**Sustainable Chinese Manufacturing Competitiveness in the 21st Century: Green and Lean Practices, Pressure and Performance**

**Abstract**

Instead of focusing on economic growth, firms in the 21st century are paying more attention to environmental aspects in order to enhance their sustainable competitiveness. ‘Green and lean’ practices have emerged as a vital method for organisations that are seeking to become competitive and environmentally sustainable. This article aims to describe and evaluate green and lean practices, pressures and performance among various Chinese manufacturing organisations. Based on a literature review, five green and lean practice propositions are identified and summarised. This research collects data from 172 Chinese manufacturing organisations and derives groupings of green and lean practice, pressures and performance via an exploratory factor analysis. The results show that due to competition, marketing pressure and regulatory factors, Chinese manufacturing organisations have increased their environmental awareness to gain environmental competitiveness. This research establishes a foundation of green and lean practice for further investigation. It also suggests that a win-win relationship between economic growth and environment in Chinese manufacturing is possible, and can be enhanced by implementing green and lean practices.

**Keywords***: Green and lean, Chinese manufacturing, environmental management, stakeholder pressure, sustainability*

**1.0 INTRODUCTION**

Today, balancing economic growth and environmental performance has become increasingly significant for firms facing regulatory factors, pressure and competition from different communities (Epstein and Buhovac, 2014). In particular, environmental issues have become extremely significant due to the reasons of high level of visibility, and managers are forced to incorporate environmental protection into corporate policy and activities (Tan et al., 2014). Stakeholders including consumers, employees, board members, regulators and shareholders are requiring or asking organisations to be more environmentally responsible with regard to their processes and products (Porter and Van der Linde, 1995; Wang et al., 2014). The reasons for these stakeholder demands include product stewardship, the potential to expand the customer base, enhanced public image, regulatory requirements and potential competitiveness (Rusinko, 2007).

According to Pearce and Turner (1990), sustainable development in organisations can be achieved by implementing a set of practices to maximise economic benefits while maintaining natural resources over time. With increased pressure for environmental sustainability, addressing environmental practices successfully can provide new ways to improve value to main business activities, and new opportunities for competition (Gunasekaran and Ngai, 2012; Tseng et al., 2014). Therefore, firms need to implement practices that re-examine both the commercial and environmental aspects of their business. This has led to research on ‘green and lean’ practices in supply chain manufacturing (Vais et al., 2005; Azevedo et al., 2012; Kurdve et al., 2014). The lean paradigm is perceived to offer reduction of waste and subsequent cost reduction, quality and productivity improvement, better use of resources and delivering value to customers (Al-Ashaab and Sobek, 2013). The green paradigm aims to lower negative environmental risks and impacts, while increasing production efficiency and eliminating organisations’ environmental waste (Zhang and Wen, 2008; Kuo et al., 2014). By implementing green and lean practices, organisations can enhance their business performance while creating environmental, social and economic benefits, which ultimately should contribute to manufacturing competitiveness (Wang et al., 2014).

According to Rao (2008), the majority of the world’s manufacturing is carried out in Asia, and this situation will continue over the next couple of decades. This brings many opportunities to developing manufacturing countries such as China. However, these opportunities also bring substantial environmental damage and burden (Kan, 2009). Economy (2007) indicates that China’s acceptance into the WTO has led to its dramatic economic growth, which has been accompanied by equally dramatic environmental degradation. In particular, recent data show that more than 80% of air pollution and 40% of water pollution were attributable to industry (Wang et al., 2014). Moreover, as one of the largest developing countries, China is becoming increasingly industrialised. An increasing number of end-of-life products have been shipped to China, but China neither has effective and efficient methods, nor the infrastructure, to take care of these products (Puckett and Smith, 2002). This causes significant an environmental burden to China’s economy and environment. The appropriate development of green and lean practices may aid these countries by lessening the environmental burden of both the manufacture and disposal of products, while even potentially improving their economic positioning. Thus, in order to be able to strategically manage environmental and business performance, managers need to understand the key practices towards green and lean implementation that are critical in order to be competitive in the global market of the 21st century.

Although prior studies have examined different methods to environmentally sustainable – such as Zhu et al.’s green supply chain management practices (2004), Costi’s environmentally sustainable decision model (2004), Cabral’s supply chain framework (2012), Hervani’s green supply chain measurement system (2005) – that organisations could adopted, these have not been widely applied (Srivastava, 2007). According to Srivastava (2007), earlier studies and reviews on green supply chain management have a limited focus and narrow perspective. They do not cover adequately all the aspects and facets in order to achieve environmentally sustainable. For example, Zhang et al. (1997) focus only on green design, while Bey (2001) presents a critical appraisal of developments in the field of industrial ecology only. Zhu et al (2004) investigated empirical findings on relationships between operational practices and performances among early adopters of green supply chain management. However, much of the work is empirical and does not focus adequately on lean related issues and practices. According to Pagell and Shevchenko (2014), in the last century, the largest shifts in supply chain practices involved the eventual understanding of systems such as lean paradigm. Moreover, Verrier et al. (2014) point out that lean and green could provide a method for companies to develop a tool to measure both productivity and environmental performance based on qualitative and quantitative analysis.

