

Relationships of Lean, Green Manufacturing and Sustainable Performance: Assessing the Applicability of the Proposed Model

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Abstract - While Lean Manufacturing (LM) focuses on minimization of wastes, Green Manufacturing (GM) emphasizes on achieving zero emissions. Little is known about the linkage between these two initiatives and their integration. Furthermore, it is also not clear whether these two initiatives can coexist in the same organization or not. To address the gaps, this paper highlights the potential synergic effect and proposes a multi-dimensional model based on assumptions (1) GM is represented by the soft aspects of Environmental Management System (EMS), (2) the EMS is the possible mediator in the relationship between LM and Sustainable Performance (SP), and (3) the mediating model can be examined using bootstrapping technique within Structural Equation Modeling (SEM). The contributions of this paper are theoretical in nature which include (i) proposal of a conceptual approach comprising of three integrated models (ii) introduction of the lean manufacturing with four bundles namely, problem solving, process, philosophy and people (LM 4P). Four hypotheses were postulated for the research. The preliminary results indicate that the model is validated by conducting semi structured interviews in few industries in Malaysia. The future direction of this paper is to empirically investigate the model for hypotheses testing through the techniques employed in SEM.

Keywords- *Lean; Green; Sustainable; Mediation; Interview.*

1. INTRODUCTION

Lean Manufacturing (LM) can reduce waste without additional requirements of resources which enable organizations starting to implement LM that resulted in a plethora of LM definitions, objectives, performance indicators, tools/techniques/methodologies, and concepts/elements [7]. EMS has become one of the main tools used by companies to handle the environmental aspects and the impacts that their activities have on the environment [10]. ISO 14001 certification is excellent for industries to embrace toward sustainable environmental management and benchmarking [4]. Scholars [36] stated that it is important for manufacturing companies to implement LM practices with environmental management as a means of obtaining eco-advantages through improvements in environmental performance. This paper focus on the mediation concept for the following reasons: (1) mediation is a very popular topic (2) mediation analysis tend to be more powerful than moderation analysis (3) When more causal or structural models are examined, the mediational part of the model is the most interesting part of the model. One of the main reasons for the intense interest in testing using mediation is trying to understand the mechanism through which the causal variable affects the outcome [27].

The model proposed in this paper is based on the theories derived from the literature review as it depicted in Fig.4. The main cause and effect relationships in figure 4 introduce the direct and indirect effects among the main constructs in the model. The main claim of this paper is that LM4P has direct effects on the SP on the companies. SP can be measured using the dimensions of financial, environmental and social. Furthermore, the indirect effect between the two nodes (i.e., constructs) is called as the mediating. GM represented by the soft dimension of EMS is the possible mediator variable. This implies that LM4P has indirect effect on SP through its direct effect on EMS.

