The evaluation of green manufacturing strategies adopted by ISO 14001 certificate holders in Jordan

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Abstract: The aim of this study is evaluating the performance of green manufacturing strategies adopted by ISO 14001 certificate holders in Jordan. The survey questionnaire was developed based on the literature and interviews with industry experts and academics, 27 manufacturing organisations were surveyed. K-mean clustering analysis was used to cluster the manufacturing organisations to green manufacturing strategic groups. Also, perfect matching analysis was used to trace the relationship between performance indicators and green actions. This study revealed that; there are three significant clusters of green manufacturing strategies: agile environment, care-taker environment and lean environment. The performance of agile strategic group is high to moderate; however, the performance of care-taker and lean is moderate to low. Different combinations of perfect matched green actions with performance indicators were adopted by each strategic group. This is the first study which reports the green manufacturing strategic patterns in Middle East, the majority of previous studies have not addressed the significant actions and performance indicators in details, the majority of previous studies have not clustered or grouped the manufacturing firms based on green key performance indicators.

Keywords: environment management system; green manufacturing strategy; ISO 14001; key performance indicators; green operation actions; Jordan.


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The evaluation of green manufacturing strategies

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1 Introduction

The enterprises are more enforced to broadening their focus beyond the financial performance toward improving their ecological performance (Shabani and Saen, 2015). A lot of drivers as governmental regulations, customers, and stakeholders have directed the organisations toward adopting more ecological friendly practices (Ahmad et al., 2014; Huang et al., 2015; Sharma and Gandhi, 2016; Zhang and Yang, 2016).

Despite the challenges face firms from different industries and sizes to be more accountable toward the ecological environment (Singh and Tivedi, 2016), some organisations have started developing more ecological friendly competitive strategies, so the image of companies in the eyes of customer is enhanced and its competitiveness and performance are enhanced too (Bhardwaj, 2016).

The corporations are directed toward confirming their adoption of environmental friendly practices. So the corporations adopted environmental management system, the widely world accepted and adopted system is ISO 14000 (Ganesh and Ranjendran, 2008). This system was developed by the International Standardization Organization (ISO) (Diakaki et al., 2006).

There is a growing body of literature has studied green supply chain management practices which dated back to mid 1990s (e.g., Sarkis, 1995; Florida, 1996; Green et al., 1996; Geffen and Rothenberg, 2000; Florida and Davison, 2001; Handfield et al., 2002; Huang et al., 2015; Tachizawa et al., 2015). The impact of strategic organisational orientation on the green supply chain management has been addressed in some studies (e.g., Bhardwaj, 2016; Kirchoff et al., 2016) however, the green strategic patterns have reported by very limited studies (e.g., Migdadi, 2016).

The green strategic patterns are the milestones of the green practices success, since the green practices are part of the overall competitive advantages that the corporations trying to realise in order to improve the performance (Kirchoff et al., 2016). This generate a question about what are the different strategic patterns adopted by ISO 14001 certificate holders in Jordan?, and to what extent these strategies are effective?, to realise this aim the following objectives were achieved.

1 identifying the key financial, operational and green performance indicators that the manufacturing organisations intended to realise
identifying the green operations actions made by the manufacturing organisations
3 measuring the financial, operational and green performance of the manufacturing organisations
4 clustering the manufacturing organisation to green strategic group according to intended key performance indicators
5 identifying the relationship between the realised financial, operational and green performance by each green strategic group
6 identifying the relationship between the green actions and the realised financial, operational and environmental performance.

This paper is issued on the following sections; the first section is the literature review, followed by the research methodology, next, the data analysis and findings are presented, followed by the discussion, finally the conclusion, applications and future researches are discussed.

2 The conceptual framework of green manufacturing strategy

According to Hong (2009), the strategic green orientation is an organisation’s long term commitment for producing environmentally friendly products. Some of green strategies and techniques can create products/systems, which in turn consumes less materials and energy, substituting input materials, reducing unwanted outputs and converting outputs to inputs (recycling) this reflect the green manufacturing term (Deif, 2011).

