

The Aspect of the Human Bias in Decision Making within Quality Management Systems & LEAN Theory

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Abstract—This paper provides a literature review to document the state of the art with respect to handling “human bias” in decision making within the established quality management systems (QMS) and LEAN theory, in the context of shipbuilding. Previous research shows that in shipbuilding there is a huge deviation from the planned man-hours under the project management to the actual man-hours used because of errors in planning and reworks caused by human bias in the information flows, among others. This reduces the efficiency, and increases operational costs. Thus, the research question is how QMS and LEAN handle biases. The findings show the gap in studying the integration of methods to handle human bias in decision making into QMS and lean, not only within shipbuilding, but in general. Theoretical and practical implications are discussed for researchers and practitioners in the areas of decision making, QMS and LEAN, and future research is suggested.

Keywords—Human bias, decision making, LEAN Shipbuilding, quality management systems.

I. INTRODUCTION

THIS paper provides a literature review to document the state of the art with respect to handling the “human bias” in decision making within the established quality management systems (QMS) and LEAN theory, in the context of shipbuilding. The shipbuilding industry faces enormous challenges, since planning and production must be adjusted to each project. In addition, changes in regulations and design modifications intensify uncertainty. Previous studies of the shipbuilding industry show that there is a huge deviation from the project planned man-hours to the actual man-hours used because of incorrect decisions, errors in planning and reworks caused by poor information flows.

Human biases are systematic errors in judgment and affect the information flows. According to Simon [15] people cannot make rational decisions because of the limitations of the human information processing system that is affected by biases. Human bias in project planning, production and decision making due to inadequate information flows generate rework, reduces the efficiency and drive up operational costs. Today, most shipbuilding companies are steered under a QMS or LEAN shipbuilding to increase their productivity. Thus, it is important to study what is the state of the art regarding how

the aspect of human bias in decision making is handled by QMS and LEAN theory?

To counterbalance the effect of bias, it is important to recognize and understand its nature and its potential effects. Quality management systems and LEAN shipbuilding are tools to reduce errors and improve efficiency. The integration of models and methods to cope with bias in a direct and systematic way, into the established QMS and LEAN shipbuilding could be the solution. Even when the aspect of human bias in decision making has been broadly studied before; according to the findings of this literature review and its search specifications, there are no previous studies about the integration of methods to directly and systematically handle human bias in decision making into quality management and LEAN.

The aspect of the human bias has been early discussed within the context of quality control in project management. Flyvbjerg [3] addresses the bias of “over-optimism and the planning fallacy” in risk assessment and decision making for a given project, whereas Purvis et al. [14] studies the impact of heuristics in project management to information systems projects. Therefore, the gap for research in this subject is evident.

This paper is structured as follows: Abstract, Introduction, research methodology, results, analysis and findings, general discussion, directions for future research, conclusions, references and endnotes.

II. RESEARCH METHODOLOGY

As discussed by Webster & Watson [17], an effective literature review is a crucial contribution for research, because it defines the key sources for a topic under study and creates a firm foundation for advancing knowledge, uncovering the areas where research is necessary.

The purpose of this paper is to conduct a systematic literature review to highlight the state of the art regarding the integration of methods and strategies to cope with human bias in decision making into quality management systems and LEAN, within the context of shipbuilding. This literature review follows academic guidelines for conducting an effective literature review and to rigorously document the process of literature search as discussed by vom Broke et al. and Webster and Watson [1], [17]. The contextual boundary is within the scope of the integration of methods to cope with human bias in decision making into quality management systems and LEAN within shipbuilding, whereas the time-

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based boundary covers all previous published articles in journals and conference proceedings until September 9th. 2013. The literature search method encompassed querying four relevant journals as proposed by Webster & Watson [17], who said that the major contributions are likely to be in the leading journals and therefore, it makes sense to start with

them. These authors explained that while journal databases facilitate the identification of relevant articles, scanning a journal table of contents is a convenient way to pinpoint others not caught by the keyword search.

