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Green Innovation Adoption in Automotive Supply Chain: The Malaysian Case

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Abstract

Green innovation has currently been receiving a great deal of international attention because of the growing concern of consumers, governments, and the community as a whole with regard to the degradation of natural resources and environmental pollution. The automotive sector is one of the leading generators of industrial waste that affect the quality of the natural environment. This study aims to investigate the determinants of green innovation adoption and its effect on firm performance. Data were gathered by surveying 153 firms in the Malaysian automotive supply chain industry. Data were analyzed using the partial least squares technique. Environmental regulations, market demand, and firm internal initiatives have a positive effect on green innovation initiatives (GII), while GIIs have a positive effect on the three categories of sustainable performance (i.e., environmental, social, and economic). These results have important implications for designing strategic plans for the Malaysian automotive industry.

Keywords: Green Innovation Initiative; Automotive Supply Chain; Sustainable Performance; Malaysia

1. Introduction

The automotive industry, with its supporting supply chain, is the largest industry in the world and employs more than 10% of the total workforce. With growing concerns about global warming and social issues, the automotive supply chain industry is confronted with increased pressure from stakeholders and regulatory agencies to achieve sustainability. As a developing nation, Malaysia increasingly emphasizes economic development while maintaining environmental and social protection. These pressures have created a challenge for companies to balance economic, environmental, and social performances (Shultz and Holbrook, 1999). Consequently, the Malaysian automotive industry and its supply chains seek to balance its economic, environmental, and social performances. For any company to survive these challenges, innovative strategies should be devised to ensure a sustainable competitive edge while satisfying all requirements from stakeholders and regulatory agencies (Olugo et al., 2011). Therefore, the automotive industry in developing countries, along with its supporting supply chain, has moved to adopt green innovations.
The Economist (2008) highlighted mass production, the Toyota production system, lean production, just-in-time, and modular consortium as important innovations from the production system perspective in the automotive industry over the last 30 years. A strong focus on these innovations has decreased costs, which has reduced prices and diluted market saturation and predatory price competition with low profit margins. Nevertheless, automotive companies cannot rely on these benefits alone as the rules of competition have changed (Katayama and Bennett, 1996), and the pressure to adopt environmentally friendly processes and green products is increasing. Therefore, green innovation is essential. However, the effect of green innovation initiatives (GII) on sustainable performance as core competencies of firms has not been paid much attention to and is rarely focused on in the automotive industry. This study investigates the effect of GII on sustainable performance (i.e., environmental, social, and economic) to fill this gap. In addition, several studies pertaining to the determinants of GII have been conducted in various industries, including logistics (Lin and Ho, 2008), manufacturing (Guoyou et al., 2013; Zhu et al., 2012), and IT (Wu, 2013). Nevertheless, the understanding of the determinants of GII that automotive companies should adopt remains a high-priority research issue (Chen et al., 2006), particularly in developing countries. To the best of our knowledge, market demand is the only factor that affects GII, according to previous studies conducted on the automotive industry (Huang et al., 2014). This study aims to explore the determinants of GII for firms in the automotive supply chain. These determinants should be fully understood to ensure that automotive managers could enhance green innovation adoption. Success in GII provides new opportunities for competition and “win-win” situations by lessening the environmental effect of automotive supply chain companies while improving their economic position.

2. Model conceptualization and hypothesis development

Kemp and Pearson (2008) defined green innovation as the production, assimilation, or exploitation of a product, production process, service, or management/business methods that is novel to the organization that develops or adopts them; it significantly reduces environmental risks, pollution, and other negative effects on resource use (including energy use) throughout its life cycle. Similarly, Wong et al. (2013) suggest that green innovation facilitates the reduction of the environmental impact of firms, which allows them to achieve eco-targets and incorporate environmental benefits. Green innovation aims to systematically align and implement this strategy throughout the supply chain from new product and service development to consumption (Jone et al., 2008).
Green innovation is classified into three main categories: green product innovation, green process innovation, and green management innovation (Chen et al., 2006; Chen, 2008). We examine green product and process innovation in the current study. Chen et al. (2006) identified green product innovation as the introduction of new or significantly improved products in response to environmental concerns (e.g., non-toxic raw materials, green design, energy savings, pollution prevention, waste recycling, and waste minimization). Green process innovation refers to modifying manufacturing processes and systems to produce environmentally friendly products that meet eco-targets (e.g., energy savings, pollution prevention, and waste recycling) (Meeus and Edquist, 2006; Kammerer, 2009).

