Volume 4 • Issue 4 • November 2013

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INTERNATIONAL JOURNAL OF

BUSINESS RESEARCH AND MANAGEMENT (IJBRM)

ISSN : 2180-2165

Publication Frequency: 6 Issues / Year

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INTERNATIONAL JOURNAL OF BUSINESS RESEARCH AND MANAGEMENT (IJBRM)

VOLUME 4, ISSUE 4, 2013

EDITED BY
DR. NABEEL TAHIR

ISSN (Online): 2180-2165

International Journal of Business Research and Management (IJBRM) is published both in traditional paper form and in Internet. This journal is published at the website http://www.cscjournals.org, maintained by Computer Science Journals (CSC Journals), Malaysia.

IJBRM Journal is a part of CSC Publishers

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INTERNATIONAL JOURNAL OF BUSINESS RESEARCH AND MANAGEMENT (IJBRM)

Book: Volume 4, Issue 4, November 2013
Publishing Date: 01-11-2013
ISSN (Online): 2180-2165

IJBRM Journal is a part of CSC Publishers
http://www.cscjournals.org

Published in Malaysia

Typesetting: Camera-ready by author, data conversation by CSC Publishing Services – CSC Journals, Malaysia

CSC Publishers, 2013

EDITORIAL PREFACE

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Constructing a Tailor-made Performance Management System Supported by Knowledge Elicitation Tools and Dynamic Modeling

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Abstract

For constructing a causality-based performance management system (PMS), the consideration of expert knowledge is indispensable. As this knowledge is usually not transparent or explicitly available, the process of tacit knowledge elicitation (TKE) plays an important role for a tailor-made construction of PMS, as does its operationalization in the form of a company-specific scorecard or a dynamic model. Owing to this importance, this paper develops a holistic, step by step approach for constructing and operationalizing an effective PMS using TKE such as interview techniques, as well as System Dynamics (SD) and the interaction of organization's personnel (experts) and Management Accounting (MA). The framework is structured by a phase model in matrix form, whereby the three main steps data generation, assessment and construction are further divided by functional responsibilities on company and MA levels. For demonstration purposes, the framework is subsequently applied to a case study within the automotive industry.

Keywords: Cause-and-effect Relationships, Expert Knowledge, Performance Management, Tacit Knowledge, Causal Maps, Strategy Maps, System Dynamics, Interview Techniques, Case Study.

1. INTRODUCTION

A necessary condition for the construction of an effective and efficient performance management system (PMS) is the consideration of company-individual cause-and-effect-relationships as well as the subsequent corresponding chain of value generation with its leading and lagging indicators in the form of a strategy map. Consequently, Management Accounting (MA) which supports the management in the construction of a PMS is faced with the task of identifying the relevant causes of performance which are mostly not financially dimensioned.

Having identified a company-specific strategy map and its controllable measures, the strategy map can be dynamically extended in order to model and simulate the impact of management decisions on the PMS, especially on the system behavior of leading financial indicators within the causally-oriented framework. As relevant, temporarily delaying cause-and-effect-relationships are usually not transparent or explicitly available, the process of knowledge elicitation in the form of tacit expert knowledge plays an important role for tailor-made construction of PMS and its

operationalization in the form of a dynamic model. Owing to this role, this research paper follows a case-study based framework to demonstrate how an efficient PMS can be constructed by the support of tacit knowledge and dynamic modeling tools such as the System Dynamics (SD) methodology.

After having pointed out the importance of causal mapping for MA and its responsibility towards Performance Management (PM) in a literature review in section 2 this research focuses on the therefore necessary process and techniques for generating such expert knowledge that is only implicitly available (section 3). The subsequent section 4 deals with the importance of dynamic modeling for PM and combines all previous aspects within a holistic framework, followed by the application of the entire approach to a case study within the automotive industry in section 5. A final section 6 summarizes the results and points out areas for further accounting research.

2. LITERATURE REVIEW: CONSTRUCTION OF PMS AND CAUSAL MAPS IN MA

MA is an academic discipline that concentrates on the support of planning, decision making and control by defining performance measures, providing relevant performance data and practicing continuous improvement by systematic performance management. Moreover, the Association for Accountants and Financial Professionals in Business (IMA) defines MA as “a profession that involves partnering in management decision making, devising planning and performance management systems, and providing expertise in financial reporting and control to assist management in the formulation and implementation of an organization’s strategy” [1]. Thus, a fundamental function of MA, in addition to allocating costs and providing information for planning, control and decision support, is the responsibility towards managers for the construction, the implementation and the continuous improvement of efficient PMS.

A PMS can be seen as a network of related key success factors of which the aim is to improve organizational effectiveness by explicit consideration of linked-to-strategy cause-and-effect relationships as well as continuous control activities (compare [2], [3]). Hence, the entire value chain between the overall organization’s strategy and single key success factors is focused on. Compared to previous decades, contemporary Management Accountants act as strategists and internal consultants whereby the analysis of corporate strategies as well as their implementation is of particular importance [4], [5]. The responsibility that all activities ensuring business strategies are consistently being met in an efficient and effective way, can be assigned to the field of PM.

Based on the criticism of quantitative approaches (i.e. traditionally and financially focused key performance indicators (KPI) as well as their combinations in ratio systems), the development and use of non-financial measures have been of great interest for the last three decades. A logical decomposition of financial measures, such as the DuPont-System of Financial Control, measures the realization of value, whereas the value-creation process is disregarded. Therefore, MA must also consider the development of modern PM and extend its view to the non-financial aspects [6], [7], [8]. An efficient PMS requires acknowledgment and understanding of the cause-and-effect relationships, so that strategies for ensuring satisfactory future performance can be implemented [9]. A PMS should be based primarily on causal relationships, as indicated by the concept of the balanced scorecard (BSC), and not exclusively on logical relationships [10]. Otherwise, the real causes of financial performance remain concealed. Within a performance management framework, non-financial as well as financial measures are leading indicators of financial performance. The relevance of detecting, displaying and understanding causal relationships is supported by various empirical studies (see e.g. [11], [12] for a review).

Hence it is rare that one effect is only influenced by one cause, cause-and-effect relationships in the complex reality are linked to each other in various forms (compare [13] for different types of causal structures). In general, it can be differentiated between unidirectional cause-and-effect relationships, whereby a cause exclusively influences the effect, and bidirectional relationships, whereby two or more factors cause an effect. Moreover, it is possible that the cause variables

may influence each other. In addition, time lags between cause and effect can occur so that the inter-temporal structure has to be explicitly considered.

The combination of relevant cause-and-effect relationships leads to an integrated model, a *causal map* [14], [15]. In a PM context, which is focused on all cause-and-effect relationships and their function as leading and lagging indicators of corporate strategy, the term '*strategy map*' is used [16], [17].

Strategy maps as specific types of causal maps are designed to illustrate and support the execution of an organization's strategy by linking KPIs according to determined cause-and-effect relationships. In brief, strategy maps can be seen as diagrams to visualize the strategic goals being pursued by organizations as well as the mental models of the participating experts [18]. Apart from facilitating the translation of a strategy into operational terms, another purpose of a strategy map is to communicate to the members of an organization how their tasks are related to the overall objectives [19].

An efficient strategy map as part of a PMS is not a standard product and consequently has to be constructed tailor-made to capture the individual cause-and-effect relationships and KPIs of the specific field and business.

Due to the importance of a company-specific strategy map as well as the identification of relevant individual cause-and-effect relationships the construction of efficient PMS is an often discussed subject in the literature [20], [21]. Apart from the application of tacit knowledge elicitation (TKE) techniques such as expert interviews for creating causal models (see e.g. [15], [18], [22], [23]) TKE is also used to improve the performance of a company [24]. The idea of enhancing the strategy map by dynamical extensions is shown by Bianchi and Montemaggiore [25] who indicate that the integration of the PMS approach with dynamic modeling tools such as the SD methodology (for the extension of the BSC with SD see also [26], [27], [28], [29]) facilitates the analysis of cause-and-effect relationships between key variables of the company. The hypothesis that the use of dynamic strategy maps can significantly improve the PMS is also described by Liang and Hou [30], who try to provide empirical evidence on the dynamic connection of BSC.

Despite of the variety of publications which integrate single elements of knowledge elicitation or dynamic aspects in the development of PMS there is a lack of approaches which combine the construction of efficient PMS with the process of knowledge elicitation and dynamic modeling in a holistic framework. Thus, this article provides a step by step approach for constructing and operationalizing an efficient PMS using TKE such as interview techniques as well as SD and the interaction of organization's personnel. In order to create a realistic construction of a strategy map – as an illustration of an organization's strategy – the following section will explore different tacit knowledge based approaches.

3. KNOWLEDGE ELICITATION FOR CONSTRUCTING TAILOR-MADE STRATEGY MAPS

3.1 Tacit Knowledge as a Vital Source of Corporate Data

Due to the fact that an efficient strategy map based on PMS has to be constructed individually for each organization, comprehensive knowledge about the domain of interest is necessary. Cause-and-effect relationships and their representation within strategy maps require the formalization of knowledge. The knowledge inherent in an organization can be available explicitly (objective, formal or explicit knowledge) or implicitly (tacit knowledge). Moreover, often it can be useful not to focus on the assessment of only one person but to allow the participation of several company members in the construction process of the strategy map. Therefore, the MA is additionally faced with a group decision problem of knowledge elicitation (see e.g. [31] for advantages and disadvantages of group decision making). Hence, a holistic PMS-concept is required which incorporates not only the relevant leading and lagging indicators but also provides a broad and interdisciplinary information base of the respective company. *Figure 1* illustrates the interaction

and the process of constructing a tailor-made strategy map using tacit knowledge and interdisciplinary expert teams.

Regarding the tacitness of knowledge, Ambrosini and Bowman [32] point out different degrees of tacitness. The two boundary points are ‘explicit knowledge’ which can be communicated, codified, explained and shared easily, and ‘tacit knowledge’ which is totally inaccessible because it is too deeply ingrained in the members of an organization. In between we can find ‘tacit knowledge that could be articulated’ and ‘tacit knowledge that can be imperfectly articulated’. Within the exploration process towards causal relationships, explicit knowledge is merely necessary for the identification of KPIs, e.g. by support of a literature analysis. However, in order to reveal company specific cause-and-effect relationships and to achieve further information about relevant measures in form of leading and lagging indicators in greater depth, intuitive subject-related tacit knowledge ([33], [34], [35]) of experts has to be considered.

In contrast to explicit knowledge, tacit knowledge is difficult to write down or to formalize. Furthermore, it is personal knowledge and its possessor cannot communicate it to another person easily [36]. In other words tacit knowledge includes cognitive images of reality as well as technical skills and capabilities. It is furthermore personalized and so it is difficult to elucidate and share it in a formalized framework of communication [37]. The higher the degree of tacitness, the more complicated is the disclosure and usage of tacit expert knowledge for constructing a PMS. Nevertheless, the necessary condition for using a PMS is that organizations’ strategy as well as related cause-and-effect relationships can be articulated clearly and communicable. In order to achieve information which can support the formulation of causal relations between leading and lagging indicators in the process of the model construction process the elicitation of tacit knowledge is of high importance whereby the formalization and application of qualitative data is further necessary [38].

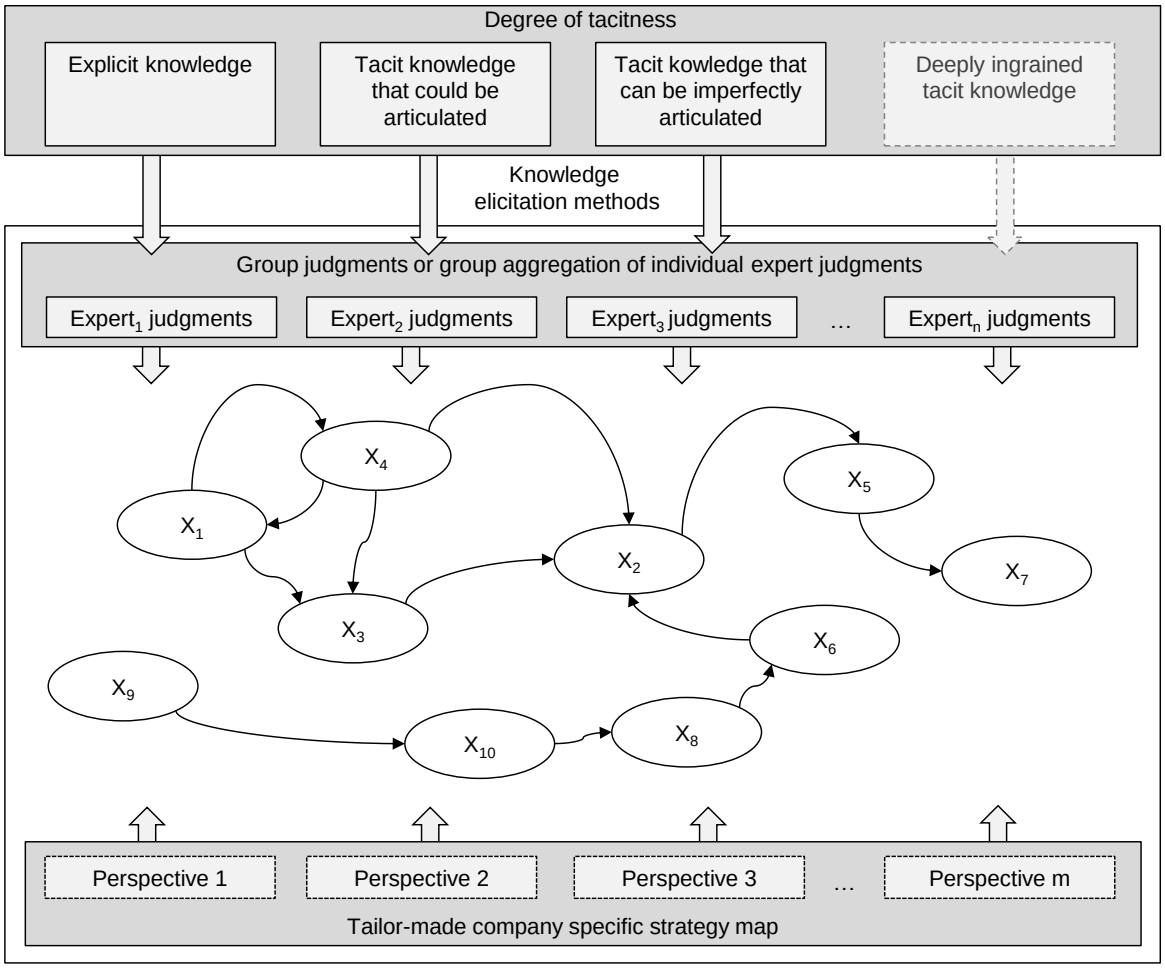

FIGURE 1: Individuals' interaction and process of constructing a tailor-made strategy map by support of tacit knowledge.

Apart from the necessity to elicit tacit knowledge, the participation of experts from various departments and functions of the company is very important (see e.g. [23], [39]). Experts may be employees, executives or managers from different hierarchical levels or areas of the organization, provided they have relevant knowledge. Compared to individual interviews, the quantity and quality of the information collected can be increased significantly by interviewing groups. These provide a much larger, fuller information base and one of a higher quality than an individual can reach (see e.g. [40], [41]).

3.2 Compilation of Existing TKE Methods

In order to identify tacit knowledge about KPI-measures and their causal links as a basis for constructing a strategy map, numerous different knowledge elicitation methods are available. Knowledge elicitation methods can be classified in various ways (see e.g. [42], [43], [44], [45]). Based on the earlier research of Cooke [46] and Burge [47], *Table 1* shows a more extensive presentation of a possible classification in the three different groups A, B and C.

Knowledge elicitation techniques

Group A: Interviews and Observations

Observations

- Active participation
- Focused observation
- Structured observation

Interviews

- Interviewing (structured, un-/ semi-structured)
- Concept mapping
- Interruption analysis
- ARK (ACT-based representation of knowledge)
- Cognitive structure analysis (CSA)
- Problem discussion/ Focused discussion
- Uncertain information elicitation
- Data flow modeling
- Entity-relationship/ Entity life modeling
- Object oriented modeling
- Semantic nets
- IDEF modeling
- Petri nets
- Questionnaire/ Question answering protocols
- Task action mapping
- User needs analysis (decision process diagrams)
- Teachback
- Role play
- Cloze experiment/ minimal scenario technique
- Likert scale items
- Group interview techniques
- Automated interviewing tools

Task analysis

- Functional flow analysis
- Operational sequence analysis
- Information flow analysis
- Interaction analysis
- Job analysis
- Time line analysis
- Cognitive task analysis

Group B: Process Tracing

Verbal reports

- Verbal on-line
  - Self-report
  - Shadowing
- Verbal off-line/ stimulated recall
  - Retrospective/aided recall
  - Interruption analysis
  - Critical retrospective

Protocol analysis

- Content analysis
- Discourse/ conversation/ interaction analysis
- Grounded theory
- Automated protocol analysis tools

Decision Analysis

- Eliciting estimations of probability and utility
- Statistical modeling/ policy capturing

Non-verbal reports

Group C: Conceptual techniques

Concept elicitation methods

- Structured interviews for concept elicitation
  - Concept-/ Step-/ Chapterlisting
  - Interview transcription
- Concept elicitation associated with repertory grid
  - Laddering
  - Triad comparison/ Triadic elicitation

Data collection methods

- Rating and ranking
  - Paired comparisons
  - Magnitude estimation
  - Controlled association
  - Reference ranking
- Repertory grid
- Sorting
  - Q sort/ P sort
  - Repeated sort/ multiple Q sort
  - Hierarchical sort
  - Multidimensional card sorting
- Event co-occurrence/ transition probabilities
- Correlations/ covariance

Structural analysis

- Multidimensional scaling
- Discrete techniques
  - Clustering routines
  - Network scaling
- Direct elicitation of structure
  - Drawing closed curves
  - Free association
  - Graph construction
  - Question-answering
- Interpretation of the structure
  - Guided interview
  - Identifying aspects of the representation
  - Comparing two or more representations

Conceptual techniques automation

TABLE 1: Groups of Knowledge Elicitation Techniques.

Group A (interviews and observations) consists of direct elicitation methods whereby watching and talking to domain experts plays an important role. The techniques are particularly suitable when there is a need for constructing an initial conceptualization of the problem domain [46]. This is of importance for the needs of MA, where experts must develop a comprehensive insight of the surrounding problem. Techniques in *group B (process tracing)* are related to special tasks, for example different methods of verbal and non-verbal reports or tools of statistical modeling for decision analysis. The tasks' underlying inferences about the cognitive processes are thereby included in the field of interest. *Group C (conceptual techniques)* consists of indirect techniques which need less verbalization and introspection. Because they cover a full range of knowledge, they can be combined with techniques from other groups in order to achieve more precise results [46].

