOCg: ‘Employees and managers are open-minded and respect each other’s opinions and contributions’.

Measure SOCh: ‘There is a team-oriented approach throughout the station (e.g., employees trust, cooperate, and help each other)’.

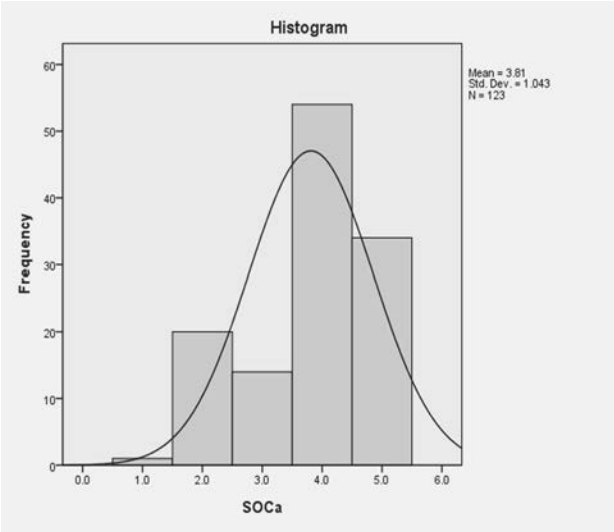
Measure SOCi: ‘Employees often do not feel responsible for plant performance and fail to demonstrate their commitment to it’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

Measure SOCj: ‘Consideration of safety is clearly evident in employee and management actions and decisions’.

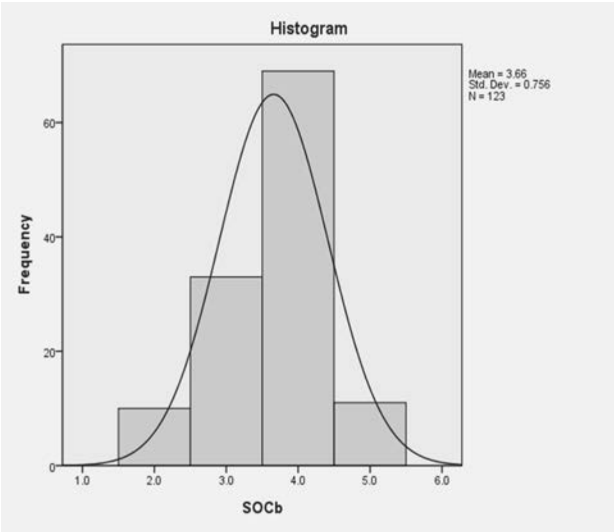
Measure SOCk: ‘Improvements are mostly driven by externally imposed requirements (e.g. regulatory rulings, owner influences)’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question (i.e. in this case, ‘mostly driven by internally imposed requirements’).

Measure SOCl: ‘A questioning attitude is cultivated (i.e. information, approaches and decisions are carefully scrutinized)’.

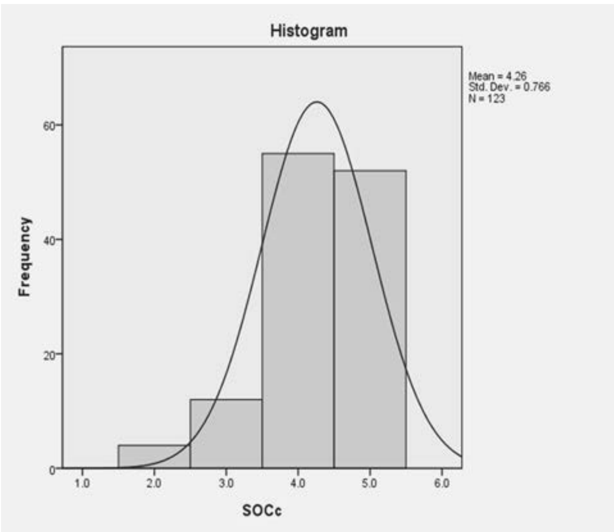
Measure SOCm: ‘The organization is focused primarily on short-term goals’.



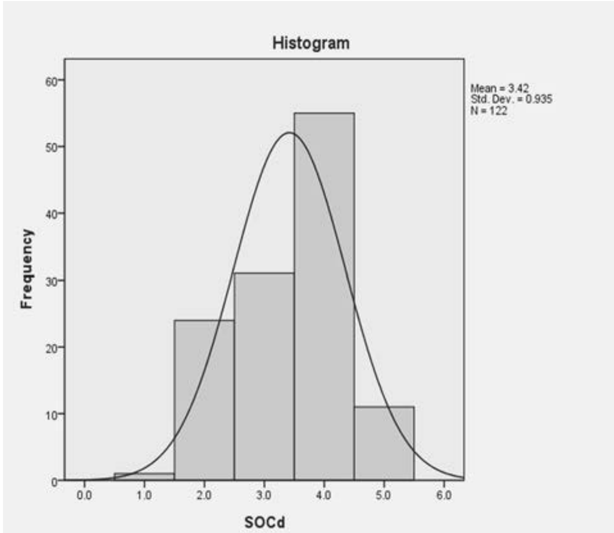
SOCa



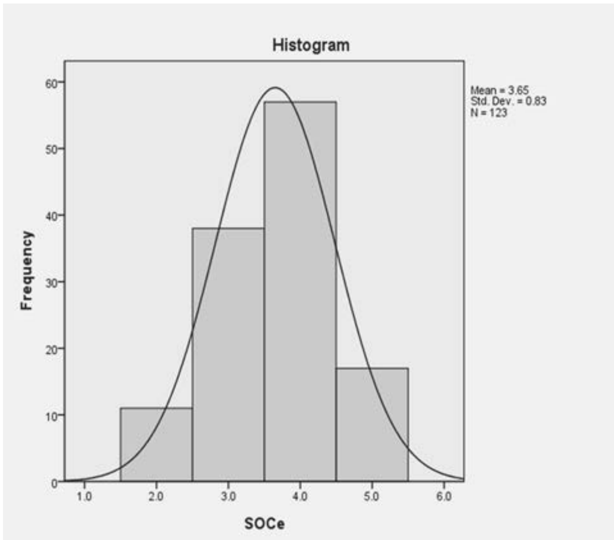
SOCb



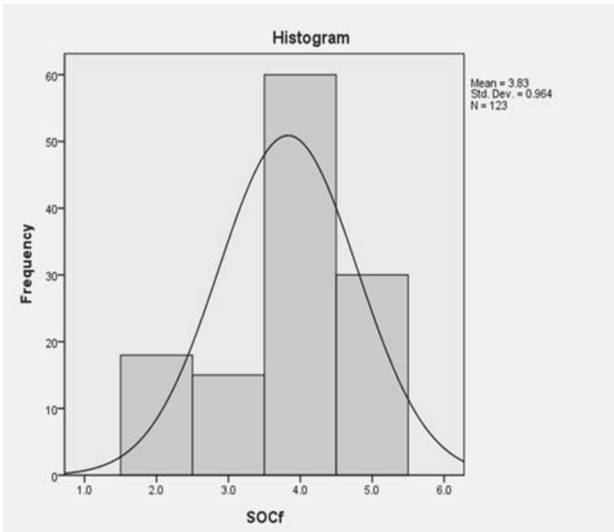
SOCc



SOCd

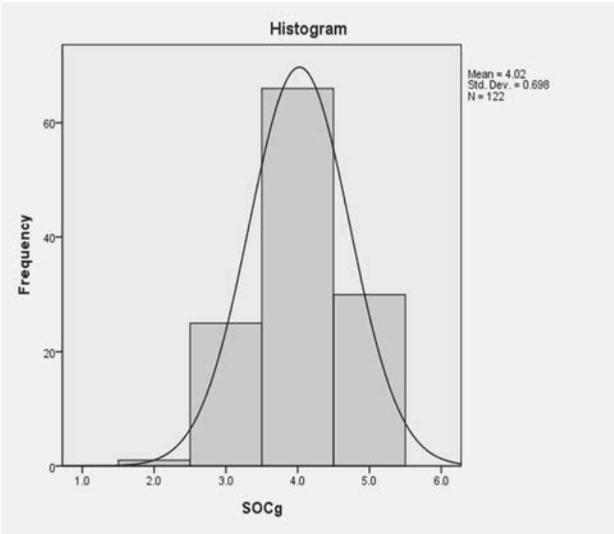


SOCe

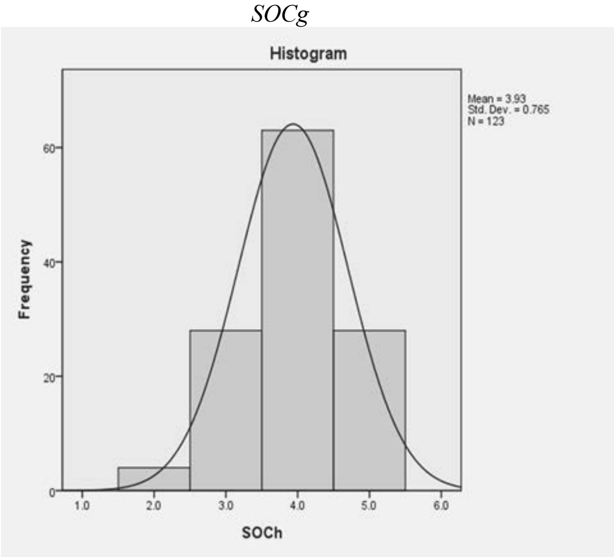


SOCf

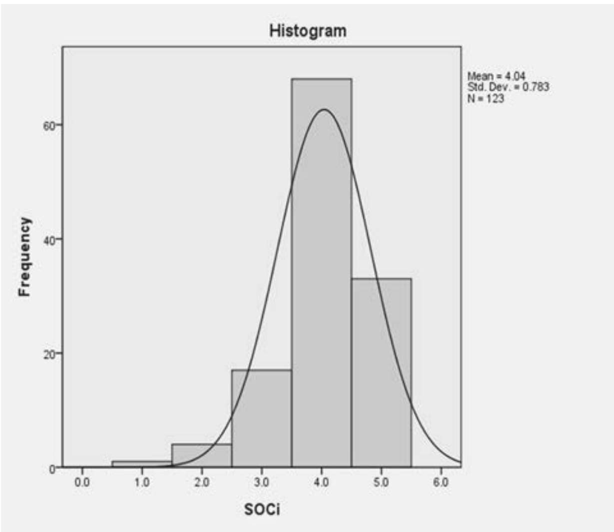
FIG. V.15(a). Histograms for measures of supportive organizational culture (SOC a, b, c, d, e and f).