According to Li et al. (2010) in order to realise the objectives of reducing energy consumption and waste emission, overcome green trade barriers, the green manufacturing strategy should be adopted by Chinese enterprises. Lawrence et al. (1998) defined the green manufacturing strategy as the response of an organisation’s products, services and activities to its natural environment. According to Migdadi (2016), the green manufacturing strategy is stream of operational actions which realise green operations performance indicators.

In this research green manufacturing strategy content is divided into two main parts; the actions and competitive priorities. The actions are the tactics made by the organisations; however, the competitive priorities are the strategic key performance indicators which are the same as the business level strategy.

2.1 The strategic patterns of green manufacturing strategies

The strategic patterns of green manufacturing strategies are the configurationally patterns of green strategies intended or realised by the manufacturing corporations. This issue is widely studied by the operations strategy literature over an extended period of time. The operations strategy configurations could be taxonomies or typologies (Miller, 1996).

The typologies are ideal patterns of operations strategy which developed according to intended set of attributes, may be some cases in reality matching these patterns or not (Doty and Glick, 1994). On the other hand, the taxonomies approach is more real which is related to numerical configuration according to really traced attributes, whether these attributes are realised or intended to be realised (Miller, 1996). The widely adopted
attributes in developing such taxonomies in operations strategy literature is the operations competitive priorities and capabilities (Migdadi, 2013). However, other operational aspects could be adopted for this purpose as the operational actions.

Only one study has developed such taxonomies of green manufacturing strategy, this is the study of Migdadi (2016), according to this study, the mobile phone manufacturers best practices green strategies could be classified to three patterns; the solid waste management pattern, hazard material management pattern, or hybrid pattern of both solid waste and hazard material. Each pattern of green operations strategy contains stream of green actions which realised particular level of performance, so the next sections discuss the relationships between operations actions, between operations actions and performance indicators and between performance indicators. So the following relationships could be traced for each pattern and for the whole industry.

H1 The manufacturing organisations adopted different patterns of green manufacturing strategy.

2.2 The relationship between performance indicators

According to Zhang and Yang (2016), the environmental performance is partially mediating the relationship between green practices and operational performance. Guang Shi et al. (2012) found that, the environmental performance affects the operational performance.

H2 The environmental performance has a significant impact on the operational performance.

Moneva and Ortas (2010) found that the environmental performance is positively correlated with the financial performance. Shi et al. (2012), found that; the environmental performance affects the operational performance, and the operational and environmental performance affects the financial performance. According to Lee et al. (2012) the operational performance affects the business performance.

H3 The environmental performance has a significant impact on the financial performance.

H4 The operational performance has a significant impact on the financial performance.

2.3 The relationship between green operations actions and performance indicators

The previous studies have investigated the relationship between green supply chain management practices and firm’s performance indicators. The performance indicators were classified to dimensions including environmental, economic and operational performance (Shi et al., 2012). The evaluation of green supply chain management performance cannot just be based on its financial dimension. Other aspects as the environmental and operational performance need to be integrated at a strategic level (Kaplan and Norton, 2001; Shabani and Saen, 2015).

The impact of green actions on the economic performance was support by the majority of studies, for example Alvarez et al. (2001) study concluded that green supply chain management has a positive relationship with an organisation’s economic
performance, Wagner et al. (2001) study indicated that the relationship between green supply chain management practices and economic performance is still mixed. Younis et al. (2016) study was more detailed in tracing the impact of green actions on the performance indicators, this study revealed that; the economic performance was affected significantly by green purchasing, only Zhang and Yang (2016) found that; the green practices have not a significant impact on the economic performance.

H5 Inter and intra organisational actions have a significant impact on the financial performance.

The impact of green operations actions on the environmental performance was traced by some studies, according to Shi et al. (2012) study the cooperation with suppliers will improve the environmental performance, the same result was supported by Frosch (1994), Sarkis (1995), Florida (1996), Florida and Davison (2001), Geffen and Rothenberg (2000), Green et al. (1996), Handfield et al. (2002) and Zhu et al. (2005). However, the study of Zhang and Yang (2016) found a positive impact of green practices in general on environmental performance, and Lin et al. (2014) study found that; green product innovation and green process innovation actions have a significant impact on the environmental performance. On the other hand, only one recent study conducted by Younis et al. (2016) found that none of the green supply chain management practices have a significant impact on the environmental performance.