In recent years, there was a significant increase in scientific publications in green-lean area, especially at operational level (Larson and Greenwood, 2004; Bergmiller and McCright, 2009; Carvalho et al., 2011; Dues et al., 2013; Garza-Ryes et al., 2012; 2015; Wiengarten et al., 2013; Pampanelli et al., 2014; Govindan et al., 2015), giving insights of which initiatives (lean-green models, framework, and techniques) should be deployed; there is no evidence of the moment to implement the green and lean practices. Many researchers point out that green and lean practice can be a catalyst for organisations to improve their environmental and business performance (Klassen, 1996; Larson and Greenwood, 2004; Bergmiller and McCright, 2009; Dues et al., 2013). However the hesitation over the green and lean practice is fuelled by the fact that there is confusion about:

1. What green and lean practices are?
2. How green and lean practices are associated with environmental pressures and performance in general in Chinese manufacturing organisations?

This paper contributes to green and lean practice by providing a cross-sectional, large-sample measurement model to test the effectiveness of developed green and lean practices in improving Chinese organisations’ environmental and business performance. Also, it shows that the different level of performance improvement is dependent on pressure levels in Chinese organisations. It tests specific hypotheses, based on literature and empirical study. This paper differs from the vast majority of the green and lean literature, which focuses on the serial or simultaneous deployment of green and lean practice, this research uses the actual experience of Chinese organisations to explain relationships between green and lean practice, environmental pressures and organisational performance. The findings indicate that a lag may exist between the green and lean pressures being felt by Chinese organisations, and their implementation of green and lean practices.

This article is set out as follows. In the next section, it identifies green and lean practices and summarises current environmental pressures and performance in general in Chinese manufacturing organisations. Following this, the methodology of the study, including questionnaire development, data collection and factor analysis, are illustrated. Then the research findings are presented, with relevant discussion towards implementation of green and lean practices in Chinese manufacturing organisations. The article concludes by summarising the implications and limitations of the study, and outlining areas for future work.

**2.0 THEORETICAL BACKGROUND**

The literature in green and lean has been growing as researchers and practitioners begin to realise that the management of operations and environmental programmes does not end at the organisation’s boundaries. The reason for green and lean practice is that it can actually improve organisational performance, both environmentally and commercially. The literature supporting this argument is relatively strong. First, many researchers point out that lean practice can be a catalyst for successfully implementing green practices, and can help to improve green performance and goals (Klassen, 1996; Larson and Greenwood, 2004; Bergmiller and McCright, 2009; Dues et al., 2013; Zhan et al., 2016). In particular, by exploring several explanatory frameworks, Dues et al. (2013) suggest that lean is beneficial for green practices, and that implementing green practices in turn has a positive influence on existing lean business practices. Furthermore, Garza-Reyes et al. (2015) suggest that green and lean can work together effectively since they are concurrent to some extent. For example, green and lean both can maintain synergies related to waste reduction, lead-time reduction, product design and the use of various approaches and techniques to manage people, organisations and supply chain relations (Larson and Greenwood, 2004; Garza-Ryes et al., 2012; 2015; Dues et al., 2013; Wiengarten et al., 2013). Moreover, researchers such as Mollenkopf et al. (2010) and Pampanelli et al. (2014) address the relationship between green and lean through different approaches to integrate them and take advantage of the green and lean synergies available when implemented concurrently. Further still, in order to measure the contribution and effect of green and lean paradigms, Carvalho et al. (2011) proposed a conceptual model that measures the relationships between green and lean practice and supply chain performance. Finally, an increasing number of researchers are beginning to investigate the effect of green and lean implementation on various composite dimensions of organisational performance, which include different aspects such as environmental, operational, financial and customer satisfaction (Dues et al., 2013; Wiengarten et al., 2013). This reflects constant debate among researchers regarding the potential benefits to be achieved by adopting green and lean practice within organisations, their supply chains and operations.

The remainder of this section will focus on the key areas that will be investigated in the empirical study, including issues related to green and lean practice, pressures and perceptions of performance from implementation.

**2.1 Green and lean practices**

By studying the literature, this article determines five key practices (mindset and attitude, leadership and management, employee involvement, integrated approach and tools and techniques) in organisations to enhance their environmental and business performance (see Table 1). The five practices identified demonstrate some of the key internal and external activities and functions within organisational supply chain management. These have been identified and summarised based on previous literature which has addressed various aspects of green and lean practices, as well as input from expert opinion.

Table 1. Green and lean practices

|  |  |  |
| --- | --- | --- |
| **Green and lean practices** | **Items** | **Source** |
| Mindset and attitude | Openness to learning | Jeyaraman and Teo (2010), Azevedo et al. (2012) |
| Belief in the programme and confidence in its success |
| Green and lean thinking |
| Required changes in organisational culture |
| Leadership and management | Dedication from senior management | Rothenberg et al. (2001), Bergmiller and McCright (2009)  |
| Strong leadership |
| Clear communication of the revised vision |
| Manager’s dedication to the programme’s implementation  |
| Employee involvement | Skill and expertise  | Florida (1996), Zhu et al. (2005) |
| Dedication of employees and resources of the entire firm |
| Working within the green and lean principles as well as philosophy |
| People have to get green and lean before organisations can |
| Integrated approach | Holistic and targeted strategy for change (which must be consistently adhered to) | Drew et al. (2004), Zhu and Sarkis (2004), Carvalho et al. (2011) |
| Integrated green and lean operating system |
| Use of all the goals, methods, techniques and green and lean elements in combination |
| Tools and techniques | Good understanding of green and lean tools and techniques  | Hines et al. (2004), Srivastava (2007), Sertyesilisik (2014) |
| Selection and application of appropriate tools and techniques |
| Having the right green and lean tools and techniques in place |
| Understanding of the organisation’s processes to apply the right tools and techniques |