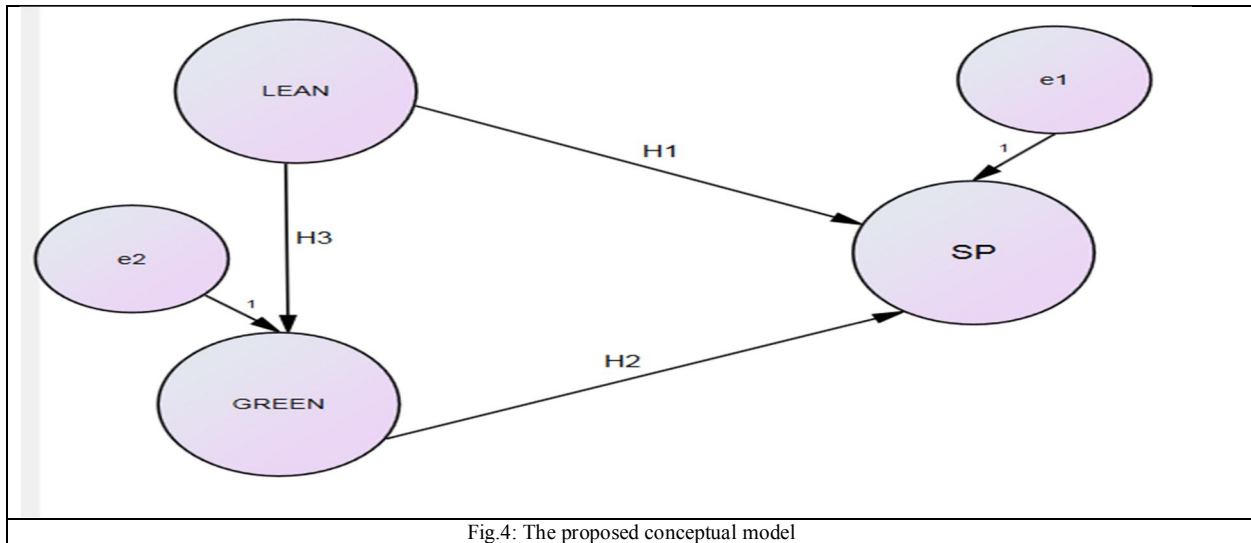


Fig.4: The proposed conceptual model

3.1 DEVELOPMENT OF THE HYPOTHESES

In guiding the direction of the analysis, and to clarify the controversial comments on LM 4P, soft EMS, and SP four hypotheses were developed from the theoretical model. These categories include many main research hypotheses postulated for this study, which reflect the findings of the earlier literature and theoretical background, and will be empirically examined in the Malaysian Manufacturing context using the structured questionnaire that will be developed and analyzed using AMOS software for SEM technique. The gaps presented at the beginning of this paper facilitated the formation of the main aim: *To develop the conceptual model and to investigate the interrelationships among the latent constructs in a sample of Malaysian Manufacturing certified industries.* Thus, the following hypotheses are proposed to be examined:

Hypothesis One:

There is a positive and significant relationship between LM4P and SP

The first hypothesis describes the causal effect between the LM4P as the exogenous latent construct and the SP as the endogenous latent construct. It is proposed that the different bundles for LM will have a positive impact of the SP.

Hypothesis Two:

There is a positive and significant relationship between soft EMS aspects and SP

The second hypothesis also discusses the direct relationship between the Soft EMS aspects and the elements of SP. This paper proposes that there EMS has a positive impact when it is applied correctly inside the organizations.

Hypothesis Three:

There is a positive and significant relationship between LM4P and Soft EMS aspects

The third hypothesis presents the synergy among two wide concepts represented by a philosophy (as LM) and a standard as (EMS).

Hypothesis Four: The mediating effects of soft EMS

In studying the dimensions of EMS namely soft and hard, [19] considered that hard EMS mediates the relationship between Soft EMS and the firm performance. [26] found that the internalization process of ISO 14001 serves an important role in mediating the relationship between ISO14001 certification and environmental performance. Based on these reflections, the hypothesis is proposed as:

Soft EMS mediates the relationship between LM4P and SP

4.0 METHODOLOGY

The design of this paper is based on two phases; namely the semi structured interview in the first phase. And the second phase which includes the empirical investigation of the model and testing the hypotheses through the techniques employed from Structural Equation Modeling (SEM). This phase is among the future direction of this paper.

4.1 SEMI STRUCTURED INTERVIEW

The interview is a form of data collection in which questions are asked orally and subjects' responses are recorded, either verbatim or summarized [29]. The interview with firms will be a great help in order to understand the nature of indicators in practice and compare it with theories which comes from literature review. In this paper, the purpose of the interview is to assess the applicability of the conceptual model proposed in this study, such that results will be utilized in order to design the questionnaire in the actual data collection phase and provide in-depth information regarding the practices used in this study. This approach was conducted by [28] in their study conducted in Lebanese Pharmaceutical Industry to assess the implementation of LM practices. [14] identified three types of interviews; namely (1) structured which uses a structured questionnaire, (2) semi- structured which uses open ended questions and (3) unstructured in which questions based solely on what the interviewee says. In this study, an in-depth semi- structured interview with open- ended questions was conducted which is similar to the study of [20]. Semi structured interviews enable the deep exploration of experiences. Open ended questions are most appropriate for exploratory research. An in-depth interview uses a few open-response, relatively general questions with some probes to obtain more detail. Using open –ended questions, the researcher does not use predetermined categories or scales to collect the data [8]. The interview protocol designed to include a guide about the definition of these practices. The sections of the interview include basic questions about the companies and the interviewee, the opinion of the interviewee about the practices of LM, and EMS and their understanding of these practices. Final section of the interview concerned with the impact of practices on SP.