Within MA literature there are different approaches for constructing strategy maps by support of tacit knowledge (see e.g. [15], [18], [22]). Comparing these approaches regarding to different criteria (for example complexity, limitation of indicators, software support or possibility of using formalized group decision rules), there cannot be made a consistent recommendation of one technique as the best method. Depending on the intended use, each approach shows specific advantages and disadvantages which have to be evaluated individually for each organization. However, all approaches point out the various interview techniques as an integral part of constructing a strategy map in MA context. Due to their specific characteristics both *group B: process tracing* and *group C: conceptual techniques* as well as observations cannot provide enough information about company-specific coherences relevant to the construction of strategy maps, therefore interview techniques should be focused on.

3.3 Interview Techniques as Appropriate TKE Methods

In order to ensure the participation of various experts in the process of constructing a PMS, we recommend the use of mixed interview techniques (unstructured, semi-structured and structured) for knowledge elicitation. In contrast to structured surveys, unstructured interviews are formless and do not follow a predetermined format. While in highly-structured interviews the content as well as the order of questions is fixed, the sequencing in semi-structured interviews may vary [46], [48]. Furthermore, in the semi-structured form of knowledge elicitation the interviewer gets the opportunity to ask open-ended questions and to interact with the interviewed experts in a more flexible way than in predetermined questionnaires.

The success of an interview session depends on the questions asked (it is difficult to know which questions should be asked, particularly if the interviewer is not familiar with the domain) and the ability of the experts to articulate their knowledge [46]. However, in order to elicit both explicit and implicit knowledge of various experts, the interview method as a selected knowledge elicitation technique provides significant advantages.

A first unstructured expert survey enables the MA professionals to acquire a first impression of the company as well as of potential problem areas. Even without any prior knowledge, the interview technique makes it possible for the elicitors to identify the company's requirements and expectations [46]. Moreover, the application of multi-personal expert interviews increases the interaction of the group members, who are supposed to elicit knowledge reciprocally from each other, and therefore the broadness and quantity of shared information [46].

Although the purpose and structure of the interview are predetermined by the systematic survey, the participants get the opportunity to present their views on the drivers of success [32]. "Through storytelling, participants can express what is done in the organization, and hence some tacit skills may be uncovered" [32, p. 820].

The combination of the interview technique with the construction of strategy maps increases the mentioned advantages. The mapping process forces the participants to reflect their behavior and thus revealing aspects that have been tacit until then. In order to improve the quality of the strategy maps and to reduce the time required the interview techniques are advantageous and allow not only the collection of explicit and tacit knowledge even with the participation of groups but also support and facilitate the mapping process [15], [46].

3.4 Need for Aggregation of Group Judgments

In addition to the determination of a knowledge elicitation technique, a method for constructing the group strategy map needs to be selected. A multi-personal strategy map can be fundamentally established in two ways: by a group of experts [49], [50] or by aggregating the individual maps of the members of a group [51]. Whether a strategy map should be constructed all at once by a group or by aggregating individual strategy maps of the members of the experts' team depends on organizations' specifics (e.g. simultaneous availability of all experts) as well as on advantages and disadvantages of each interaction type. Based on the identified expert knowledge the elicitation process should lead to a company-specific strategy map. The relevant

cause-and-effect-relationships may then be allocated to the typical BSC perspectives (in *Figure 1*: perspective A to D, whereby each KPI is denoted by X_i).

In addition to the consideration of explicit and tacit knowledge a holistic orientated PMS is of fundamental importance to ensure the long-term success of the company. The described importance of tacit knowledge and the advantages of interview techniques create the base of a holistic framework for the construction and operationalization of efficient PMS.

4. HOLISTIC FRAMEWORK FOR THE CONSTRUCTION AND OPERATIONALIZATION OF EFFICIENT PERFORMANCE MANAGEMENT SYSTEMS

4.1 Concept for a Holistic Framework

Based on the theoretical aspects of the previous sections, this chapter introduces a holistic framework for the tailor-made construction of causal-oriented PMS by support of TKE and SD. The framework is structured by a phase model in matrix form (see *Figure 2*). This complex but transparent structure is useful as there is a substantial interaction of tasks and participating groups.

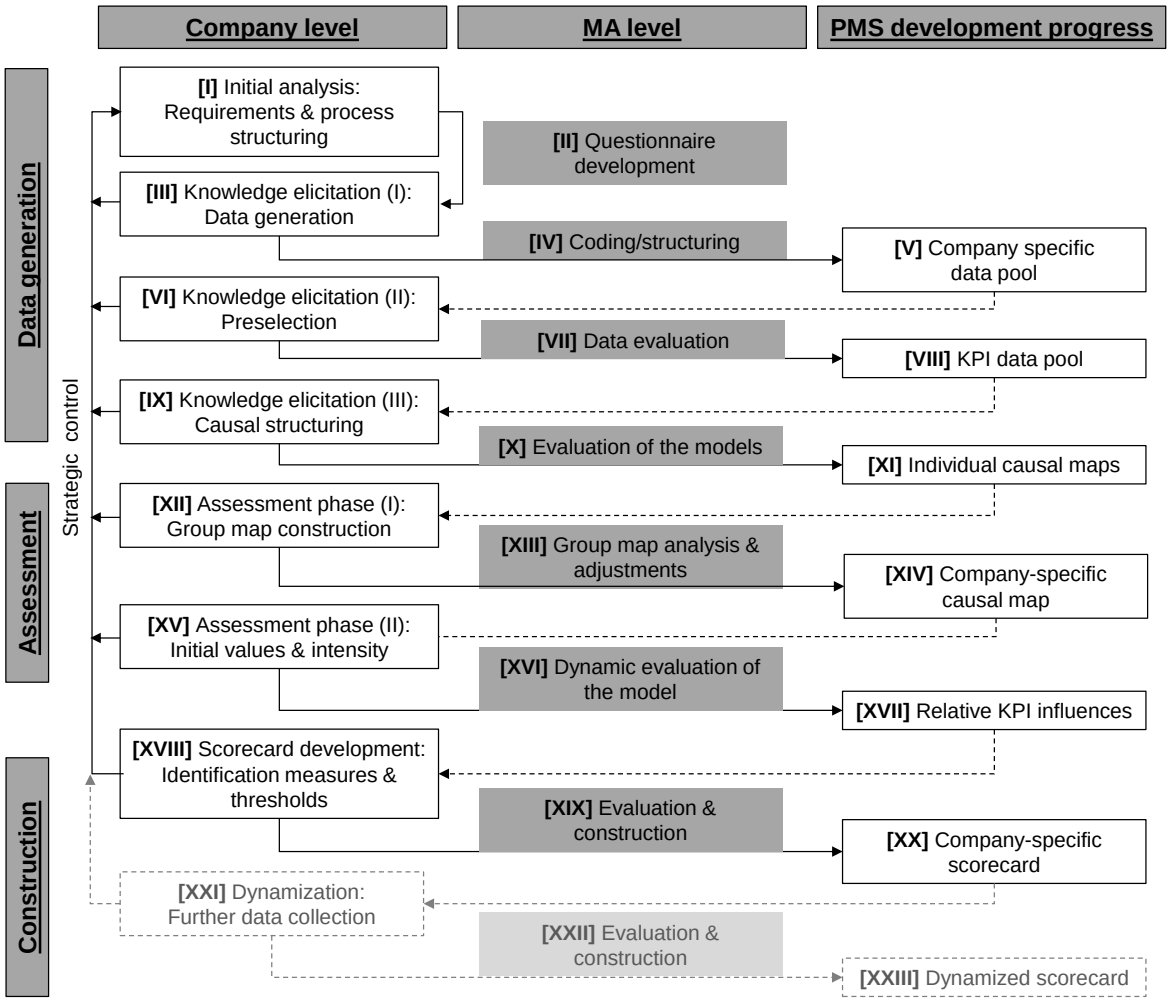

FIGURE 2: Holistic Framework for PMS Construction and Operationalization.

The entire PMS development process is classified into the three main steps *data generation*, *assessment* and *construction*. The main steps are functionally divided according to the

responsibilities on a *company level* and on a *MA level* which interactively lead to a certain object of the *development progress of the PMS*. *Strategic control* [52] accompanies the whole framework.

4.2 General Description of the Procedure

Within the **data generation** phase the starting point is an [I] *initial analysis* about company's individual requirements towards a PMS. *Requirements* are the aim of the PMS development and the scope of the construction (entire company, division, business unit or department). Subsequently, it is helpful to structure the construction process chronologically and functionally. The initial analysis should be conducted by MA professionals and top management.

Next, an interdisciplinary and cross-functional expert team (organization's personnel) has to be compiled in order to cope with a holistic construction perspective. Having multiple personalities within the units of an organization, a group can enhance the generation of relevant information as well as the identification and selection of performance relevant factors that are crucial for the construction of a strategy map. Considering a problem from different points of view, discussing several opinions among the members of the group, these interactions lead to an elicitation of information that may not have been regarded until then. Such group-dynamic processes help to ensure that fewer errors of judgments occur. In addition, the participation of employees in the development of the PMS facilitates their acceptance and engagement in the subsequent implementation [40], [41], [53].

A further important aspect within the initial analysis is the determination of the overall strategic goal the PMS has to be connected to. The overall goal is then directly transferred to a general reference point for further interviewing. If no consensus about the overall strategic goal can be reached by the top management, the question towards the overall strategic goal will be the first question for all participants (experts). Based on the assumption that the determination of an overall goal can be realized, an interdisciplinary expert team, associated with this goal has to be compiled. In our framework experts have to participate six times within the construction process. MA has to ensure that experts, who can either directly or indirectly influence the outcome and who have special interest or knowledge about the field of interest, are included. In order to cope with further arising complexity, we suggest a team size which is not too small and not too large, for instance a team size of five to eight members (for relationships between team task, team size and processes see e.g. [54]). Additionally, by including a strategy related expert team in the construction process, it is easier to gain higher acceptance for the PMS as well as a facilitated implementation.

The initial analysis is followed by the [II] *development of questionnaires*. The MA professionals have to prepare appropriate interviews for the first meeting of knowledge elicitation.

Within the knowledge elicitation at first basic company information has to be collected ([III] *Knowledge Elicitation (I): Data generation*). The data generation (in form of an open questionnaire) includes necessary information about corporate structures and second level goals. The aim is to map the entire value chain including internal processes, areas of concern, possible improvements and corresponding potential measures. By using semi-structured individual interviews for all participating experts, a cross-functional holistic view of the company can be reached. Interviews should be recorded (by notes or dictation machine). Owing to the fact that the information can be very personal and sensitive as well as contain criticism, MA professionals have to act as neutral and non-influencing interviewers and have to guarantee absolute confidentiality and ensure experts' anonymity, especially with the top management. In case an obligation of secrecy does not exist, it is possible that experts won't answer completely or concisely, because they are afraid of potential consequences from the top management. In order to ensure anonymity, at no stage in the construction process is MA allowed to communicate data which can be clearly traced to single experts.

After having executed the first interviews, MA professionals have to systematically analyze the recorded interviews by [IV] *coding/structuring* in order to build a [V] *company specific data pool* as a first step stone of a PMS construction. Coding can be done manually or by support of appropriate software solutions (e.g. atlas.ti). Manual coding has the advantage that MA professionals can obtain a better understanding of the situation. Although manual coding causes more effort than software solutions the MA professionals get a deeper view inside the answers and the information provided by the interviewed experts. The company specific data pool which has to be generated must contain a comprehensive and as complete as possible set of strategy related factors of corporate success on the one hand as well as actions which affect the success factors on the other hand.

In the next step, the company specific data pool has to be reduced by less relevant success factors and actions. Therefore, the experts are asked in a second step [VI] *Knowledge Elicitation (II): Preselection* to select the 15 most important success factors and the 5 most important actions from the entire data pool from their individual perspective. This preselection and [VII] *data evaluation* on the part of MA makes it possible to compile a [VIII] *KPI data pool* by using threshold values. To improve the preselection, scoring methods can be used, where e.g. each expert has to prioritize his personally chosen success factors from 1 to 3. Another possibility would be a complete ranking of the selected success factors with regard to their importance (score 1 to 15).

In order to receive more detailed additional information (before constructing a group causal map (GCM)) the experts should be asked to link their personal 15 KPIs according to the belonging cause-and-effect relationships ([IX] *Knowledge Elicitation (III): Causal structuring*). With the provided information, MA professionals can undertake an [X] *evaluation of the models* for constructing [XI] *individual causal maps* as a final step within the data generation phase.

After having collected all relevant data, the start within the **assessment** phase is [XII] *Assessment Phase (I): Group map construction*, whereby the experts are asked to agree on a company-specific group map. MA professionals should support this step strongly as a strategic partner. They have to ensure that the most relevant (high scores) KPIs out of the [VIII] KPI data pool are included. A further support for the determination of causality within the group map is the information provided by individual causal maps. The entire process should be supervised and moderated by the MA professionals. Simultaneously they have to [XIII] *analyze the group map* (e.g. ensure that no KPI is unconnected and that there is a top KPI) and secure necessary adjustments until an adequate [XIV] *company-specific causal map* is constructed.

In order to achieve an evaluation of single KPIs' importance within the GCM a comprehensive assessment of all model parameters is necessary. For this reason, in [XV] *Assessment Phase (II): Initial values & Intensity* all experts are separately asked at first to give an assessment about the current values of the KPIs. The purpose is on the one hand to receive an overview of experts' estimation on corporate matters and on the other hand to create initial values for further modeling. For estimating the current stages of KPIs we suggest an ordinal scale from "1 = very low" to "7 = very high". In a second estimation the experts are asked to assess the intensity of the identified cause-and-effect relationships between the KPIs. Therefore, we recommend an ordinal scale from "0 = no causal influence" to "5 = very strong causal influence". Additionally, the experts should set a time delay in months (if applicable). Furthermore there is a need for evaluating the before identified actions by connecting the actions to one or more KPIs from the group model. Hereby the intensity should be given by an ordinal scale from "1 = very low influence" to "5 = very strong influence".

With this collected data a [XVI] *dynamic evaluation of the model* should be accomplished by MA. For this purpose Forrester's [55] System Dynamics (SD) approach can be used. Using SD, it is possible to simulate the impact of management decisions on the system structure and the system behavior (e.g. on top financial indicators). This approach can be seen as an operationalization of a strategy map. Based on the dynamic character of PMS, the use of SD is furthermore necessary to take into account temporarily delaying and retroactive influences. In order to enable the

company to predict financial results, the dynamic structures of the cause-and-effect relationships must be considered explicitly [26].

A particular strength of SD is the possibility to formulate forecasts. As a strategy map is a limited static model, dynamic SD models are able to evaluate and test alternative assumptions and dynamic influences of different strategic actions [14], [56].

Through the SD support it is possible to simulate the [XVII] *relative influence of each KPI* on other KPIs, e.g. on the top KPI. In this way the most important KPIs can be revealed. Outgoing from the results of the performed SD simulation (depending on the influence intensity) a priority score has to be given to all KPIs instantly. The priority domain could be divided into "1 = low impact (priority level 1)", "2 = medium impact (priority level 2)" and "3 = high impact (priority level 3)". The priorities have to be used later on for monitoring and control actions. High priority KPIs are having a stronger impact e.g. on the top KPI. Therefore, special attention has to be paid to these KPIs in the case of threshold values' deviations.

Out of this information a [XVIII] *scorecard development with relating measures and thresholds* is subsequently possible as a first step in the **construction** phase. Within this step top management, experts and MA professionals should be included. After having reached consensus about adequate measures and belonging thresholds, a final [XIX] *evaluation & construction* step on behalf of MA professionals is necessary to develop a ready-for-use [XX] *company-specific scorecard*, which should underlie a strategic control (like all other mentioned steps). Strategic control hereby consists of implementation control, premise control and strategic surveillance [51].

As an extension of the framework (which is not further regarded here as we only focus on the construction process), a next step would be the [XXI] *dynamization* process whereby *further data collection* is necessary for completely transforming the company-specific scorecard by additional [XXII] *evaluation and construction* (e.g. stock and flow identification, generation of model equations) into a [XXIII] *dynamized scorecard*. A quantitative dynamized model would have the advantage of a possible use of statistical methods to validate the model (long-term data required). The dynamization process can be an important issue (see e.g. [57], [58]) but is not a key matter in this contribution.

This PMS construction framework closes a gap in the existing literature as it shows transparently without any black box how it is possible to synthesize TKE methods, causality and dynamic modeling in a tailor-made and practice-oriented PMS. Furthermore it is unique in the way it shows the interaction between MA and the participating interdisciplinary expert group regarding to the tasks which have to be mastered in all stages of the design process. Moreover a positive impact on the acceptance and the maintenance of the PMS can be assumed, since all experts take an active part in the entire construction process.

The importance of TKE in form of interview techniques, the necessity of considering causality aspects and the benefits that can occur from the support of SD within the PMS construction process are essential components that concur with many important research contributions within the field of designing a PMS (see e.g. [15], [18], [22], [28]). Even though other research contributions suggest a broader and more sophisticated range of methods for analyzing and mapping KPIs (see e.g. [15], [18]), this can also be disadvantageous, however: Rising complexity due to the combination of several methods induces less transparency and a more demanding implementation and calculation process from a practical point of view.

There is an elusive number of contributions to the field of PMS design, therein many research frameworks are highly academic and presented on a more abstract level (see e.g. [59], [60]) which could erect barriers for practitioners.

With respect to the fact that a PMS has to be designed tailor-made our aim is to highlight this individual construction process but not to generate or statistically validate a generalized KPI list

for companies in the same business sector (see e.g. [61], [62] for this way of proceeding). For a better understanding of our research contribution as well as for a practical validation the framework is applied to a case study in the automotive sector within the next section.

5. APPLICATION OF THE FRAMEWORK TO A CASE STUDY IN THE AUTOMOTIVE SECTOR

The framework presented within the previous section is now applied to a small sized company in the automotive sector in Germany. The orientation of the company has a very strong focus on customer satisfaction (corporate mission) which is seen as the driving force for any financial performance influencing the long-term business success. In order to improve this long-term business success, the purpose of the study is to apply various interview techniques to identify the company-specific success factors and their relationships to each other. In particular, the investigation should enable the company to determine the factors which influence the customer loyalty (as the predetermined top goal). Therefore the financial indicators are indirectly represented by the top goal customer loyalty. On account of this, cause-and-effect-relationships relevant to the performance of customer loyalty are to be identified, analyzed and assessed in the course of this case study. In addition, the framework shall facilitate the development of conceptual recommendations for the design and implementation of a company-specific PMS. A SD model is constructed to cope with dynamic effects within the PMS and to provide a quantitative tool, which is able to facilitate the development of the scorecard.