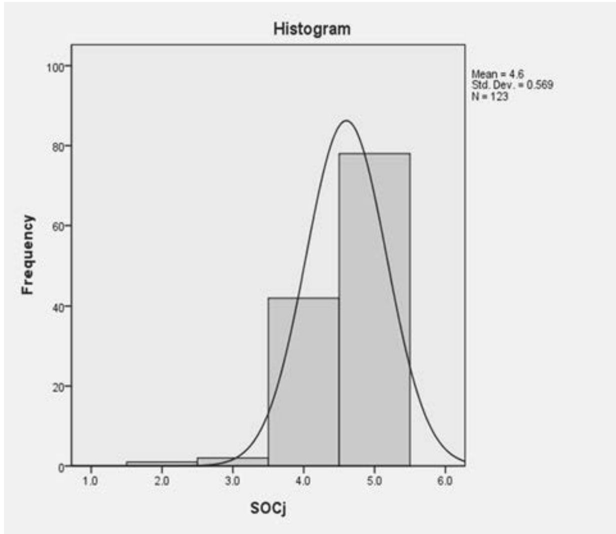
SOCg



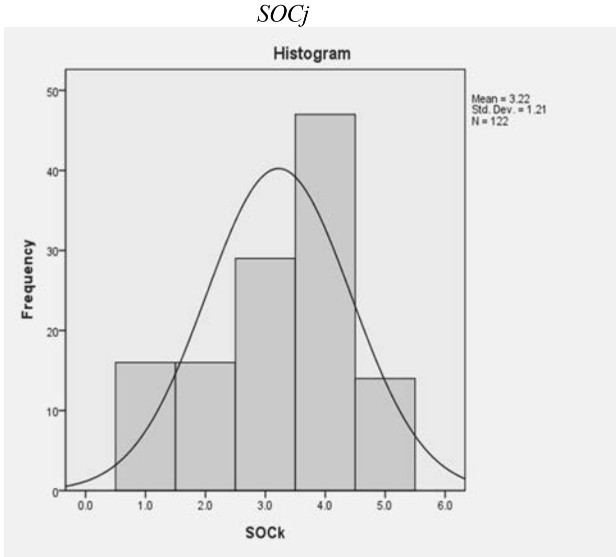
SOCh



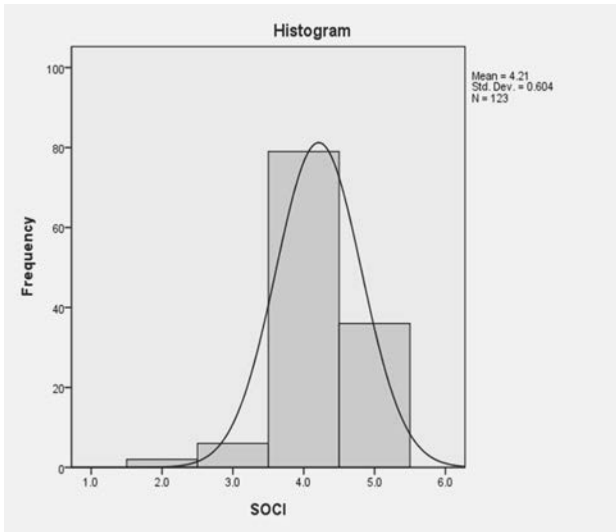
SOCi



SOCj

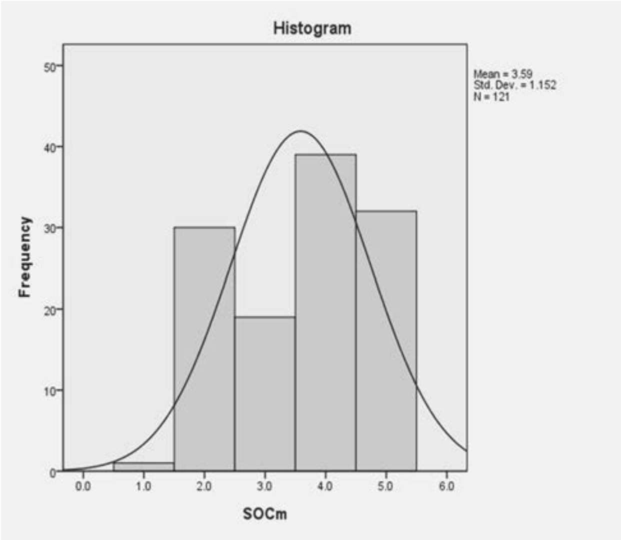


SOCk



SOCl

FIG. V.15(b). Histograms for measures of supportive organizational culture (SOC g, h, i, j, k and l).



SOCm

FIG. V.15(c). Histograms for measures of supportive organizational culture (SOC m).

V.16. ORGANIZATIONAL EFFECTIVENESS

Measure OEa: ‘The organization has difficulty making operational changes smoothly and in a timely manner’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

Measure OEb: ‘Maintenance technicians consistently conduct high-quality corrective and preventive maintenance’.

Measure OEc: ‘The ratio of corrective to preventive maintenance is high relative to best performing NPPs of similar design’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question (i.e., in this case, interpreted as ‘the ratio of corrective to preventive maintenance is similar to best performing NPPs of similar design’).

Measure OEd: ‘The plant chemistry programme ensures the plant consistently operates within the chemistry specifications’.

Measure OEe: ‘Projects involving multiple departments are typically behind schedule, over-budget, and not well coordinated’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question (i.e. in this case, ‘on schedule, on budget, and well-coordinated’).

Measure OEf: ‘Safety objectives are consistently met or exceeded’.

Measure OEg: ‘System and/or performance analysis engineers are not effective at resolving problems that affect plant safety or performance’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

Measure OEh: ‘Radiological conditions are effectively controlled (i.e. field levels are as low as reasonably achievable and dose control is effective)’.

Measure OEi: ‘Quality of documentation (i.e. design, work-process and procedural documentation) needs to improve’. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question (i.e. in this case interpreted as: ‘quality of documentation is adequate and does not need to improve’).

Measure OEj: 'Operators effectively act on changing plant conditions to ensure ongoing safe and reliable plant operation'.

Measure OEk: 'Weekly operations objectives are regularly not met'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

Measure OEl: 'Work planning and management is effective (e.g. planned work-scope is stable, little time is wasted waiting on approvals or parts)'.

Measure OEm: 'The average number of critical component failures per year is low relative to other similar plants'.

Measure OEn: 'Recurrence of known and avoidable operational problems is not always prevented'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

Measure OEo: 'The organization is effective at managing its external interfaces (i.e. the regulator, public, suppliers, contractors)'.

Measure OEp: 'Environmental objectives are sometimes not met'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

Measure OEq: 'Maintenance objectives (e.g. level of corrective and preventive maintenance backlog) based on industry best practice are consistently met or exceeded'.

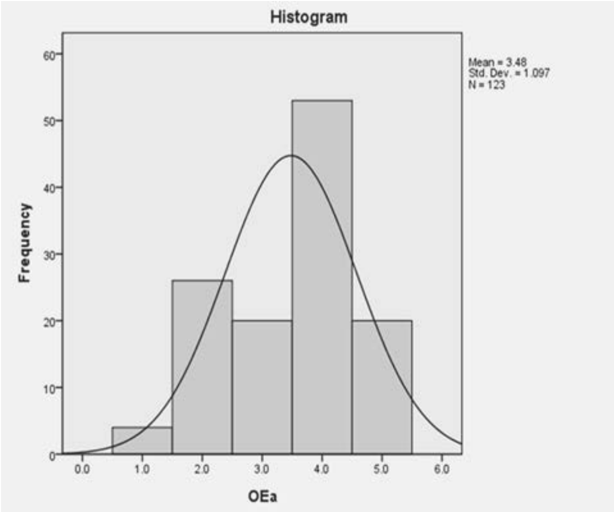
Measure OEr: 'Financial objectives are often not met'. Note the data was reverse coding corrected to support statistical analysis and should be interpreted as the results for the equivalent positively worded question.

Measure OEs: 'Regulatory objectives are consistently met or exceeded'.

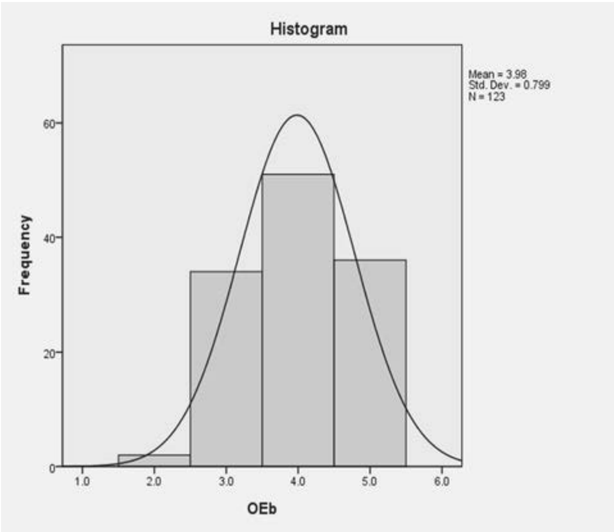
Measure OEt: 'System health improvement initiatives are effective'.

Measure OEu: 'Corrective and preventive maintenance and outage work is completed on schedule and in a timely manner'.

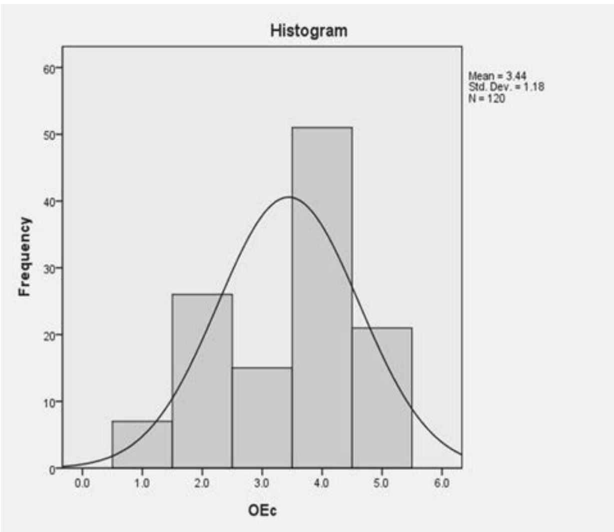
Measure OEv: 'Financial resources (budgets) are adequate and allocated wisely'.