All five key green and lean practices are integrative and need cross-functional cooperation, rather than being oriented towards a single function or department. First, the mindsets and attitudes of people operating a green and lean system are fundamental. Green and lean practice is not only about changing things, but about changing how people think. It argues that organisations should think small and flexible rather than big, and that problems create opportunities to improve rather than necessitating blame (Jeyaraman and Teo, 2010). Second, strong, committed leadership is essential to successfully implement green and lean practices, which must be driven from the top-down. In a green and lean environment, leadership is about defining the values and goals of the organisation and developing strategy. The literature also supports that the difference between green and lean failure and success starts with leadership (Rothenberg et al., 2001). Third, employee involvement can assist green and lean practice in different ways, with key factors including attitude, experience, knowledge, skills, prioritising and thinking of the enterprise, customer consciousness, taking initiative, adaptation, commitment, influence, collaborative skills and discipline (Florida, 1996; Unnikrishnan and Hedge, 2006). Fourth, Drew et al. (2004), clearly state that the effectiveness of the green and lean system depends on adopting an integrated approach. Therefore, green and lean should be seen as an integrated, comprehensive management pattern and a philosophy of manufacturing that must be consistently practised throughout an organisation. Finally, it is easy to see how many benefits – increasing product quality, smaller inventories and a shorter payback period – can be achieved by increasing our understanding of green and lean tools and techniques, and using them appropriately (Hines et al., 2004; Srivastava, 2007). Therefore, tools and techniques should be considered as a part of critical green and lean practice in organisations.

Based on the five key green and lean practices identified, this exploratory study will determine the progress of our Chinese manufacturing organisation sample in implementing green and lean practices. Given that research and focus on the green and lean concept and its implementation in China is a recent phenomenon, we propose two general hypotheses:

***H1:*** *Chinese manufacturing organisations are in the initial stages of implementing green and lean practice.*

***H2:*** *Implementing green and lean practice in Chinese manufacturing organisations lags behind the green and lean pressures that they have experienced.*

**2.2 Pressures for implementation of green and lean practices**

Organisations’ internal and external partners have intensified pressure for the enhancement and enforcement of environmental practices. This study has recognised pressures from partners who spearhead the enforcement of green and lean implementation and other related environmental programmes. Hall (2000) explained that manufacturing organisations strive to fulfil stakeholders’ demands, whose protests go beyond environmental mandates, while several suppliers are facing frequent and significant demands from their consumers. Henriques and Sadorsky (1996) pointed out four key environmental partner groups: regulatory partners – which create standards or have powers to persuade governments to develop rules; organisational partners – which are explicitly associated with business firms and can create financial effects for those firms; community partners and other third parties – which have vested interests and can solicit public support for, or opposition to, a company’s environmental practices; and media partners – which have the capability to influence society’s attitudes towards a particular company. These four major forms of pressure for a better environment operate at both the domestic and global levels. For example, a study conducted on industries in India identified that some international pressure for a better environment could turn out to be a prospective opportunity for such organisations with a vested interest in enhancing their environmental practices (Dinda, 2004). The same thing also happens in Chinese enterprises. For example, several Chinese manufacturing organisations obtained ISO 14001 certification to fulfil environmental standards for their international clients, which also helps them to market their products to other potential clients.

However, not all firms have experienced similar forms of pressure, or to a similar degree, to improve the environment. Particularly after China became a member of the WTO, globalisation may have contributed to greater pressure and influence on Chinese manufacturing to enhance environmental commitments. Christmann and Taylor (2001) viewed that sales and exports and conducting business with international clients are two key factors that can encourage the environmental commitments of Chinese enterprises. Often, it is the current international environmental concern that is being addressed by Chinese regulatory organisations that may view one environmental concern and industry as more crucial than others. Therefore, pressures for a better environment are significantly derived from regulations, market, suppliers and internal factors. The present study aims to assess how Chinese firms are experiencing such pressure to enforce green and lean practices. This leads to our third hypothesis:

***H3:*** *Chinese manufacturing organisations are feeling significant pressure from a variety of sources to introduce and implement green and lean practices.*

**2.3 Green and lean performance**

Previous research has investigated the effect of green and lean practices on various composite dimensions of organisational performance, including different aspects of environmental, operational and economic performance and customer satisfaction (Florida, 1996; Florida and Davison, 2001; Dues et al., 2013; Wiengarten et al., 2013). For example, King and Lenox (2001) argue that green and lean conscious manufacturing could lead to improvement in industrial and environmental performance. Rao and Holt (2005) suggest that ‘greening’ the different phases of the supply chain through implementing green and lean practices could lead to an integrated, environmentally-friendly supply chain, which ultimately leads to sustainable competitiveness and economic performance.

In this study, green and lean performance is multifaceted, and business performance and environmental performance are of specific interest. Business performance takes into account the organisation’s responsibilities to its shareholders, and has a profit maximisation objective (Rappaport, 1987). In line with earlier research, business performance can be conceptualised by two dimensions: market performance and financial performance (Narasimhan and Kim, 2002; Menor et al., 2007; Yang et al., 2011). Environmental performance refers to the organisation’s performance in environmental responsibilities (Kleindorfer et al., 2005; Zhu and Sarkis, 2004; Zhu et al., 2004). Although some researchers indicate a positive relationship of environmental management to business and environmental performance (Hervani et al., 2005; Dues et al., 2013), it is still not clear whether benefits or costs dominate when implementing green and lean practices in China. Therefore, whether managers perceive improvements in business and environmental due to implementing green and lean practices will be the major issue investigated in this study. Given the strength of the overall literature in supporting the ‘win-win’ scheme, and even though it remains mixed, our final hypothesis is as follows:

***H4:*** *The implementation of green and lean practices in Chinese manufacturing organisations has improved the business and environmental performance of those implementing organisations.*

**3.0 METHODOLOGY**

This section introduces the research methodology for developing the survey instrument, operationalizing the variables and factors, gathering the data and determining the reliability of factor groupings.