The first **data generation** step of the framework application starts with an [I] *initial analysis* (compare again *Figure 2*) of the individual requirements towards the PMS. As mentioned above, the aim of the company is the identification and operationalization of cause-and-effect-relationships relevant to the performance in order to ensure and improve the long-term business success. Due to company's strong focus on customer satisfaction (see Figure 6 for the results of the impact analysis using SD), the specific purpose of the PMS is to increase customer loyalty and should be reached by an optimization of all related processes. Therefore, all relevant processes are to be depicted by controllable measures in a company specific scorecard.

In order to consider a wide range of knowledge an interdisciplinary team of experts consisting of members through all parts of the company which are directly or indirectly connected to the financial performance, the overall strategic goal (customer loyalty) is now compiled. The expert group consists of six employees from different organizational levels: two Chief Executive Officers (expert 1 and expert 2), an Operations Manager (expert 3), a Key Account Manager (expert 4) as well as two Service Employees (expert 5 and expert 6).

As a result of the [II] *development of questionnaires* we applied individual semi-structured interviews in the first meeting of [III] *Knowledge Elicitation (I): Data generation*. Subsequently, we systematically analyzed the recorded interviews in a [IV] *coding/structuring* process particularly with regard to mentioned KPIs in order to generate a comprehensive [V] *company specific data pool (see Table 2)*. Instead of an automated coding with software support we perform a manual coding. Although manual coding requires a higher effort for MA it is advantageous to obtain a better understanding of the situation (due to the intensive reading/listening process) and the company which is desirable in our context.

Compilation of key performance indicators	
Dependency on insurers	HR development (trainees)
Job rotation (employees)	Incentive system
Accuracy of invoices	Initial training employees
Acquisition of new customers (insurers)	IT
Acquisition of new customers (private sector)	Jour-Fix-Dates
Bottlenecks (caused by staff)	Lack of time
Claims management	Maintenance customer data
Communication between departments	Market leadership
Communication within departments	Market share
Competitors	Marketing events
Complaints	Ongoing process controls
Coordination (departments)	Overflow
Coordination (time limits)	Personnel management (management)
Corporate flexibility	Personnel management (top management)
Corporate growth	Processes between departments
Corporate image	Processes within departments
Corporate structure	Product quality
Cost rates	Quality of employees
Customer loyalty	Quality of insurer relationship
Customer satisfaction	Selection suppliers
Customer structure	Selection trainees
Delivery quality	Service quality
Earned income (employees)	Service range
Employee loyalty (specialized personnel)	Team buildings
Employee loyalty (trainees)	Teamwork
Employee motivation	Training employees
Employee satisfaction	Volume of sales
Employees error rate	Willingness for responsibility (employees)
External recruiting	Willingness for responsibility (managers)
Final check (products)	Working atmosphere
Fixed responsibilities	Working time

TABLE 2: Company Specific Data Pool.

In a second step in [VI] *Knowledge Elicitation (II): Preselection,* the experts are asked to select the 15 most important success factors and the 5 most important actions from the before compiled data pool. With regard to further steps it is additionally necessary to assess all selected items with a score (1 = “important”, 2 = “very important” and 3 = “extremely important”). Based on this expert-individual preselection and a [VII] *data evaluation* which combines selection and scoring via threshold values to a [VIII] *KPI data pool*, a subsequent prioritization of these individually selected success factors leads to the third step of [IX] *Knowledge Elicitation (III): Causal Structuring*. This is performed to receive more detailed additional information before constructing a GCM. In order to construct graphical representations of the company-specific success factors, the experts are asked to link their personal 15 KPIs according to the individually relevant cause-and-effect relationships.

A final step within the data generation phase is the [X] *evaluation of the model*s which is task of the MA professionals to enable construction of the [XI] *individual causal maps*.

The following **assessment** phase ([XII] *Assessment Phase (I): Group map construction*) starts with an expert survey (structured interviews) about their agreement or improvements on a company-specific group map. At the MA level, we have to [XIII] *analyze the group map* as well as

the construction process to ensure that all relevant KPIs are included, no KPI remains unconnected and a top KPI is selected.

From the aggregation of individually explicated cause-and-effect relationships, the [XIV] *company specific GCM* results are illustrated in *Figure 3*.

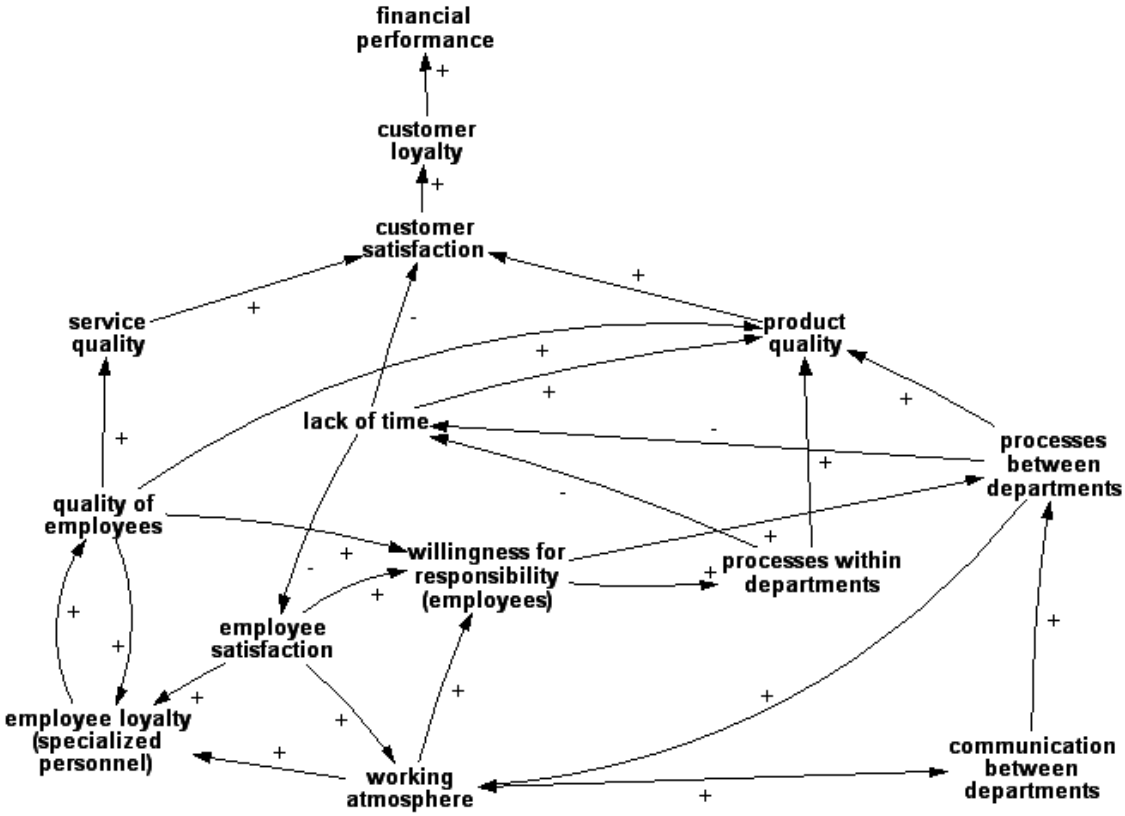

FIGURE 3: Company Specific GCM.

Before the GCM is analyzed in detail, the actual states of the corresponding variables should be determined for achieving a comparable starting point. Therefore, in the following [XV] *Assessment Phase (II): Initial values & Intensity,* the experts are invited to estimate the current values of the selected KPIs. As mentioned above, we used an ordinal scale from "1 = very low" to "7 = very high" to gain an overview of the experts' estimations of the current key success factors. These judgments can also be used as initial values for further modeling. In addition, the members of the company have to assess the intensity of the identified cause-and-effect-relationships. For this purpose an ordinal scale from "0 = no causal influence" to "5 = very strong causal influence" is used.

In order to enable an initial feedback as well as to identify areas for performance improvement further model evaluations are recommended. Visualizations can thereby support the evaluation process, for instance network-like representations of the assessments as shown in *Figure 4*. The figure illustrates the individual assessments of the current situation. The higher the scale value, the better is the current status of the relevant KPI. Similarities and differences in individual perceptions can be visualized by the network-like representation to facilitate the evaluation of the surveys.

The further analysis of the GCM and the visualization of the experts' assessments in our case study show that the experts focus on the working atmosphere and the processes within and

between the departments as relevant KPIs. The identification of KPIs reveals that the experts point out a demand to improve the processes and the communication within and between the departments and the working atmosphere. Regarding to “willingness to take responsibility”, experts’ perceptions diverge strongly. Relevant factors to improve company performance are indicated to be the reduction of the lack of time and the augmentation of employees’ satisfaction and qualification. Not surprisingly, “customer loyalty” is selected as the top non-financial KPI.

In order to operationalize these individual statements and to enable objective feedback to all participants, *Figure 5* shows the average values of the assessments of the interdisciplinary expert team.

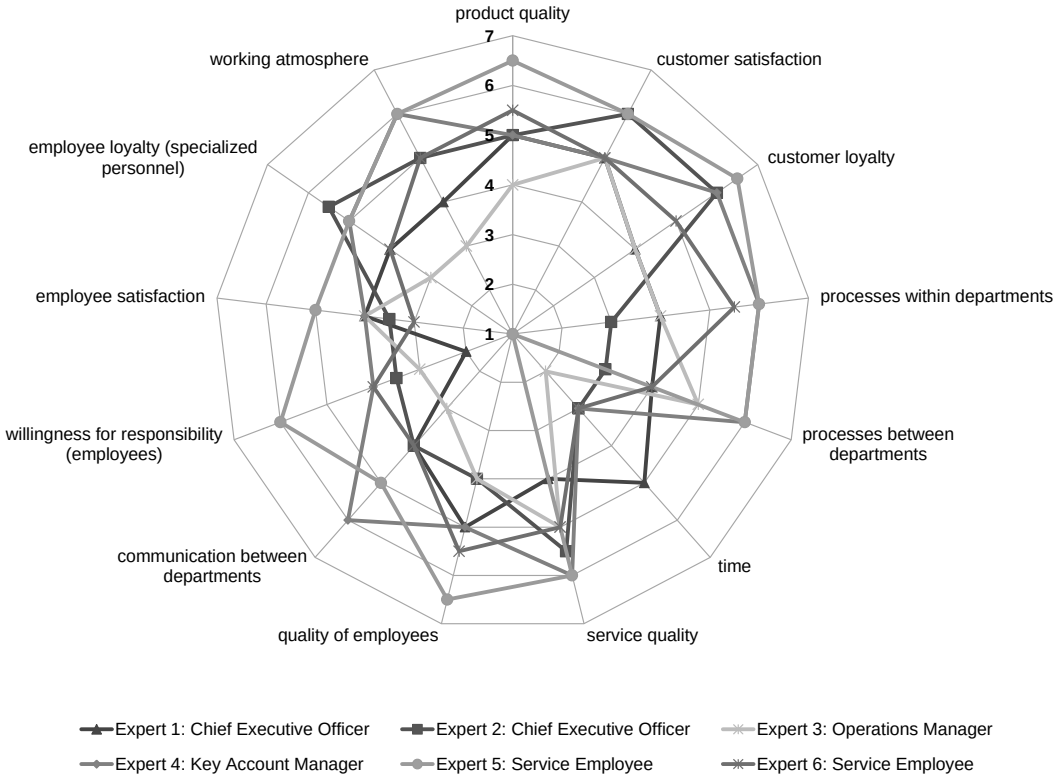

FIGURE 4: Individual Assessment of the Current Situation.

FIGURE 5: Assessment Current Situation.

The greater the distance of the average line to the center point, the better is the actual state of the KPI. In the assessments of the expert team, customer loyalty, service and product quality as well as customer satisfaction all reach already scale values bigger than five. Hence, the potential for improvement of these variables is low. This visualization also confirms that there is a need for actions and improvements in the areas of internal processes, inter-divisional communication, the increase of time (decrease of lack of time) and the increase of employee satisfaction.

Apart from these analysis options, the collected data constitute the base for the [XVI] *dynamic evaluation of the model*. The purpose of this step in the application of our holistic framework is to simulate the [XVII] *relative influence of each KPI* on the top (non-financial) KPI customer loyalty using SD techniques. In order to identify the most important KPIs, SD is used for impact analysis. The quantification of the previous qualitative GCM to a SD model leads to a priority ranking of the KPIs. After a single-period simulation, the variables of the model are arranged according to the intensity of their impact on the customer loyalty. *Figure 6* shows the relative impact of the KPIs on customer loyalty subdivided in three priority areas from “1 = low impact (priority level 1)” to “3 = high impact (priority level 3)”.

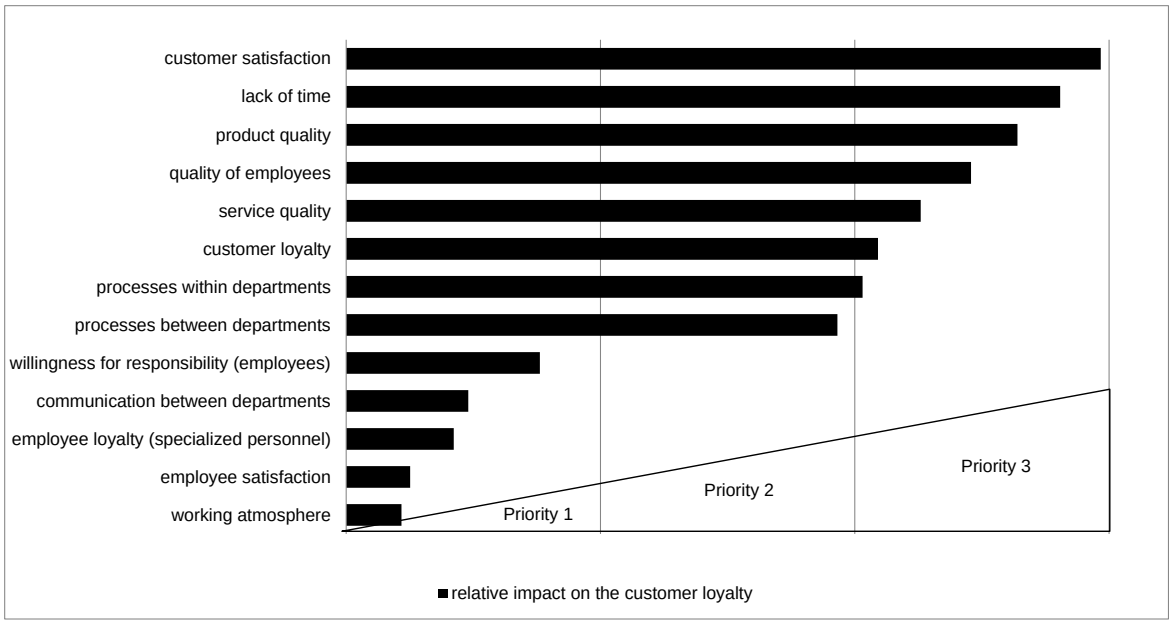

FIGURE 6: Relative Impact on Customer Loyalty.

The impact analysis using SD confirms that customer loyalty is highly influenced by customer satisfaction, lack of time as well as product and service quality (priority 3). In contrast, the impact of willingness to accept responsibility, communication between departments, employee loyalty and satisfaction and working atmosphere is perceived as rather low (priority 1).

On completion of the assessment phase, *Figure 7* illustrates the combination of the qualitative GCM and the BSC perspectives.

The following **construction** phase starts with further interviews on the topic [XVIII] *scorecard development with relating measures and thresholds.* The purpose of this step is the identification of measures for the most import KPIs. Furthermore, the expert team is asked to reach a consensus about adequate thresholds to ensure a continuous monitoring and control of the relevant KPIs. The result of this task in our case study is shown in *Figure 8*. During the process of monitoring and control particular attention must be paid to high priority KPIs and belonging measures (compare again *Figure 6*). In case of threshold deviations of high priority KPIs the case study company has to intervene promptly and effectively as the SD simulation results show that high priority KPIs are having a stronger impact on customer loyalty.

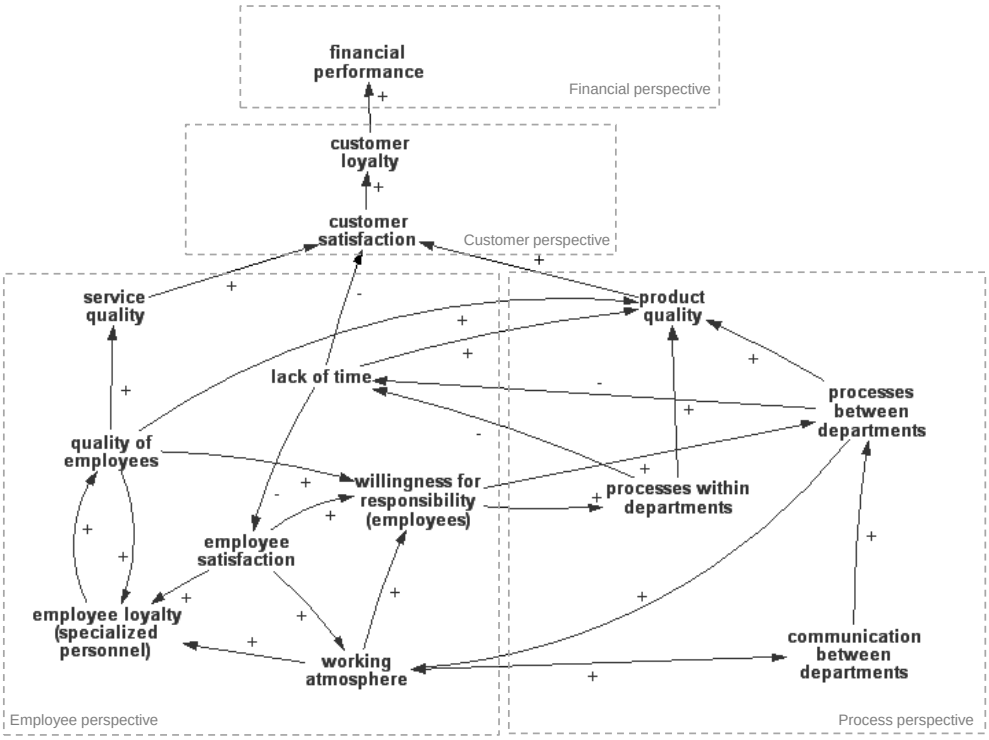

FIGURE 7: GCM with Perspectives.