H6 Inter and intra organisational actions have a significant impact on the environmental performance.

Figure 1 The conceptual framework of green manufacturing strategy (see online version for colours)
Zhang and Yang (2016) study found a positive impact of green practices on environmental and operational performance, Younis et al. (2016) study was more detailed in tracing the impact of green actions on the performance indicators, this study revealed that; only environmental cooperation and green purchasing were found to have a significant impact on the operational performance.

H7 The inter and intra organisational green actions have a significant impact on the operational performance.

3 Research methodology and methods

This section aims to discuss the research methodologies. This section shows how to achieve study objectives and answering the research questions.

3.1 Identifying the population, sample and collecting data

The population of this research includes all manufacturing firms that adopt ISO 14001 in Jordan. There is no published statistics about the number of manufacturing firms that adopt ISO 14001 in Jordan.

Table 1 The main characteristics of respondents

<table>
<thead>
<tr>
<th>Character</th>
<th>Age</th>
<th>Gender</th>
<th>Job title</th>
<th>Year that the firm get certified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent</td>
<td>78% from the respondents aged (30 year) and over.</td>
<td>78% from the respondents were male.</td>
<td>62.9% of the respondents were quality manager, quality assurance, engineer of quality, public safety and environment of projects. And the others are managers of project, general managers …, etc</td>
<td>62.9% of the respondents’ firm gets the ISO 14001 certification in 2005 and beyond.</td>
</tr>
<tr>
<td></td>
<td>22% from the respondents aged lower (30 year).</td>
<td>22% from the respondents were female.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

So the following steps were followed to determine the research population and sample.

1 All consulting firms that grant ISO 14001 in Jordan were contacted in order to determine the population of study. These firms were; SGS, Lloyds, DNV, TUV, and Absolute Quality Certification (AQC).

2 Some of the granted firms in Jordan have reservation to disclose their clients’ information. Two of the consultation firms mentioned above disclose only the number of the manufacturing firms’ clients that adopt ISO 14001.

3 The investigation was started by using the convince sampling technique.

4 Then, Snowball sampling technique was used to reach more manufacturing firms that adopt ISO 14001. Snowball sampling technique is also one of a non-probability sampling technique that is used when members of population are difficult to locate. Based on this technique each manufacturing firm that listed in disclosed list of the consultation firms was asked about other manufacturing firms that adopt ISO 14001 that may know.
5 After that, an approximate number of the total population was identified. The approximated number of population is about 40 manufacturing firms adopt ISO 14001. Maximum sample size reached was 27 manufacturing firms. Sample size represents about 67.5 from the total population. The main characteristics of the respondents are shown in Table 1. The data were gathered by using interviews with some respondents, others were contacted via e-mail of fax.

3.2 Questionnaire design and development

The dimensions and items of questionnaire were identified clearly by revising the literature. Table 2 shows the number of dimensions and elements in each section of the questionnaire; the first section contains three dimensions and 26 elements, the second section contains eight dimensions and 51 elements, and the last section contains three dimensions and 26 elements.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Questionnaire dimensions and elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section</td>
<td># of dimension</td>
</tr>
<tr>
<td>Key-performance indicators</td>
<td>3</td>
</tr>
<tr>
<td>Green operation actions</td>
<td>8</td>
</tr>
<tr>
<td>Performance indicators</td>
<td>3</td>
</tr>
</tbody>
</table>

The scales of the research questionnaire were identified as follows:

a) The scales of the second section of the questionnaire (that asks about Key performance indicators that the manufacturing firm seeks to realise) were:
   - 0 not at all
   - 1 taken at very low degree
   - 2 taken at a low degree
   - 3 taken at a medium degree
   - 4 taken at significantly
   - 5 taken at very significantly

b) The scales of the third section of the questionnaire (the level of adopting the green practices) were:
   - 0 not considering at all
   - 1 extremely low
   - 2 low
   - 3 moderate
   - 4 high
   - 5 extremely high.

c) The scale of the fourth section of the research (the realised performance by the firms as a result of adopting ISO 14001) were:
3.3 Check the face validity of questionnaire

Three experts from industry and five academics professionals were asked about the validity of the research questionnaire. The industry experts were consultants of ISO 14001 accreditation at consultation corporations. They gave specific recommendations about the questionnaire based on their experience.