The automotive industry has made remarkable contributions to the world economy and people’s mobility, but its products and processes are significant sources of environmental impact (Nunes and Bennett, 2010). Given that automobiles cause major environmental impacts upon use, the environmental impacts of the automobile manufacturing process should be explored (Keoleian et al., 1997; Graedel and Allenby, 1997). The application of environmental pressures reduces emissions and waste throughout vehicle production, use, and end-of-life. These pressures come in the form of stringent, complex, and costly regulations and demands from a growing number of stakeholders for improved environmental performance (Geffen and Rothenberg, 2000). Continuous innovation is vital to overcoming pressures from customers, competitors, and regulators (Porter and Van der Linde, 1995). In the past, most automotive companies considered environmental compliance an additional production cost instead of considering it a fundamental process to prevent negative environmental impacts. However, strict environmental regulations and environmentalists have changed the competitive rules and patterns for companies. The increasing costs of traditional modes of compliance and advances in material and process technologies have driven some automotive supply chain companies to adopt green innovative approaches to overcome environmental challenges (Richards and Pearson, 1998).

Several studies have been conducted on the determinants of GII. A summary of 25 studies on key determinants of GII is provided in Appendix I. The occurrences and percentages for each type of green innovation key determinants (Appendix I) are as follows: regulations (68%), market demand (40%), firm internal initiatives (68%), technological capability (8%), competitive advantage (8%), and customer benefit (4%). Regulations are the most studied, followed by firm internal initiatives and market demand. Therefore, these three factors are identified as the key determinants of GII and examined in the present study.
Numerous empirical findings confirm a positive relationship between green innovation and firm performance (Lau et al., 2010). Green innovation is closely associated with corporate environmental management and eco-target achievement; therefore, green innovation is widely believed to stimulate environmental performance (Chen et al., 2006; Kammerer, 2009). Green product and process innovation not only reduce negative environmental impact, but they also increase the economic and social performance of a company through waste and cost reduction (Kleindorfer et al., 2005). Companies implement green process innovation in the manufacturing process to shorten production time and reduce costs (Lambertini and Mantovani, 2009). In addition, a good product innovation improves market position, affirms brand name, leapfrogs competition, creates breakthroughs, and attracts new customers (Chandy and Tellis, 2000; Mu et al., 2009). Therefore, three performance types (i.e., environmental, social, and economic) are considered the benefits and outcomes of GII.

Figure 1 presents the proposed theoretical model to investigate the effect of the three identified key determinants of GII on Malaysian automotive supply chain companies. This study also investigates the effect of GII on environmental, economic, and social performances. The control variables selected for this framework are ownership, size, and ISO certification.

Figure 1. Proposed Theoretical Model
2.1. Environmental regulations

Environmental regulations include stringency, flexibility, realistic objectives or adequate timeframes for implementing innovative solutions, clear requirement specifications, and appropriateness to a country’s circumstances (Eiadat et al., 2008). Firms that belong to more regulated industries will tend to include more environmental issues in their management strategies than less regulated firms (López–Gamero et al., 2010). Porter and van der Linde (1995) claimed that strict environmental regulations and the associated compliance costs could force industries to adopt innovative measures to increase resource efficiency and enhance productivity. Government environmental regulations could overcome organizational inertia and cause organizations to accept new ideas, stimulate creative thinking, upgrade outdated facilities, and invest in technological improvements (Eiadat et al., 2008). According to other studies, environmental regulations significantly encourage firms to invest in non-polluting technologies and to consider environmental concepts for their products and processes (Fergusson and Langford, 2006; Blayse and Manley, 2004; Qi et al., 2010). Two recent studies that analyzed the effect of regulatory stringency on green innovation in Switzerland and Germany presented contradictory results: Although regulatory stringency positively affects green innovation in the chemical and pharmaceutical industry (Seijas–Nogareda, 2007), it has no such effect in the food and beverage industry (Engels, 2008). These conflicting findings may be due to industry characteristics, which makes investigating the effect of environmental regulations in various industries important. Therefore, the present study hypothesizes that