**3.1 Questionnaire development**

The survey questionnaire was initially in English, and then translated into Chinese by one a Chinese researcher. The data collected in this research consist of questionnaire responses from managers in Chinese processing and manufacturing industries, who have experienced the introduction of green and lean practices and seen the profound impact that these can have on organisational performance. A broad perspective on green and lean practice was identified from the literature, as well as input from expert opinion for measuring the constructs of the research model.

The questionnaire contained three parts: items affecting practices, pressures and corresponding performance. The first part is green and lean practices (please refer to table 3), 19 items were developed by the author based on a number of sources from the literature (Larson and Greenwood, 2004; Kleindorfer et al., 2005; Mason et al., 2008; Mollenkopf et al., 2010; Kurdve et al., 2011; Carvalho et al., 2011; Cabral et al., 2012; Garza-Reyes et al., 2012; Salleh et al., 2012; Dues et al., 2013; Wiengarten et al., 2013; Diaz-Elsayed et al., 2013; Sobral et al., 2013; Sertyesilisik, 2014; Banawi and Bilec, 2014; Pampanelli et al., 2014; Duarte and Cruz-Machado, 2015; Garza-Reyes, 2015) and expert opinion. The answers in this part were based on a five-point scale (where 5 = ‘implementing successfully’ to 1 = ‘not considering it’). The second part is pressures (see table 4), 18 items were based on a number of previous literature studies (Henriques and Sadorsky 1996; Hall, 2000; Wang et al., 2014), and questions were answered using a five-point Likert-type scale (where 5 = ‘extremely important’ to 1 = ‘not at all important’). In the third part, 12 items developed from the literature (Zhu and Sarkis, 2004; Zhu et al., 2004) focused on environmental and business performance (see table 5). Questions about the influence of green and lean practice on business and environmental performance factors were answered using a five-point scale (where 5 = ‘significant’ to 1 = ‘not at all important’). A brief introduction of the three groups of items was provided at the beginning of the survey instrument to avoid confusing respondents through the use of the five-point Likert scales.

**3.2 Sample and data collection**

The questionnaire was pilot-tested on a group of managers attending a seminar, and their feedback collected to improve the questionnaire. The participating managers were experts in green and lean practices; most of them were Master of Business Administration (MBA) students at the present authors’ business school and working at different organisations. Based on the suggestions from the pilot test, the part questions were further clarified, making them easier to understand and allowing for more precise answers.

This research conducted data collection in different areas across the whole of China; one or two representative cities were chosen to collect data in each area. The two main approaches were by post and on-site form-filling in MBA classrooms. In the first approach, surveyed organisations were selected by industry type and distribution of area. The postal addresses of these organisations were acquired from the Yellow Pages (China Telecom). In the second approach, in different areas several universities with MBA programmes were selected. Relevant staffs in these universities were contacted and their agreement sought prior to the survey; they were then posted the questionnaires to be distributed to relevant MBA students in their classes, as well as information on the method of collecting data. Students were advised that to participate in the survey, they must be working at manufacturing organisations that were considering or engaging in green and lean practices and performance. The completed questionnaires were then returned to the authors.

Out of a total of 626 questionnaires administered to all the representatives and organisations, a total of 172 usable and unique replies were received. The biases were examined through dividing the 172 participants into two groups: received by post (n = 64, 37.2%), and on-site form filling in MBA classrooms (n = 108, 62.8%). The distribution of participating organisations by size and industry type is shown in Table 2. While 9.3% of the surveyed organisations had more than 5,000 employees, 25% had fewer than 200. This suggests that the survey covered firms of widely differing scale.

Table 2. Distribution of survey respondent organisations

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| **Category** | **Item** | ***N*** | **%** |
| 1. Organisation size | >5,000 employees | 16 |  9.3 |
| 3,000–5,000 employees | 24 | 14.0 |
| 1,000–3,000 employees | 57 | 33.1 |
| 200–1,000 employees | 32 | 18.6 |
| <200 employees | 43 | 25.0 |
| Total | 172 | 100 |
|  |  |  |  |
| 2. Type of industry | Motor assembly | 34 | 19.8 |
| Power generation | 39 | 22.7 |
| Engineering and metal | 26 | 15.1 |
| Electronics manufacturing | 23 | 13.4 |
| Chemical related manufacturing | 9 | 5.2 |
| Family apparatus industry | 22 | 12.8 |
| Packaged food  | 7 | 4.1 |
| Other | 12 | 7.0 |
| Total | 172 | 100 |

**3.3 Factor analysis**

Prior to the analysis, exploratory factor analysis was performed to further confirm groupings of green and lean practice, pressure and performance from the data collected. Both the initial eigenvalue test and the scree test indicated the presence of five factors for practice, four factors for green and lean implementation pressure, and two factors for performance that were retained for rotation. This factor analysis empirically grouped the scale items of green and lean practice as predicted (see Table 3), confirming the original groupings. We retained the labels of the five factors on green and lean practice which included mindset and attitude, leadership, employee involvement, integrated approach and tools and techniques. The five green and lean practice factors explain 69.1% of the inherent variation. Further analysis confirms the reliability of these five factors (a Cronbach’s alpha of 0.796, 0.809, 0.817, 0.850, 0.914 respectively for each group). A similar factor analysis of the implementation pressure of green and lean practices and performance items also grouped the scale items as predicted (see Tables 4 and 5). The four green and lean pressure factors explain 68.3% of the inherent variation, while two performance factors explain 76.1% of the inherent variation. Four pressure factors are labelled as regulations, market, suppliers and internal factors. The two performance factors are labelled as business performance and environmental performance. Further analysis confirms the reliability of the four green and lean pressure factors (Cronbach’s alpha of 0.761, 0.818, 0.677 and 0.701, respectively), as well as the reliability of these two performance factors (with levels of Cronbach’s alpha equal to 0.801 and 0.878). All Cronbach alpha values in this study are well above the limit of 0.60 (Flynn et al., 1990; Lawrence and Hottenstein, 1995).