3.4 Data analysis

Different analysis techniques were used to achieve research objectives and test hypotheses, these are:

1. K-mean clustering analysis which is a statistical technique that used to group respondents together. The main purpose of this analysis is to categorise n objects in k (in which k greater than one) groups, called clusters, SPSS was used to determine the criteria for updating the cluster centres by using iteration option, and the default value for it is 10. This analysis was used to realise the fourth objective: clustering the manufacturing organisations that adopt ISO 14001 according to key performance indicators in Jordan. All clustering trials were generated, and the significant clusters were identified.

2. Matching analysis: this analysis was used since the size of sample is too small. The technique of analysis that used to report the relationships between performance indicators and between actions and performance indicators is mainly the linear regression analysis, but this technique requires a significant sample size (n > 30) which is not satisfied by this study sample size.

   This is a simple statistical technique seeks to identify the perfect match between performance indicators and between performance indicators and green actions. Perfect match it means, the factors has the same level of adoption. The perfect match represents a high absolute correlation between factors. Other kind of non-perfect matches between indicators are out of the scope, since such matching requires statistical verification as ($r^2$-value) which is inapplicable in the context of this research as a result of sample size.

The followings are the procedures were followed:

a the average performance for each performance indicators group (financial, operational and green) of each strategic group cases was computed

b the level of performance or action adoption was assigned for each strategic group according to the following scale
**4 Data analysis and findings**

**4.1 Clusters of organisations according to key performance indicators**

After collecting the data from the respondents, key performance indicators grouped into three dimensions; environmental, operational, and or financial indicators. Then average of key performance indicators groups by each organisation was computed. Then, the organisations clustered by using K-means cluster analysis technique, several trial and errors done to estimate the optimal clusters with ten iterations. Optimal numbers of clusters were identified with three clusters. Table 4 shows the result of this analysis.

<table>
<thead>
<tr>
<th>Key performance indicators</th>
<th>Mean square error of three clusters</th>
<th>Mean square error of four clusters</th>
<th>Mean square error of five clusters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental key performance indicators</td>
<td>.138</td>
<td>.093</td>
<td>.092</td>
</tr>
<tr>
<td>Environmental key performance indicators</td>
<td>.232</td>
<td>.185</td>
<td>.085</td>
</tr>
<tr>
<td>Environmental key performance indicators</td>
<td>.129</td>
<td>.103</td>
<td>.119</td>
</tr>
<tr>
<td>Sum of mean square error</td>
<td>0.499</td>
<td>0.381</td>
<td>0.296</td>
</tr>
</tbody>
</table>

Figure 2 Optimal number of clusters (see online version for colours)

Three clusters is the optimal number of green manufacturing strategies, since the maximum rate of changes in sum mean square error determines the optimal number of cluster needed where the noise is minimal. Table 3 shows the summation of mean square error.
error for each number of clusters, and Figure 2 shows that graphically. Figure 2 shows the rate of changes in mean square error which was maximum at three clusters, so the optimal number of clusters is three. By using K-mean cluster analysis, the results show that there are three significant clusters according to the key performance indicators.

Table 4  Clusters of organisations according to key performance indicators

<table>
<thead>
<tr>
<th>Performance indicators</th>
<th>K-means cluster analysis of organisation (*)</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cluster (3)**</td>
<td>Cluster (2)**</td>
</tr>
<tr>
<td>Environmental indicators</td>
<td>3.09*</td>
<td>4.25*</td>
</tr>
<tr>
<td>Operational indicators</td>
<td>3.99*</td>
<td>4.46*</td>
</tr>
<tr>
<td>Economic indicators</td>
<td>3.58*</td>
<td>4.26*</td>
</tr>
</tbody>
</table>

Notes: *Represents the average degree of importance attached to each key performance indicators by cluster, importance is measured on a six-point scale (interval scale 0–5: 0 = not at all and 5 = very significantly).
**The numbers in the parentheses indicate the number of cluster. The observed F-statistics were derived from one-way ANOVA and the p-values are associated with the observed F-statistics.