Table I establishes the considered journals for this literature review and the parameters for querying.

TABLE I
CONSIDERED JOURNALS

| Journal | Key Words for search1 ¹ | Key Words for search2 | Key Words for search3 | Search | Cove-range | Hits* | Revi ewed |
|---|------------------------------------|-----------------------|-----------------------|------------------------------|----------------------------|-------|--------------|
| Sage Journals | HB, QM, DM, LEAN | Bias, DM, LEAN | Bias, DM, QM | Key-words, titles, abstracts | Jan. 1847 up to 09.09.2013 | 0-0-0 | 0 |
| Journal of Judgment & Decision Making (SJDM) | HB, QM, DM, LEAN | Bias, DM, LEAN | Bias, DM, QM | Without specifications | All dates up to 09.09.2013 | 0-0-0 | 0 |
| Journal of behavioral decision making | HB, QM, DM, LEAN | Bias, DM, LEAN | Bias, DM, QM | Without specifications | All dates up to 09.09.2013 | 0-0-0 | 0 |
| Journal of Social, Behavioral, and Health Sciences | HB, QM, DM, LEAN | Bias, DM, LEAN | Bias, DM, QM | Titles, abstracts | All dates up to 09.09.2013 | 0-0-0 | 0 |

However, as discussed by Webster & Watson [17], a high quality review is complete and focuses on concepts. Thus, to be complete it must cover all relevant literature on the topic and is not confined to one set of journals. Even if it makes sense to start querying the leading journals in the area, searching by the topic across all relevant journals in different databases must also be done.

The databases used for searching the specified concepts to write this literature review, as well as the established parameters for querying, are listed in Table II. The search criteria were limited to article titles, abstracts and key words to guarantee the direct linkage to the topic. Furthermore, since probably there are thousands of articles related to each of the

established concepts for searching, a combination of them was required.

Other specifications limited the search to academic journal articles and conference proceedings. Since the words used for querying the different databases were in English, the search included only academic journal articles written in English. Articles published by magazines and news webs sides were excluded.

However, in some databases like Google Scholar, it was not possible to predetermine the criteria for searching and in those cases the searching involved full text but with the condition that all the established concepts would be found.

TABLE II
CONSIDERED DATABASES

| Data-base | Key Words for searc1 | Key Words for search2 | Key Words for search3 | Key Words for search4 | Key Words for search5 | Se-arch | Cove-range | Hits* | Revi ewed |
|-------------------------------------|----------------------|-----------------------|-----------------------|-----------------------|-----------------------|--|-----------------------------|--------------|--------------|
| Emerald | HB, QM, DM, LE-AN | HB, DM, LE-AN | HB, DM, QM | Bias, QM | Bias, LEAN | Key-words, titles, abstracts | All dates up to 09.09.2013 | 0-0-0-0-0 | 0 |
| Globethics.net | HB, QM, DM, LE-AN | HB, DM, LE-AN | HB, DM, QM | Bias, QM | Bias, LE-AN | Key-words, titles, abstracts | All dates up to 09.09.2013 | 0-0-0-0-0 | 0 |
| IEEEExplore, Digital Library | HB, QM, DM, LE-AN | HB, DM, LE-AN | HB, DM, QM | Bias, QM | Bias, LE-AN | Key-words, titles, abstracts | All dates up to 09.09. 2013 | 0-0-0-1-0 | 0 |
| Science-Direct | "HB, QM, DM, LE-AN" | "HB, DM, LE-AN" | "HB, DM, QM" | Bias, QM | Bias, LE-AN | Key-words, titles, abstracts | All dates up to 25.09.2013 | 0-0-5-240-55 | 0 |
| Pro-Quest | "HB, QM, DM, LE-AN" | "HB, DM, LEAN" | "HB, DM, QM" | Bias, QM | Bias, LE-AN | Any-where in the page | All dates up to 09.09.2013 | 0-0-0-0-0 | 0 |
| Wiley, OL | HB, QM, DM, LE-AN | HB, DM, LE-AN | HB, DM, QM | Bias, QM | Bias, LE-AN | Key-words, titles, abstracts | All dates up to 09.09.2013 | 0-0-0-0-0 | 0 |
| ACM Digital library | HB, QM, DM, LE-AN | HB, DM, LE-AN | HB, DM, QM | Bias, QM | Bias, LE-AN | Words or phrases, key-words, publication title | All dates up to 09.09.2013 | 0-0-0 | 0 |
| Cite-SeerX | HB, QM, DM, LE-AN | HB, DM, LE-AN | HB, DM, QM | Bias, QM | Bias, LE-AN | Keywords, titles, abstracts | All dates up to 09.09.2013 | 0-0-0-0-0 | 0 |
| GoogleScholar | HB, QM, DM, LE-AN | HB, DM, LE-AN | HB, DM, QM | Bias, QM | | Without specifications | All dates up to 09.09.2013 | 0-0-0-1-29 | 0 |
| Taylor & Francis O | HB, QM, DM, LE-AN | HB, DM, LE-AN | HB, DM, QM | Bias, QM | Bias, LE-AN | Without specifications | All dates up to 09.09.2013 | 0-0-0-0-0 | 0 |