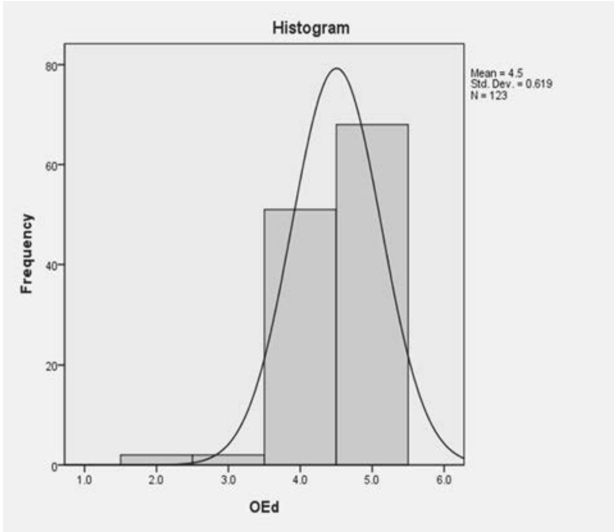
OEa



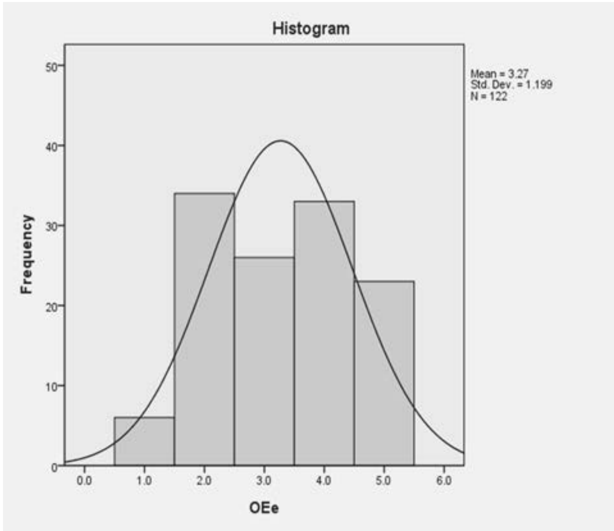
OEb



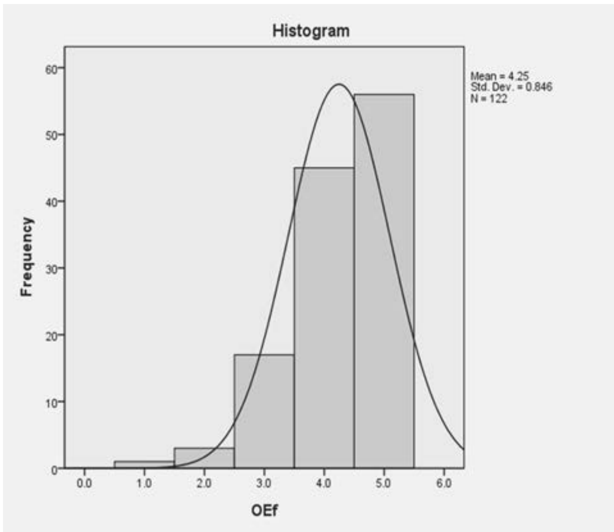
OEc



OEd

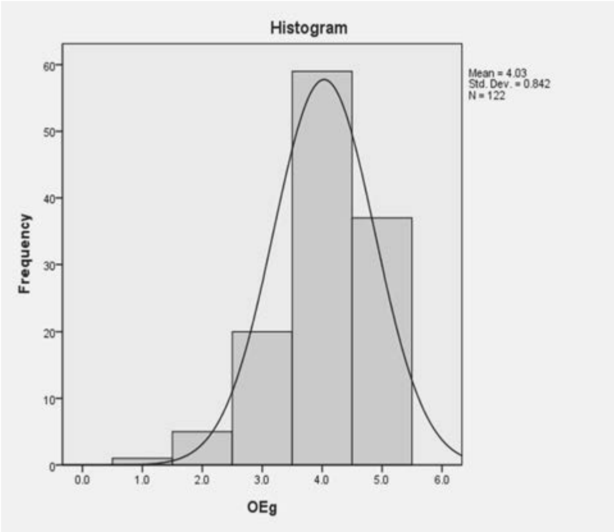


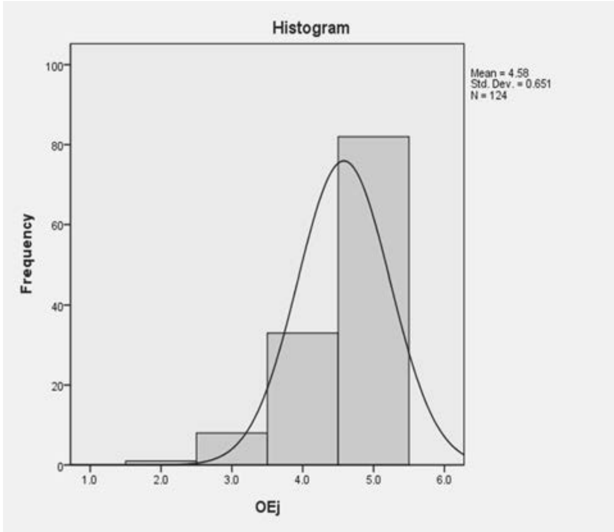
OEe



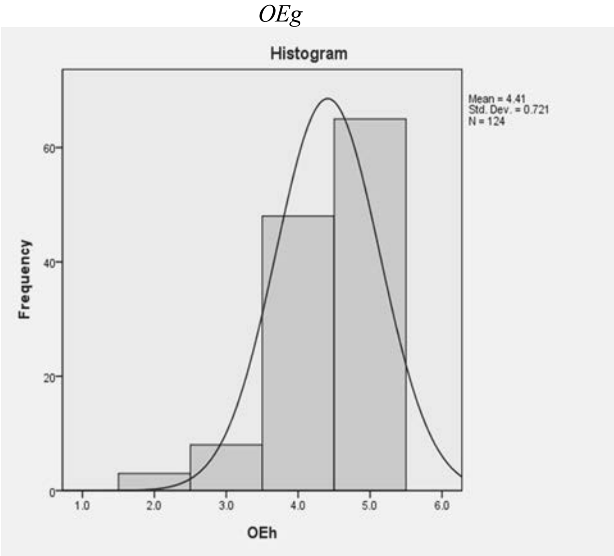
OEf

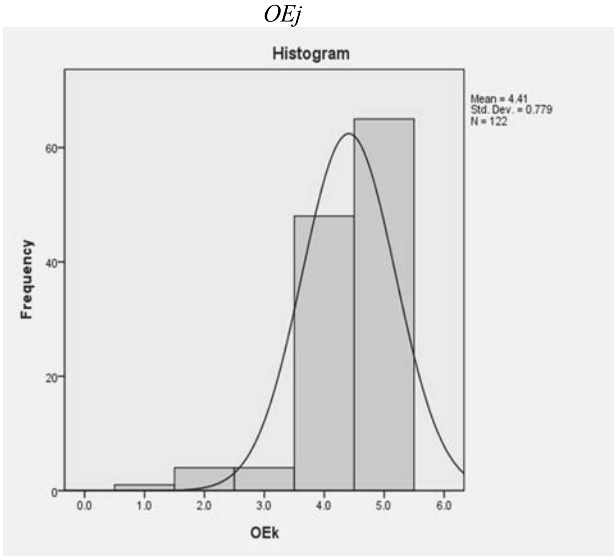
FIG. V.16(a). Histograms for measures of organizational effectiveness (OE a, b, c, d, e and f).



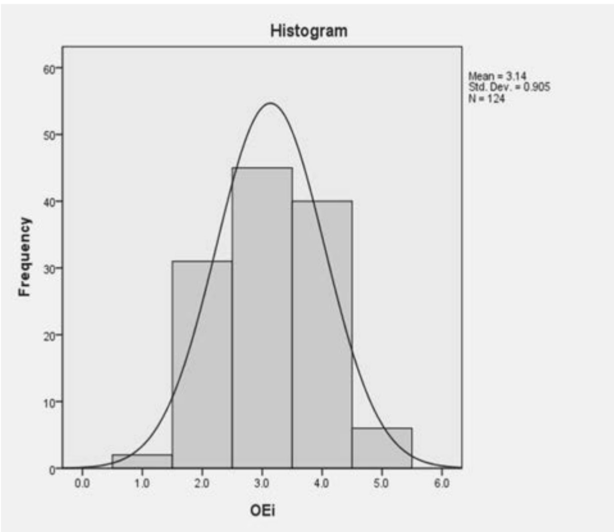


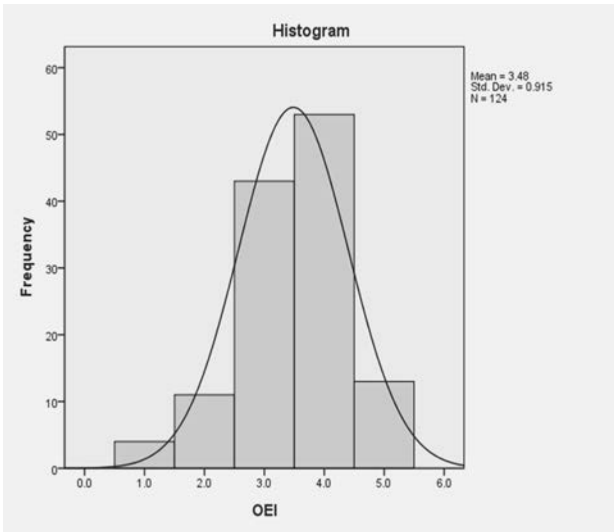
OEg *OEj*





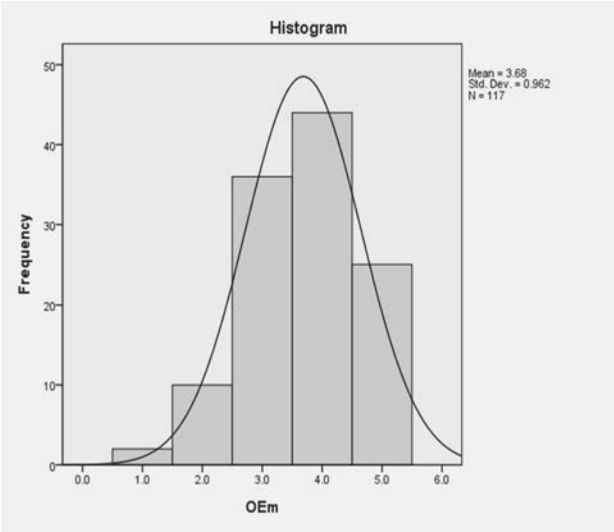
OEh *OEk*



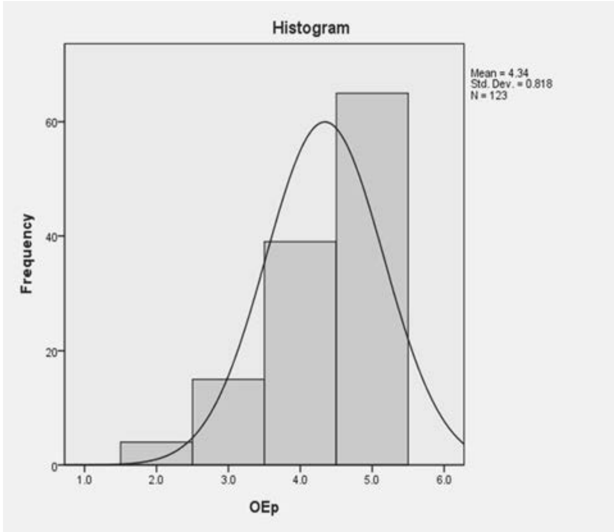


OEi *OEl*

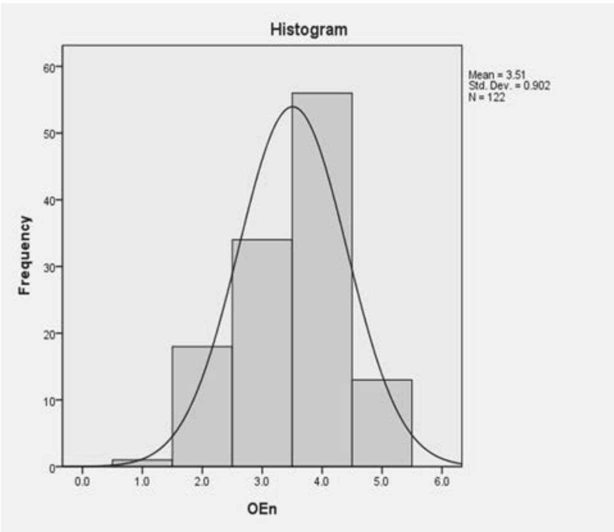
FIG. V.16(b). Histograms for measures of organizational effectiveness (OE g, h, i, j, k and l).