Table 4 shows there are three clusters of green manufacturing strategies, which are: care-taker environment, agile environment, and lean environment green strategy. The first cluster is called care-taker environment, since the manufacturing firms of this cluster seeks to realise all key performance indicators (environmental, operational and economic or financial) in moderate to low levels.

The second cluster is called agile environment, since K-mean values of this cluster were the highest relative to other clusters. So that this means the manufacturing firms in this cluster seeks to realise all key performance indicators (environmental, operational and economic or financial) in a highly level.

The third cluster is called lean environment, since the K-mean values of this cluster indicated that; the environmental key performance indicators, economic environmental key performance indicators were sleeked to be realised in moderate manner, and at lower degree of importance for operational key performance indicators.

4.2  The evaluation of agile strategic group performance

Table 5 shows the relationship between performance indicators and green actions of agile strategic group. It can be seen that; the high performance indicators realised were the environmental and operational performance indicators, however, the realised financial performance was moderate. There is a perfect match between environmental and operational performance indicators. The perfect match is high, accordingly, the second hypothesis (H2) is accepted. No perfect match between financial performance and operational or environmental performance indicators, so the third hypothesis (H3) and fourth hypothesis (H4) are rejected.
### Table 5
The relationship between performance indicators and green actions of agile strategic group

<table>
<thead>
<tr>
<th>Average</th>
<th>Financial performance</th>
<th>Operational performance</th>
<th>Environmental performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dependent</td>
<td>3.22 (M)</td>
<td>3.69 (H)</td>
</tr>
<tr>
<td>3.52 (H)</td>
<td>Environmental performance</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>3.69 (H)</td>
<td>Operational performance</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>4.63 (H)</td>
<td>Internal commitment actions</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>3.00 (M)</td>
<td>Cooperation with suppliers actions</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>4.45 (H)</td>
<td>Cooperation with customers actions</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>3.42 (M)</td>
<td>Eco-design and packaging actions</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>3.04 (M)</td>
<td>Investment and recovery actions</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>3.83 (H)</td>
<td>Distribution and transportation actions</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>2.73 (M)</td>
<td>Warehousing and green building actions</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>4.60 (H)</td>
<td>Reverse logistics actions</td>
<td>H</td>
<td>M</td>
</tr>
</tbody>
</table>

Notes: \[ \text{H} \] – high perfect match; \[ \text{M} \] – moderate perfect match; \[ \text{L} \] – low perfect match.

There is a perfect match between internal commitment actions, distribution and warehousing actions, cooperation of customers actions, and reverse logistics actions as independents and both the environmental and operations performance indicators as dependents, the perfect match is high, so the sixth hypothesis (H6) and seventh hypothesis (H7) are accepted. There is a perfect match between cooperation with suppliers actions, eco-design actions, investment and recovery actions, and warehousing and green building actions as independents and the financial performance indicators as dependents, the perfect match is moderate, so the financial performance is affected by both inter and intra organisational green actions, accordingly the fifth hypothesis (H5) is accepted.

#### 4.3 The evaluation of lean strategic group performance

Table 6 shows the relationship between performance indicators and green actions of lean strategic group. It can be seen that; the performance was low to moderate. The moderate performance indicators realised were the environmental, however realised financial
performance and operational indicators were moderate. There is a perfect match between financial and operational performance indicators. The perfect match is low, accordingly the third hypothesis (H3) is accepted. No perfect match between environmental performance and operational performance indicators, so the second hypothesis (H2) is rejected.