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| Table 3. Constructs and measure of the green and lean practices |
| Survey items | 1 | 2 | 3 | 4 | 5 |
| Holistic and targeted strategy for change (must be consistently adhered to) |  |  | 0.707 |  |  |
| Integrated green and lean operating system |  |  | 0.811 |  |  |
| Use of all the goals, methods, techniques and green and lean elements in combination |  |  | 0.751 |  |  |
| Dedication from senior management |  | 0.639 |  |  |  |
| Strong leadership |  | 0.547 |  |  |  |
| Clear communication of the revised vision |  | 0.870 |  |  |  |
| Manager’s dedication to the programme’s implementation  |  | 0.843 |  |  |  |
| Skill and expertise  |  |  |  | 0.846 |  |
| Dedication of the employees and resources of the entire firm |  |  |  | 0.772 |  |
| Working within the green and lean principles as well as philosophy |  |  |  | 0.667 |  |
| People have to get green and lean before organisations can |  |  |  | 0.561 |  |
| Openness to learning | 0.890 |  |  |  |  |
| Belief in the programme and confidence in its success | 0.708 |  |  |  |  |
| Green and lean thinking | 0.673 |  |  |  |  |
| Required changes in organisational culture | 0.890 |  |  |  |  |
| Good understanding of green and lean tools and techniques  |  |  |  |  | 0.664 |
| Selection and application of appropriate tools and techniques |  |  |  |  | 0.746 |
| Having the right green and lean tools and techniques in place |  |  |  |  | 0.587 |
| Understanding of the organisation’s processes to apply the right tools and techniques |  |  |  |  | 0.688 |

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| Table 4. Constructs and measures of implementation pressure |
| Survey items | 1 | 2 | 3 | 4 |
| Control governmental environmental regulations |  |  | 0.703 |  |
| Regional environmental regulations |  |  | 0.627 |  |
| Export countries’ environmental regulations |  |  | 0.756 |  |
| Products potentially conflict with laws |  |  | 0.634 |  |
| Export |  | 0.688 |  |  |
| Sales to foreign customers |  | 0.714 |  |  |
| Chinese consumers’ environmental awareness |  | 0.690 |  |  |
| Establishing company’s green image |  | 0.655 |  |  |
| Supplier’s advances in developing environmentally-friendly goods |  |  |  | 0.638 |
| Environmental partnership with suppliers |  |  |  | 0.735 |
| Supplier’s advances in providing environmentally-friendly packages |  |  |  | 0.663 |
| Making sure that suppliers will remain in business |  |  |  | 0.609 |
| Company’s environmental mission | 0.625 |  |  |  |
| Internal multinational policies | 0.739 |  |  |  |
| Potential liability for disposal of hazardous materials | 0.640 |  |  |  |
| Cost for disposal of hazardous materials | 0.782 |  |  |  |
| Cost of environmentally-friendly goods | 0.665 |  |  |  |
| Cost of environmentally-friendly packages | 0.771 |  |  |  |
| Table 5. Constructs and measures of green and lean performance |  |  |
|  |  | Survey items | 1 | 2 |
| Reduction of air emissionReduction of waste waterReduction of solid wastesDecrease of consumption for hazardous/harmful/toxic materialsDecrease of frequency of environmental accidentsImprove an enterprise’s environmental situationSales improvementMarket share improvementEfficiency of production improvementReturn on revenue improvementReturn on investment improvementDeclining debt | 0.638 |  |
| 0.735 |  |
| 0.663 |  |
| 0.609 |  |
| 0.688 |  |
| 0.714 |  |
|  | 0.690 |
|  | 0.655 |
|  | 0.703 |
|  | 0.627 |
|  | 0.756 |
|  | 0.634 |

Items for each factor on green and lean practice, pressure and performance, as well as other descriptive data, including sample size, means and standard deviations per question, are presented in Tables 6, 7 and 8.

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| Table 6. Descriptive statistics for green and lean practices |
| **Survey items** | **Mean** | **S.D.** | ***N*** |
| *Mindset and attitude (α = 0.796)* | 3.61 | 0.876 | 155 |
|  Openness to learning | 3.84 | 0.973 | 160 |
|  Belief in the programmes and confidence in their success | 3.49 | 1.045 | 166 |
|  A firm’s culture and its results | 3.94 | 0.964 | 170 |
|  Required amendments in organisational culture | 3.17 | 0.934 | 169 |
| *Leadership and management (α = 0.809)* | 3.35 | 0.747 | 161 |
|  Dedication from senior management | 3.21 | 0.957 | 170 |
|  Strong leadership | 3.14 | 0.797 | 166 |
|  Clear communication of the revised vision | 3.48 | 0.890 | 168 |
|  Manager’s dedication to its implementation  | 3.61 | 0.854 | 171 |
| *Employee involvement (α = 0.817)* | 3.80 | 0.687 | 159 |
|  Skill and expertise  | 4.06 | 0.839 | 164 |
|  Dedication of the employees and resources of the entire firm | 3.65 | 0.856 | 161 |
|  Working within the green and lean principles as well as philosophy | 4.13 | 0.887 | 170 |
|  People have to get green and lean before organisations can | 3.39 | 0.818 | 172 |
| *Integrated approach (α = 0.850)* | 3.19 | 0.797 | 167 |
|  Holistic and targeted strategy for change | 3.08 | 0.812 | 169 |
|  Integrated green and lean operating system | 3.51 | 0.868 | 171 |
|  Use all the goals, methods, techniques and green and lean elements in combination | 2.97 | 0.974 | 170 |
| *Tools and techniques (α = 0.914)* | 3.67 | 0.774 | 166 |
|  Understands tools and techniques properly  | 3.76 | 0.836 | 168 |
|  Selection and application of appropriate tools and techniques | 4.10 | 0.829 | 170 |
|  Having the right tools and techniques in place | 3.31 | 0.917 | 171 |
|  Understand the organisations’ processes to apply the right tools and techniques | 3.52 | 0.958 | 167 |