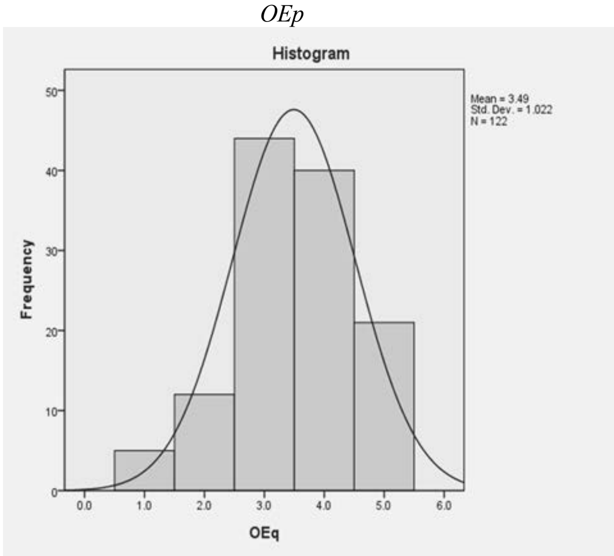
OEm



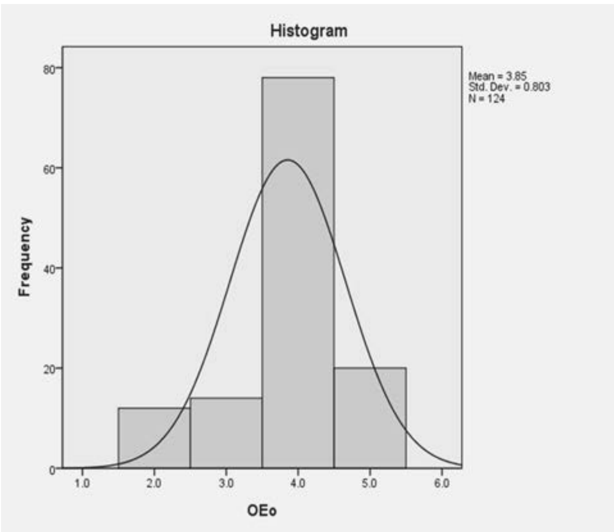
OEp



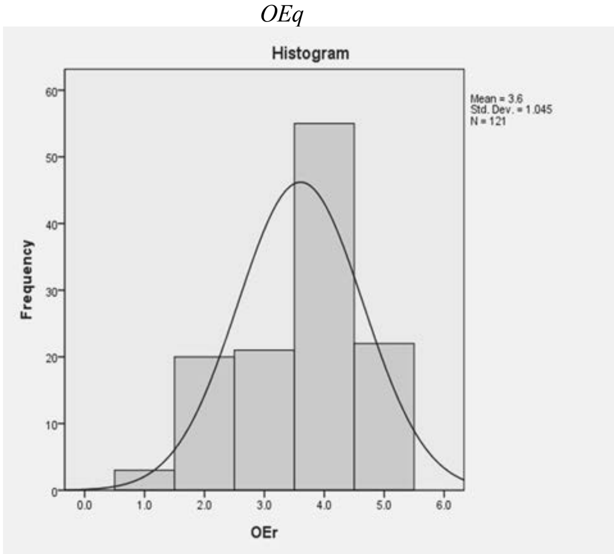
OEn



OEq

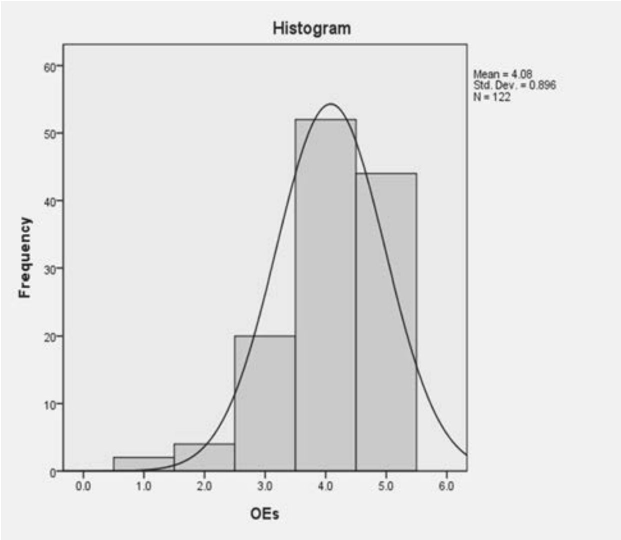


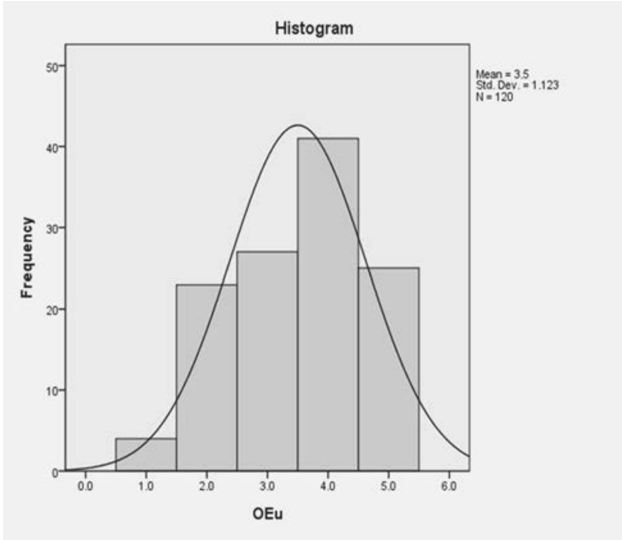
OEo



OEr

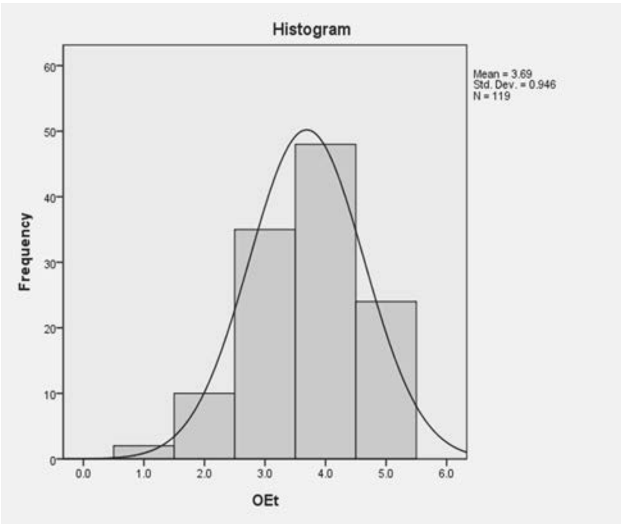
FIG. V.16(c). Histograms for measures of organizational effectiveness (OE m, n, o, p, q and r).

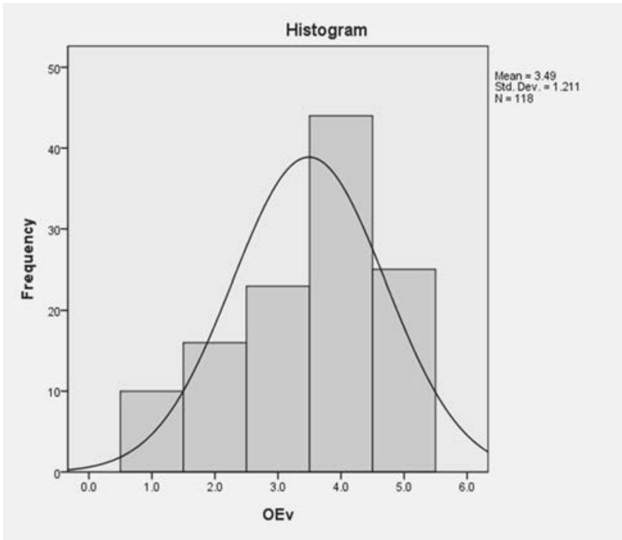




OEs

OEu





OEt

OEv

FIG. V.16(d). Histograms for measures of organizational effectiveness (OE s, t, u and v).

Appendix VI

DESCRIPTIVE DEMOGRAPHIC DATA

Survey question G1 (see Appendix I) asked respondents to '*please indicate the number of employees (excluding contractors) at your station'*. This question was included to obtain demographic data and gives an indication of the range in staffing levels at the responding stations. Figure VI.1 below shows the distribution of responses to Survey question G1.

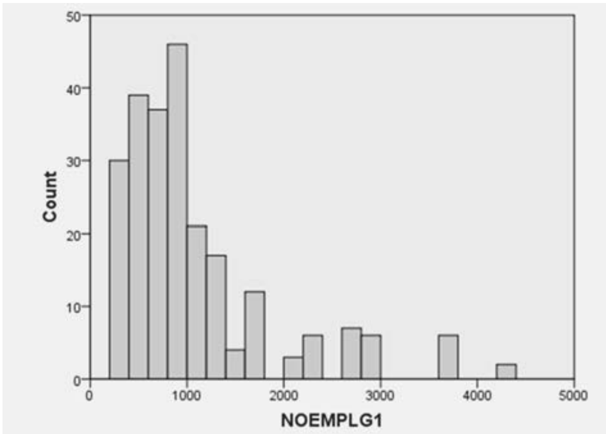


FIG. VI.1. Number of stations by number of employees (see Ref. [2]).

Appendix VII

MULTIPLE REGRESSION DATA ANALYSIS

To investigate these inter-relationships, piece-wise multiple linear regressions were performed. A summary of the analysis is provided in this appendix. For the more detailed statistical analysis using Path Analysis methodology, please see Ref. [2]. These multiple regressions help to explore and understand the nature and strength of the dominant relationships between the various constructs and sub-constructs.

The SPSS software backward elimination multiple regression procedure was used to explore all possible direct main-effect relationships between constructs (i.e. specific knowledge management practices, organizational technology support, quality of knowledge processes, supportive organizational culture, and organizational effectiveness). This was done to the sub-construct level. Significance levels of 0.05 were used as a cut-off. The upper and lower bounds of the 95% confidence intervals for each estimated coefficient (*B*) are provided to show the probability that it does not include zero. Significance results of interest are discussed in the interpretations. Please refer to the discussion of Section 8 for guidance on the proper interpretation of these regression results. A result of P = 0.000 is highly significant.