III. RESULTS

The search resulted in 331 articles, but after reading the abstracts only one article was included in the review, because those not included approached the concepts under the study in a different context and did not comply with the specific combination of the concepts. The purpose was to search first the articles that included the combination of all the specified concepts and then limit the search to the context of shipbuilding, but since no article that had the combination of the concepts was found, the contextual part relating to the limitation to the shipbuilding industry could not be done.

IV. ANALYSIS & FINDINGS

The analyzed article from Flyvbjerg [3] discusses how Kahneman and Tversky's theories of the planning fallacy and the outside view can be used to conduct quality control of decisions and due diligence in project management. The article discusses the deviation from the estimates of costs and benefits analyses in risk assessment for investment projects to the actual ex post costs and benefits. The author refers to Kahneman and Tversky (1979a, & 1979b) who argued that this inaccuracy is caused by systematic fallacy in decision making, affecting people to underestimate the costs, completion times and other risks, but overestimating the benefits of their actions. Flyvbjerg cites to Kahneman (1994) and says that Kahneman identified a cure for this fallacy, taking an outside view of planned actions, using the experience from previous ventures already completed. In summary, the studied article offers a new methodology for quality control of front-end estimates, based on the mentioned theories above and its application, but to risk assessment and forecasting of investment projects.

Thus, the findings of this study show that there is no previous research about the integration of methods and strategies to systematically cope with human bias in decision making into the established quality management systems, like Total Quality Management (TQM) and LEAN; and that there is a gap to study the interconnection of these concepts and their application into a standard quality management platform.

V. GENERAL DISCUSSION

The shipbuilding industry faces enormous challenges, since planning, procurement and production must be adjusted to each shipbuilding project. Moreover, changes in regulations and design modifications required by those placing the orders, lead to constant adjustments in the project planning, intensifying uncertainty. Cognitive bias is an illusion of thought; deviations in judgment that depart from the standards of logic and accuracy, [4, p. 725]. Human bias may also worsen uncertainty and the process of decision making under uncertainty.

As indicated by Ciobanu & Neupane [2, p. 128-131] in their case study a large per cent of the total man-hours used for the design, construction and delivery of the project are reworks due to change in orders, late revision or updating of drawings. Their findings indicate a huge deviation from the planned man-hours under the project management to the actual man-

hours used. Errors caused by bias in planning and production generate rework and delays, idle time, reduce the efficiency, and hence increase operational costs.