4.2 VALIDATION OF THE PROPOSED MODEL

The proposed model in this paper is validated through the in depth interviews conducted with Operations Management managers from different disciplines including quality and environmental managers. In addition, the interview protocol was validated also with experts and academics from International Islamic university Malaysia and other universities in Malaysia to examine the content and face validity. Thus, before holding the interviews these issues were accurately conducted.

5.0 RESULTS FOR THE SEMI STRUCTURED INTERVIEW

To validate the proposed conceptual model and to assess its applicability, an in depth personal interviews were conducted with the managers in three manufacturing companies in Malaysia. Each interview continues for period in the range of 20 to 30 minutes. Analysis of the profile of the interviewee managers in the three companies is illustrated in Fig. 5. The interviewee managers were asked about their opinion about these practices and their impact to the sustainable performance. Open ended questions included as: What do you think about the impact of the implementation of these practices on your company's staineable performance? The response from the interviewed managers in explained in Table 2 where the interviewed managers are classified into the three companies. The nature of work of these companies identified as company A in the medical equipment's while company B in plastic products and company C in dairy products.

5.1 Profile of the interviewees Managers

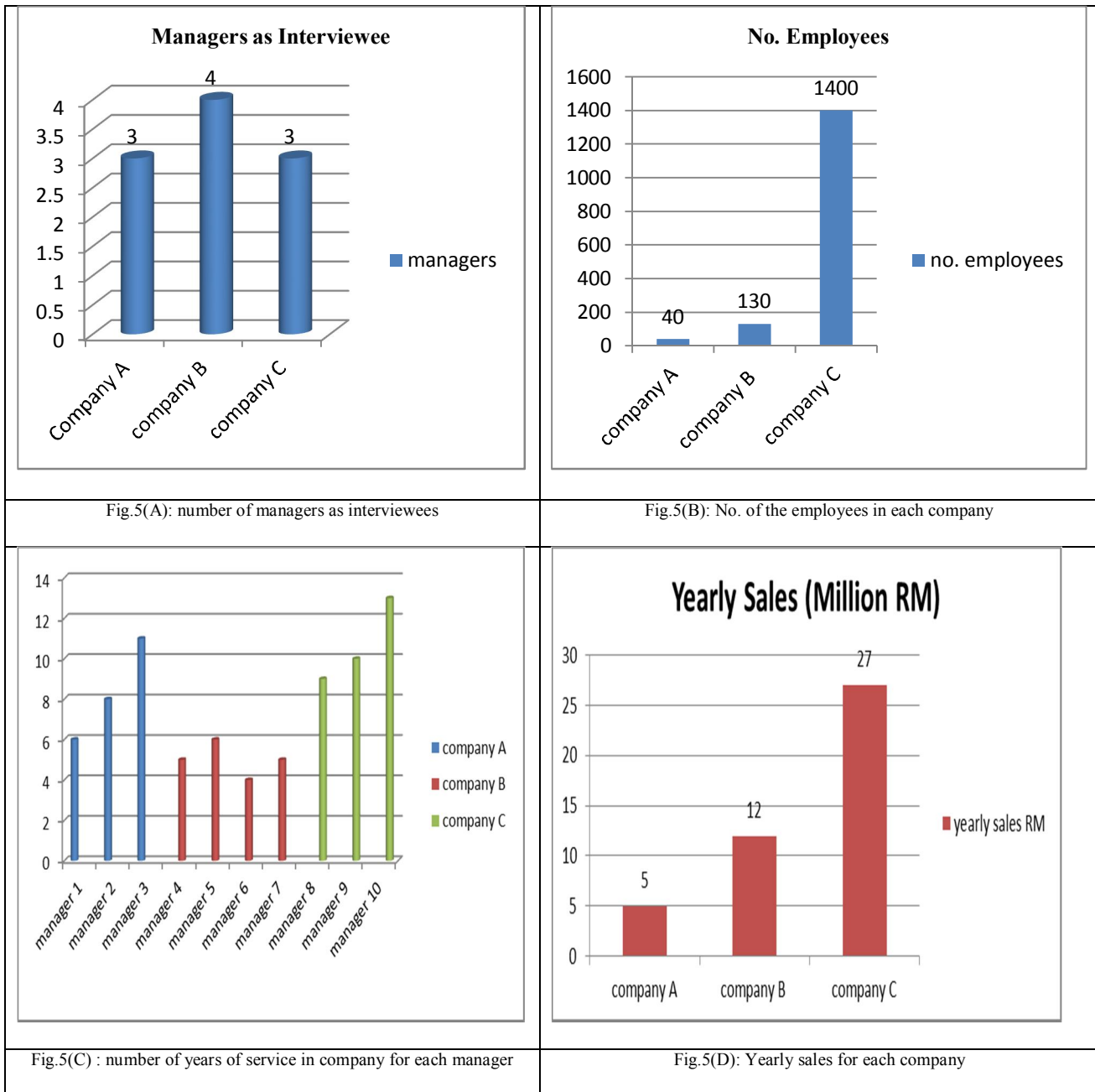


Figure 5 highlights different issues concerned with the interviewed managers in the targeted companies, while a comparison between the three companies namely A, B and C is depicted in Table 1

Table1: comparison among the respondent companies

Characteristic	Company A	Company B	Company C
Size of the company	Small	Medium	Large
Yearly sales of each company	Lowest	Median	Highest
No. of Interviewed managers	A and C are similar	Highest than (A and C)	C and A are similar

Table2: results of the semi structured interview

Company	Manager	Q1: What do you think about the impact of the implementation of these practices on your company sustainable performance?
A	1	Of course implementing these practices can have a great impact on the company's Operations and processes. I am sure that the cost is minimized which is good for our company.
	2	Actually The implementation of these practice will create a knowledge culture between employees and encourage them to use the best techniques to improve the performance in our company
	3	Of course it will lead to achieve higher levels of quality inside and outside the company. These are universal practices and management standards, thus, it will enable our company to gain the competitive advantage
B	1	In fact, starting from the vision and mission of our company we can observe tangible benefits from implementing these practices. We started in building trust with other markets which enable us to produce more products when we started using some tools for Lean and quality such as 5S