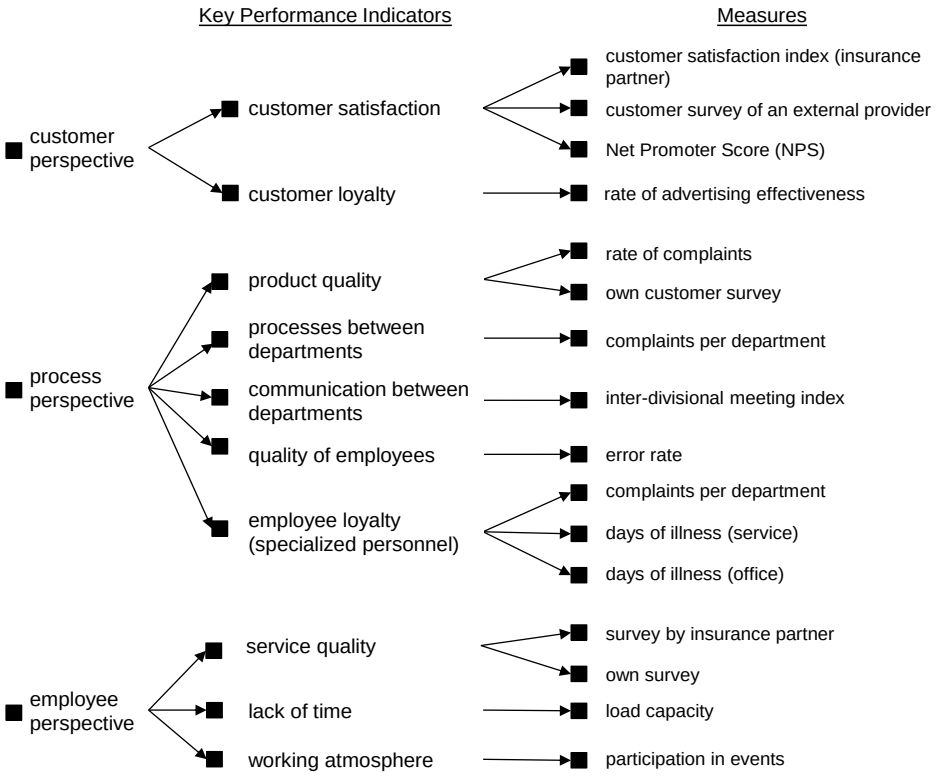

FIGURE 8: Company specific scorecard: KPIs and Measures.

A final [XIX] *evaluation & construction* on the MA level leads to a [XX] *company-specific scorecard*. It classifies the KPIs into perspectives (customer, process and employee). Each KPI is furthermore accompanied by relevant measures as well as belonging threshold values for achieving controllability within the scorecard.

In order to improve the previous static representation of the company-specific cause-and-effect relationships, further data collection as well as a long-term measurement of the KPIs and its measures can lead to possibilities of SD modeling in a [XXI] *dynamization* process. For this purpose, further data collection and an additional [XXII] *evaluation and construction* is necessary. Next, Management Accountants and company's expert team would have to estimate the dynamic effects to identify the stocks and flows in the GCM and to generate SD model equations. Based on these additional investigations the static strategy map can then be transformed into a [XXIII] *dynamized scorecard*. A further dynamic modeling is not considered within this case study, as the possibility of a framework is mentioned for future research. See for example [28] or [29] for SD modeling in a PM context.

With respect to the practical impacts it can be stated that the company could achieve an improvement of its control system which is from now on enhanced by further KPIs which are seen to be performance-relevant. As a result the company has to cope with new tasks on strategic and operational level. During the transparent procedure it was possible to give a reality check to the top management level. Especially the assessment of the current situation (see again *Figure 5*) was considered to be extremely revealing as it points out potential weaknesses. In general the communication inside the company could be improved. Furthermore tacit knowledge and causal relations have been elicitated and transported bottom-up to the top management. This enabled the identification and the usage of important KPIs and their presumed impacts on companies' performance within a causal model as a part of the control system. Since customer loyalty is a KPI which cannot be controlled in the short or medium term in this case one can be eager towards the long-term development and companies' experience with the constructed PMS.

There are some potential limitations to this study. On the one hand, we used a limited number of experts to develop the PMS. It is thus possible that the PMS is not truly representative as it only reflects the views of the six participating experts. With respect to the transferability, on the other hand, the developed PMS and its KPIs should be only used with caution for other companies. Instead companies should use the process itself to design their own KPIs. Our aim is to show transparently how an efficient PMS can be constructed tailor-made and not to present a universally valid list of KPIs which influence customer loyalty. Results haven't been validated statistically yet for the case company.

6. CONCLUSION AND FURTHER RESEARCH

The task of constructing, implementing and maintaining PMS is clearly assigned to the functional range of MA. It is fundamental for a PMS to be tailor-made for each organization. Accordingly, the consideration of company-specific cause-and-effect relationships is of particular importance, so that the organizations' strategy for ensuring satisfactory future performance can be implemented. Strategy maps as a specific type of causal maps are designed to illustrate and support the execution of an organization's strategy by linking KPIs according to determined cause-and-effect relationships in the form of leading and lagging (financial) indicators. Non-financial indicators play an important role in this context. In order to construct a strategy map according to the greatest possible extent to reality it is inevitable to refer to a broad information basis which should be derived from expert knowledge. As this knowledge is mostly not expressly available, the process of TKE is important for a tailor-made construction of PMS and its operationalization in the form of a company-specific scorecard or a dynamic model. Within this research, the variety of TKE methods were classified into three groups (interviews and observations, process tracing and conceptual techniques). From a MA perspective, the interview techniques turned out to be the most adequate TKE method since the other techniques are not expedient in a PM mapping context when there is a need for handling groups and a vast number of qualitative assessments.

Based on the relevance of tacit expert knowledge and because up to now a coherent framework does not exist, a holistic step by step approach for constructing and operationalizing efficient PMS was pointed out in this paper. The framework is supported by TKE in the form of interview techniques, SD and the interaction of organizations experts and MA. The approach fundamentally consists of the three main steps of data generation and assessment and construction are further divided by functional responsibilities on company and MA level. Additionally, the current stage of PMS development is transparent after each interaction step. Apart from interview and group aggregation techniques, the approach applies SD for the preliminary assessment of determined KPIs towards the organizational top goals.

In a further section the applicability of the approach was demonstrated with a case study within the automotive industry. As qualitative factors were playing an important role, the use of interview techniques with non-metric scaling turned out to be helpful and facilitating for the experts during the two interview rounds in the assessment step as well as for the following group aggregation. Moreover, the case study showed that the intermediate steps of the PMS development progress (especially the visualization of the individual assessment of the current situation) are highly appreciated by top management level as they are very helpful to facilitate the creation of an objective and anonymous view on the current organizational situation from an interdisciplinary employee perspective. Thus, it was directly possible to perceive a need for action.

A final step within the approach was not supported by the case study. Therefore it is necessary to create a long-term database in order to perform a more comprehensive dynamic modeling of the PMS. At least 30 data points are recommended. However, in this case it has to be reemphasized that the entire presented framework should be embedded into appropriate strategic control activities which can reveal changes within strategy, assumptions or external factors. These changes again require an adjustment of the entire model. Despite this, a further SD modeling would offer the possibility for verifying the validity of experts' tacit knowledge and could be an interesting aspect for further research.

Owing to the fact that the PMS construction process is permanently confronted by multiple conflicting goals which are further influenced by various indicators, the use of appropriate multi-criteria decision aid methods could be an additional possibility for improving and facilitating the PMS design and implementation process. As partnering in decision making ranks among the fundamental tasks of MA [63] the support of multi-criteria decision problems in the context of PM such as selection, priorization or evaluation of strategic goals, KPIs, measures and possible actions likewise belongs to the responsibility of MA. Despite of attempts to combine methods of multi-criteria decision aid with single steps of the PMS construction process (see e.g. [64] and [65] for selecting BSC metrics with Analytic Hierarchy Process (AHP), [66] for an evaluation of AHP-software support from a MA perspective and [67] for evaluating and determining the most important BSC's indicators and European Foundation for Quality Management (EFQM) criteria with TOPSIS) there is still a lack of sufficient consideration of causal models and dynamics in strategic decision making. Therefore, a future research direction can be seen in the improvement of PM frameworks concerning the integration of multi-criteria decision making techniques in order to facilitate a transparent and systematic process of constructing and implementing PMS in a multi-personal decision environment.

Acknowledgements: We would like to thank the participants from our case study for their support and collaboration. Furthermore, we would like to thank the referees for their helpful comments.

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Apply Web-based Analytic Tool and Eye Tracking to Study The Consumer Preferences of DSLR Cameras

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Abstract

Consumer's preferences and purchase motivation of products often lie in the purchasing behaviors generated by the synthetic evaluation of form features, color, function, and price of products. If an enterprise can bring these criteria under control, they can grasp the opportunities in the market place. In this study, the product form, brand, and prices of five DSLR digital cameras of Nikon, Lumix, Pentax, Sony, and Olympus were investigated from the image evaluation and eye tracking. The web-based 2-dimensional analytical tool was used to present information on three layers. Layer A provided information of product form and brand name; Layer B for product form, brand name, and product price for the evaluation of purchase intention (X axis) and product form attraction (Y axis). On Layer C, Nikon J1 image samples of five color series were presented for the evaluation of attraction and purchase intention. The study results revealed that, among five Japanese brands of digital cameras, LUMIX GF3 is most preferred and serves as the major competitive product, with a product price of US$630. Through the visual focus of eye-tracking, the lens, curvatured handle bar, the curve part and shuttle button above the lens as well as the flexible flash of LUMIX GF3 are the parts that attract the consumer's eyes. From the verbal descriptions, it is found that consumers emphasize the functions of 3D support lens, continuous focusing in shooting video, iA intelligent scene mode, and all manual control support. In the color preference of Nikon J1, the red and white colors are most preferred while pink is least favored. These findings can serve as references for designers and marketing personnel in new product design and development.

Keywords: Website Technique, Consumer Preference, Eye Tracking.

1. INTRODUCTION

With the technological advance, cameras have been developed from the previous conventional film-type into digital ones. The prevalence of digital cameras also makes it possible for more and more people to share their photographs instantly through the Internet platform. Therefore, digital cameras have become an indispensable necessity everyone or every family cannot do without. In designing and developing new products, if designers can bring consumer's opinions regarding product purchase such as preferences of product form and color, acceptable range of product price, functional conditions to meet their needs, it will be critical for the product's success in the market place.

In the past, designers often process the product design thinking from their own points of view and define consumer preferences by their subjective way of assessment. Such kind of thinking method, however, does not truly reflect consumer's preferences and needs for products. In this study, therefore, the web-based 2-dimensional analytical tool and eye tracking experiment are combined to explore subject's opinions regarding the product form and prices of five Japanese DSLR cameras (Nikon, Lumix, Pentax, Sony, Olympus) as well as color preferences for Nikon J1 series. Moreover, verbal descriptions regarding the functional preferences of DSLR cameras are integrated to offer references for the design and development of DSLR cameras in the future.

2. LITERATURE REVIEW

In this study, consumer's behaviors regarding DSLR camera purchase are explored. Moreover, views from scholars of related studies on the application of web-based 2-dimensional analytical tool, eye tracking, and product price acceptability are collected and synthesized for further experiments in the study.

2.1 The Web-based 2-dimensional Analytical Tool

In this study, the context of commercial center was simulated where product samples were placed on the same plane for consumers to conduct their preference comparison. Lin and Huang developed the web-based 2-dimensional analytical tool based upon the gravitation theory. Through the coordinates of product samples from each subject in the survey, objective analysis of the products tested in the four quadrants can be conducted for market segmentation and positioning [1]. More importantly, the result of market segmentation can be effectively applied for the policy making of essential competition strategies [2]. For enterprises, market segmentation is an important strategic commercial domain [3, 4]. Through web techniques, Lin, Chang and Huang further extended the functions of web-based 2-dimensional analytical system. Their system is able to (1) collect subject's personal data and coordinates of the product samples tested in the survey; (2) collect and calculate the gravitation centers of product samples from the database; (3) present visualized diagrams for market segmentation based on the coordinates of gravitation centers of product samples; (4) specify preferences for special target user groups (gender, vocation, living area and the like demographic variables) by the presentation of specific single product sample [5]. For product form, Chuang and Kao claim that product image is composed of such elements as colors, lines, textures, and structure, which form certain types of feelings. Together with visual and perceptual experiences, such feelings can help people recognize products and perceptual functions [6]. Chen and Owen proposed a style description framework for the analysis of product style, in which six attributes are included: (1) form elements, (2) joining relationships, (3) detail treatments, (4) materials, (5) color treatments, (6) textures. For affective domain, design elements of product form play a key role in user's image perception [7]. Through web techniques, Huang and Lin further extended the functions of web-based 2-dimensional analytical tool. The output systematic diagrams and tables could help researchers process market segmentation, select competition products, potential target user groups, and morphological analysis for product form elements. With digital data and graphic output, the web-based design decision tool could help designers and marketing managers set up proper policies for product form design and marketing of new products, in which a certain number of product samples are needed for morphological analysis [8]. In this study, the variables along axes of the 2-dimensional analytical tool were based on the preference and purchase intention proposed by Wind and Green to investigate the differences among different user groups for market segmentation [9, 10].

2.2 Consumer Behavior

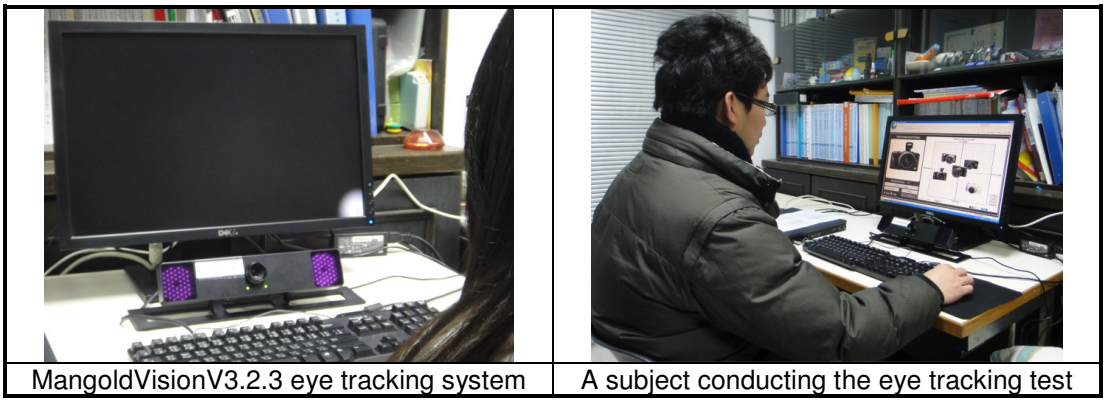
Consumer behavior is an integral discipline whose structure consists of social science, psychological science, economics and marketing. Many scholars define consumer behavior from different perspectives. For instance, Peter and Olson define it as thinking, cognition, and interaction procedure people respond to the purchasing conditions and environment [11]. Engel, Kollat, and Blackwell consider it a kind of behavior people use money or substitute of money for commodity or service. There exist a series of strategies during the exchange, including before and after the action of purchase [12]. Schiffman and Kanuk define it as the behavior people

search for products, services or ideas, acquire, evaluate and propose information to satisfy their needs [13]. Zikmund refers it a psychological and contextual procedure and physical activity where people select, purchase, and use products to satisfy their needs and desires [14]. Zaltman thinks it the way people acquire, purchase, and dispose products, services, and ideas. The more we understand consumer behavior, the more we can find the rules in such kind of behavior [15]. Engel, Blackwell, and Miniard refers it the activities involved in the way people acquire, consume, and dispose products or services, which is a dynamic strategic procedure including the specification of needs, search of information, information processing, evaluation prior to and after purchase, purchase action, and disposal [16].

From the above studies, it is clear that the scale of a market is formed by consumer's behaviors. Different target user groups vary in their behaviors. It will be helpful for the design and development of new products if enterprises can take the preferences of different user groups and develop suitable strategies for them. In this study, college students are selected as target user group for DSLR cameras for the exploration of major competing products, price acceptability and color preferences so as to offer references for the design and marketing strategy of related products in enterprises.

2.3 Eye Tracking

Human vision is the most important information channel to help people deal with the majority of incoming messages. The physical structure of the eye determines only what we feel, and the information stored in the human brain is used to interpret the signals seen, and to guide the eye to collect new information. Therefore, from the eye movement, we can explore the intention of an observer [17]. Meanwhile, he also points out that when people look at artistic works, they will first pay attention to some things interesting; then move their eyes; stay there for a short while; and repeat the process again and again. People comprehend the outer stimulus during the gaze period; the duration of eye fixation is about 300 milliseconds (ms). The eye movement of people's visual perceptions toward a product form can be precisely tracked by infrared reflection of cornea and relative positions of pupils [18, 19]. In visual scanning, subjects will move their eyes to the area attracting them and stay there for more than 100 milliseconds (ms) so that the brain can receive the visual information. Such kind of procedure is defined as eye fixation. Henderson and Hollingsworth and Tatler, Baddeley and Gilchrist claim that in earlier period of scanning, subjects will have similar fixation durations, but in later scanning, the fixation is more dispersed, mostly because of the scene and meaning of different areas in the content [20, 21]. In this study, the 2-dimensional analytical tool was integrated with the Mangold eye tracking system (VisionV3.2.3 in Figure 1). The fixation is determined by the gazes in specific areas of product sample images. The conditions of a gaze are set up to be 30Hz, so it takes 33.333 ms to form 1 Gaze. Through the detection of eye fixations, we can understand the visual responses consumers have toward product forms of different features. More importantly, the fixations subjects scan specific areas of product sample images are compared with the verbal descriptions subjects have in considering the product form elements of DSLR cameras they prefer. The results obtained from the study can serve as references for product designers.



MangoldVisionV3.2.3 eye tracking system	A subject conducting the eye tracking test

FIGURE 1: MangoldVisionV3.2.3 eye tracking system (Courtesy of PITOTECH Co.,Ltd, Taiwan).

In the experiment, the implicit factors consumer consider about the purchase of DSLR cameras are visualized by the eye tracking system. To visualize such a complicated and dark-box type of cognition, the web-based 2-dimensional analytical tool is combined with the eye tracking system to record quantitative data and verbal descriptions from think aloud so as to build up the visual responses subjects use in looking at product sample images. Such kind of visual perceptual data will be compared and contrasted with the voice of subjects in terms of their preferences towards product form. Through a comparative analysis of qualitative (psychological feelings) and quantitative data (eye fixations), it is expected to have an in-depth understanding of the consumer's preferences towards product form design.