**H1**: Environmental regulations have a positive effect on GII in automotive supply chain companies.

2.2. Market demand

Market demand is a key to business success. For automotive companies to continuously respond to customer requirements and changing expectations, market orientation is essential (Kirca et al., 2005; Zhou et al., 2009). Zhou et al. (2005) stated that customers become sensitive and selective over time. Hence, firms should understand their target customers and anticipate their changing preferences to promptly meet market demand and gain competitive advantage (Desarbo et al., 2001; Zhou et al., 2009). Several studies conducted on the automotive industry observe an increasing trend in environmental concern among customers (Oltra and Jean, 2009; Lin et al., 2013) and emphasize the emergence of
“green customers.” Therefore, a green market forces automotive firms to produce and adopt innovative products and processes, respectively.

Green market demand is important in the spread of green innovation (Halila and Rundquist, 2011; Triebswetter and Wackerbauer, 2008). Chiou et al. (2011) identified an increasing number of environmentally conscious customers who prefer fuel-efficient and environmentally friendly products. Environmentally conscious customers demand innovative green products and are willing to pay high prices for green products (Chen et al., 2008). Consequently, green product and process innovation is profitable for automotive supply chain companies. Thus, the following hypothesis is developed:

**H2:** Market demand has a positive effect on GII in automotive supply chain companies.

### 2.3. Firms’ internal initiatives

According to a resource-based viewpoint, the internal characteristics of firms (e.g., strategy, structure, and core capabilities) are important determinants of innovation (Fagerberg et al., 2005). Resources are classified into tangible (e.g., financial reserves), intangible (e.g., reputation), and personnel (e.g., culture, training) (Barney, 1991). With regard to the innovation aspect, the most important asset of firms is its general commitment to innovation. R&D units are tools for solving organizational problems. R&D expenditure is a common proxy for and closely related to firm innovation activity (Sánchez, 1997). Rehfeld et al. (2006) indicated that R&D activities positively influence green product innovation. Technology accumulation, organizational encouragement, human resource quality, and top management support also influence the adoption of green innovation (Lin and Ho, 2008; Bansal, 2003). A company with high human resource quality (e.g., superior education or training) has high innovation ability. Top management is important in organizational support (Zailani et al., 2014). Therefore, top management is expected to develop the environmental innovation strategy of firms (Eiadat et al., 2008). Consequently, firm internal initiatives influence the adoption of green innovation. Hence, the following hypothesis is developed:

**H3:** Firm internal initiatives have a positive effect on GII in automotive supply chain companies.

### 2.4. Sustainable performance

Sustainability is important to organizations in the twenty-first century (Presley et al., 2007). Robins (2006) categorized sustainability into three primary components, which are often referred to as the triple bottom line: economic, social, and environmental. Organizations
are pressured by multiple stakeholders to achieve sustainable performance (McMullen, 2001). Organizations are becoming increasingly aware that choices made with regard to products and processes affect environmental and social performance (Sarkis, 2001). Thus, organizational decision makers are overwhelmed by a plethora of stakeholder issues, environmental agency pressures, and increased social consciousness from workers, consumers, and communities; these conditions should be balanced to ensure a reasonable return on investment and long-term enterprise viability for organizational stakeholders (Presley et al., 2007).

Pollution results from inefficient use of resources by automotive suppliers, and they can increase their productivity through green innovation to shoulder environmental costs (Chen et al., 2006; Porter and van der Linde, 1995). Porter and van der Linde (1995) argued that companies that pioneer green innovation have the first-mover advantage, which allows them to charge relatively high prices for their green products and obtain competitive advantages. Moreover, firms that apply environmental management not only avoid the hassle of protests or penalties regarding environmental protection, but also improve their corporate image, develop new markets, and increase their competitive advantages (Presley et al., 2007). Moreover, companies could innovatively embody the green concept in their products and processes to differentiate their products from competitors (Chen et al., 2006; Hart, 1995; Porter and van der Linde, 1995). Hence, the following hypotheses are developed:

**H4:** GII has a positive effect on economic performances of automotive supply chain companies.

**H5:** GII has a positive effect on environmental performances of automotive supply chain companies.

**H6:** GII has a positive effect on social performances of automotive supply chain companies.

2.5. Control variables

This study considers the following variables, which may affect the results of the study: firm ownership, number of employees (firm size), and ISO certification status. These variables are chosen because they have significant effects. Large firms are more innovative than small firms because the former has more resources and capital than the latter (Lee and Ging, 2007; Damanpour, 1996). Firm ownership (local or foreign) also influences innovation but not for small and medium enterprises (Lee and Ging, 2007). Firms with ISO certification are more involved in green initiatives than firms without ISO certification because of the required certification standards.
3. Research methodology

3.1. Measure of constructs

This study employed a quantitative survey with a structured questionnaire. The questionnaire had five sections with a total of 53 items: company basic information, GII (green product and process innovation), determinants of GII (regulations, marketing demand, and firm internal initiatives), sustainable performance (environmental, economic, and social performances), and respondents’ personal information. Except for basic company information and respondents’ personal information, the items were measured by using the 5-point Likert scales anchored by “strongly disagree” and “strongly agree.” The items were adapted from previous studies to ensure content validity. The scale for environmental regulation was adapted from Eidat et al. (2008), Eltayeb et al. (2010), Lin and Ho (2008), and Zhu et al. (2007); the scale for market demand and firm internal initiatives was adapted from Horbach (2008), Michel et al. (2001), Kammerer (2009), Lin and Ho (2008), and Eidat et al. (2008); the scales for green product and process innovation were measured using items based on Chen et al. (2006); and the scale for economic, environmental, and social performance was adapted from Rao (2002), Chen et al. (2006), Zhu et al. (2007), Kassinis and Soteriou (2003), and Carter (2005).

3.2. Data collection and the sample

The sampling frame consists of all firms in the Malaysian automotive supply chain industry, which includes firms that produce raw materials, components, vehicles, and spare parts. This study focuses on the Malaysian automotive industry for the following reasons: (1) the automotive industry with its supporting supply chain is one of the most important, strategic, and fast-growing industries in Malaysia. The huge potential effect of GII on sustainable performance of automotive companies makes investigating the determinants of GII necessary; (2) the automotive industry is one of the main pollution sources in Asia; and (3) several automotive companies worldwide take advantage of component manufacturers in Asia to benefit from low production costs. The successful implementation of GII allows component manufacturers to attract additional international automotive companies.

The sampling list is obtained from the website of the Malaysian Automotive Association. Malaysia currently has four passenger and commercial vehicle manufacturers, namely, Proton, Perodua, Naza, and Modenas. Moreover, the country has nine motor vehicle assemblers and 343 components or parts manufacturers. The total number of firms on the list
is 356. Given our small sampling frame and low response rate from the mail survey (Sekaran, 2003), the survey questionnaire was sent to all firms.

This study targeted engineers, manufacturing managers, operation managers, production managers, quality managers, executive directors, and managing directors of Malaysian automotive companies; they were chosen as our respondents because they are directly involved in the process, which makes them knowledgeable and experienced in all operations and activities in their respective companies. The survey was conducted using a structured mail questionnaire directed to the corresponding respondent in each firm. A total of 153 usable responses were received out of the 356 distributed questionnaires.

3.3. Analysis

The casual relationships between constructs were analyzed through structural equation modeling (SEM). SEM analysis was chosen over regression analysis, because SEM can analyze all paths in a single analysis (Gefen et al., 2000; Hair et al., 2013). Partial least squares (PLS) approach was selected because of its small size requirements and the exploratory nature of the research (Hair et al., 2011). SmartPLS M3 Version 2.0 (Ringle et al., 2005) was used for the analysis. The sample size of 153 exceeded the minimum sample requirements recommended by Wixom and Waston (2001). According to the procedure of Hulland (1999), PLS is analyzed and interpreted in two stages. In the first stage, the measurement model has to be tested by performing validity and reliability analyses on each measure to ensure that only reliable and valid construct measures are used prior to making conclusions about the nature of construct relationships (Hulland, 1999). In the second stage, the structural model is tested by estimating the paths between model constructs to determine their significance and the predictive ability of the model.