	2	Of course as a manager, I can understand that there are some lessons learnt from practicing these standards and philosophies. Some companies use either qualitative or quantitative techniques to measure the impact. We are happy since there is reduction in the production costs due to implementing these practices.
	3	Of course continuous improvement is shown in the processes. Customer satisfaction level is improved, number of complaints about our services is minimized, and thus, we have better productivity and quality.
	4	Using TQM, lean and the standards can result in improvement in the performance. We have increased the profit, better business practices, more comfortable environment, and more customer satisfied.
C	1	These practices allowed our firm to improve our processes and activities through minimization of the wastes and resources.
	2	Surely I recommend that all companies to start their journey towards achieving lean and TQM in addition to the other standards. Even though it takes time and efforts but potential benefits and impact can be achieved in next stages.
	3	These practices changed the view of the employees since they at the beginning were reluctant to adopt the tools. The impact needs time to be observed. I can say that it creates a quality culture and motivates us to open new markets and businesses with other outside Malaysia.

6. CONCLUSIONS AND MAIN IMPLICATIONS

To the knowledge of the authors this study is the first to explore the interrelationships among special model for Lean, entitled LM4P, taking into consideration its effect towards Green management (the combined Lean and green). One of the major contributions for this paper is introducing the mediation concept in terms of the relationship between LM and soft dimension of EMS. Furthermore, it introduces this mechanism using bootstrapping technique for structural equation modeling. Another contribution can be indicated from using the multi-dimensional model for LM which comprises of the four pillars of Toyota Production System (TPS). These pillars are classified under the bundles of problem solving, people, process, and philosophy and considered as the most common bundles for representation of LM. Furthermore, this paper followed the methodological triangulation which consists of two phases in data collection. Results of the semi structured interviews with the managers in the manufacturing industries indicated that the proposed model is validated; hence, it works and can be applied inside the different manufacturing sectors. Authors conclude that model goes in parallel with the ideas generated in this paper. As the main aim of the in depth interviews is to assess the model and ensure its validity, the second phase which is the quantitative phase through developing the questionnaire can be established. Managers should follow these systems and methodologies in order to keep the innovation strategy. It is believed that when these tools and techniques are implemented properly, then it will have a good impact and generate profits to the companies after implementation. Furthermore, it is understood that these systems can be aligned together in the organizations, thus achieving the desired results.