2.4 Acceptability in Product Prices

Dodds et al. found that the impact of product prices on the perceived quality decreases with the increase of other clues, but compared to other external cues such as brand or product image, product price is still an important indicator of consumer's purchasing decisions [22]. Anderson and Vincze pointed out that product price is the amount of money consumers pay for goods or services, the monetary sum a buyer is willing to pay to obtain a product or service [23]. Therefore, product price can be divided into the objective price specified by the vendor and the identified price perceived by the consumers. The perceived price of a product combines the actual price of the product with the non-monetary price, such as time costs, search costs, mental costs, and the like. The perceived price of a product is different from the actual objective price because consumers are not able to know the real costs, causing it difficult to judge the rationality of the objective product price. As a result, the objective price of a product is often transformed into cheap-lower price or expensive-higher price, an easy way to feel the perceived price. From the above, product price is one of the important factors that will affect consumer's purchase intention of a product. Therefore, in terms of the product information, a layer without product price is used to examine the subject's perceived price (subjective judgment) while the other layer with product price is used for the objective price (rational judgment) to explore the product price strategy. Through the manipulation of product price information, Lin and Huang found that there exist significant differences in terms of subject's purchase intention for the same product. Three product price strategies for product price setting: type I: reasonable price; type II: too expensive and should be lowered; type III: a good bargain for the product price strategy of DSLR cameras [24].

3. METHODS

To explore consumer's preferences toward product form and price acceptability, five Japanese brands of DSLR cameras, including Nikon, Lumix, Pentax, Sony, and Olympus were used for the 2-dimensional marketing survey. With data from the eye tracking experiment and think aloud experiment, consumer's preferences to product form features of DSLR cameras were clarified.

Moreover, five color series of Nikon J1 were used for the color preference test. The results could serve as references for designers in product form design and color scheme.

3.1 Select Product Samples

Through websites, images of five Japanese brands of DSLR cameras were collected, including their logo and product prices (Table 1).

Product image					
Product title	Nikon1 J1	Lumix GF3	Pentax Q	Sony α	Olympus
Price in US dollars	$ 830	$ 630	$ 840	$ 899	$ 699

TABLE 1: DSLR camera images of Nikon, Lumix, Pentax, Sony, and Olympus.

3.2 Setup Web-based 2-dimensional Analytical Tool

The web-based 2-dimensional analytical tool was adopted to present information on three layers. A layer provides information of product form and brand name but without product price; B layer for product form, brand name, and product price for the evaluation of purchase intention (X axis) and product form attraction (Y axis). On C layers, Nikon J1 image samples of five color series were presented for the evaluation of attraction and purchase intention.

On the scale, as can be seen in Figure 2, X axis indicates the purchase intention and Y axis means the product form attraction. From product without price (Layer A) and eye tracking system as well as verbal descriptions in think aloud, subject's preferences in product functions are specified. From product with price (Layer B), major competition products are identified. From Layers A and B, product price acceptability is explored. At last, color preference test is conducted from Layer C. The results can work for references in design and marketing strategy.

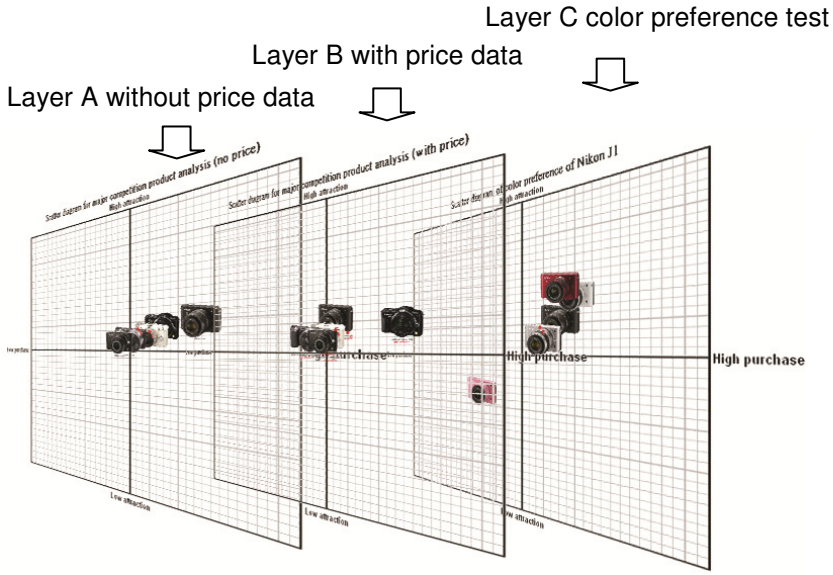


FIGURE 2: Three layers in the web-based 2-dimensional analytical tool.

3.3 Eye Tracking Setup and Product Information

Experimental facility: MangoldVisionV3.2.3 eye tracking system. Monitor resolution is set to be 1024 x 768. Screen capture setting: the desktop eye focus unit is connected to the test host.

Hardware calibration: adjust the angle of desktop eye focus unit according to the distance between subject's seat height and monitor. Instead of being fixed and stiff, the subject can slightly turn his or her head. The accuracy percentage of focus is set to 70%. If a subject's accuracy is lower than 70%, then a recalibration is needed. In the eye tracking test, it is hoped that the subject will not be influenced by the price information when he or she evaluates the product form. Therefore, Layer A (without product price information) is used for the eye tracking test. When product samples are played in different viewing angles, the fixations and number of gazes of detailed areas of product form are collected. Meanwhile, the think aloud test is also conducted to explore the subject's preferences to product form features and functions. In this study, areas of product form details and functions were previously set. Scores of 0 and 1 were assigned for specific areas of interest and functions. For the objectivity of research, a weighting of 1 is assigned to every subject in terms of the areas of interest and functions. The presentation details of DSLR cameras, taking Nikon J1 as an example, are (8/900/37.5), meaning 8 pictures, 900 frames, 24 frames per second (fps), and 37.5 seconds in total presentation. Details for other brands are Lumix GF3 (8/1045/43.5), Pentax Q (9/1125/46.9), Sony α (9/1245/51.8), Olympus (7/930/38.7), (Table 2). Because of different numbers of pictures and presentation time periods, only eye tracking data of major competition products are selected for preferences of product form feature and function. No comparisons are conducted among products of different brands.

Brands	Pictures played	Frames	Total presentation time (sec.)
Nikon	8	900	37.5
LUMIX	8	1045	43.5
PENTAX	9	1125	46.9
SONY	9	1245	51.8
Olympus	7	930	38.7

TABLE 2: Presentation Details of Five DSLR Cameras.

3.4 Purchase Behavior Evaluation and Eye Tracking Experiment

60 college students were invited for the eye tracking experiment. Features of product forms of five DSLR cameras were played to collect the fixations subjects gazed at the product form images. Experimental procedure:

(1) For each subject, focus calibrations of the eye tracking system and LCD monitor were first conducted.
(2) Through homepage of the web-based 2-dimensional analytical tool, a briefing for the purposes of the experiment was introduced.
(3) Images of five DSLR cameras were imported to the system. Subjects were asked to place product images on the 2-dimensional scale according to their perceptions of product form attraction and their subjective purchase intention.
(4) During the eye tracking test, subjects were asked to speak out their preferences in product form features and functions, from which the product form features and functions of major competition products were identified.

4. RESULTS AND ANALYSIS

4.1 Major Competition Product Analysis

60 college students (30 males and 30 females) took part in the eye tracking test in which product form, logo, and price information are presented in different layers. With the coordinates of product samples in the test, the scatter diagram of five DSLR cameras was exported (Figure 3). The major competition product analysis reflects that along Y axis (attraction of product form), Nikon and Lumix were more attractive than the other three brands while Lumix was most competitive along X axis (purchase intention). Through such kind of scatter diagram, the major competition products can be prompted in real time for designers and marketing personnel.

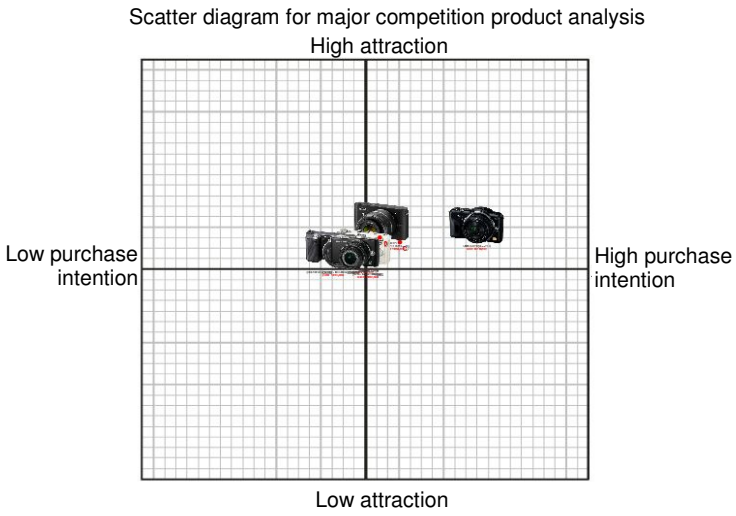


FIGURE 3: Major competition product analysis (layer with product price information).

With the coordinates of gravitation centers, and brands data of DSLR cameras, one-way MANOVAs were conducted. The result of MANOVA indicates that Wilks' Lambda F=16.604; p value=.000 (<0.05), meaning that there existed significant differences among 5 DSLR samples. Moreover, through marginal tests, it was found that these five samples were significantly different along X axis (marginal test F=29.363, P value =0.000<0.05) and Y axis (marginal test F=2.550, P value =0.039<0.05), meaning that there were significant differences among five brands of DSLR cameras in terms of product form attraction and purchase intention. In terms of product form attraction and purchase intentions, the average values are Nikon (1.39, 4.79), LUMIX (9.89, 4.03), PENTAX (-0.28, 2.14), SONY (-2.39, 1.97), Olympus (-0.95, 1.76). Furthermore, the Duncan post hoc test reflected that these five competitive samples could be divided into three clusters in purchase intention. Among them, Lumix (9.89, US$630) was of the relatively lower price and had the highest degree of purchase intention. In terms of product form attraction, Nikon and Lumix were of the cluster of highly attractive. From the results, it is clear that student user group will give a higher priority to buy Lumix whose price is much lower.

As far as price acceptability is concerned, the coordinates of Lumix were (4.73, 3.30) on Layer A where no price information was offered and (9.89, 4.03) on Layer B where price data was offered. The coordinate of Lumix image with price data fell to the right side of that of Lumix image without price data (Figure 4) means that consumers are more likely to buy this product. Furthermore, a pairwise t test was conducted for the comparison of purchase intentions (X axis). The result of t test (t= -5.38, P value=0.00<0.05) indicated that subjects thought Lumix was much more valuable. For subjects' preferences to Lumix's product form feature and functions, fixations and verbal descriptions subjects had for Lumix image on Layer A were further examined.

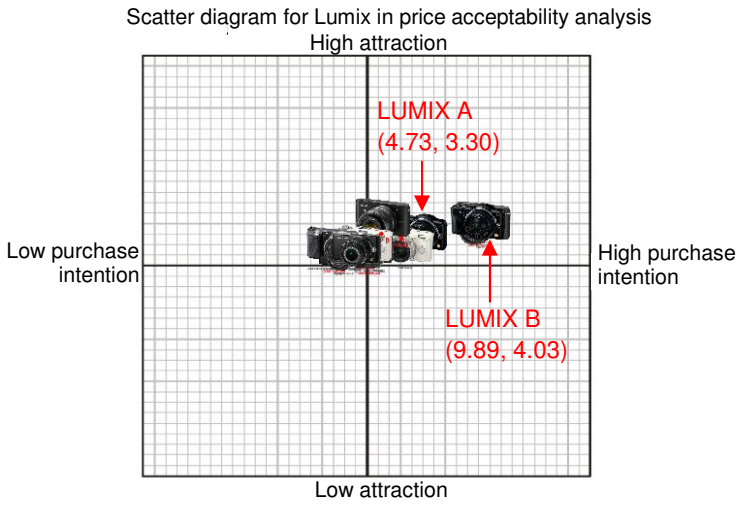


FIGURE 4: Scatter diagram for Lumix in price acceptability on Layers A and B.

4.2 Eye Tracking Data for Major Competition Products

Through the product form without price information in Layer A and the frequency of visual focus in eye tracking system and verbal descriptions from think aloud, which product form features and functions in major competition product Lumix attracted the subjects were explored.

In this study, areas of interest in product form of Lumix DSLR camera were defined. As illustrated in Table 3, the lens are denoted as pn1; curvatured handle pn2; lens switch button pn3; screen pn4; multiple circle shuttle dial pn5; curve above the lens pn6; pull up flash pn7, shutter button pn8; recording key pn9; iA key pn10.

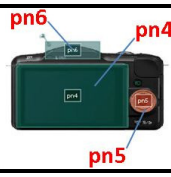
Lumix areas of interest				
				

TABLE 3: Area of interest in product form of Lumix DSLR camera.

In this study, MV Analyzer in MangoldVision was used to analyze fixations of visual focus in areas of interest of Lumix product form. Through one-way ANOVA, there existed significant differences among ten different areas of interest in Lumix product form, F =42.7, P value =0.00<0.05. Further analysis was therefore conducted.

From post hoc of Duncan MRT, ten areas of interest in Lumix product form can be classified into two clusters. The first cluster includes the lens (pn1) (5414 ms, 32.8%), curvatured handle (pn2) (3570 ms, 21.6%), and curve above the lens (pn6) (2440 ms, 14.8%). The average fixation and percentage of frequency in these areas are significantly higher than those in other areas. Among these areas of interest, the lens (pn1) includes the following special functions: M4/3 system; 2X Focal length conversion ratio; support continuous focus in recording; autofocus speed can reach 0.18 seconds; support 3D camera and other users' needs. In addition, the curvatured handle (pn2) meets ergonomics design. Moreover, the design of front curve of the handle and the curve above the lens (pn6) are visually attractive. The accumulated fixations of these areas of interest (pn1, pn2, and pn6) reach 69.2% of the total fixations. To demonstrate the remarkable differences between these three areas and other seven areas of interest, pair-wise comparisons were conducted. The contrast coefficients of the pair-wise comparisons are 7, 7, -3, -3, -3, -3, 7, -3, -3, -3, and t=17.07, P value =0.00＜0.05, indicating that the areas of the lens (pn1), curvatured

handle (pn2), and curve above the lens (pn6) are significantly different from the other areas. They can be looked upon as the appealing items consumers pay more attention to.

Besides, twelve functions are offered for subjects' references in think aloud test while the Lumix images are played. These functions include (1) 2.1 MP Live MOS sensor; (2) M4 / 3 system, lens of 2X focal length conversion ratio; (3) recording supports continuous auto focus; (4) autofocus speed can reach 0.18 seconds; (5) 3D lens support; (6) fast 23-point contrast-detect auto focus; (7) iA intelligent scene mode; (8) fully manual control support; (9) RAW file supports; (1) 320 shots / per charge; (11) compact dimensions: 107.5 x 67.1 x 32.0mm; (12) light-weighted: 222g.

In this study, a score of 1 is assigned to the function item that is considered important by the subject and 0 for the function considered not important. The relative weight of each subject is set to 1 for variance verification. The result of one-way ANOVA indicates significant differences among twelve functions, F=18.47, P value =0.00<0.05. From post hoc of Duncan MRT, four clusters can be found. Among them, "3D lens support" (0.276) belongs to first cluster; "recording supports continuous auto focus" (0.177), and "iA intelligent scene mode" (0.172) belong to second cluster. These three functions are considered much more important than other nine functions. The function "iA intelligent scene mode" is a functional setting property of the software while the other two are related to characteristics of lens. This result confirms the finding in eye tracking system where subjects fix their eyes on lens (pn1) for the longest period of time. In other words, the lens is an important feature of product form and function of Lumix DSLR camera. Furthermore, pair-wise comparisons demonstrate that these two clusters are considered significantly more important than other two clusters (contrast coefficients are -3, -3, 9, -3, 9, -3, 9, -3, -3, -3, -3, -3; t=13.26; P value =0.00＜0.05). Accordingly, from the opinions of consumers, "3D lens support", "recording supports continuous auto focus", and "iA intelligent scene mode" are the most important functions in Lumix DSLR camera.

4.3 Subject's Color Preferences Toward Nikon J1

To understand consumer's preferences of colors of DSLR cameras and to avoid too many choices of colors in a single series that may result in future inventory problems, five major colors of Nikon J1 are used for the test. 80 subjects were invited for this preference evaluation. The result indicated that the pink series of Nikon J1 (-6.44, -4.93) falling in third quadrant was least preferred. All of the other four color series fell in first quadrant, Red (5.05, 8.37), Whit (6.78, 7.27), Black (5.13, 4.42), and Silvery (2.90, 2.22). As can be seen in Figure 5, they are much more preferred.

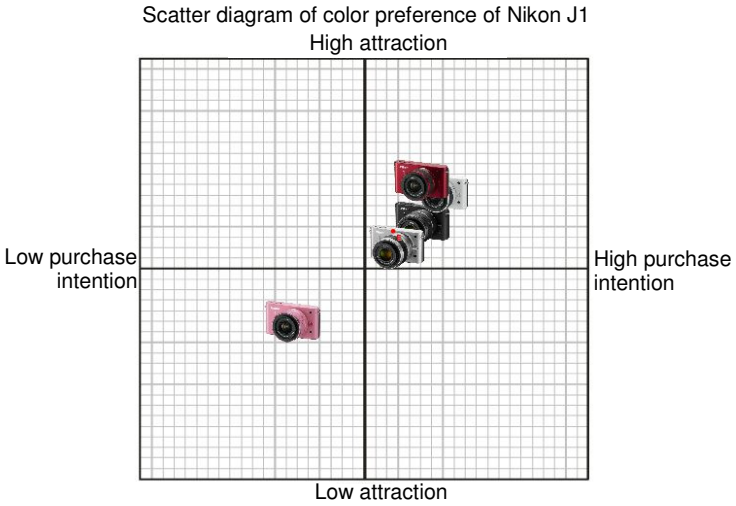


FIGURE 5: Scatter Diagram of Color Preference of Nikon J1.

To check whether there exist significant differences among five color series of Nikon J1, coordinates of 80 subjects in 2-dimensional analytical tool were used for the variable in MANOVA. The result demonstrated significant differences along X axis (purchase intention) (marginal test F=21.781, P value =0.000<0.05) and along Y axis (product form attraction) (marginal test F=34.728, P value =0.000<0.05). Furthermore, post hoc Duncan MRT reflected three clusters in purchase intention, the white, black, and red series are most preferred; silvery series the second; pink series the least preferred. In terms of product form attraction, three clusters can also be found: the red and white series are most attractive; black and silvery series the second; the pink series the least. From the above, it is clear that among five color series, red series (5.05, 8.37), and white series (6.78, 7.27) will be most favored; black and silvery series the second; the pink series (-6.44, -4.93) do not catch consumer's eyes. This result coincides with the cancelation of the pink series in recent media advertising.