The *t* statistic is the coefficient (i.e. *B)* divided by its standard error. The standard error is an estimate of the amount it varies across response cases (i.e. a measure of the precision of the regression coefficient). The larger a coefficient is compared to its standard error (i.e. the larger the *t-value*), the more probable that coefficient (i.e. *B)* is different from zero. SPSS software compares the *t-value* of each independent variable with values in Student's *t* distribution to determine the *P-value*. Student's *t* distribution describes how the mean of a sample with a certain number of observations is expected to behave. If 95% of the *t* distribution is closer to the mean than the *t-value* for the coefficient, then the *P-value* will be 5% (i.e. a significance level of 0.05). The *P-value* is the probability of seeing a result as extreme as observed (i.e. a *t-value* as large as observed) if random distributed data with no correlation to the dependent variable were sampled. A *P-value* of 0.05 or less is the generally accepted point at which to reject the null hypothesis. With a *P-value* of 5% (or 0.05) there is only a 5% chance that results observed would have occurred in a random distribution (i.e. a 95% probability that the variable is having an effect, assuming the model is specified correctly). The 95% confidence interval for coefficients shown by SPSS software provides the same information.

In this appendix, the acronyms for KM practices (KMPs) and organizational technology support (OTS) are used. Recall that KMP sub-constructs include:

— *KM strategy and planning* (KMS) — the extent to which corporate wide KM policy and strategy has been established and the planning to implement it has been put in place;
— *Support for organizational learning* (SOL) — the extent to which management provides sufficient resources and enables various mechanisms for individual, group, or institutional level learning;
— *Process management related KM practices* (PMP) — the extent to which management establishes and maintains effective knowledge-based business processes (i.e. process-oriented KM practices);
— *Information management related KM practices* (IMP) — the extent to which effective information management practices have been implemented (i.e. that support knowledge processes);
— *Organizational performance management related KM practices* (OPM) — the extent to which knowledge-based performance management practices have been put in place;

— *Training related practices* (TRP) — the extent to which industry best practices for training have been put in place and address KM related issues of training;
— *Human resource (HR) related KM practices* (HRP) — the extent to which HR related KM practices such as competency development and knowledge retention have been put in place.

Recall the level of organizational technology support (OTS) construct is based on two sub-constructs, the effective use of:
— *Information systems and technology* (IST) (i.e. enterprise IS and IT); and
— *Advanced operational support systems* (OSS) (i.e. advanced NPP-specific decision support systems).

Also in this appendix, the acronyms for quality knowledge processes (QKPs) and organizational effectiveness (OE) are used. Recall that QKP sub-constructs include:
— *Quality of knowledge acquisition and adoption processes (KA)* — the process of obtaining and adopting new external knowledge (whether tacit or explicit) into the organization. This is interpreted to include knowledge identification and selection processes for the purpose of acquisition;
— *Quality of knowledge sharing and transfer processes (KS)* — the exchange of knowledge within the organization (directly or indirectly) and including processes of knowledge conveyance and distribution;
— *Quality of knowledge generation and validation processes (KG)* — the creation of new knowledge, typically by incremental knowledge development, and its validation within the organization. It may also include knowledge identification and selection processes associated with internal knowledge generation processes;
— *Quality of knowledge retention and storage processes (KR)* — the process of keeping knowledge (whether tacit or explicit) within the organization and maintaining its availability and relevance for future use. It incorporates the related concepts of knowledge capture, preservation, storage, retrieval, accessibility, identification and protection in the context of internal organizational knowledge retention;
— *Quality of knowledge utilization and application processes (KU)* — the concept of internal organizational knowledge use (whether tacit or explicit) and including the process of adapting or interpreting it in a problem context.

Appropriate procedures for data entry and preparation, data quality and screening (including removal of outliers), handling of missing data, missing value analysis, and reliability screening of measures (construct reliability analysis) were followed and are described in Ref. [2]. Construct reliability analysis was performed to ensure the integrity of each construct. The following measures were considered unreliable and removed from the data set and statistical analysis: Part A, question 6d (i.e. TRPd), Part B, question 1a (i.e. ISTa), Part B, question 2i (i.e. OSSi), Part C, question 1a (i.e. KAa), Part D, question 1c (i.e. SOCc), and Part E, question 1c (i.e. OEc). Improvements to these measures are planned for future versions of the survey and these are summarized in Appendix VIII.

VII.1. DIRECT ONE-TO-ONE REGRESSIONS AMONGST ALL CONSTRUCTS

The inter-item correlation matrix and inter-item covariance matrix was produced using SPSS ‘Scale Reliability’ option to better understand the degree of correlation amongst the construct variables. Table VII.1 summarizes the findings. As expected, some degree of correlation and covariance exists between all the constructs. All correlations were positive.

TABLE VII.1. INTER-ITEM CORRLATION AND COVARIANCE SUMMARY

Summary item statistics							
	Mean	Minimum	Maximum	Range	Max./Min.	Variance	N of items
Inter-item covariances	0.171	0.033	0.369	0.336	11.039	0.005	16
Inter-item correlations	0.472	0.052	0.777	0.725	14.928	0.024	16

To explore direct one-to-one relationships between the constructs (i.e. and sub-constructs), all relevant one-to-one regressions between them were initially performed. Given that some degree of correlation and covariance exists between all the constructs, the one-to-one regression coefficients may be somewhat misleading if interpreted on their own. However, the explained variance and significance is useful and is shown in Table VII.2. Note that all one-to-one regression coefficients were found to be positive and significant at 0.05 or better, however only 11 (of 54) of these relationships explained more than 40% of the variance of any one dependant variable. In these 11 (and indeed for all one-to-one regression cases) it is important to remember that one or more other constructs may be affecting the same dependent variable (as is seen in the subsequent regressions). Careful simultaneous interpretation of relationships is required and is explored further in the following sections.

TABLE VII.2. CONSIDERATION OF ONE-TO-ONE CONSTRUCT REGRESSIONS

Model *IV → DV*	Adjusted R square (variance explained)	P-value
KMS → KA	0.124	0.000
SOL → KA	0.252	0.000
PMP → KA	0.328	0.000
IMP → KA	0.158	0.000
OPM → KA	0.309	0.000
TRP → KA	0.235	0.000
HRP → KA	0.344	0.000
IST → KA	0.171	0.000
OSS → KA	0.223	0.000
SOC → KA	0.379	0.000
KMS → KG	0.183	0.000
SOL → KG	0.198	0.000
PMP → KG	0.306	0.000
IMP → KG	0.176	0.000
OPM → KG	0.258	0.000
TRP → KG	0.194	0.000
HRP → KG	0.244	0.000
IST → KG	0.119	0.000
OSS → KG	0.146	0.000
SOC → KG	0.406	0.000
KMS → KS	0.287	0.000
SOL → KS	0.401	0.000
PMP → KS	0.387	0.000
IMP → KS	0.213	0.000
OPM → KS	0.270	0.000
TRP → KS	0.274	0.000
HRP → KS	0.418	0.000
IST → KS	0.104	0.000
OSS → KS	0.128	0.000
SOC → KS	0.455	0.000
KMS → KU	0.152	0.000
SOL → KU	0.187	0.000
PMP → KU	0.201	0.000
IMP → KU	0.263	0.000
OPM → KU	0.223	0.000
TRP → KU	0.210	0.000
HRP → KU	0.264	0.000
IST → KU	0.181	0.000
OSS → KU	0.173	0.000
SOC → KU	0.368	0.000
KMS → KR	0.299	0.000
SOL → KR	0.335	0.000
PMP → KR	0.297	0.000
IMP → KR	0.093	0.000
OPM → KR	0.125	0.000
TRP → KR	0.299	0.000
HRP → KR	0.409	0.000
IST → KR	0.029	0.034
OSS → KR	0.067	0.003
SOC → KR	0.468	0.000
KMS → SOC	0.408	0.000
SOL → SOC	0.542	0.000

TABLE VII.2 (cont.). CONSIDERATION OF ONE-TO-ONE CONSTRUCT REGRESSIONS

Model *IV → DV*	Adjusted R square (variance explained)	P-value
PMP → SOC	0.379	0.000
IMP → SOC	0.154	0.000
OPM → SOC	0.163	0.000
TRP → SOC	0.244	0.000
HRP → SOC	0.439	0.000
IST → SOC	0.060	0.004
OSS → SOC	0.067	0.003
KMS → OE	0.299	0.000
SOL → OE	0.191	0.000
PMP → OE	0.296	0.000
IMP → OE	0.185	0.000
OPM → OE	0.162	0.000
TRP → OE	0.220	0.000
HRP → OE	0.265	0.000
IST → OE	0.093	0.000
OSS → OE	0.111	0.000
SOC → OE	0.479	0.000
KA → OE	0.249	0.000
KS → OE	0.324	0.000
KG → OE	0.331	0.000
KR → OE	0.481	0.000
KU → OE	0.496	0.000

Before testing the specific relationships amongst the constructs, a check for multi-collinearity was done using SPSS 'Reliability Statistics'. The variance inflation factor (VIF) for each item-to-total correlation was examined for all relevant cases by systematically testing each covariate as the DV. The values above 3.0 are shown in Table VII.3, in each case. In general, a reasonably low level of multi-collinearity exists (i.e. none were above 4, and this is well below the generally accepted threshold of concern, i.e. values of VIF much greater than 5). However, simultaneous regression and interpretation of relationships is needed.