7. LIMITATIONS AND FUTURE DIRECTION

Similar to other research in operations management, this study suffers from limitations. The proposed meditational model is theoretically proposed here. Researchers and academics have to continue investigating the interrelationships among the practices described in this paper. Malaysian managers can benefit from this paper by understanding how these practices can affect their organizations towards minimization of the expected wastes from different processes. Another limitation is that this paper is focused on the manufacturing industries. It is expected that the proposed model in this study to be also applicable in different service companies like banks and hospitals “lean health care”. Authors strongly recommend other scholars to investigate the proposed hypotheses in other sectors to develop general criteria for LM-EMS and SP linkages.

REFERENCES

- [1] B.Al sulami and S.Mohamed (2011). “Key sustainability indicators for infrastructure systems : AN Australian perspective”, Sixth International conference on construction in the 21st century, construction challenges in the new decade,1133- 1140, KL, Malaysia
- [2] M. Alsmadi, M., Z.Khan (2010). “Lean sigma: The new wave of business excellence, literature review and a framework”. In Engineering Systems Management and Its Applications (ICESMA), 2010 Second International Conference on (pp. 1-8). IEEE
- [3] M.Alsmedi, A.Almani, and R.Jerisat (2012). “A comparative analysis of Lean practices and performance in the UK manufacturing and service sector firms”. Total Quality Management & Business Excellence, 23(3-4), 381–396
- [4] M.R. Amin and S.Banerjee (2010) “Benchmarking environmental performance: five leading steel mills in India”, Benchmarking: An International Journal, 17 (3), 378-395
- [5] F.M.Andreas, E.S.Cooperman, B.Gifford and G.Russell (2011). “A Simple Path to Sustainability: Green Business Strategies for Small and Medium-Sized Businesses”, Praeger, USA
- [6] M.A.Balzarova and P.Castka (2008). “Underlying mechanisms in the maintenance of ISO 14001 environmental management system”. Journal of Cleaner Production16: 1949–1957
- [7] J.Bhamu and K.S.Sangwan (2014). “Lean manufacturing: literature review and research issues”. International Journal of Operations & Production Management 34(7), 876–940