5. CONCLUSIONS AND SUGGESTIONS

DSLR camera images of NIKON, LUMIX, PENTAX, SONY, and OLYMPUS were used for a 2-dimensional analytical tool to explore major competing products and product price acceptability of users. In this study, the evaluation tests were combined with an eye tracking system to take down the visual focus of subjects in viewing the product sample images to investigate the form features that attracted the subjects' eyes. In addition, subjects were asked to speak out why they preferred certain DSLR cameras in terms of the characteristics in their product forms and functions. At last, five color series of NIKON J1 were used for the color preferences of users for the color scheme of DSLR cameras in the future. Through the interactive interface in the web-based 2-dimensional analytical tool, images of five DSLR cameras were played with an aim to enable subjects fully understand the details of product form and to enhance the precision of measurement. Some major findings are listed below:

1. From the web-based 2-dimensional analytical tool and eye-tracking equipment, different areas of interest can be analyzed from a specific or few product samples. The form features in different AOIs can offer a different model for consumer preference analysis.
2. In major competition DSLR cameras, Lumix GF3 (US$630) had the highest degree of purchase intention. This indicates that product price is a top priority for college students. In terms of product form attraction, Nikon and Lumix are more attractive; their product form design features are worthy of designer's references.
3. According to the fixations in eye tracking test, different areas of interest in DSLR cameras will play different roles. In the case of Lumix GF3, the lens (pn1), the curvatured handle (pn2) and curve above the lens (pn6) are the product form features that will catch the consumer's eyes. Their gaze durations accounted for 69.2% of the total fixations.
4. From the verbal descriptions of think aloud, some functions are significantly favored by the consumers. For twelve functions of Lumix, one of the major competition products, "3D lens support", "recording supports continuous auto focus", and "iA intelligent scene mode" are the most important functions in Lumix DSLR camera.
5. In the color preference evaluation of Nikon J1, the red and white series are most attractive; black and silvery series the second; the pink series the least.

Because of the calibration process of eye focus on LCD screen, subjects are suggested not to move their heads as much as possible so as not to affect the accuracy of measurement. Therefore, it is suggested to control the eye tracking test during the range of 15~20 minutes.

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Success Factors of Open Innovation - A Literature Review

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Abstract

This paper reviews the research on the open innovation process in order to identify critical success factors. The study consists of a systematic review of 29 referred empirical articles on the open innovation process. The studies reviewed highlight different success factors for the open innovation process. These factors are grouped into nine themes: 1) relational aspects, 2) the people involved in the process, 3) governance, 4) facilitators, 5) provision of resources, 6) strategy, 7) process management, 8) leadership and 9) culture. Based upon the findings, the study proposes a number of future research directions that may stimulate more intensive investigation of this field.

Keywords: Open Innovation, Open Innovation Process, Open Innovation Practices, Success Factors, Literature Review.

1. INTRODUCTION

In the past, organizations used to conduct most of their innovative activities in-house as this was viewed as a strategic asset, and in some industries even as a market entry barrier [1]. With the increasing complexity of products and technologies, the rising costs of innovation coupled with shorter development lead times, organizations today are forced to open up their innovation activities and to enter not only into different forms of cooperation, but into new forms as well [2]. As a consequence, Chesbrough [1] argues that the innovation approach applied by organizations has shifted from a closed system to an open system. In contrast to the former, the latter focuses on the acquisition of external knowledge, blurring organizational boundaries [3]. Ståhle [4][5] goes so far as to make a distinction between open systems and complex, self-organizing systems that are the bases for innovation ecosystems.

Over the years open innovation has developed into a highly debated topic. For example, EURAM 2012 in Rotterdam devoted four tracks to open innovation. Even though there exists a plethora of papers discussing the relevance of open innovation, the focus has been on theoretical contributions or insights into major multinationals such as Procter & Gamble. So far only little work has been undertaken to explore the actual implementation and use of open innovation and any challenges it may bring about in the broad mass of organizations, be they private or public [6]. This is not surprising given the novelty of the phenomenon under investigation. In order to better understand the open innovation process, however, we need to have more (empirical) studies. More information about the relevance of the term to organizations would also help in confronting its critics [7].

If the management of the innovation process in itself poses a huge challenge to organizations, this applies even more so to an open innovation approach [8]. How does knowledge flow between the organization and its external environment happen, how do organizations change from a closed innovation system to an open one, and when and why do they change? What are the implications for the organizations? These are just some of the questions that may rise in connection with open innovation, but they all address critical aspects of which we need a better understanding.

With this in mind, this paper reviews the empirical research on the open innovation process in order to identify factors that support successful implementation of the process, an area of growing interest among both academics and practitioners [9]. Our research question is as follows: What are the success factors of the open innovation process as derived from the empirical research literature?

The paper is organized as follows: In section two we briefly discuss the literature related to the research aim. Section three then describes the method employed to answer the research problem. Next, the results are presented, and in the final section, the conclusion and implications of the study are laid out.

2. THEORETICAL BACKGROUND

2.1 Open Innovation

Chesbrough [10] defines open innovation as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (p. 1). This definition suggests that organizations should put even greater emphasis on collaboration and networking [11]. "The open innovation paradigm assumes that organizations can and should use external as well as internal ideas, and internal and external paths to market, as they look to advance their technology" ([12], p. 23). In contrast to earlier concepts discussed in the academic literature, the open innovation paradigm regards internal and external knowledge as being of equivalent quality. The focal point is the business model, that is, its relevance to innovation is now considered as well. R&D evaluation is reconsidered, which means that R&D projects that do not fit in with the business model may be commercialized elsewhere, referring to the latter having outbound flows of knowledge firms can benefit through the application of external revenue models [10]. In contrast, inbound flows of knowledge refer to an outside-in process intended to acquire knowledge from external sources [8]. Additionally, it is acknowledged that knowledge is widely distributed, which requires firms to become good networkers in order to gain access to this pool of knowledge. The bilateral flow of knowledge has also contributed to a stronger role of IP management, opening up further means of revenues. Intermediaries also benefit from this new situation as they help to bring together the different actors and thus enabling transactions. Against this background it is clear that there is also a need for new approaches to measure open innovation activities [10].

Chesbrough [1] argues that the changing business environment has required organizations to turn from a closed innovation approach to an open one. This observation has paved the way for open innovation debates. Dahlander and Gann [13], however, conclude that a binary classification of open innovation systems and closed ones fails to go into sufficient depth. Instead, the authors argue that the two systems should be viewed as a continuum, making possible varying degrees of innovation systems and thus of openness.

McLaughlin [14] stresses that open innovation can only happen if there is sufficient openness and participation from all actors involved. Yet this is easier said than done. Indeed, organizations have reported serious difficulties when trying to implement open innovation activities [15][8]. Two tendencies in particular – the "not-invented-here" and "not-sold-here" attitudes – seem to have a serious impact on the successful implementation of open innovation activities (e.g. [15][16]). In this connection, West *et al.* [17] call for research efforts to better understand the meaning of incentives and organizations of R&D workers.

Buganza *et al.* [18] demonstrate the influence of industry-level variables, such as R&D intensity, strengths of the appropriability regime, turbulence and uncertainty, on the adoption and institutionalization of open innovation. This indicates that organizations need to revise their current business models and organizational structures so as to cope with the new requirements presented by open innovation [19]. In addition, as open innovation puts even greater emphasis on networking, firms have to find ways of working more closely with other partners, even competitors, without losing their competitive advantage. Thereby it is important to have a coherent strategy at hand that allows firms to integrate their collaborative activities [11]. Simard and West [20] stress the role of network ties in conjunction with open innovation, and call for studies that would shed light on informal ties in the context of open innovation. They also correctly observe that the mere existence of ties does not automatically trigger the transfer of knowledge; instead a certain level of trust must exist among the partners involved. Additionally, Simard and West [20] make reference to network portfolios which consist of complementary ties, as firms are likely to be involved in a number of different networks that need to be managed in order to meet the anticipated expectations.

To address this challenge and to link the open innovation framework to the related literature, Lichtenthaler [8] proposes an expanded definition of open innovation, which says that the term comprises "systematically performing knowledge exploration, retention, and exploitation inside and outside an organization's boundaries throughout the innovation process" (p. 77). The intention of this definition is to more firmly anchor the concept of open innovation to related field of studies, such as knowledge management, organizational learning and firm boundaries. Feller et al. [2] argue that in order to fully understand organizations' open innovation activities, it is imperative to include the economic structures, institutions and regulatory environments as well.

What is striking about the current discussion on open innovation is its preoccupation with technological innovation. This is surprising in view of the increasing relevance of service-specific innovations [21][22], but it probably reflects the still dominant economic perspective which puts the focus on technological innovation and hence on technology transfer [7]. This perspective may also explain why open innovation is still mainly discussed from the point of view of high-technology organizations [23]. In a recent paper, however, Chesbrough [24] discusses the applicability of open innovation to services, so more papers on this topic are likely to follow soon.

Dahlander and Gann [13] noted that the downsides of open innovation seem to have been underestimated so far. This may well be explained by the relative infancy of research on open innovation. On the other hand, it implies that the current discussion on and understanding of open innovation is rather unbalanced and fragmented. This is justification enough to dig deeper into the operational level and to look into open innovation processes and its antecedents.

2.2 Open Innovation Process

The open innovation process consists of different phases. In a simple model, it comprises the search for innovation opportunities, the selection of suitable opportunities that organizations want to pursue, the implementation of the projects chosen and the capture of benefits as a consequence of the innovative activities [25]. In an open innovation process firms would then make the decision on whether or not to include external sources in all or some of the phases.

"Open Innovation. Researching a New Paradigm", a volume edited by Chesbrough et al. [10], identifies a number of factors influencing the open innovation process. It seems that of particular relevance are the individuals (as they come up with innovations), networks (as open innovation is by definition about collaboration between internal and external actors), governance (as these networks need to be coordinated and maintained), and national institutions and innovation systems (as they are likely to influence the ways in which innovation processes involving several actors are going to happen). Lindegaard [26] particularly highlights the role of people in conjunction with open innovation activities, emphasising the aspects of trust and having people with proper mindsets and the capacity to build relationships both internally and externally. He claims that in order to make all kinds of innovation happen, managers need to put people first.

This also implies that the individuals in charge need to understand that different people are needed for the different stages of the open innovation process. The importance of proper mindsets is confirmed by Rufat-Latre *et al.* [27]: the right mindset, they say, puts the emphasis on competencies rather than market share as a means of competing.

Lindegaard [26] further asserts that organizations need two different types of people: innovation leaders and intrapreneurs. The former are responsible for strategic and tactical issues in relation to open innovation activities, whereas the latter are responsible for operational issues. Additionally, Lindegaard stresses the relevance of having a strategy and an open innovation culture. He further emphasizes that there are certain elements that need to be put in place before organizations actually launch their open innovation initiatives, which are a clear mandate, a strategic purpose, an ideation theme, a stakeholder analysis, a communication strategy, a shared language about innovation in the organization, organizational approaches that allow the involvement and commitment of all relevant internal and external actors, and the adoption of an attitude that strives for being innovative rather than becoming innovative. Gassmann *et al.* [16] have observed that open innovation processes are still conducted in a trial and error mode rather than in a professional manner. The authors also highlight the need for suitable metrics for open innovation.

Gassmann and Enkel [28] propose three core processes that organizations can choose among in opening up their open innovation process: inside-out, outside-in and coupled. In an inside-out process an organization may generate profits by transferring internal ideas to the outside environment. In an outside-in process, organizations expand their own knowledge base through the inflow of external knowledge provided by suppliers, customers or other market actors. Finally, in a coupled process, organizations combine outside-in and inside-out processes. Given the different locus of the innovation process, each process requires different characteristics. Gassmann and Enkel [28] conclude that organizations using an inside-out process are very interested in branding and setting standards, whereas organizations employing an outside-in process focus on early supplier integration and customer co-development. Organizations using a coupled process take a relational view of the organization.

3. METHODOLOGY OF LITERATURE REVIEW

In the current review process, the authors adopted the principles of a systematic review as recommended by Jesson *et al.* [29].

First, a research plan was developed comprising the research question of interest, the keywords, and a set of inclusion and exclusion criteria. The paper's aim was to determine the current status of research on the open innovation process in order to identify success factors facilitating the process.

To help answer the research question, we specified inclusion and exclusion criteria. The inclusion criteria were: published in 2003-2012, empirical papers, peer reviewed, and English language. On the other hand grey literature such as reports and non-academic research as well as studies published in other than the English language was excluded. An excel data sheet was produced to highlight key aspects related to the research aim: name of author(s), year of publication, research aim / objectives, theoretical perspective / framework, method, main findings, and name of the journal.

Once all the relevant issues had been specified, ProQuest ABI/Inform, Web of Science and EBSCO were accessed and searched for materials using the keywords "open innovation process", "open innovation practices" and "open innovation activities". This was done in October 2012 and again in February 2013. The databases were searched for articles mentioning one of the three keywords in the abstract or title. Depending on the keyword used, different numbers of hits were generated. For example, the keyword "open innovation process" yielded 5 hits with ProQuest, 9 hits with EBSCO, and 7 hits with Web of Science, while the keyword "open

innovation practices" gave 3 hits with ProQuest, 1 hit with EBSCO, and 10 hits with Web of Science.

Next, one of the authors scanned the titles and abstracts of the articles and, if relevant, further sections of the articles, beginning with the conclusions, to make sure that they actually fell within the scope of interest. The specified criteria were met by 29 papers, which thus constituted the basis of the analysis. In the next stage the authors proceeded to discuss the findings, helping them to clarify what is known about the open innovation process. The final stage of the review process involved the writing up of the findings.

4. PRESENTATION OF FINDINGS

4.1 Studies Included

The 29 papers that formed the basis for our analysis are summarized in Table 1. The oldest publication dates from 2006 and the most recent one from 2012. The majority of papers were published in 2011 and 2012, indicating a rise in empirical research interest. This clearly shows how much time is needed by a new field of research to find its place in the research community.

Author(s)	Year	Research aim/objectives	Theoretical perspective / framework	Method (empirical / theoretical)	Main findings	Journal
Puck, Rygl & Kittler	2006	To test for the influence of cultural diversity on intra-team communication and conflict and to empirically examine the impact of the openness of intra-team communication and the intensity of knowledge transfer on the performance of multicultural process-innovation teams.	Literature related to cultural diversity and team performance	Survey among 84 team members of 20 culturally diverse process innovation teams within a German sportswear company; regression analyses	Knowledge transfer and communication openness have significant impact on different performance measures. National cultural diversity has no significant impact on intra-team communication and knowledge transfer.	Journal of Organisational Transformation and Social Change
Dodgson, Gann & Salter	2006	To examine how the use of technology supports the movement towards open innovation.	Literature related to the use of technology in the innovation process	Inductive case study approach conducted with P&G. Data were collected from interviews, participant workshops and literature.	Show how innovation technologies supported P&G to shift to an open model of innovation.	R&D Management

Buganza and Verganti	2009	To investigate the ability of firms to manage inbound knowledge flows from universities. Three research questions were addressed: Do Italian companies pursue an open innovation model? Are motivations to collaborate influenced by technology lifecycles? Are different strategies used to manage relationships with the academic world?	Literature related to open innovation	Interview-based (multiple) case study involving four Italian companies	The sample firms do acquire external knowledge from universities, but in doing so take into account the technology lifecycle and its associated phases. To manage their relationships with universities, the sample companies make different decisions vis-a-vis four main organizational variables (number of people involved in the organizational unit (OU) that is devoted to managing relationships with universities, positioning of the OU within (or outside) the firm´s boundaries, degree of work speciailization in the OU, and degree of process formailzation).	European Journal of Innovation Management
Feller, Finnegan, Hayes & O'Reilly	2009	To explore the ways in which firms use hierarchical relationships and the market system to supply and acquire intellectual property and/or innovation capabilities from sources external to the firm	Literature related to transaction cost economics	Field study involving documents and interviews published by a list of sample firms, analysis of the companies' web-based systems for acquiring IP, secondary content (e.g. news articles), and elite interviews with key personnel	The authors present an analysis of four governance structures and discuss the influence of knowledge dispersion, uncertainty and transaction costs on the emergence of such structures.	Information Technology & People

Van de Vrande et al.	2009	To investigate if open innovation practices are also applied by SMEs	Literature related to open innovation and innovation in SMEs	Used a survey database collected by EIM, a Dutch institute for business and policy research. A total of 605 respondents passed the screening phase	Open innovation applies not just to MNEs but to a much broader group of SMEs. For technology exploitation, the data suggest that many SMEs attempt to benefit from the initiatives and knowledge of their (non-R&D) workers. For technology exploration, by far most SMEs try in some way to involve their customers in innovation processes by tracking their modifications in products, proactively involving them in market research, etc. Furthermore, external networking to acquire new or missing knowledge is an important open innovation activity among SMEs. In contrast, outward and inward IP licensing, venturing activities and external participations are only practised by a minority of the respondents. More popular practices such as customer involvement and external networking are informal, unstructured practices that do not necessarily require substantial investments.	Technovation
Lichtenthaler	2009	To address the relationship between outbound open R&D strategies and firm performance. Research question: What is the relationship between outbound open innovation strategies and firm performance under different environmental conditions?	Literature related to outbound open innovation, firm performance and environmental moderators	Involved two data sources: survey data from Lichtenthaler and Ernst´s (2007) study and performance data from financial databases and annual reports	Findings showed a positive relationship between outbound open innovation strategies and firm performance.	R&D Management
Chiaroni, Chiesa & Frattini	2010	To study the process through which a firm evolves from being a closed to an open innovator. Main question posed: What changes in a firm´s organizational structures and management systems does the shift from closed to open innovation entail?	Literature related to open innovation and organizational change	Multiple case study approach involving 4 Italian firms from different industries, data from interviews and secondary sources	The analysis highlights the meaning of four dimensions (inter-organizational networks, organizational structures, evaluation processes and knowledge management) with regard to the process from closed to open innovation	R&D Management

Sieg, Wallin & von Krogh	2010	What managerial challenges do companies face when attempting to solve R&D problems through an innovation intermediary?	Literature related to innovation intermediaries	Exploratory, data-rich research design involving seven cases from four countries	The findings suggest three challenges: 1) enlisting internal scientists, 2) selecting the right problems, and 3) formulating the R&D problem in order to enable novel solutions. The authors also provide remedies to these challenges	R&D Management
Chatenier, Verstegen, Biemans, Mulder & Omta	2010	To examine the competencies that professionals need in order to work in open innovation teams and to cope with the challenges they face	Concept of competence	Qualitative approach involving explorative interviews and focus group discussions. 17 interviews were conducted with professionals from the Dutch agribusiness sector. The two focus group discussions took place with representatives of multiple groups that were involved in different aspects of open innovation	The study resulted in a competence profile for open innovation professionals.	R&D Management
Niehaves	2010	To investigate the variables that impact on the qualities of open process innovation, using the public sector domain as an example. Research question: Does personnel resource scarcity impact on the involvement of customers and consultants in public sector business process management (BPM)?	Literature related to open innovation and business process management	Multi-method study: interviews with experts in local government BPM in Germany and quantitative analysis of BPM-collaboration with customers and consultants (survey approach)	Highlight that personnel resource scarcity has consequences for BPM-related collaboration. It restricts the involvement of customers.	Business Process Management
Spithoven, Clarysse & Knockaert	2010	How do companies in traditional sectors cope with the lack of absorptive capacity that is needed to effectively organize inbound open innovation activities?	Literature related to open inbound innovation and absorptive capacity	The authors collected data through interviews with CEOs and triangulated this information with member views (obtained through Internet questionnaires) and objective data on each of 12 Belgian collective research centres.	Firms lacking absorptive capacity are forced to search for alternative ways to engage in inbound open innovation.	Technovation
Colombo, Dell´Era, Frattini	2011	To investigate how an NPD service provider organizes and manages relationships with its clients in the early stages of the development process so as to faciliate the transfer and integration of knowledge into the clients´ innovation process.	Literature related to open innovation, NPD service providers and inter-organizational knowledge exchange	Multiple case study approach involving three projects undertaken by a leading NPD service providers	Paper highlights the importance of trust in determining the successful completion of the kind of relationship in question.	International Journal of Innovation Management