Human bias and uncertainty are factors that potentially affect the whole life-cycle of a project; from its beginning, to the delivery of the vessel. Bias in forecasting man-hours for production affects the project planning; errors in planning increases time pressure in production and generate production errors and rework. Over-optimism in forecasting a lower use of man-hours inflates the actual production costs and reduces benefits, whereas bias in the information flows can create further errors. Also inaccuracy in forecasting the delivery time of a project may generate delays and financial penalties.

According to Simon [15], people lack knowledge and have a very limited information-gathering and computing capacity to make decisions based on the economic principles of rational behavior. Robin Hogarth [5, p. 2-6], established that the four major consequences of the limited information-processing capacity are that first, the perception of the information is not comprehensive, but selective; second, the nature of processing, in which people process the information in a sequential manner since they cannot deal with a lot of information simultaneously; third, the processing capacity, which shows that people do not possess intuitive calculators that allow them to make 'optimal' calculations; and fourth, the limited capacity of human memory. Memory can be divided into two types; the limited *short-term memory* that refers to our memory of information that has just been received and on which operations are on performance, and the so called long-term memory which is the repository of our knowledge [5, p. 133].

These types of memory had also been called as the two systems by Kahneman [9]. He established that system 1 operates in an automatic and quick way, with little or no effort at all and no sense of voluntary control; like for example orienting to a loud and unexpected sound, which is a normal and involuntary operation of system 1, which then, mobilizes the voluntary attention of system 2, which allocates attention to the activities that demand mental effort, including calculations and complex computations. However, system 2 has the ability to adjust the way system 1 works, by programming the normally automatic functions of attention and memory. Indeed, system 2 is the one that operates when there is a need for choice, judgment and decision making. The problem is that system 1 constantly generates suggestions for system 2: impressions, intuitions, intentions and feelings.

According to Kahneman [9], these impressions and feelings endorsed by system 2, turn into beliefs and impulses, which turn into voluntary actions, affecting choice and decision making. And more, system 1 has biases, also called systematic errors that are predisposed to work in specific circumstances and cannot be turned off.

The leading author declared in his book "Thinking Fast and Slow" [9, p. 28] that, "*because system 1 operates automatically and cannot be turned off at will, errors of intuitive thought are often difficult to prevent. Biases cannot always be avoided, because system 2 may have no clue to the error. Even when cues to likely errors are available, errors can be prevented only by the enhanced monitoring and effortful activity of system 2. (...) The best we can do is a*

compromise: learn to recognize situations in which mistakes are likely and try harder to avoid significant mistakes when the stakes are high”.

By referring to Paul Slovic, Kahneman [9, p.103] explains the *affect heuristic*, in which people let their likes and dislikes determine their beliefs about the world, because in the context of attitudes system 2 is more an endorser of the emotions of system 1, rather than a critic of those emotions. It seeks for information and arguments consistent with its beliefs, without the intention of examining them. The result is that an active and automatic coherence seeking system 1 proposes solutions to an undemanding system 2 and very often system 1 produces quick answers to difficult questions by substitution, generating coherence where there is none, *“because substitution occurs automatically, you often do not know the origin of judgment that you (your system 2) endorse and adopt. If it is the only one that comes to mind, it may be subjectively undistinguishable from valid judgments that you make with expert confidence. This is why subjective confidence is not a good diagnostic of accuracy: judgments that answer the wrong question can also be made with high confidence”*, [9, p. 243].

Both systems have the need to process information. Information-processing is an important part of making decisions. Memory affects judgment and the process of decision making in different ways, while processing the information. Hogarth [5, p. 207] presented a model to explain each of the parts of processing information: acquisition of information; processing of information; output; action; outcome and feedback. In the example, he also explained how different human bias can affect each of the parts of the information processing.

As discussed by Ciobanu & Neupane [2] in their case study from the shipbuilding industry, some of the possible causes connected to the problems of rework may be related to poor information flows and inaccuracy in the planning system.