TABLE VII.3. SUMMARY OF CHECKS FOR MULTI-COLLINEARITY

Model	VIF > 3.0 (covariate responsible)
KMS+SOL+PMP+OMP+TRP+IMP+HRP+IST+OSS→SOC	3.014 (PMP)
SOC+SOL+PMP+OMP+TRP+IMP+HRP+IST+OSS→KMS	3.153 (SOC)
KMS+SOC+PMP+OMP+TRP+IMP+HRP+IST+OSS→SOL	3.022 (PMP)
SOC+SOL+KMS+OMP+TRP+IMP+HRP+IST+OSS→PMP	3.356 (SOC)
SOC+SOL+PMP+KMS+TRP+IMP+HRP+IST+OSS→OPM	3.354 (SOC)
SOC+SOL+PMP+OMP+KMS+IMP+HRP+IST+OSS→TRP	3.374 (SOC); 3.027 (PMP)
SOC+SOL+PMP+OMP+TRP+KMS+HRP+IST+OSS→IMP	3.225 (SOC)
SOC+SOL+PMP+OMP+TRP+IMP+KMS+IST+OSS→HRP	3.159 (SOC)
SOC+SOL+PMP+OMP+TRP+IMP+HRP+KMS+OSS→IST	3.223 (SOC)
SOC+SOL+PMP+OMP+TRP+IMP+HRP+IST+KMS→OSS	3.338 (SOC)
SOC+SOL+PMP+OMP+TRP+IMP+HRP+IST+KMS+OSS→KA	3.372 (SOC); 3.029 (PMP)
SOC+SOL+PMP+OMP+TRP+IMP+HRP+IST+KMS+OSS→KG	3.397 (SOC)
SOC+SOL+PMP+OMP+TRP+IMP+HRP+IST+KMS+OSS→KS	3.257 (SOC)
SOC+SOL+PMP+OMP+TRP+IMP+HRP+IST+KMS+OSS→KU	3.327 (SOC); 3.029 (PMP)
SOC+SOL+PMP+OMP+TRP+IMP+HRP+IST+KMS+OSS→KR	3.386 (SOC); 3.019 (PMP)
SOC+SOL+PMP+OMP+TRP+IMP+HRP+IST+KMS+OSS→OE	3.372 (SOC); 3.029 (PMP)
KA+KG+KS+KU+KR→OE	3.434 (KG)

VII.2. KM PRACTICES & TECHNOLOGY SUPPORT vs. QUALITY OF KNOWLEDGE ACQUISITION AND ADOPTION PROCESSES

Table VII.2 summarizes the significant results from the regression analysis of all the constructs of the KM practices (KMPs) and organizational technology support (OTS) against knowledge acquisition and adoption (KA) after non-significant factors were eliminated.

TABLE VII.4. REGRESSION OF KM PRACTICES & TECHNOLOGY SUPPORT ON QUALITY OF KNOWLEDGE ACQUISITION AND ADOPTION (see Ref. [2])

Dependent variable: KA						
Covariate	B[a]	Std. error[b]	t[c]	P-value[d]	95% confidence interval	
					Lower bound	Upper bound
OPM	0.415	0.106	3.906	0.000	0.205	0.626
HRP	0.29	0.059	4.893	0.000	0.172	0.407
OSS	0.207	0.051	4.093	0.000	0.107	0.307

[a] B — the values for the regression coefficient for predicting the dependent variable from the independent variable.
[b] associated with the corresponding B coefficients.
[c, d] the t-statistics (i.e. from Student's t-test).

Note: The footnotes [a, b, c] and [d] are valid for Tables VII.2–VII.19.

From Table VII.2, it can be seen that only the covariates OPM, HRP, and OSS were significant with KA at the 0.05 level.

VII.3. KM PRACTICES & TECHNOLOGY SUPPORT vs. QUALITY OF KNOWLEDGE SHARING AND TRANSFER PROCESSES

Table VII.3 summarizes the significant results from the regression of all the knowledge management practices (KMPs) and organizational technology support (OTS) on the quality of knowledge sharing and transfer processes (KS) after non-significant factors were eliminated.

TABLE VII.3. REGRESSION OF KM PRACTICES & TECHNOLOGY SUPPORT ON QUALITY OF KNOWLEDGE SHARING AND TRANSFER (see Ref. [2])

Dependent variable: KS						
Covariate	B	Std. error	t	P-value	95% confidence Interval	
					Lower bound	Upper bound
HRP	0.295	0.062	4.742	0.000	0.172	0.418
IMP	0.418	0.091	4.587	0.000	0.237	0.598
SOL	0.404	0.083	4.879	0.000	0.24	0.568

From Table VII.3, it can be seen that only covariates HRP, IMP, and SOL were significant with KS at the 0.05 level.

VII.4. KM PRACTICES & TECHNOLOGY SUPPORT vs. QUALITY OF KNOWLEDGE RETENTION AND STORAGE PROCESSES

Table VII.4 summarizes the significant results from the regression analysis of all the KMPs and OTSs combined on quality of knowledge retention and storage (KR) after non-significant factors were eliminated.

TABLE VII.4. REGRESSION OF KM PRACTICES & TECHNOLOGY SUPPORT ON QUALITY OF KNOWLEDGE RETENTION & STORAGE (see Ref. [2])

Dependent variable: KR						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
HRP	0.355	0.054	6.533	0.000	0.247	0.463
TRP	0.409	0.095	4.293	0.000	0.22	0.597
OPM	-0.197	0.097	-2.028	0.045	-0.39	-0.005

From Table VII.4, it can be seen that only covariates HRP, TRP, and OPM were found to be significant with KR at the 0.05 level. Note that OPM correlates negatively with KR, however, has an upper bound close to zero and is close to the 0.05 cut-off, and as this finding is not expected or supported in the literature, the significance of the relationship is suspect and therefore was not included. It is possible that a measurement deficiency may be affecting the results. Measure OPMa was questionable in terms of reliability. Further discussion and analysis is provided in Ref. [2].

VII.5. KM PRACTICES & TECHNOLOGY SUPPORT vs. QUALITY OF KNOWLEDGE GENERATION AND VALIDATION PROCESSES

Table VII.5 summarizes the significant results from the regression analysis of all the KMPs and OTSs combined on knowledge generation and validation (KG) after non-significant factors were eliminated.

TABLE VII.5. REGRESSION OF KM PRACTICES & TECHNOLOGY SUPPORT ON QUALITY OF KNOWLEDGE GENERATION & VALIDATION (see Ref. [2])

Dependent variable: KG						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
OPM	0.571	0.088	6.45	0.000	0.395	0.746
KMS	0.255	0.047	5.455	0.000	0.162	0.347

From Table VII.5, it can be seen that only covariates KMS and OPM were found to be significant with KG at the 0.05 level.

VII.6. KM PRACTICES & TECHNOLOGY SUPPORT vs. QUALITY OF KNOWLEDGE UTILIZATION AND APPLICATION PROCESSES

Table VII.6 summarizes the significant results from the regression analysis of all the KMPs and OTSs combined on knowledge utilization and application (KU) after non-significant factors were eliminated.

TABLE VII.6. REGRESSION OF KM PRACTICES & TECHNOLOGY SUPPORT ON QUALITY OF KNOWLEDGE UTILIZATION & APPLICATION (see Ref. [2])

Dependent variable: KU						
Covariate	B	Std. error	t	P-value	95% confidence Interval	
					Lower bound	Upper bound
IMP	0.419	0.077	5.452	0.000	0.267	0.571
HRP	0.235	0.047	5.005	0.000	0.142	0.328
IST	0.224	0.051	4.37	0.000	0.123	0.326

From Table VII.6, it can be seen that only covariates IMP, HRP, and IST were found to be significant with KU at the 0.05 level.

VII.7. KM PRACTICES & TECHNOLOGY SUPPORT vs. SUPPORTIVE ORGANIZATIONAL CULTURE

Table VII.7 summarizes the significant results from the regression analysis of all the KMPs and OTSs combined on supportive of organizational culture (SOC) after non-significant factors were eliminated.

TABLE VII.7. REGRESSION OF KM PRACTICES AND TECHNICAL SUPPORT ON SUPPORTIVE ORGANIZATIONAL CULTURE (see Ref. [2])

Dependent variable: SOC						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
IMP	0.168	0.066	2.555	0.012	0.038	0.297
HRP	0.156	0.049	3.173	0.002	0.059	0.253
IST	0.097	0.042	2.283	0.024	0.013	0.18
SOL	0.405	0.063	6.462	0.000	0.281	0.53
KMS	0.169	0.044	3.856	0.000	0.082	0.256

From Table VII.7, it can be seen that only covariates IMP, HRP, IST, SOL, and KMS were found to be significant with SOC at the 0.05 level.

VII.8. SUPPORTIVE ORGANIZATIONAL CULTURE vs. QUALITY OF KNOWLEDGE PROCESSES

Similarly, to explore the possible impact supportive organizational culture (SOC) has on the quality of knowledge processes and organizational effectiveness, a series of linear regressions were run for SOC on each of the QKPs (i.e. KA, KG, KR, KU, and KS). Tables VII.8.1-VII.8.5 below summarize these findings. The causal relationship for all of these is interpreted to be from SOC to each of the QKP constructs.

TABLE VII.8.1. REGRESSION OF SUPPORTIVE ORGANIZATIONAL CULTURE ON KNOWLEDGE ACQUISITION & ADOPTION (see Ref. [2])

Dependent variable: KA						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
SOC	0.628	0.086	7.318	0.000	0.458	0.798

From Table VII.8.1 it can be seen that SOC strongly correlates with KA and with high significance. Table VII.8.2 below summarizes the regression of SOC on KG.

TABLE VII.8.2. REGRESSION OF SUPPORTIVE ORGANIZATIONAL CULTURE ON KNOWLEDGE GENERATION & VALIDATION (see Ref. [2])

Dependent variable: KG						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
SOC	0.572	0.065	8.856	0.000	0.444	0.7

From Table VII.8.2 it can be seen that SOC strongly correlates with KG and with high significance. Table VII.8.3 below summarizes the correlation of SOC on KS.

TABLE VII.8.3. REGRESSION OF SUPPORTIVE ORGANIZATIONAL CULTURE ON KNOWLEDGE SHARING AND TRANSFER (see Ref. [2])

Dependent variable: KS						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
SOC	0.753	0.077	9.764	0	0.6	0.905

From Table VII.8.3 it can be seen that SOC strongly correlates with KS and with high significance. Table VII.8.4 summarizes the correlation of SOC on KU.

TABLE VII.8.4. REGRESSION OF SUPPORTIVE ORGANIZATIONAL CULTURE ON KNOWLEDGE UTILIZATION & APPLICATION (see Ref. [2])

Dependent variable: KU						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
SOC	0.538	0.066	8.183	0	0.408	0.668

From Table VII.8.4 it can be seen that SOC strongly correlates with KU and with high significance. Table VII.8.5 summarizes the correlation of SOC on KR.

TABLE VII.8.5. REGRESSION OF SUPPORTIVE ORGANIZATIONAL CULTURE ON KNOWLEDGE RETENTION & STORAGE (see Ref. [2])

Dependent variable: KR						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
SOC	0.616	0.062	9.859	0	0.492	0.739

From Table VII.8.5 it can be seen that SOC strongly correlates with KR and with high significance.

VII.9. SUPPORTIVE ORGANIZATIONAL CULTURE vs. ORGANIZATIONAL EFFECTIVENESS

Table VII.9 summarizes the correlation of SOC on OE.

TABLE VII.9. REGRESSION OF SUPORTIVE ORGANIZATIONAL CULTURE ON ORGANIZATIONAL EFFECTIVENESS (see Ref. [2])

Dependent variable: OE						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
SOC	0.6	0.06	10.079	0	0.482	0.718

From Table VII.9 it can be seen that SOC strongly correlates with OE and with high significance.

VII.10. RELATIONSHIPS AMONGST THE QUALITY OF KNOWLEDGE PROCESS CONSTRUCTS

Regressions were run for all the possible 'many-to-one' relationships amongst the quality of knowledge process constructs and also their possible links to organizational effectiveness (OE) to explore what relationships could be supported in the data. Tables VII.10.1–VII.10.5 and Figure 8 summarize these findings.