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| Table 7. Descriptive statistics for pressure |
| **Survey items** | **Mean** | **S.D.**  | ***N*** |
| *Regulations (α =0.761)* | *4.11* | *0.695* | *160* |
| Control governmental environmental regulations | 4.26 | 0.853 | 172 |
| Regional environmental regulations | 4.02 | 0.863 | 165 |
| Export countries’ environmental regulations | 4.13 | 0.789 | 171 |
| Products potentially conflict with laws | 3.88 | 0.870 | 167 |
| *Market (α = 0.818)* | *4.09* | *0.701* | *161* |
| Export | 3.85 | 0.927 | 164 |
| Sales to foreign customers | 4.24 | 0.772 | 168 |
| Chinese consumers’ environmental awareness | 4.09 | 0.756 | 167 |
| Establishing company’s green image | 4.14 | 0.825 | 166 |
| *Suppliers (α = 0.677)* | *4.02* | *0.638* | *159* |
| Supplier’s advances in developing environmentally-friendly goods | 4.12 | 0.699 | 170 |
| Environmental partnership with suppliers | 3.93 | 0.750 | 164 |
| Supplier’s advances in providing environmentally-friendly packages | 4.06 | 0.802 | 168 |
| Making sure that suppliers will remain in business | 3.88 | 0.691 | 166 |
| *Internal factors (α = 0.701)* | *4.06* | *0.821* | *162* |
| Company’s environmental mission | 4.12 | 1.072 | 167 |
| Internal multinational policies | 4.08 | 1.198 | 170 |
| Potential liability for disposal of hazardous materials | 4.23 | 1.156 | 168 |
| Cost for disposal of hazardous materials | 3.99 | 1.093 | 165 |
| Cost of environmentally-friendly goods | 3.86 | 1.107 | 170 |
| Cost of environmentally-friendly packages | 4.05 | 0.984 | 172 |

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| Table 8. Descriptive statistics for environmental and business performance |
| **Survey items** | **Mean** | **S.D.** | ***N*** |
| *Environmental performance (α = 0.801)* | 3.75 | 0.891 | 155 |
| Reduction of air emission | 3.42 | 1.167 | 158 |
| Reduction of waste water | 3.38 | 0.919 | 164 |
| Reduction of solid wastes | 3.51 | 0.936 | 156 |
| Decrease of consumption of hazardous/harmful/toxic materials | 3.69 | 1.170 | 167 |
| Decrease of frequency of environmental accidents | 3.86 | 1.083 | 169 |
| Improve an enterprise’s environmental situation | 4.06 | 0.997 | 172 |
| *Business performance (α = 0.878)* | 3.53 | 0.862 | 164 |
| Sales improvement | 3.26 | 0.968 | 168 |
| Market share improvement | 3.79 | 1.187 | 171 |
| Efficiency of production improvement | 3.97 | 0.881 | 165 |
| Return on sales improvement | 3.61 | 1.193 | 172 |
| Return on investment improvement | 3.51 | 0.992 | 169 |
| Declining debt | 3.17 | 1.087 | 167 |

**4.0 FINDINGS AND DISCUSSION**

**4.1 Hypothesis testing**

To examine the hypotheses we conducted a comparison of the mean values of each of the factors identified by the analysis. H1 states that Chinese manufacturing organisations have implemented or initiated some green and lean practices. This hypothesis is partly supported by practices of green and lean mindset and attitude, leadership and management, employee involvement, integrated approach and tools and techniques (with mean values of 3.61, 3.35, 3.80, 3.19 and 3.67). H2 states that green and lean practices in Chinese manufacturing organisations lag behind the pressure that they have experienced. The results show that this hypothesis is supported (see Tables 6 and 7). All four green and lean pressure factors have mean values above 4.0, while five green and lean practice factors have mean values below 3.80. H3 states that Chinese manufacturing organisations experience pressure from a variety of sources to introduce and implement green and lean practices. Table 7 shows that all four mean values of the green and lean pressure factors are above 4.0 (which indicate ‘important’): that is, regulations (4.11), market (4.09), suppliers (4.02) and internal factors (4.06). Therefore, H3 is supported. H4 states that the implementation of green and lean practice in Chinese manufacturing organisations has enhanced their performance. This hypothesis is also supported by the factors of business performance (3.53) and environmental performance (3.75).

**4.2 Discussion**

Today, more and more Chinese manufacturing organisations have practical concerns about balancing green and lean in their businesses. As mentioned previously, understanding green and lean manufacturing has become a strategic priority for theory and practice, in order to gain sustainable competitiveness. This research clarifies how this may be done. The findings imply that Chinese manufacturing organisations need to raise awareness and become better educated in green and lean manufacturing. Specifically, the results show that some green and lean practices are at the forefront of implementation than others.