Selective perception, concrete information, consistency of information sources, framing, anchoring and adjustment, illusion of control, representativeness, law of small numbers and ‘success/failure attributions’, as well as some ‘heuristics’ used to reduce mental effort like intelligent ‘rules of thumb’, are some of the human bias that can potentially affect each of the stages of information processing and therefore, decision making, Hogarth¹ [5, p. 216-222].

Furthermore, as argued by Kahneman & Tversky 1972, [10], biases may lead to perceptual distortion of the problem, inaccurate judgment, illogical interpretation, or even irrationality. Wallace [16] expressed that, *“for many decision makers the first reaction to a decision problem and in particular to its random aspects, are based on false ideas and feelings”*.

Framing Bias is one of the systematic errors that can seriously affect decision making, because the positive or negative frames are biased interpreted as losses or gains, contributing to risk aversion in decisions involving sure gains and to risk seeking in decisions involving sure losses. This

tendency leads to preference reversals when the same decision problem is presented in different frames, Kahneman & Tversky 1979 [11].

Hogarth [5, p. 231] said that, *“many judgemental biases could be attributed to different aspects of human behaviour which have provided, and still do provide adaptive responses to many situations. In the design of the present human system, nature has determined a number of trade-offs (heuristics) between, on the one hand, different parts of the system (in order to coordinate the whole) and on other, different types of error”*.

In 1992, Tversky and Kahneman introduced a developed version of their original Prospect Theory from 1979, “Advances in Prospect Theory: Cumulative Representation of Uncertainty” and it is also known as Cumulative Prospect Theory. The study included both decision making under risk and uncertainty.

Purvis, McCray, & Roberts [14] indicated in their study that a formal project management is crucial for the effective use and application of organizational resources to meet the demands, within and across projects. But they also make it clear that the use of project management as a tool is based on concrete and accurate project specifications; and biases in the formulation of such specifications can lead to failed projects. The authors said that in many situations different types of bias can arise from the application of heuristics by project personnel; but the impact of biases could in many cases be offset by recognizing and understanding these heuristics and their potential effects.

During many years the shipbuilding industry has used project management tools, motivated from the construction industry and based on the assumption that they are pretty much alike, but gradually they also incorporated some tools from the manufacturing industry. Then, the evolution in the manufacturing industry towards ‘LEAN manufacturing’ inspired the construction industry to develop “LEAN construction”. Then, the shipbuilding industry created ‘LEAN Shipbuilding’, to become more competitive, [2, p. 2 and 132].

As discussed by Ciobanu and Neupane [2, p. 131-132], the LEAN concept focuses on improving the information flow along the production process from the suppliers to the customers. The five principles of LEAN: Value, Value Stream, Flow, Pull and Perfection are valuable in improving the flow of information. Basically, LEAN is a quality management philosophy built on common sense and simple thoughts, with the goal of *cost reduction by identifying customers and specifying value, creating flows and eliminating waste*, Ohno, 1998 [12].

Many shipbuilding companies have today implemented the so called “LEAN shipbuilding”. But biases are not treated in a concrete and direct way in these systems. Simple counter methods that are coherent with the LEAN philosophy of common sense, simple thoughts and continual improvement could be implemented in the standard LEAN platform.

As discussed by Kahneman [9, p. 128], one should assume that any number on a table has an anchoring effect on us, as well as any positive or negative wording in a decision problem involves a framing effect; and we should mobilize system 2 to combat these effects. In such situations it is important to remove the anchoring information, the positive/negative

¹Hogarth citing R. M. Hogarth and S. Markridakis, Forecasting and Planning: an Evaluation Management Science, 27 (2), Feb. 1981. Copyright 1981 The Institute of Management Sciences).

wording, and leave only the absolutely necessary data/facts to further analyze them and make decisions.