- [8] J.W.Creswell and V.L. Plano Clark (2011). “Designing and conducting mixed methods research” (2nd ed.). Thousand Oaks, CA: Sage
- [9] R.Chavez, C.Gimenez, B.Fynes, F.Wiengarten, and W.Yu (2013). “Internal lean practices and operational performance. The contingency perspective of industry clock speed”. *International Journal of Operations & Production Management*, 33(5), 562–588.
- [10] L.M.S. Campos, D.A.De. Melo Heinzen, M.A.Verdinelli and P. Augusto Cauchick Miguel (2015). “Environmental Performance Indicators: A Study on ISO 14001 Certified Companies”. *Journal of Cleaner Production*, Article in Press 1-11
- [11] B.F. Daily, J.W.Bishop, and R.Steiner(2007). “The Mediating Role of EMS Teamwork as it pertains to HR Factors and Perceived Environmental Performance”. *Journal of Applied Business Research*, vol. 23, no. 1: 95-109.
- [12] C.M. Dües, K.H.Tan, and M.Lim (2013). “Green as the new lean: how to use lean practices as a catalyst to greening your supply Chain”. *Journal of Cleaner Production* 40, 93-100.
- [13] L.Fonseca(2012). “Sustainability/Social Responsibility influence for organizational sustainable success, PhD Thesis, ISCTE-IUL.
- [14] N. Freestone (2012). “The use of semi-structured interviews in pedagogical research. Kingstone University”. On line:
https://itp.nyu.edu/classes/fungus/interview_technique/Semi_structured_interviews.pdf
- [15] W.Hadid, and S.Afshin Mansouri (2014). “The lean-performance relationship in services: a theoretical model”. *International Journal of Operations & Production Management*, 34(6), 750–785.
- [16] W. He, C.Liu, J.Lu and J.Cao (2015). Impacts of ISO 14001 adoption on firm performance: Evidence from China, *China Economic Review*, 43-55.
- [17] J.Hertin, F.Berkhout, M. Wagner and D.Tyteca (2008). “Are EMS environmentally effective? The link between environmental Management systems and environmental performance in European companies”, *Journal of Environmental Planning and Management*, 51(2): 259-283
- [18] J.F.Hair, W.C.Black, B.J. Babin, and R.E.Anderson(2010). “Multivariate Data Analysis”. Seventh Edition. Prentice Hall, Upper Saddle River, New Jersey
- [19] H.Kaur (2010). “Impact of HR factors on environmental performance: Impact of HR factors on employee attitudes and environmental performance of ISO14001 EMS companies”. LAP LAMBERT Academic Publishing.
- [20] M.Korkala and F. Maurer(2014). “Waste identification as the means for improving communication in globally distributed agile software development”. *The Journal of Systems and Software*,95, 122-140.
- [21] M.Kurdve, M.Zackrisson, M. Wiktorsson and U.Harlin (2014). “Lean and green integration into production system models – experience from Swedish industry”. *Journal of Cleaner Production*. 1-11
- [22] G.Kundu and B.M. Manohar (2012). “Critical success factors for implementing lean practices IN IT”, *International Journal for Quality Research*, 6(4), 301–312.
- [23] J.Moyano-Fuentes and M.Sacristan-Diaz (2012), “Learning on lean: a review of thinking and research”, *International Journal of Operations & Production Management*, 32 (5), 551-582.
- [24] A.L.Puvasvaran, A.Perumal, R.K.S.Tian, S.A.L.Vasu and M.R.Muhamad (2012). "Integration Model of Iso 14001 With Lean Principles". *American Journal of Applied Sciences*, 9(12), 1974–1978.
- [25] P.Puvasvaran, and V.A.A.N.Norazlin (2014), “Developing Lean – EMS Integration Database for Sustaining ISO14000 Certification” , *Manufacturing Science and Technology* 2(2): 34-44
- [26] G.Qi, S. Zeng, X.Li and C.Tam (2012). “Role of internalization process in defining the relationship between ISO 14001 certification and corporate environmental performance”. *Corporate Social Responsibility and Environmental Management*, 19(3), 129-140.
- [27] D.A. Kenny (2014), Mediation, [On line] <http://davidakenny.net/cm/mediate.htm#DIA>, accessed on 4-5-2015.
- [28] M.Khlat, A.H.Harb and A.Kassem (2014). “Lean Manufacturing: Implementation and assessment in the Lebanese Pharmaceutical Industry”. *Int. Journal of Computing and Optimization*, Vol. 1, no. 2, 47 - 62
- [29] J.H.Mcmillan (2012). “Educational research: fundamentals for the consumer”, 6th ed, Pearson, USA.
- [30] J.Miller, C. McCartney, A.Baron, J.McGurk, and V.Robinson (2010). “Sustainable organization performance. What really makes the difference? Shaping the future report”, 1-42, Chartered Institute of Personnel and Development, online: Website: www.cipd.co.uk
- [30] MacKinnon et al.(2013). “Developments in Mediation Analysis”. In T.D. Little (Ed), *the Oxford Handbook of Quantitative Methods*,

Vol 2, (pp.338-360), Oxford University Press, Oxford, USA

- [31] D.Nawrocka and T.Parker (2009). "Finding the connection: environmental management systems and environmental performance". *Journal of Cleaner Production*, 17(6), 601–607
- [32] G.Y. Nee, and N. Abdul Wahid (2010). "The Effect of ISO 14001 Environmental Management System Implementation on SMEs Performance: An Empirical Study in Malaysia". *Journal of Sustainable Development*. 3(2): 215- 220.
- [33] R.Voola, J. Carlson and A.West (2004). "Emotional intelligence and competitive advantage: examining the relationship from a resource-based view", *Strategic Change*,13(2), 83-93.
- [34] W.Wu and X.H.Wang (2011). "Development of an Environmental Performance Indicator Framework to Evaluate an Environmental Management System for Shoal water Bay Training Area", Queensland, Australia, *Labour and management in development Journal*, 11, 1-26.
- [35] H-D.Wan, A.M.Sahasrabudhe and L.Rivera (2014). "Prioritization of lean tools using gap analysis and analytic network process". *Revista S&T*, 12(28), 9-25
- [36] M.G.M.Yang, P.Hong and S.B.Modi (2011). "Impact of lean manufacturing and environmental management on business performance: An empirical study of manufacturing firms". *Int. J. Production Economics* 129, 251–261

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