VII.10.1. Influence of other quality of knowledge processes on quality of knowledge acquisition & adoption processes

Table VII.10.1 summarizes the significant results from the regression analysis of all the other quality knowledge processes QKPs (i.e. KR, KG, KU, and KS) together on KA.

TABLE VII.10.1. REGRESSION OF OTHER KNOWLEDGE PROCESSES ON KNOWLEDGE ACQUISITION & ADOPTION (see Ref. [2])

Dependent variable: KA						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
KG	0.672	0.098	6.841	0.000	0.478	0.867
KS	0.239	0.086	2.784	0.006	0.069	0.409

From Table VII.10.1 above, it can be seen that only covariates KG and KS were found to be significant with KA at 0.05 or lower level. The data supports links between KA<--->KS and KA<--->KG, however, causal direction is not determined and subject to future research (thus the dotted line with two-way arrows are used) (see Ref. [2] for more details).

VII.10.2. Influence of other quality of knowledge processes on quality of knowledge sharing & transfer processes

Table VII.10.2 summarizes the significant results from the regression analysis of all the other quality knowledge processes QKPs (i.e. KA, KR, KG and KU) together on KS.

TABLE VII.10.2. REGRESSION OF OTHER KNOWLEDGE PROCESSES ON KNOWLEDGE SHARING AND TRANSFER (see Ref. [2])

Dependent variable: KS						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
KG	0.312	0.118	2.634	0.010	0.077	0.546
KR	0.502	0.086	5.839	0.000	0.332	0.672
KA	0.262	0.094	2.784	0.006	0.076	0.448

From Table VII.10.2 it can be seen that only covariates KG, KR, and KA were found to be significant with KS at the 0.05 level. The findings support a KR<--->KS link, and links from KG<--->KS and KA<--->KS and all with causal direction to be determined (thus the dotted line with two-way arrows are used). Recall the same KA<--->KS relationship was also significant in the previous regression which looked at all possible QKP links to/from KA.

VII.10.3. Influence of other quality of knowledge processes on quality of knowledge retention & storage processes

Table VII.10.3 summarizes the significant results from the regression analysis of all the other quality knowledge processes QKPs (i.e. KA, KG, KU, and KS) together on KR.

TABLE VII.10.3. REGRESSION OF OTHER KNOWLEDGE PROCESSES ON KNOWLEDGE RETENTION & STORAGE (see Ref. [2])

Dependent variable: KR						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
KU	0.316	0.086	3.661	0	0.145	0.487
KS	0.452	0.077	5.839	0	0.299	0.606

From Table VII.10.3 it can be seen that only covariates KU and KS were found to be significant with KR at the 0.05 level. The findings establish significant links exist between KR<--->KS and KU<--->KR, again with causal direction not determined (thus the dotted line with two-way arrows are used).

VII.10.4. Influence of other quality of knowledge processes on quality of knowledge generation & validation processes

Table VII.10.4 summarizes the significant results from the regression analysis of all the other quality knowledge processes QKPs (i.e. KA, KR, KU, and KS) together on KG.

TABLE VII.10.4. REGRESSION OF OTHER KNOWLEDGE PROCESSES ON KNOWLEDGE GENERATION & VALIDATION (see Ref. [2])

Dependent variable: KG						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
KU	0.212	0.07	3.005	0.003	0.072	0.351
KA	0.428	0.063	6.841	0	0.304	0.552
KS	0.181	0.069	2.634	0.01	0.045	0.317

From Table VII.10.4 it can be seen that only covariates KU, KA, and KS were found to be significant with KG at the 0.05 level. The findings clearly support the following links: KU<--->KG, KA<--->KG and KS<--->KG. Recall the links KA<--->KG and KS<--->KG were earlier found to be significant but casual direction is not determined (thus the dotted line with two-way arrows are used).

VII.10.5. Influence of other quality knowledge processes on quality of knowledge utilization & application processes

Table VII.10.5 summarizes the significant results from the regression analysis of all the other quality knowledge processes QKPs (i.e. KA, KR, KG, and KS) together on KU.

TABLE VII.10.5. REGRESSION OF OTHER KNOWLEDGE PROCESSES ON KNOWLEDGE UTILIZATION AND APPLICATION (see Ref. [2])

Dependent variable: KU						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
KR	0.328	0.09	3.661	0.000	0.151	0.506
KG	0.341	0.113	3.005	0.003	0.116	0.566

From Table VII.10.5 it can be seen that only covariates KR and KG were found to be significant with KU at 0.05 level. The findings support links from KG<--->KU and KR<--->KU, however, the causal direction is not known (thus the dotted line with two-way arrows are used).

VII.11. LINKING QUALITY OF KNOWLEDGE PROCESSES WITH ORGANIZATIONAL EFFECTIVENESS

Table VII.11 summarizes the significant results from the regression analysis of all the quality knowledge processes QKPs (i.e. KA, KR, KG, KU, and KS) together on organizational effectiveness (OE).

TABLE VII.11. REGRESSION OF QUALITY OF KNOWLEDGE PROCESSES ON ORGANIZATIONAL EFFECTIVENESS (see Ref. [2])

Dependent variable: OE						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
KR	0.361	0.078	4.639	0.000	0.207	0.516
KU	0.385	0.076	5.037	0.000	0.234	0.536

From Table VII.11 it can be seen that only covariates KR and KU were found to be significant with OE at 0.05 level. The findings support links from KU<--->OE and from KR<--->OE respectively and the causal direction cannot be determined simply from the regression, however, causal links from KU→OE and KR→OE are supported in the literature (see Refs [5] and [18]) and therefore are assumed here.

VII.12. TESTING ALL DIRECT LINKS TO ORGANIZATIONAL EFFECTIVENESS

Table VII.12 summarizes the significant results from the regression analysis of the full model: all the knowledge management practices (i.e. KMS, SOL, PMP, OPM, TRP, IMP, and HRP), both of the organizational technology support constructs (i.e. IST and OSS), supportive organizational culture (SOC), and all of the quality knowledge processes QKPs (i.e. KA, KR, KG, KU, and KS) together regressed on organizational effectiveness (OE). This test was to examine whether any direct relationships were more significant than the hypothesized model relationships.

The initial finding was that KR, KU, SOC, KMS, and SOL were all significant; however, SOL had a negative *B-value*. This was inconsistent with the positive Pearson correlations for SOL with OE in the correlation matrix. Also, SOL had a high Pearson correlation coefficient with SOC (i.e. 0.720) and therefore the negative *B-value* was thought to be the result of multi-collinearity with SOC. To test this, SOC was removed from the model and the regression re-run. The result was SOL dropped out entirely as not significant. SOL was then removed, SOC put back in and the model re-run. This resulted in KR, KU, SOC, KMS, and HRP all being significant, however, this time, HRP had a negative *B-value*. This was similarly inconsistent with the positive Pearson correlation for HRP with OE in the correlation matrix, and HRP had a high correlation coefficient with SOC (i.e. 0.688). As the model run without SOC had already shown HRP not to be significant, it was concluded to again be the result of multi-collinearity with SOC. Thus HRP was also removed from the model. The model was rerun and KR, KU, SOC, and KMS were significant, as shown in Table VII.12. This agreed with the path analysis finding that the only KM practice that had a significant direct link to OE was KMS.

TABLE VII.12. REGRESSION OF ALL DIRECT CONSTRUCT LINKS TO ORGANIZATIONAL EFFECTIVENESS (from the analysis data used for Ref. [2])

Dependent variable: OE						
Covariate	B	Std. error	t	P-value	95% confidence interval	
					Lower bound	Upper bound
KU	0.367	0.064	5.746	0.000	0.241	0.494
KMS	0.083	0.040	2.052	0.043	0.003	0.163
SOC	0.215	0.071	3.011	0.003	0.073	0.356
KR	0.193	0.069	2.801	0.006	0.056	0.329

From Table VII.12 it can be seen that only covariates KU, KMS, SOC, and KR were found significant with OE at 0.05 level. All other constructs dropped out of the model. The findings are consistent with the earlier regression findings and support the hypothesized KMPM relationships, and provide evidence that the mechanism by which the KMPs influence OE is primarily via SOC and QKPs (and more specifically, ultimately through KU and KR). This model had an overall adjusted R-squared value of 0.687 which means that about 68.7% of the variance in OE is explained by the model.

Appendix VIII

RECOMMENDED CHANGES TO NEXT SURVEY

Member States may wish that the IAEA repeat this survey in the future. The following are a number of recommended improvements. These changes would still enable the results of the first survey to be directly compared to future survey response data. The base set of questions remains unchanged with only minor but important edits to improve measurement quality and consistency. Several new questions are also proposed. The new questions include measures for the supportive organizational culture construct to support measurement of sub-construct dimensions of safety culture, knowledge management culture, and overall (i.e. general) organizational culture. The new questions also include several new measures for the organizational effectiveness construct that allow measurement of sub-construct dimensions of operational effectiveness (includes equipment reliability), safety effectiveness, and general organizational effectiveness. It is hoped the new sub-constructs will reveal additional new insights in the survey findings.

The following revisions to the questionnaire are recommended to be incorporated in the next IAEA Global NPP KM Survey:

(1) Part A, Section 2, the section title should be changed from 'Support for Organizational Learning' to — 'Management Support for Organizational Learning'.

(2) Part A, question 2a (measure SOLa) (see Appendix I) reads: "Knowledge creation and application (e.g. finding better methods, technology innovation) is encouraged, recognized and rewarded." To improve clarity and consistency of response, it should be revised to — a. 'Managers encourage, provide budget for, and reward knowledge generation and innovation initiatives (e.g. finding better methods, applying new technology)'.

(3) Part A, question 2b (measure SOLb) (see Appendix I) reads: "Sharing of knowledge is promoted and rewarded (e.g. experts are encouraged and rewarded to coach or mentor other employees)". To improve construct clarity and consistency of response, it should be revised to — b. 'Managers expect, support and reward knowledge sharing (e.g. senior experts are expected and rewarded to coach or mentor junior employees)'.

(4) Part A, question 2c (measure SOLc) (see Appendix I) reads: "Open communication and a no-blame approach to reporting problems and sharing lessons learned are promoted (e.g., regular communication is encouraged between maintenance and operations personnel)". To improve construct clarity and consistency of response, it should be revised to — c. 'Managers promote open communications on problems and lessons learned (e.g., regular informal discussions between maintenance and operations personnel)'.

(5) Part A, question 2d (measure SOLd) (see Appendix I) reads: "Learning opportunities are encouraged (e.g., joining specialist groups or attending training seminars)". To improve clarity and consistency of response, it should be revised to — d. 'Managers support or provide learning opportunities (e.g., joining specialist groups or attending seminars, special assignments etc.)'.

(6) Part A, a new question 2e (measure SOLe) should be added to read: e. "Managers support and provide resources for technical root-cause analysis and event reviews (e.g. problem diagnosis, failure analysis, post-incident assessments, etc.)".