Overconfidence can be mitigated but not eliminated, since it is a direct consequence of system 1 that can be tamed, but not vanquished [9, 264]. However, decision makers can be encouraged to consider all the competing hypothesis and solution scenarios and discuss them with the team. But it is important to consider that very often public doubts about a suggested solution from the general leader are suppressed as a fear of disloyalty and eventually it contributes to overconfidence on the part of the leaders, if only supporter feedback is expressed.

Thus, team members should be encouraged to discuss possible threat scenarios that have not been considered before. This does not provide complete protection against undesired results, but it contributes to reducing the damage to plans that are subject to the biases of WYSIATI (what you see is all there is), overconfidence and uncritical optimism [9, p. 265].

In general, as discussed by Phebe & Suganthi [13], steering a quality management system (QMS) has become a key strategy in business and in fact, the companies have to optimize their tools constantly in order to increase their productivity and permanently improve the effectiveness and efficiency of their system.

The implementation of methods to cope with biases in a direct, specific and systematic way is also coherent with the eight fundamental principles of quality management of: customer focus, leadership, process approach, system approach, factual approach, involvement of people, mutually beneficial supplier relationships, and continual improvement. ISO/TC 176 Quality Management and Quality Assurance, defines a quality management principle as *a comprehensive and fundamental rule or belief, for leading and operating an organization, aimed at continually improving performance over the long term by focusing on customers while addressing the needs of all other interested parties* [8].

The principle of leadership establishes that, *“Leaders establish unity of purpose and direction of the organization. They should create and maintain the internal environment in which people can become fully involved in achieving the organization’s objectives”*. Whereas, the principle of involvement of people expresses the following: *“People at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization’s benefit”* [7].

David Hoyle [6] said that this principle means that the management should encourage personnel to make contributions and utilize their personal experience; and that the management should be open and not hide its discussions, except if national or business security could be threatened, because a closed-door management leads to distrust among the workforce. Hoyle [6], also declared that an organization that applies the involvement of people would be that one in which the personnel are, among other aspects, actively seeking opportunities to make improvements; actively seeking opportunities to enhance their competence, knowledge and experience; and freely sharing knowledge and experience in teams and groups.

Today, there are several heuristics and mathematical models, methods and strategies to solve risk, uncertainty and

human bias. These tools should be integrated into quality management systems and LEAN shipbuilding to cope with the different type of biases in a direct and systematic way along the different phases during the project life cycle, to reduce rework, eliminate waste and ensure predictability in the project planning, improve efficiency and become more competitive.

VI. DIRECTIONS FOR FUTURE RESEARCH

An area for future research should be the examination of proper methods to counter the different type of biases and its integration to quality systems and Lean to eliminate waste and support the implementation of the principles of quality management.

Case studies about which methods are the most adequate to handle human bias in forecasting and project planning, as well as in the information flows could be performed. Another area would be to study how these methods could be integrated into a standard quality platform and to analyze how it works in practice.

Another study could be to analyze if the deviation in costs from the project planning to the actual costs is mainly due to errors in forecasting or because of errors during the production phase.

VII. CONCLUSION

According to the findings of the literature search and its respective specifications, the conclusion is that there is no previous research into the inclusion of methods to cope with biases in decision making in a direct and systematic way into the established quality management systems and LEAN theory. Today, there are several heuristic and mathematical models, methods and strategies to solve risk, uncertainty and human biases.

These tools should be integrated into quality management systems and LEAN shipbuilding to counter biases in a direct way through the different phases during the project life cycle, to eliminate waste and ensure predictability in the project planning, improve efficiency and become more competitive.

ACKNOWLEDGMENT

The paper has considerably benefited from extensive comments of one anonymous referee, as well as from Rania Fahim, which have substantially improved the paper. I am also grateful to Kaare Kittelsen for reviewing the paper regarding English language. Of course, any responsibility for the opinions expressed in the article rests only with the author.

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ⁱIt has been used the following abbreviations for both, Table I and Table II: HB means Human Bias, QM means Quality Management, DM means decision making.