Table 6  The relationship between performance indicators and green actions of lean strategic group

<table>
<thead>
<tr>
<th>Average</th>
<th>Independent</th>
<th>Financial performance</th>
<th>Operational performance</th>
<th>Environmental performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1.67 (L)</td>
<td>0.43 (L)</td>
<td>3.1 (M)</td>
</tr>
<tr>
<td>3.1 (M)</td>
<td>Environmental performance</td>
<td>M</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>0.43 (L)</td>
<td>Operational performance</td>
<td>L</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td>4.00 (H)</td>
<td>Internal commitment actions</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>4.20 (H)</td>
<td>Cooperation with suppliers actions</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>3.67 (H)</td>
<td>Cooperation with customers actions</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>1.63 (L)</td>
<td>Eco-design and packaging actions</td>
<td>M</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>0.1 (L)</td>
<td>Investment and recovery actions</td>
<td>M</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>3.50 (M)</td>
<td>Distribution and transportation actions</td>
<td>M</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>2.25 (L)</td>
<td>Warehousing and green building actions</td>
<td>M</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>2.29 (L)</td>
<td>Reverse logistics actions</td>
<td>M</td>
<td>L</td>
<td>L</td>
</tr>
</tbody>
</table>

Notes:  - high perfect match;  - high perfect match;  - low perfect match.

There is a perfect match between eco-design and packaging actions, investment and recovery actions, warehousing and green building actions and reverse logistics as independents and both the financial and operational performance indicators as dependents, the perfect match is low. So the fifth hypothesis (H5) and seventh hypothesis (H7) are accepted. There is a perfect match between transportation and distribution actions as independents and the environmental performance indicators as dependents, the perfect match is moderate. Accordingly, the sixth hypothesis (H6) is accepted.
4.4 The evaluation of care-taker strategic group performance

Table 7 shows the relationship between performance indicators and green actions of care-taker strategic group. It can be seen that; the performance was low to moderate. The realised operational performance indicators were the moderate, however realised financial performance and environmental indicators were low. There is a perfect match between financial and environmental performance indicators, the perfect match is low, so the third hypothesis (H3) is accepted. No perfect match between environmental performance and operational performance indicators, accordingly, the second hypothesis (H2) is rejected.

Table 7 The relationship between performance indicators and green actions of care-taker strategic group

<table>
<thead>
<tr>
<th>Average</th>
<th>Independent</th>
<th>Financial performance</th>
<th>Operational performance</th>
<th>Environmental performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.07 (L)</td>
<td>Environmental performance</td>
<td>L</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>2.70 (M)</td>
<td>Operational performance</td>
<td>M</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>3.70 (H)</td>
<td>Internal commitment actions</td>
<td>H</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>1.98 (L)</td>
<td>Cooperation with suppliers actions</td>
<td>L</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>1.30 (L)</td>
<td>Cooperation with customers actions</td>
<td>L</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>2.11 (L)</td>
<td>Eco-design and packaging actions</td>
<td>L</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>3.83 (H)</td>
<td>Investment and recovery actions</td>
<td>H</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>2.75 (M)</td>
<td>Distribution and transportation actions</td>
<td>M</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>2.04 (L)</td>
<td>Warehousing and green building actions</td>
<td>L</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>3.63 (H)</td>
<td>Reverse logistics actions</td>
<td>H</td>
<td>L</td>
<td>M</td>
</tr>
</tbody>
</table>

Notes: - high perfect match; - high perfect match; - low perfect match.

There is a perfect match between distribution and transportation actions as independents and the operational performance indicators as dependents, the perfect match is moderate, so the seventh hypothesis (H7) is accepted. There is a perfect match between cooperation with suppliers’ actions, cooperation with customer actions, eco-design actions, and warehousing and green building actions as independents and both the financial and
environmental performance indicators as dependents, the perfect match is low, so the fifth hypothesis (H5) and the sixth hypothesis (H6) are accepted.

4.5 Cross strategic patterns performance evaluation

Table 8 shows the relationship between performance indicators and green actions across strategic groups, it can be seen that; there is a perfect match between operational performance and environmental performance indicators as independents and the financial performance indicators as dependents. The perfect match is low. Also, there is a perfect match between environmental performance indicators as independents and operational performance as dependents, the perfect match is high.

![Table 8](image)

Notes: – high perfect match; – high perfect match; – low perfect match.