Rönnberg Sjödin, Eriksson & Frishammar	2011	To explore the problems and opportunities faced by process firms and their equipment suppliers throughout the lifecycle stages of collaborative development projects	Lifecycle model by Lager and Frishammar (2010)	Exploratory case study approach involving two process firms from nothern Europe, 28 semi-structured interviews conducted	Produced a table that summarizes data concering opportunities, problems and the intensity of collaboration at different lifecycle stages. The fndings further demonstrate that being totally open in development activities is not always the most suitable option. Instead, different degrees of openness may be suitable at different stages.	Int. J. Technology Management
Whelan, Parise, de Valk & Aalbers	2011	To understand how opportunities for innovation diffuse throughout interpersonal networks	n/a	Interviews with over 80 innovation brokers, study of social media and web 2.0 technologies usage in over 30 organizations with the help of interviews, surveys and network-analysis techniques	Highlighted the critical meaning of innovation brokers (i.e. idea scouts and idea connectors) to a successful open innovation process.	MIT Sloan Management Review
Østergaard, Timmermans & Kristinsson	2011	To investigate the relation between employee diversity and innovation in terms of gender, age, ethnicity, and education	Literature related to diversity and innovation	Innovation survey data from Danish firms and data from the IDA dataset (Integrated Database for Labour Market Research), logistics regressions	Findings showed a positive relationship between education and gender diversity and the likelihood of introducing an innovation. Age diversity was found to have a negative effect and ethnicity no significant effect of ethnicity on the firm´s likelihood to innovate.	Research Policy
Westergren	2011	To examine the contextual factors that influenced an open innovation project failure	Literature related to open innovation and the concept of service development	Case study approach conducted at Power Drive (a Swedish hydraulic drive systems manufacturer); data collection through semi-structured interviews and document reviews		Inf Syst E-Bus Manage
Schiele	2011	To identify and better understand the characteristics of highly innovative suppliers	n/a	Consortial benchmarking approach	Highlights the importance of a firm establishing itself as an attractive customer to successful buyer-supplier collaboration.	Research-Technology Management

Bogers	2011	To explore the tension field of knowledge sharing and protection in R&D collaborations and to identify which strategies can be developed to cope with this tension. The research question posed is: How can firms balance knowledge sharing and protection in R&D collaborations?	Literature related to knowledge sharing and protection	Multiple case study approach involving 8 R&D collaborations, conducted a series of exploratory interviews with managers at a variety of companies (the Netherlands and Sweden), and used annual and other reports, corporate and technical journals, collaboration reports and other data sources	Provides a holistic perspective on the knowledge paradox in R&D collaboration as a coupled process of open innovation. In addition, the study presents two strategies to overcome the open innovation paradox.	European Journal of Innovation Management
Buganza, Chiaroni, Colombo & Frattini	2011	Research questions posed: How do firms operating in different industries organize themselves to streamline the adoption and the institutionalization of open innovation? What are the main reasons behind the differences in the organizational implications of open innovation?	Theoretical framework addressing external organization, internal organization and "ignition" for open innovation	Multiple case study approach involving 8 Italian "early adopters" of the open innovation principles	The findings demonstrate the influence of industry-level variables on organizations´ approaches to open innovation. Some firms tend to leverage exploitative inter-organizational networks and establish units to institutionalize structured and formalized screening processes. Other firms tend to use networking relationships for explorative purposes and adopt more informal, ad hoc structures and evaluation procedures.	International Journal of Innovation Management
Bianchi et al.	2011	To investigate the adoption of open innovation in the bio-pharmaceutical industry	Literature related to open innovation. Used a framework comprising three main variables: organisational modes for open innovation, types of partners and phases of the R&D process.	Longitudinal study involving 20 leading bio-pharmaceutical companies. Data collected through expert interviews (1 round) and secondary material, i.e. annual reports, professional databases and reports	The firms in the sample have gradually modified their innovation network by including more and more external partners operating outside their core areas, thus supporting the idea that (i) a different and more "agnostic" open innovation approach (West et al., 2006) to the sources and uses of innovation has been adopted and that (ii) alliances play an increasing role among the organizational modes implemented by firms in the sample in both Inbound and outbound open innovation. This lends support to the notion that firms are more and more intensely searching for weak ties linking their innovation process to external actors in a typical open innovation approach (Dittrich and Duysters, 2007).	Technovation

Ollila & Elmquist	2011	To provide an empirical exploration of the challenges of managing an open innovation arena	Literature related to open innovation management	Longitudinal case study approach. Case is an open innovation arena involving 22 partners from academia, industry and government conducting joint research on traffic and vehicle safety	The authors identified three types of managerial challenges: challenges that arise at the interface with partner organizations, challenges related to collaboration between the partners, and challenges related to the arena itself.	Creativity and Innovation Management
Feller, Finnegan & Nilsson	2011	To explore how open innovation can transform public administration by examining how one network of Swedish municipalities transforms value creation and service delivery by collaborating with one another and external parties to accelerate the creation and exploitation of innovation.	Literature related to e-government and open innovation and Osterwalder et al.'s (2005) business model ontology	Case study approach with embedded units of analysis, focusing on the Sundsvall Region with six participating municipalities. Data sources included public domain material, interview material and documents provided by the interviewees	Based on the findings four emerging typologies of governmental transformation were identified: aggregation, syndication, consumption, and co-creation.	European Journal of Information Systems
Tranekjer & Knudsen	2012	Two research questions posed: Who and why do outsiders produce knowledge for open innovation in the first place? What motivates individuals and firms to create and freely reveal knowledge that is of use to other (even competing) innovators?	Literature related to inter-organizational relationships and open innovation in conjunction with the nature of provider firms	Cross-sectional study among Danish SMEs operating in manufacturing and R&D. 355 responses received	Providers are involved in product development projects as suppliers and benefit from providing (in the form of their own knowledge development and innovation efforts). The provider is typically a customer or a supplier to the receiver firm, but rarely a competitor.	J Prod Inno Manag
Muller & Hutchins	2012	To present open innovation at Whirlpool Corp	n/a	Case study	The authors highlight three lessons learned: maintain a balance of open innovation and internal innovation, make open innovation a win-win proposition for partners and for yourself, and innovation is messy and open innovation is messier.	Strategy & Leadership
Lee, Hwang & Choi	2012	To examine current open innovation practices in the public sector of leading countries	Literature related to open innovation in private and public sectors	Used data from secondary sources that contained information on the current open innovation practices of the public sector in selected countries, namely the USA, Canada, selected European, and Asian countries, New Zealand and South Africa.	Some countries such as the USA, Australia and Singapore developed open innovation policies at the national level, creating a favourable innovation climate. Additionally, a number of organizations and projects led by citizens helped the government to engage external knowledge in solving complex issues that are beyond its control. Outside-in strategies appear to be dominant, although there have been some attempts to exploit the value of government data through inside-out approaches.	Management Decision

Bullinger et al.	2012	To examine if and how open innovation practices are adopted by the public in the field of health care	Literature related to open innovation, open innovation in health care as well as an introduction to the open health platform representing the unit of analysis	Communication elements provided on the open health platform, e.g. personal messages and comments	Provides initial insights into open innovation practices in health care.	Health Policy
Pullen et al.	2012	To examine which combination of network characteristics leads to high innovation performance	Social system perspective and Groen´s multidimensional framework	Questionnaire approach addressing Dutch SMEs operating in the medical devices sector (60 useable responses received) plus semi-structured interviews in 50 of the same companies	The findings demonstrate that a business-like way of networking and a rather closed approach towards open innovation is related to high innovation performance. The focus should be on goal-complementarity.	J Prod Inno Manag
Nakagaki, Aber & Fetterhoff	2012	To report on what is working and what is not working regarding Roche´s open innovation activities	n/a	Report on Roche´s work in progress regarding open innovation	Identified and discussed two important elements that affect Roche's ability to embrace open innovation: creating the compelling eureka moment that will inspire senior management to champion open innovation and changing the mindset to create an open innovation culture that pervades the organization.	Research-Technology Management
Parida, Westerberg & Frishammar	2012	To shed light on which open innovation activities SMEs can engage in to spawn their own innovation efforts.	Literature related to open innovation and SMEs, open innovation and innovation performance	Survey approach targeting technology-based SMEs in the information and technology (IT) sector in Sweden	Identified innovation performance as a suitable dependent variable for future studies on the topic of open innovation. The results suggest that inbound open innovation activities have different influence patterns on the two aspects of innovation performance (radical and incremental).	Journal of Small Business Management

TABLE 1: Overview of Empirical Papers Included in The Literature Review.

4.2 General Observations

The most common methods applied in the research reviewed are case studies (13 papers), followed by surveys (6 papers). The remaining papers employ a mixture of different methods. Overall there is a distinct emphasis on qualitative approaches. The focus on case study approaches is understandable in view of the topics under investigation inasmuch as they can help to reach a better understanding of what is going on in particular settings [30], or to build a body of knowledge in a new field of study [31].

As regards the types of organization studied, most of the papers describe open innovation in private organizations. The exceptions are the papers by Niehaves [3], Feller *et al.* [32], Bullinger *et al.* [33], and Lee *et al.* [34], which deal with public organizations. Furthermore, most papers have studied the phenomenon from a firm-level perspective, confirming the observation by West *et al.* [17] that the individual level continues to remain an under-researched topic. In addition, the review indicates that open innovation primarily takes place within the boundaries of a firm. This is interesting and suggests that organizations remain reluctant to take advantage of open innovation activities outside their controllable areas. This, however, is easy to understand in the light of the emphasis placed by many organizations on control in the wake of the financial crisis and other

corporate scandals. Besides, many organizations are quite simply not used to working in this way. The one exception here is the paper by Ollila and Elmquist [35], which focuses on an open innovation arena involving partners from different areas (academics, practitioners and policy makers) who came together for the specific purpose of this joint research.

Only one of the papers reviewed [23] discusses open innovation from the perspective of failure. This in itself is a clear indication that the field is still very much in its infancy and working to carve out its own place in the scientific community. However in order to make progress in this endeavour it will be necessary to have a more balanced research effort.

Chiaroni *et al.* [6] showed the need to align performance measures under an open innovation perspective. Traditional measures developed for closed innovation systems are no longer applicable in this new context [16].

Table 1 clearly underscores the predominance of specialist journals in the body of relevant literature. This is understandable in view of the novelty of the topic, but in order to achieve a wider acceptance it will be necessary to have a broader selection of journals in the future.

4.3 Factors Facilitating The Open Innovation Process

Table 2 shows the factors that seem to facilitate an open innovation process as reported in the papers reviewed. The factors can be grouped along the following dimensions: relational issues, people, governance, facilitators, resources, strategy and leadership, culture, and process (referring to the open innovation process per se).

Factors supporting the open innovation process	**Studies**
Relational issues	
Understanding of the nature of collaboration	Buganza et al. (2011); Bogers (2011)
Trust	Lichtenthaler (2009); Westergren (2011); Colombo et al. (2011); Schiele (2012)
Prior shared experiences & history of collaboration	Schiele (2012); Tranekjer & Knudsen (2012)
Smooth and continuous communication	Van de Vrande et al. (2009); Ollila & Elmquist (2011); Schiele (2012)
Openness	Tranekjer & Knudsen (2012)
Open communication	Puck et al. (2006)
Mutual exchanges	Tranekjer & Knudsen (2012)
Mutual support and empathy	Bullinger et al. (2012)
Compatibility of partners, e.g. shared objectives/goals, visions, mindsets	Feller et al. (2011); Westergren (2011); Rönnberg Sjödin et al. (2011); Ollila & Elmquist (2011); Schiele (2012); Muller & Hutchins (2012); Pullen et al. (2012)
Knowledge transfer	Puck et al. (2006)
Understand the distinctive characteristics of each of the partners involved	Colombo et al. (2011); Bullinger et al. (2012)
Win win situation for all actors involved	Westergren (2011); Tranekjer & Knudsen (2012)
Finding a suitable language among the actors	Sieg et al. (2010)
Effective organisation and management of relationships	Feller et al. (2011)
People involved in the open innovation process	
Creation of the eureka moment	Nakagaki et al. (2012)
Diversity in terms of gender, age and education	Østergaard et al. (2011)
Competencies, skills and capacities, e.g. managerial, brokering solutions, being socially competent	Van de Vrande et al. (2009); Lichtenthaler (2009); Chatenier et al. (2010)
Committed	Muller & Hutchins (2012)
Attitudinal and personality traits	Colombo et al. (2011)

Motivation	Van de Vrande et al. (2009); Feller et al. (2011)
Preparedness and willingness to develop new skills	Dodgson et al. (2006)
Involvement of people with overlapping roles to make possible the integration of different types of knowledge	Bullinger et al. (2012)
Willingness to adopt a new mindset	Nakagaki et al. (2012)
Governance	Feller et al. (2009)
Mechanisms and structures	Chiaroni et al. (2010); Buganza et al. (2011); Bogers (2011); Ollila & Elmquist (2011); Lee et al. (2012)
Configuration of relevant organizational unit	Buganza & Verganti (2009)
Control and coordination	Rönnberg Sjödin et al. (2011); Buganza et al. (2011)
Clear statement of the objectives of the project/problems to be solved	Sieg et al. (2010); Muller & Hutchins (2012)
Clear distribution of roles, tasks and responsibility	Van de Vrande et al. (2009); Westergren (2011)
Dedicated project-team	Muller & Hutchins (2012)
Team performance evaluation (i.e. qualitative and quantitative measures)	Puck et al. (2006)
Explicit performance measures (showing the value of OI activities)	Chiaroni et al. (2010); Rönnberg Sjödin et al. (2011); Nakagaki et al. (2012)
Application of internal and external measures of success	Westergren (2011)
Planned and organised purposefully from the outset	Rönnberg Sjödin et al. (2011)
Clear definition and selection of a problem that can be feasibly addressed	Nakagaki et al. (2012)
Clear decision-making responsibilities	Rönnberg Sjödin et al. (2011); Ollila & Elmquist (2011)
Knowledge management systems	Chiaroni et al. (2010)
Adminstration-related problems	Van de Vrande et al. (2009)
Adaptation of new ways of sourcing and exploiting competencies	Feller et al. (2011)
Handling of any resulting intellectual property	Feller et al. (2011)
Effective aggregation of external competence and components to deliver	Feller et al. (2011)
Contracts that make sure that agreement are met	Pullen et al. (2012)
Facilitators	
Innovation brokers	Whelan et al. (2011)
Relationship managers	Muller & Hutchins (2012)
Team training and coaching	Puck et al. (2006)
Open innovation champion	Chiaroni et al. (2010)
Intermediaries	Feller et al. (2009)
Collective research centres	Spithoven et al. (2010)
Provision of resources	
Personnel resources	Niehaves (2010)
First-class personnel and equipment	Schiele (2012)
Availability of time and resources	Dodgson et al. (2006); Van de Vrande et al. (2009); Nakagaki et al. (2012)
Balance between innovation and day-to-day management tasks	Van de Vrande et al. (2009); Nakagaki et al. (2012)
Strategy	Schiele (2012)
Being aware of technical and feasibility issues	Colombo et al. (2011)

Match between open innovation decisions and a firm´s overall strategy	Buganza & Verganti (2009)
Being aware of the impact of industry-level variables	Buganza et al. (2011)
Clear principles that help transform the culture into an open one	Lee et al. (2012)
Alternative strategies	Dodgson et al. (2006)
Open innovation process	
Understand the different stages within the process	Colombo et al. (2011); Rönnberg Sjödin et al. (2011)
Understand the phase of a technology´s lifecycle	Buganza & Verganti (2009)
Understand the uniqueness of open innovation process per se	Van de Vrande et al. (2009)
Untestand the influence of different types of innovation performance (radical vs. Incremental)	Parida et al. (2012)
Leadership	
Leaders need to take the lead in the change process	Lee et al. (2012)
Change management experienced	Dodgson et al. (2006); Feller et al. (2011)
Culture	
Networking and knowledge-sharing culture	Tranekjer & Knudsen (2012)
Culture that encourages personnel to move away from perceiving an outside view as an admission of failure	Nakagaki et al. (2012)

TABLE 2: Overview of success factors facilitating the open innovation process.

It is clear from the Table that the dimensions of relational aspects, people and governance are central to successful implementation of the open innovation process. As regards relational aspects, it seems that the existence of trust and partner compatibility are crucial. This is not surprising inasmuch as they have earlier been identified as critical to the implementation of cooperation, e.g. strategic alliances (e.g. [36][37]). The emphasis on governance indicates that the open innovation process benefits from structures and mechanisms, such as the coordination or measurement systems, that have been primarily developed and implemented to address open innovation activities. In reference to the measurement of open innovation activities, Westergren [23] stresses that in order to measure the success of open innovation projects, measures need to be applied that address both the external and internal environment. Measures normally applied tend to focus mainly on the internal environment. Nakagaki *et al.* [38], reflecting on their experience at Roche, add that quantifiable measures are needed that show the value of open innovation activities to organizations, as they would attract CEO attention and so are likely to increase commitment. Yet these metrics are difficult, if not impossible to develop, so at Roche the emphasis is placed on collecting “small wins (for instance, the use of an open approach to solve an internal problem or provide new knowledge to the organization)” (p. 36).

As regards the individuals involved in open innovation processes, it seems to be crucial that they have certain skills and competencies that allow them to collaborate with actors from different social and professional backgrounds. Additionally, these people are highly motivated and committed and show the preparedness and willingness to learn and adopt. Following Lindegaard [26] and Rufat-Latre *et al.* [27], Nakagaki *et al.* [38] stress the importance of having a proper open innovation mindset in organizations, although they at once admit that this is easier said than done. It is clear from these findings that the recruitment and selection process should play a vital role in the run-up to open innovation activities. This also underlines the strategic role that HRM should play in open innovation, as new strategies need to be developed to cope with the specific requirements of open innovation.