Mindset and attitude is fundamental to green and lean success. There must be total, long-term commitment to green and lean within the organisation. Clearly, the cognitive dimension is the key, and the concepts and tools must be learned, but they are not enough in themselves: many organisations have invested considerably in green and lean training programmes without ever seeing sustainable shop floor benefits. Some aspects of mindset and attitude have been well identified as the key to implementing green and lean practice successfully. In particular, this study’s findings demonstrate that the most significant items in green and lean mindset and attitude were ‘a firm’s culture and its results’ (with a mean value of 3.94), and openness to learning (with a mean value of 3.84).

Strategic commitment from leadership refers to a willingness to commit resources and continually invest in employees, and to promote a culture of green and lean. According to Rothenberg et al. (2001) nothing dampens commitment from shop floor employees faster than leadership and management not following through their commitment to green and lean practices. Without a deep understanding of underlying green and lean principles, leaders will be incapable of leading green and lean implementation, and unable to create such a culture. Management also needs to make sure that the right people are in the right positions, which requires an understanding of the kinds of employees that green and lean success requires. Our research findings show that leadership is significant in green and lean practices: in particular, they show that the manager’s dedication to implementation (3.61), and maintaining clear communication of the revised vision (3.48), are two major items among the others.

Successful implementation of corporate practices can be achieved only through the efforts made by an organisation’s employees. In addition, employee involvement can improve pollution control. For example, Dow Chemical has been able to reduce pollution and waste by encouraging employee involvement (Denton, 1999). This study identifies three ways in which employees can improve their organisation’s business and environmental performance. Our findings show that employee involvement is highlighted in implementation of green and lean practices. First, as a long-term approach, it requires a permanent commitment by employees. Thus, employees are required to be committed to change their way of thinking and doing things, to continuous learning and to discipline. According to Womack and Jones (2003), very different types of skills are demanded from those needed in non-green and non-lean forms of organisation. It is important for employees to have a deep understanding of the concepts underpinning green and lean – not just its tools and techniques. Thus, human capital development is at the very core of green and lean. It is employees who continuously improve products and processes. This involvement must be genuine and based on a deep appreciation of the fact that employees have a lot to offer. In particular, based on the empirical study, extra attention should be given to the items of understanding and working within the green and lean philosophy and principles (4.13), and employee skill and expertise (4.03) that employees may have in green and lean.

The vital to successful green and lean practice is the integrated nature of its methods and practices. The green and lean integrated approach is a helpful, emerging approach to improve organisations’ business performance by creating value for customers, continuous improvement and eliminating waste as a sustainable information integration practice (Kurdve et al., 2014). In addition, it can improve organisations’ environmental performance by reducing the impact of pollution and degrading (Alshuwaikhat and Abubakar, 2008). This research builds on the need for an integrated approach towards the alignment of structures and systems, which includes: the behaviours and infrastructure that support green and lean practices; the integration of green and lean practice with technologies; and the integration of green and lean practice with other business systems and programmes. Our findings demonstrate that an integrated approach plays an important role in green and lean practices, especially for the integrated green and lean operating system (3.51) and a holistic and targeted strategy for change (3.08). However, some researchers point out that the integrated approach does not bring significant environmental performance improvements (Franchetti et al., 2009). Further discussions with managers in Chinese organisations revealed that instead of adopting the entire green and lean approach, many organisations in China are seeking to implement only specific elements of green and lean to pursue instant improvements.

Tools and techniques have an important role in various industrial sections in China. Implementing green and lean tools and techniques is a proven method to improve business performance and beat the competition in today’s rapidly changing business environment. Moreover, some of them can be used to improve organisations’ environmental performance. For example, *kaizen* is a process of continuous improvement that creates a sustained focus on eliminating all forms of waste from a targeted process. Typically, the resulting continual improvement culture and process are very similar to those sought under environmental management systems, ISO 14001 and pollution prevention programmes. Therefore, it can be used to improve organisations’ environmental and business performance. Furthermore, the United States Environmental Protection Agency (2007) introduced a toolkit which can offer lean operational managers and environmental practitioners practical techniques to improve environmental performance, reduce business costs and risk, as well as identify and eliminate waste. Our findings show that tools and techniques are highlighted in green and lean practices. They also suggest that organisations have paid more attention to understand those tools and techniques properly (with a mean of 3.76) and apply the appropriate tools and techniques (with a mean of 4.10).

Besides, Table 7 shows that the sample data collected from Chinese manufacturing organisations demonstrate a broad set of pressures on the implementation of green and lean practices. All the items identified in the questionnaire survey seem to be important due to their high mean values: that is, all close to or above 4.00 (which means ‘important’). This indicates that the pressures from green and lean implementation are quite strong, and that managers in Chinese manufacturing organisations are well realised these pressures in order to deal with environmentally related problems. Overall, regulatory factor is the most important pressure based on the empirical study conducted, while pressures from the supply chain and internal factors are not as strong. Specifically, governmental environmental regulation is the one of the highest rated pressures (4.26), while the cost of environmentally-friendly goods is the pressure with the lowest mean value (3.86). This may indicate that managers in Chinese manufacturing organisations are not viewing environmental manufacturing as providing strong economic advantages.