The matches between actions and financial performance indicators are low and moderate, but the matches between actions as independents and operational and environmental performance indicators as dependents are low, moderate and high. Three actions have perfect matches with financial, operational and environmental performance indicators, these actions are cooperation with customers, reverse logistics and eco-design and packaging actions.
Two actions have perfect match with operational and environmental performance indicators, these actions are internal commitment and distribution and transportation actions. Further two actions have perfect match with financial and operational performance indicators, these actions are investment and recovery, and warehousing and green building actions. However, cooperation with supplier action has a perfect match with financial performance indicators only.

The actions have high perfect match with operational and environmental performance indicators are cooperation with customers and internal commitment, however, the actions have moderate to high perfect high match with both indicators are distribution and transportation actions. Reverse logistics actions have perfect match with environmental performance indicators. Eco-design and packaging, investment and recovery, warehousing and green building, and cooperation with suppliers’ actions have low to moderate match with financial indicators.

5 Discussion

The number of strategic patterns generated by this study was three which the same number as those generated clusters by Migdadi (2016). But the patterns titles differ from Migdadi (2016). The difference in patterns titles is related to different indicators used in clustering; Migdadi (2016) used the green performance indicators, but in this study all indicators financial, operational and green performance indicators were used. Furthermore, the study of Migdadi (2016) reported the patterns adopted by one industry which is the mobile phone producers sector, but this study reported the patterns adopted by different manufacturing sectors.

Different perfect matches between performance indicators were realised by each strategies pattern, agile had a high perfect match between environmental and operational indicators, however, lean had a low perfect match between operational and financial indicators, but care-taker had a low perfect match between environmental and financial indicators. So generally the performance of agile is better than lean and care-taker strategic patterns. This result supports the differences between the strategic patterns, the adoption of each strategic pattern leads to different levels of performance.

Further this difference in performance could be supported by the perfect matched actions with performance indicators. The high operational and environmental performance of agile strategic pattern was determined by unique highly matched actions in comparison with lean and care-taker strategic patterns. These actions were; internal commitment, cooperation with suppliers, distribution and transportation, and reverse logistic. The moderate financial performance of agile strategic pattern was determined by unique moderately matched actions in comparison with lean and care-taker strategic patterns. These actions were; cooperation with suppliers, eco-design and packaging, investment and recovery and warehousing and green building.

Lean and care-taker strategic patterns realised the same level of financial performance which is low, the shared low matched actions with financial performance between these two patterns could explain this level of performance, these actions were; eco-design and packaging, investment and recovery and warehousing and green building. These actions were shared between all patterns so these actions could be the most effective actions on the financial performance indicators. But there is some unshared low matched actions between lean strategic group and other patterns such as the reverse logistics actions. Also
the same for agile which was cooperation with customers actions. These unique actions adopted by each pattern could explain the difference in financial performance in comparison with agile pattern.

The low operational performance of lean strategic pattern was determined by unique low matched actions in comparison with agile and care-taker strategic patterns. These actions were; eco-design, investment and recovery and warehousing and green building actions. However the moderate environmental performance of lean in comparison with care-taker could be determined by unique moderately matched actions which were distribution and transportation actions. The low environmental performance of care-taker strategic pattern was determined by unique low matched actions in comparison with agile and lean strategic patterns. These actions were; cooperation with suppliers, eco-design, and warehousing and green building actions. However the moderate operational performance of care-taker in comparison with lean could be determined by unique moderately matched actions which were distribution and transportation actions.

The cross patterns matching between performance indicators as presented in Table 8 shows that; the operational and environmental performance were low matched with financial performance this result support the results of Guang Shi et al. (2012) and Lee et al. (2012) study, however, the match between the environmental and operational performance was high, this result supports the result of Guang Shi et al. (2012) study. Almost the environmental performance is general leads by defualt to operational performance, for example improving the percentage of recycling or remanufacturing of product will reduce the operational cost and time, reducing solid waste requires using recycling, remanufacturing using eco-components, which affects the operational performance, reducing green gases emissions requires improving the operational processes so the operational performance will be improved.

The financial performance is expected to be low affected by the operational and environmental performance, since the financial performance is determined by a lot of factors, not only the green strategies. On the other hand, the investment in green strategies is still in its infancy stage in Jordan which requires more time to trace its financial impact. Moreover, the target for the majority of corporations in the early adoption of green practices is to improve the environmental performance which affects the operational performance by defualt, the financial performance is not the core issue at this stage, this performance could be traced over time as a consequence of adopting green practices.