Facilitators play a crucial part in making possible the open innovation process. It seems that the main task of these individuals or specialized organizations is to bring together the different actors and their concerns and backgrounds so as to make them work together more efficiently and smoothly. Facilitators can be suggested to play the role of boundary spanners, operating as they do on the boundaries of open innovation stakeholders.

The findings concerning the dimension of strategy imply that in order to increase the likelihood of success in open innovation processes, open innovation per se needs to be included in organizations' overall strategies. This requires leaders who are willing and capable of leading the organization through this process of change.

5. CONCLUSIONS

This paper has reviewed empirical research studies exploring the open innovation process. More precisely, the purpose was to identify factors that enable successful implementation of open innovation processes. In the business environments of today and the future, effective management of open innovation possibly represents one of the main challenges facing organizations, regardless of size. Open innovation management should involve certain preparatory stages in order to increase the prospects of success in open innovation activities. The decision to open up the innovation process will therefore be accompanied by a certain lead time. Its length will vary from organization to organization, industry to industry, culture to culture and depend on the open innovation process chosen.

For this review we identified 29 empirical studies that met the selection criteria specified. This is a relatively small number, clearly underlining the limitations of our knowledge regarding this topic. It seems that research in this area is primarily driven by the personal interests of individual researchers. On this basis it can be concluded that the existing literature provides only fragmented insights into open innovation processes and their implementation in reality, which is in line with previous findings (e.g. [8][13]). Given the assumed importance of open innovation as an alternative approach to addressing current and future business challenges, there is clearly a need for more intensive research. This would also help to underpin the legitimacy of open innovation as a research field.

Our review suggests that factors promoting a successful open innovation process can be found in the areas of relational aspects, people, governance, facilitators, resources, strategy and process management. These areas show that well-researched topics are addressed. When launching open innovation activities, therefore, the individuals in charge can to a certain degree build upon previous experience and existing knowledge. The factors derived from our literature review represent the main contribution of our research.

Additionally, some research directions can also be derived from our literature review that in the authors' view warrant more attention and development:

1) The evaluation of open innovation processes. In times of austerity the need to legitimize investment in innovation-related projects is an even greater challenge than usually. However even during times of economic normalcy organizations will be keen to evaluate open innovation activities. Organizations need to have measures at hand that will allow them to better control and allocate their resources in different business operations. Given the scope of open innovation, these measures need to go beyond the boundaries of the organization and to address all actors involved and their concerns. Research into this area deserves particular focus and attention in the future.

2) The role of different types of innovation in the open innovation process. Different types of innovation may require different open innovation approaches. Future research could investigate possible differences between open innovation approaches that address technological innovations and those that address service and/or societal innovations.

3) The role of people in the open innovation process. The open innovation process involves different actors with different goals, expectations and attitudes. Therefore, following Chatenier *et al.* [39], the authors call for more research addressing the individuals concerned, as this would help us better understand and explain the successes or failures of open innovation processes.

4) The application of a variety of research designs and methods. Longitudinal designs would allow researchers to study the open innovation process as it actually unfolds in organizations. In addition, longitudinal studies provide the opportunity to observe whether the open innovation process changes over time as organizations grow older or face new challenges. The use of mixed methods would also help towards a more holistic understanding of the subject of the open innovation process than can be achieved using mono-methods approaches. Academics are therefore urged to go beyond traditional techniques, such as questionnaires, interviews and case studies, when studying this topic.

5) Country comparisons. Our understanding would also benefit from studies that take account of country differences in discussing the open innovation process. Is it plausible to assume that the open innovation process will vary from country to country, reflecting each country's culture, individual systems and institutions.

6) The estimation of possible trade-offs of having an open innovation process. Because of the novelty of the topic, open innovation is mainly discussed in terms of something positive, as something that can benefit organizations. This might well be true, but so too might the exact opposite [13][40]. A better understanding of the downsides of having an open innovation process will also help us achieve of clearer view of the trade-offs that managers have to make when pursuing an open innovation approach. Our understanding of the topic would clearly benefit from a more nuanced discussion.

7) The contribution of HRM to open innovation. Our findings have highlighted the crucial role played by people and relational issues. Therefore, the role of HRM in organizations' open innovation activities presents a promising field of study, too. What types of HRM policies are needed to help organizations prepare, execute and manage open innovation activities? What training programmes need to be applied to develop proper mindsets as well as skills and competencies?

The present study is not without its limitations. The choice of search procedure meant that we did not achieve full coverage of all the relevant empirical articles on the open innovation process. Papers may therefore have been excluded that did in fact address the open innovation process, but because of "conceptual ambiguity" ([13], p. 700) were not captured. Yet, if the "era of open innovation" really has started [1], then this procedure is certainly well justified. Finally, this paper proposes some research directions that are not exhaustive but rather represent the initial stages of a new line of inquiry.

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An Empirical Case Study on Prediction of Corporate Failure in The Selected Industrial Unit in India

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Abstract

Industrial Sickness has been growing in such large proportions that in the wake of industrial development, a large number of new units covering all types of units in small, medium and large sectors are added in this category. The rapid growth and magnitude of industrial sickness is puzzling issue not only for present time but also for all times to come, especially for India. It has become a matter of serious concern for all; concerned directly or indirectly with the industrial units; not only because Billions of rupees locked up in Millions of sick units but also for the fortunes for numerous classes to be affected. The failure of a unit is an event which brings a lot of mental torture to entrepreneurs, managers and to their families. The society is also affected by the phenomenon of sickness as unemployment spreads widely, availability of goods and services decrease and the prices soar up. The share holders lose their hard-earned savings. Creditors lose their cash and future prospects of business. The socio-economic implications of industrial sickness are so severe that it may disturb the whole industrial climate. Under such scenario this study on "An Empirical Case Study on Prediction of Corporate Failure in the Selected Industrial Unit in India" is an attempt to identify sickness at early stage with help of Altman's discriminate Analysis model so the corporate failure can be minimized.

Key words: Industrial Sickness, Corporate Failure, Prediction Models.

1. INTRODUCTION

Incidence of industrial sickness is a continuous process and at a particular time some units in a particular industry will be running sick even if the industrial climate is favorable from all points of view. Its analogy can be understood from a society in which some are healthy, some are of medium health, some are sick and others are recouping from sickness. Similar case is with industrial units. Continuous sickness leads to closure. Hence, to avoid closure of industrial unit one has to act much in advance before the incidence of closure takes place. The effort should be to arrest or minimize the rate of sickness. This study on prediction of corporate failure is an effort to identify sickness at early stage with help of Altman's discriminate Analysis model.

2. IMPORTANCE OF THE STUDY

Industrial sector contribute a major portion in the National income of India. Its Development is the key event of modern industrial age. But the incidence of industrial sickness has been growing in such large proportions that in the wake of industrial development, a large number of new units covering all types of units in small, medium and large sectors are added in this category. The rapid growth and magnitude of industrial sickness is puzzling issue not only for present time but also for all times to come. It has become a matter of grave concern for all; not only because the billions of rupees locked up in millions of sick units but also for the fortunes for numerous classes to be affected. The failure of a unit is an event which brings a lot of mental torture to entrepreneurs, managers and to their families. The society is also affected by the phenomenon of

sickness as unemployment spreads widely, availability of goods and services decrease and the prices soar up. The share holders lose their hard-earned savings. Creditors lose their cash and future prospects of business. Under such scenario the study on prediction of corporate failure becomes necessary to protect the future of millions. This study will be helpful for the policy makers, politicians, economists, entrepreneurs, Bankers, Financial institutions, employees and researchers. It will give a road way in prediction of bad health of a company.

3. OBJECTIVE OF THE STUDY

(i) To identify the tools of predicting Corporate industrial sickness

(ii) To test the widely used model –multiple discriminate analysis (MDA) Z Score model using data from a selected company

4. REVIEW OF LITERATURE

Ramser and Foster (1931) were the first pioneers of quantitative studies into the potentiality of financial ratios to predict bankruptcy (1931). They had analysed eleven different financial ratios of 173 firms with securities registered in the state of Illinois. It was found in their study that the less successful firms and the firms subsequently failed had ratio values lower than the more successful firms. However, two turnover ratios, viz. sales to net worth and sales to total assets exhibited an opposite tendency. [1]

Undoubtedly, Beaver's (1968) contribution on empirical findings to the failure prediction is a commendable job particularly; the accounting data have shown the ability to predict failure for at least five years prior to failure. To him the user cannot among ratios indiscriminately. Persistent difference in predictive ability were found, many of which were not correctly anticipated by priori arguments in the literature.2 Although Beaver, study was criticized on the ground that the work was based on univariate approach, but in reality it set the stage for the multivariate attempts by others. [2]

Altman (1968) made a significant breakthrough in the area of business bankruptcy prediction by developing a model known as Z-score. He collected necessary data pertaining to bankrupt and non-bankrupt firms and thereby established their linear combination to derive a discriminant function for group separation. He applied a statistical technique known as multiple discriminant analysis that evolved a set of discriminant coefficient which when applied to actual ratios formed mutual exclusive grouping. [3] The discriminant function runs in the form of

Z = V1X1+ V2 X2+ ..... + VnXn
Where Z = overall index V1V2.....Vn = the discriminant coefficients, X1X2 ..... Xn = Independent variables (ratios.)

Altman used matching pair sample of 33 bankrupt with 33 non-bankrupt manufacturing firms on the basis of industry and assets size. The bankrupt firms thus included in the study were those that filed bankruptcy petition under chapter X of the National Bankruptcy Act from 1946 through 1965. The data for the same were collected from Moody 's Industrial Manuals and selected annual reports for 1-5 years before bankruptcy. Initially, 22 variables were selected for the study, which covers five ratio categories, viz. liquidity, profitability, leverage, solvency and activity.

He eliminated sales to total assets variable, which he considered important in the 5 variable model and achieved 94 per cent classification accuracy just one year prior to bankruptcy. But for its practical application, Altman, say it needs further tests on a broad cross-section of bankrupt and non-bankrupt firms.

Deakin, (1968) analysed 32 firms that failed between 1964 and 1970. His definition of 'failure is based on bankrupt, insolvent or liquidate firms. Following the paired sample observation he matched failed firms with non-failed firms on the basis of industry, asset size and year of financial

data. He could not derive linear discriminant function by using paired sample. So, he selected a random sample of 32 non-failed firms drawn from Moody's Industrial Manual for the years 1962-1966. This supported the linear combination to derive the discriminate function as random sample tend to be more representative of the population and are more relevant for predictive purpose. His study showed mis-classification of less than 5 per cent for the first three years prior to failure for the original sample. However, in the fourth and fifth prior to failure error rates increased to 21 per cent and 17 per cent respectively which according to him, "probably were too high for decision making purposes. [4]

John Argenti's (1976) study on corporate failure is by far the best theoretical study for analysis of corporate failure. The approach is dynamic and traces the firm's path from healthy to failure. Argenti has typified three trajectories of organization's failure. He distinguished the symptoms of failure from the causes of failure and explained. He says "If the management of a company is poor the accounting information will be neglected or such information will be deficient and the company will not respond to change, some may be damaged because of a powerful constraint. Poor managers will make at least one of the three errors; they will overtrade; or they will launch a big project; or they will let the gearing rise to level that even a normal business hazard will became a constant threat, when these symptoms appear, the financial ratio will deteriorate and managers will resort to creative predictive models based on financial ratio. He presents three trajectories of failure. [5]

Kavery attempted (1980) to predict the borrower's health by utilizing financial ratios as predictor variables. His sample consisted of good, irregular and sick small scale, industrial units.8 He selected initially 22 variables for the study. Putting them under several tests, viz. t-test, analysis of variance, discriminant analysis and Scaled Vector, he selected 5 variables one from each ratio category for developing final discrimination. He found that the ratio-stock to cost of goods sold had the highest predictive power than the other four ratios namely, current assets to current liabilities, current assets to net sales, net profit to total capital employed and net worth to total outside liabilities. At one year advance to sickness 76 per cent classification accuracy was achieved for the initial sample. The holdout sample provided 69 per cent classification accuracy before one year of sickness. [6]

Bhattacharya (1982) attempted to develop a model using multiple discriminant analysis in order to identify the different symptoms, which explain the sickness phenomena, their relative contribution in determining the propensity of sickness.9 He selected 28 sick and 26 healthy companies for the study. He constructed two sets of model. Both the models have shown identical classification result. The first model correctly classified the observations with 80 per cent accuracy while the second model achieved 78 per cent classification accuracy in the first year prior to sickness. Bhattacharya claimed his first model superior to the second one on the basis of less number of sick companies misclassified as healthy companies. [7]

Thus, the foregoing empirical studies attempt to examine the health status of the firms in advance before they become sick or failure. These studies have unearthed the fact that financial ratios have the ability to predict the survival business. The very purpose of these studies is to investigate the potential ratios that can give indications about the survival or failure of firms/

The cell defined a Sick Industry as follows- A Industrial Unit (a) which could not reach the stage of normal production with normal profit or (b) has incurred loss or remained at the unprofitable level for consecutive 3 to 6 years from the first year of commercial production or (c) could not produce above the break-even point for reasons beyond the control of the entrepreneurs.

Gupta, (1983) has carried out a study on corporate sickness by using a simple non-parametric test for measuring the relative differentiating power of various financial ratios.7 His sample for the study included only units from cotton textile industry, which later extended to non-textile group. He selected 56 ratios and classified them under two groups i.e. profitability ratios and balance sheet ratios. To rest the magnitude of each ratio, he made any array of sample of sick and non-

sick companies and determined the optimum cut off points for each ratio. The least minimum misclassification number / percentage was chosen as the deciding parameter. [8]

His sample considered of 20 sick and 21 non-sick textile companies, the later was matched on the basis of product, age, size, assets and sales. Ratios for each sample company were calculated and tested in each year for a period covering 13 years i.e. from 1962 to 1974. Five profitability ratios were finally selected which had shown the possession of high degree of predictive power under the test when applied to a homogenous group. He observed that companies having low or inadequate equity base (reserve strength) are more prone to sickness. His study also pointed out that liquidity ratios had poor showing relating to corporate health.

S. N. Bidani and P.K. Mitra (1993) developed a clinical model of the anatomy of any industrial unit. The modal shows four functional area; of an industrial unit which are; Finance, production, marketing and personnel. There is a middle circle which shows corporate management which is responsible for co-coordinating these four function. [9]

Bakul Dholakia, (1989) in "Industrial Sickness in India: need for Comprehensive identification Criteria analyze that "Prevention is better than cure- in the context of growing industrial sickness in the country. The criteria used by financial institutions sickness is the recurrence of cash loss argues that the use of various criteria based on the cash loss syndrome delays units identification of sickness and results in a high proposition of terminally sick. He suggests a comprehensive set of empirically criteria which would serve as an early warning system. Abnormal fluctuations in a firm's relative position within the industry of which it belongs should be explicitly used to determine sickness at the incipient stage. This is likely to help prevent industrial sickness. This would require restructuring of existing systems and procedures adopted by the financial institutions. [10]

Ramachandra K.S. (2001) in "Reviving Sick units" discussed the reviving the sick SMEs in various aspects, like providing technology, management training, skilled labour, export promotion and giving finance. The root cause for all the above problems is the financial problem. The finance should provide sufficient amount at an easy disbursal system to promote the SME.s It focused more on the credit facility and availability of several schemes for SMES. [11]

5. RESEARCH HYPOTHESIS

Ho: Corporate Failure can be predicted with help of statistical tools and Altman's model is a strong model for predicting corporate failure

H1: Altman's Z score Model is not a strong model for predicting corporate failure

To make the reasons more reliable the present research study will be restricted to the selected sick unit for in-depth Analysis.

To analyze the past performance of the company ratio technique and Altman's Z score will be used

Altman used a statistical methodology called Multiple Discriminat Analysis (MDA) which predict the relationship between mainly dichotomous response variable and one more independent predictor variable by determining a set of discriminant coefficient which best result in mutually exclusive response variables, to generate his model. Financial statement data one year prior to bankruptcy will be used to develop the following five variable models

$$Z=1.2\ X1+1.4X2+3.3X3+0.6X4+.999X5$$

Here:
X1 = working Capital/Total assets
X2 = Retained Earnings/total assets/Total Assets

X3 = EBIT/Total Assets
X4 = Market Value of Equity/Book Value of Total Debt
X5 = Sales/Total Assets

If the Z score is above 2.99 indicate Good health
Between 1.81 to 2.99 Indicate Gray Zone
Below 1.81 Indicate probable Failure

The researcher has selected a company from textile sector. Due to confidentiality name of the company will remain Unit 'X 'the company was engaged in power loom production

The financial ratios calculated to apply Z score are as follows for last five Years

Ratios/ Years	Year 1	2	3	4	5
X_1= Working Capital / Total Assets	0.33	0.23	0.21	0.31	0.22
X_2 = Retained Earning / Total assets	0.20	0.19	0.21	0.11	0.13
X_3 = Earnings before Interest & Taxes / Total assets	1.01	0.84	0.63	0.15	0.30
X_4 = Market value of equity / Book value of total debt.	2.22	2.07	2.01	2.02	2.04
X_5 = Sales / Total assets	0.29	0.39	0.28	0.21	0.19

Source: calculated from the financial statement of the selected company

TABLE 1: Calculated Value of Various Ratios For Last Five Years.

On the basis of above ratios the researcher has calculated Z score for the five years applying Altman's model. The value in given in the table

Year	Z Score	
1	4.77	Average =3.02
2	4.18	
3	3.40	
4	1.82	
5	0.93	

TABLE 2: Table Showing Calculated Value of Z Score.

The above table shows that 4th year company give an indication of probale sickness as the Z score value come to 1.82. in the next year the Z core declined to 0.93 which show sickness. In this way we can say that Z score is the perfect measure of corporate sickness. It gives an indication of probable sickness and complete sickness. If the companies keep checking their financial performance through the Altman's model the sickness can be predicted and revival or correction strategy may be started in time.

Conclusion:

From the above analysis and review of literature the researcher can conclude that altman's model is a simple tool for predicting corporate failure. To keep an eye on the investments, investors should consider checking their companies' Z-score on a regular basis. A deteriorating Z-score give a signal about the trouble ahead and provide a simpler conclusion than the mass of ratios. The Management can also check the financial health of their companies by applying Z score.

But we should keep in mind that Z score gives an indicator about financial health. It is not the perfect proof of bad financial condition. As it gives indication about poor financial health the companies should have detailed analysis of their companies to confirm. Altman's has further Modify the model to make the result more reliable and suggested different model for manufacturing and non manufacturing companies. Regular check up can stop the tendency of Industrial closure or sickness. Early prediction of sickness can help easy recovery from the sickness and avoid corporate failure or closure.

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