In addition, from Table 8 it can be seen that the data collected from Chinese manufacturing organisations show various perceived performance implementations on green and lean practices. Based on the research findings, the largest influence of green and lean practices is the environmental performance measurement, with the more general ‘improve an enterprise’s environmental situation’ (mean value = 4.06). Overall, the business performance (3.53) received was not as good as environmental performance (3.75) received. For environmental performance, green and lean practices were considered to have a great impact on decrease of frequency of environmental accidents (3.86), reduction of consumption of hazardous materials (3.69), solid wastes (3.51), air emission (3.42) and waste water (3.38). However, green and lean practices may still have a hard time being accepted and implemented in Chinese manufacturing organisations if they are focusing on providing environmental benefits and less on the improvement of business performance, especially in beneficial ways. Therefore, without economic payback, it could be difficult for organisation managers to convince their top management team to implement green and lean practices and gain the strengths of the other benefits.

**5.0 CONCLUSION**

**5.1 Implications of the study**

As mentioned previously, the development and implementation of more efficient, environmentally-friendly practices has become necessary for organisations to gain sustainable manufacturing competitiveness in the 21st century (Yang et al., 2010). Chinese organisations have raised awareness about environmental concerns because of competition, regulatory factors, marketing drivers and pressures. For example, Chinese organisations are striving to promote their exporting ideologies by complying with global organisational regulations such as ISO 14001 standardisation and ISO 9000 certification. Similarly, they have looked to enforce different green and lean practices to enhance their environmental commitments, so as to respond to export standards and enable them to act as suppliers serving international clients from China. Environmental management within organisations – particularly dedication from top managers and assistance from middle-managers – is essential for the advancement of green and lean practices in China. This is similar to any manufacturing organisation’s involvement in any part of the world. Therefore, provision of educational programmes on the management of green and lean practice is one of the key requirements in this focus to create synergistic effects, or to reinforce their effect on sustainable competitiveness.

Moreover, this study extends the GSCM concept proposed by Zhu et al (2004), and provides further evidence to ascertain the vital practices of the green and lean paradigm within the supply chain context. In particular, GSCM is defined as the practice of monitoring and improving environmental performance within the supply chain context which only supports environmental sustainability across the supply chain (Zhu and Sarkis, 2004; Wang and Gupta, 2011). Therefore, GSCM is specifically centred on environmental activities involved across the supply chain (Gilbert, 2001; Sarkis, 2003). However, the green and lean practices identified in this study is a more generic and comprehensive term, not only supports environmental performance but also supports business and social sustainability through applying lean paradigm in managing supply chains. Thus, the notion of green and lean practices encompasses the inclusion of environmental considerations along with business performance within the supply chain management context.

Nevertheless, the findings of this study indicate that green and lean practices are still at an early stage of development in China. Chinese manufacturing organisations have identified its significance, although they have fallen behind in transforming these philosophies into action. It remains unclear what challenges are facing this transformation, although the lack of management competence, essential instruments and most probably an economic rationale for commitment, all may pose challenges. Thus, even with greater pressures for better environmental commitment in Chinese organisations, such knowledge has not transformed into strong enforcement of green and lean practices, let alone any enhancements anticipated in certain areas of commitment. It appears that the Chinese government has created new policies to encourage green and lean practices and other organisational environmental programmes primarily to export greater products and to encourage more international investment. To achieve both economic and environmental commitment, business investment should be developed by changing existing policies and developing infrastructure to assist in addressing loopholes. These are vital considerations which the legislators of the Chinese government should take into account.

**5.2 Limitations of the study**

It is important to recognise the limitations of this study. First, the data collected is from Chinese manufacturing organisations. As we have outlined, these organisations are only at a very early stage of adopting many green and lean practices, and have very different characteristics compared to organisations in other countries. The question of whether more mature organisations are having similar situations internationally requires to be further studied. Second, the validity of this research is limited due to difficult data collection. This research did not take a random sample of companies; rather, the sample was drawn from organisations with which the author had an existing relationship. Moreover, not all organisations responded to the questionnaires sent. These factors might affect or limit the validity of this thesis. Third, the five green and lean practice factors developed cannot be expected to be correct on all matters. They have been developed based on a limited review of the existing literature, and opinions from a limited number of experts based largely on their personal experiences of green and lean. Thus, although they represent a range of perspectives, more research and interviews with members of different companies (and companies owned in a different manner) could have led to a better, more concrete analysis of multi-variance. Given these limitations, the results of this research should be treated more as a general indication than organisational evidence.

**5.3 Recommendations for further research**

In spite of the insufficient study and unfamiliarity of green and lean practices in China, Chinese manufacturing and the Chinese government have created commitments to encourage greater development. After China became a member of the WTO, more international business organisations have created foreign direct investment in businesses or joint ventures in China. By promoting quality products and environmental reputation, Chinese manufacturing can collaborate with international business organisations in China by transforming into reliable suppliers to their international clients for long-term relationships. This is a plan which may enhance the economic and environmental impacts of the industry. Mutual benefits at organisational and country levels can be achieved if green and lean practices are sincerely put into account.

This study was a commitment made to examine green and lean practices in China. Therefore, the research and its findings are fact-finding in nature. Future studies can explore the extensive relationships pointed out in this study, and can help to reveal extensive trends in one of the biggest countries in the world – one which will have a genuinely international effect on the economic and environmental focus of society in the future. Moreover, further research needs to explore different relationships such as moderating and mediating relationships which may have impacts on performance, and other factors recognised in this study. Furthermore, although the pressures on the implementation of green and lean practices identified represent a range of perspectives, a greater number of researchers and interviews, from more companies, could have led to a better, more concrete multivariate analysis. Finally, more widely focused and random sample research throughout China would offer a comprehensive view of such commitments and what is happening across the country, not just in particular economic regions.

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