The financial performance across patterns was perfectly matched with different combination of actions whether inter or intra-organisational actions, this result is some how support the results of Wagner et al. (2001) and Younis et al. (2016) study, but this result is not supporting the result of Zhang and Yang (2016) study. The majority of actions were low to moderately matched with the financial performance, no any action had a high perfect match. This could be justified in the context of recent adoption of green practices in Jordan which requires more time to trace its impact over time.
with reverse logistics too. The widely shared actions between both indicators indicate again that; these two indicators affect each others, so the actions have somehow the same perfect match with the both performance indicators.

6 Conclusions

6.1 Contribution and findings

This study seek to answer the following research question; what were the different strategic patterns adopted by ISO 14001 certificate holders in Jordan?, and to what extent these strategies were effective?. Despite there is a growing body of literature has studied green supply chain management practices which dated back to mid 1990s, however, the impact of strategic organisational orientation on the green supply chain management has been addressed in some studies, also, the green strategic patterns has reported by very limited studies. So this study has bridged this gap in the literature by reporting the green manufacturing strategic patterns adopted by ISO 14001 certificate holders in Jordan, and evaluating the performance of these patterns.

Green manufacturing strategic patterns adopted by ISO 14001 certificate holders in Jordan were agile, lean, and care-taker strategic patterns. The performance of agile strategic pattern was better than lean and care-taker strategic pattern. High performance indicators realised by agile were the environmental and operational performance indicators, however the realised financial performance was moderate.

Different perfect matches between performance indicators realised by each strategies pattern, agile had a high perfect match between environmental and operational performance indicators, however, lean had a low perfect match between operational and financial performance indicators, but care-taker had a low perfect match between environmental and financial performance indicators. The high operational and environmental performance of agile strategic pattern was determined by unique highly matched actions in comparison with lean and care-taker strategic patterns.

The moderate financial performance and high operational and environmental performance of agile strategic pattern was determined by unique highly matched actions in comparison with lean and care-taker strategic patterns. Lean and care-taker strategic patterns realised the same level of financial performance which is low; this level of performance is determined by the shared low matched actions with financial performance between these two patterns.

The low operational performance of lean strategic pattern was determined by unique low matched actions in comparison with agile and care-taker strategic patterns, also, the moderate environmental performance of lean in comparison with care-taker could be determined by unique moderately matched actions. The low environmental performance of care-taker strategic pattern was determined by unique low matched actions in comparison with agile and lean strategic patterns, the moderate operational performance of care-taker in comparison with lean could be determined by unique moderately matched actions.
6.2 Limitations, applications, and future research

This is the first study to report the green practices in Jordan, but there are some limitations in this study; the first limitation is the study sample, which consists of 20 seven manufacturing organisations in Jordan. This limitation leads to another limitation in the analysis, which is related to reporting the relationships between the study dimensions. Consequently, this study adopted perfect match analysis between the dimensions without reporting the degree and the amount of impact between actions and performance indicators, and between performance indicators, so it is recommended to conduct other studies whether in Jordan or other countries by using more extended sample size.

Another limitation is related to reporting the practices of ISO 14001 certificate holders; other non-certificate holders could adopt green practices, so it is recommended to report the practices of non-certificate holders in future and make a comparison in performance between the certificate and non-certificate holders. This study reported the practices of manufacturing corporations, so it is recommended to report the practices of service corporations. This study was conducted in one country context, future studies could survey the practices across countries whether at regional level or cross regions.

The reported perfect matched actions and performance indicators in this study represent indicative models; these models could be used by other researchers in future to develop base theory for the effective actions within each strategic pattern. Moreover, the green advocates have some facts about the current status of green manufacturing strategies in developing countries such as Jordan, which points to the degree of concern about the green practices in Jordan. The manufacturing corporations’ executives whether already adopted green practices or looking to adopt such practices in future in Jordan have better understanding about the effectiveness of adopted green strategies.

References


The evaluation of green manufacturing strategies