(7) Part A, question 3a (measure PMPa) (see Appendix I) reads: "For all processes and procedures, priority is placed on ensuring the requirements, methods, inputs, outputs, interfaces, responsibilities, and workflow are documented correctly and maintained up to date". To improve clarity and consistency of response, it should be revised to —

a. ‘All processes are regularly reviewed to ensure the requirements, methods, inputs, outputs, interfaces, responsibilities, and workflow are documented and maintained up to date’.

(8) Part A, question 3c (measure PMPc) (see Appendix I) reads: “Procedures are aligned to knowledge and information requirements of both work tasks and decision processes”. To improve clarity and consistency of response, it should be revised to — c. ‘Procedures are regularly reviewed and aligned with knowledge, competency, and information requirements of the work-task participants and decision-process owners’.

(9) Part A, question 3e (measure PMPe) (see Appendix I) reads: “Comprehensive knowledge management procedures (e.g. for knowledge loss risk assessment) are documented and in use”. To improve clarity and consistency of response, it should be revised to — e. ‘Effective knowledge management processes are defined and in use (e.g. knowledge loss risk management, or organizational competency requirements assessment)’.

(10) Part A, question 3f (measure PMPf) (see Appendix I) reads: “Knowledge management processes and procedures are extended to suppliers, and technical support organizations”. To improve clarity and consistency of response, it should be revised to — f. ‘Knowledge management requirements and procedures are extended to suppliers, contract service providers and technical support organizations’.

(11) Part A, a new question 3g (measure PMPg) should be added to read: g. “Knowledge management principles are embedded in the organization’s management systems”.

(12) Part A, a new question 3h (measure PMPh) should be added to read: h. “Documented measures of knowledge process quality exist for all management systems and regular self-assessments are conducted”.

(13) Part A, question 5a (measure OPMa) (see Appendix I) reads: “Independent external peer review assessments are conducted regularly (e.g. WANO, INPO, or IAEA-OSART reviews)” and was used as a measure but was of questionable reliability and should be revised to the following — a. ‘Independent external peer-review assessments are conducted and recommendations are implemented (e.g. WANO, INPO, or IAEA OSART reviews)’.

(14) Part A, two new questions, 5g and 5h (measures OPMg and OPMh) should be added to read — g. ‘Performance metrics are clearly defined and are regularly tracked (e.g. human performance, safety performance, system and equipment performance etc.)’; — h. ‘Evidence of effective competency management and knowledge management in regards to nuclear safety is regularly required by the regulatory authority’.

(15) Part A, question 6b (measure TRPb) (see Appendix I) reads: “Sufficient training is provided to achieve and maintain the required level of competence for all job positions” and was not a reliable measure and should be revised to the following — b. ‘Competence requirements for all positions are regularly reviewed and sufficient on-going training for all employees ensures they are fully met’.

(16) Part A, question 6d (measure TRPd) (see Appendix I) reads: “Collaboration with universities and colleges ensures an appropriate supply of new graduates” and was not a reliable measure and should be replaced with the following measure — d. ‘Formal training programmes, extensive on-the-job training, formal mentoring programmes, and mandatory job rotations are used to develop new employees in their first several years’.

(17) Part A, question 6e (measure TRPe) (see Appendix I) reads: “Other techniques are used for training (e.g. story-telling, concept mapping, pre-job briefings, informal seminars, mentoring programmes etc.). Please specify: ...” and should be revised for clarity to the following — e. ‘Other techniques are used for training (e.g. story-telling, concept mapping, pre-job briefings, informal seminars, etc.). Please specify: …’.

(18) Part B, question 1b (measure ISTb) (see Appendix I) reads: “Computer and/or web-based training” and should be revised slightly to the following — b. ‘Computer-based and/or web-based training software/tools’.

(19) Part B, question 1i (measure ISTi) should be added to read: — i. ‘Software to enable work groups to access, edit, and control shared electronic resources (e.g. group-ware software such as SharePoint, or Livelink).’

(20) Part B, question 2h (measure OSSh) (see Appendix I) reads: “Automated field data collection (i.e., smart instruments, field-bus, radio frequency identification (RFID) tagging, data logging, equipment monitors)” and should be revised slightly to the following — h. ‘Automated field data collection (e.g. smart instruments, field-bus, online valve diagnostics/monitoring, event data logging, equipment monitors)’.

(21) Part B, question 2i (measure OSSi) (see Appendix I) reads: “Other (please specify …” and was not a reliable measure, however, it should be retained without any changes as it provides very useful information on the extent of adoption of new technologies in NPPs. It is not known if it will be used directly in the statistical analysis in future.

(22) Part C, question 1a (measure KAa) (see Appendix I) reads: “The organization has difficulty finding and hiring appropriately qualified graduates” and was not a reliable measure and should be replaced with the following measure — a. ‘The organization excels at acquiring and adopting new technology or solutions to meet its needs’.

(23) Part C, two new questions, 2g and 2h (measures KGg and KGh) should be added to read — g. ‘Adequate technical data and information is generated to support analysis and assessment of plant structures, systems and components’; and — h. ‘Adequate and effective use of analysis techniques is made (e.g. for probabilistic risk, human factors, transients, events, root-causes, hazards, failure modes, etc.)’.

(24) Part C, a new question 3f (measure KSf) should be added to read: — f. ‘New employees have limited opportunities for learning and as a result it takes a long time for them to be able to work effectively and independently’.

(25) Part C, new questions 5f–5g (measures KRf and KRg) should be added to read — f. ‘There is a general need to improve knowledge retention and storage processes; and — g. ‘Data, information and records are not effectively captured, stored and made available when needed’ (to be reverse coded).

(26) Part D, question 1c (measure SOCc) (see Appendix I) reads: “There is a prevailing attitude and commitment to follow defined processes and fully comply with procedures” and was not a reliable measure and should be revised to the following — c. ‘Employees share responsibility for ensuring work processes and procedures are clear and effective and can be followed properly’.

(27) Part D, new questions 1n–1t (measures SOCn, SOCo, SOCp, SOCq, SOCr, SOCs, and SOCt) should be added to read — n. ‘There is a strong expectation for continuous learning and employee development through-out the organization’; — o. ‘Experienced staff share a strong sense for responsibility for development of junior staff’; — p. ‘Employees do not feel responsible for their team’s or group’s collective performance’ (to be reverse coded); — q. ‘Technical decisions are seen as opportunities for learning and are made in an open, consultative and participative manner when possible’; — r. ‘Employees who share their knowledge and mentor others are not clearly valued and appreciated through-out the organization’ (to be reverse coded); — s. ‘There is a strong appreciation and respect for knowledge of plant systems, structures or components and their role in nuclear safety is important to ensure safe decisions and actions’; and — t. ‘The organizational culture can interfere at times with the safety culture (e.g. organizational politics, gender issues, union issues, external influences etc.)’ (to be reverse coded).

(28) Part E, question 1c (measure OEc) (see Appendix I) reads: "The ratio of corrective to preventive maintenance is high relative to best performing NPPs of similar design" and was not a reliable measure and should be revised to the following — c. 'When comparing to best performing similar plants, maintenance staff spend too much time fixing problems instead of preventing them'.

(29) Part E, new questions 1w-1bb (measures OEw, OEx, OEy, OEz, OEaa and OEbb) should be added to read: — w. 'Long-term planning for equipment life-cycle and asset management is effective and adequately factored into financial budget plans'; — x. 'Safety management programmes and procedures including quality assurance and continuous improvement systems need improvement' (to be reverse coded); — y. 'Technical decision making is supported by sound analysis and assessment and is very efficient and effective'; — z. 'Operating conditions of systems, structures and components are not effectively monitored and maintained to defined safety standards' (to be reverse coded); — aa. 'Maintenance and operational decisions are risk-informed and effectively consider nuclear safety significance'; and — bb. 'Operators are always aware of and ensure the plant never operates outside of the licensed operating limits and conditions'.

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ABBREVIATIONS

AGR	advanced gas reactor
BWR	boiling water reactor
CAD	computer aided design
COP	community of practice
FBR	fast breeder reactor
GCR	gas cooled reactor
HRP	human resource related KM practices
IMP	information management related KM practices
IST	information systems and technology
K	knowledge
KA	knowledge acquisition and adoption
KG	knowledge generation and validation
KM	knowledge management
KMP(s)	knowledge management practice(s) (i.e. the set of the KM practices)
KMPM	Knowledge Management Performance Model
KMS	knowledge management strategy and planning
KR	knowledge retention and storage
KS	knowledge sharing and transfer
KU	knowledge utilization and application
LWCGR	light water cooled gas reactor
NEI	Nuclear Energy Institute
NPP	nuclear power plant
OE	organizational effectiveness
O&M	operations and maintenance
OM&A	operations, maintenance and administration
OPM	organizational performance management related KM practices
OSS	(advanced) operational support systems
OTS	organizational technology support (i.e. the set of information systems and technology and advanced operational support systems)
PHWR	pressurized heavy water reactor
PMP	process management related KM practices
PWR	pressurized water reactor
QKP	quality knowledge processes (i.e. the set of quality of knowledge processes)
R&D	research and development
RFID	radio frequency identification
SNPM	Standard Nuclear Performance Model (i.e. from NEI)
SOC	supportive organizational culture
SOL	support for organizational learning
TRP	training related KM practices
WWER	pressurized water reactor (a Russian designed PWR)

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Turner, C.	Atomic Energy Canada Ltd, Canada
Tume, P.	Atomic Energy Canada Ltd, Canada

CONTRIBUTORS TO REVIEW OF SURVEY

Archer, P.	Atomic Energy Canada Ltd, Canada
Gilbert, J.V.	Model Performance LLC, United States of America
Gysel, T.	Kernkraftwerk Leibstadt NPP, Switzerland
Kosilov, A.	International Atomic Energy Agency
Koupriyanova, I.	Russian INIS Center, Russian Federation
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Sula, R.	Temelin NPP CEZ, a.s., Czech Republic
Turner, C.	Atomic Energy Canada Ltd, Canada
Yanev, Y.	International Atomic Energy Agency
Zhao, Y.	Atomic Energy Canada Ltd, Canada

CONTRIBUTORS TO REVIEW OF THE DOCUMENT

Berezina, T.	Independent consultant, Austria
Isotalo, J.	International Atomic Energy Agency
Kosilov, A.	International Atomic Energy Agency
Mc Donald, A.	International Atomic Energy Agency
Walsh, S.	International Atomic Energy Agency

CONTRIBUTORS TO TRANSLATIONS OF SURVEY

Archer, P.	Atomic Energy Canada Ltd, Canada
Kosilov, A.	International Atomic Energy Agency
Koupriyanova, I.	Russian INIS Center, Russian Federation
Zhao, Y.	Atomic Energy Canada Ltd, Canada

CONTRIBUTORS TO THE DOCUMENT

de Grosbois, J.	Atomic Energy Canada Ltd, Canada
Kumar, V.	Carleton University (PhD supervisor), Canada

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