4. Results

4.1. The sample

The discriminant analysis shows that 41.2% of the respondent firms are locally owned, 36.6% are foreign based, and 22.2% are joint ventures (local and foreign). For the ISO certification status, 92.2% of the respondent firms are ISO certified, and 7.8% are not ISO certified. Common ISO certifications in the Malaysian automotive supply chain are ISO/TS16949, ISO14000, and ISO9001. An examination of the number of employees indicates that respondents are mostly large companies with more than 200 employees.
(75.2%), and more than half of the firms have annual sales turnovers of more than RM200 million (65.4%).

4.2 Common method variance

According to Podsakoff and Organ (1986), common method bias is problematic when a single latent variable accounts for the majority of the explained variance. The unrotated factor analysis results indicate that the first normalized linear combination explains only 28.55% of the total 82.62% variance, which proves that common method bias is not a serious problem in the study.

4.3. Measurement Model Results

The reliability and validity of the reflective constructs were assessed. Composite reliability (CR) is assessed in connection with internal reliability, which is similar to Cronbach’s alpha. Table 1 shows that CR of all constructs was above 0.7, which satisfies the rule of thumb in Hair et al. (2013). Hair et al. (2010) suggested accepting items with loadings of at least 0.6. Given that the loadings associated with each scale were all greater than 0.6, individual item reliability was reasonably judged. Convergent validity was evaluated using average variance extracted (AVE). The AVE of all constructs was above 0.5, which signifies a satisfactory degree of convergent validity (Fornell and Larcker, 1981).

Table 1
Measurement Model Evaluation.

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Items</th>
<th>Factor Loadings</th>
<th>CR</th>
<th>AVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Regulations (ER)</td>
<td>5</td>
<td>0.675 - 0.840</td>
<td>0.890</td>
<td>0.619</td>
</tr>
<tr>
<td>Marketing Demand (MD)</td>
<td>5</td>
<td>0.655 - 0.937</td>
<td>0.904</td>
<td>0.659</td>
</tr>
<tr>
<td>Firms’ Internal Initiatives (FII)</td>
<td>6</td>
<td>0.765 – 0.967</td>
<td>0.936</td>
<td>0.712</td>
</tr>
<tr>
<td>Green Product Innovation (GPI)</td>
<td>4</td>
<td>0.847 – 0.926</td>
<td>0.937</td>
<td>0.790</td>
</tr>
<tr>
<td>Green Process Innovation (GPOI)</td>
<td>4</td>
<td>0.841 – 0.925</td>
<td>0.925</td>
<td>0.756</td>
</tr>
<tr>
<td>Economic Performance (ECP)</td>
<td>5</td>
<td>0.776 – 0.911</td>
<td>0.932</td>
<td>0.733</td>
</tr>
<tr>
<td>Environmental Performance (ENP)</td>
<td>6</td>
<td>0.801 - 0.956</td>
<td>0.944</td>
<td>0.737</td>
</tr>
<tr>
<td>Social Performance (SP)</td>
<td>6</td>
<td>0.774 – 0.954</td>
<td>0.930</td>
<td>0.689</td>
</tr>
</tbody>
</table>

CR= Composite Reliability; AVE= Average Variance Extracted
Two approaches were used to assess the discriminant validity of constructs. First, the cross loadings of indicators were examined. No indicator loads were higher than an opposing construct (Hair et al., 2012). Second, according to the Fornell and Larcker (1981) criterion, the square root of AVE for each construct should exceed the intercorrelations of the construct with other model constructs (Table 2). Both analyses confirmed the discriminant validity of all constructs.

Table 2 shows that although Malaysian automotive supply chain companies have experienced great pressure from market demand (mean = 3.90), a lack of pressure has been observed from environmental regulation (mean = 3.24). Automotive companies have good internal initiatives, including environmental management system, top management support, and R&D budget allocation (mean = 4.00), which support the development of green product and process innovation. Although the green product innovation rate is satisfactory (mean = 3.75), the green process innovation rate lags (mean = 3.35). Finally, all sustainable performances are high among automotive companies.

Table 2
Discriminant Validity Coefficients.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>ER</th>
<th>MD</th>
<th>FII</th>
<th>GPI</th>
<th>GPOI</th>
<th>ECP</th>
<th>ENP</th>
<th>SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>ER</td>
<td>3.239</td>
<td>0.759</td>
<td>0.787</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MD</td>
<td>3.898</td>
<td>0.613</td>
<td>0.235</td>
<td>0.812</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FII</td>
<td>3.995</td>
<td>0.755</td>
<td>0.024</td>
<td>0.049</td>
<td>0.833</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPI</td>
<td>3.748</td>
<td>0.863</td>
<td>0.479</td>
<td>0.299</td>
<td>0.409</td>
<td>0.889</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPOI</td>
<td>3.575</td>
<td>0.789</td>
<td>0.280</td>
<td>0.386</td>
<td>0.277</td>
<td>0.096</td>
<td>0.869</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECP</td>
<td>3.644</td>
<td>0.833</td>
<td>0.260</td>
<td>0.166</td>
<td>0.310</td>
<td>0.458</td>
<td>0.323</td>
<td>0.856</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENP</td>
<td>3.833</td>
<td>0.866</td>
<td>0.362</td>
<td>0.293</td>
<td>0.127</td>
<td>0.242</td>
<td>0.569</td>
<td>0.171</td>
<td>0.858</td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>3.857</td>
<td>0.699</td>
<td>0.069</td>
<td>0.436</td>
<td>0.224</td>
<td>0.441</td>
<td>0.264</td>
<td>0.287</td>
<td>0.382</td>
<td>0.830</td>
</tr>
</tbody>
</table>

The reflective-reflective second-order construct of GII is characterized by green product and process innovation. We assign all indicators from first-order to second-order constructs using the repeated indicators approach to establish the second-order constructs. Table 3 shows that the same measurement model evaluation criteria is applied to the GII construct, and validity and reliability are well established.
Table 3
Second-order Construct Evaluation.

<table>
<thead>
<tr>
<th>Factor Loadings</th>
<th>CR</th>
<th>AVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Product Innovation</td>
<td>0.773</td>
<td>0.708</td>
</tr>
<tr>
<td>Green Process Innovation</td>
<td>0.706</td>
<td></td>
</tr>
</tbody>
</table>

4.4. Assessment of the structural model

The measurement model had satisfactory results, and the structural model was evaluated subsequently. The predictive accuracy of the model was evaluated in terms of the explained variance portion. The results suggest that the model is capable of explaining 60.6% of the variance in GII, 28.6% in economic performance, 28.6% in environmental performance, and 23.4% in social performance. Aside from estimating the magnitude of $R^2$, predictive relevance developed by Stone (1974) and Geisser (1975) is included as additional model fit assessments. This technique indicates the ability of the model to predict the manifest indicators of each latent construct. Stone–Geisser $Q^2$ (cross-validated redundancy) was computed to examine predictive relevance using a blindfolding procedure in PLS. Following the guidelines of Chin (2010), $Q^2$ value greater than zero implies that the model has predictive relevance. The present study obtained 0.213 for average cross-validated redundancy (for all endogenous variables), which is far greater than zero. Thus, the model exhibited acceptable fit and high predictive relevance. Nonparametric bootstrapping was applied (Wetzels et al., 2009) with 5,000 replications to test the structural model. Table 4 presents the structural model that resulted from PLS analysis. All paths were significant, and the hypotheses were supported. The strength of the effect of determinants on GII was investigated by the effect size ($f^2$) (Hair et al., 2013). A notable detail is that the internal initiatives of firms have the highest effect on GII ($f^2 = 0.465$), followed by environmental regulations ($f^2 = 0.414$), and marketing demand ($f^2 = 0.218$).
Table 4
Path coefficient and hypothesis testing.

<table>
<thead>
<tr>
<th>Relationships</th>
<th>Path Coefficient</th>
<th>Std. deviation</th>
<th>t-value</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>ER -&gt; GII</td>
<td>0.448</td>
<td>0.097</td>
<td>4.612***</td>
<td>Supported</td>
</tr>
<tr>
<td>MD -&gt; GII</td>
<td>0.314</td>
<td>0.080</td>
<td>3.938***</td>
<td>Supported</td>
</tr>
<tr>
<td>FII -&gt; GII</td>
<td>0.455</td>
<td>0.097</td>
<td>4.697***</td>
<td>Supported</td>
</tr>
<tr>
<td>GII -&gt; ECP</td>
<td>0.535</td>
<td>0.100</td>
<td>5.332***</td>
<td>Supported</td>
</tr>
<tr>
<td>GII -&gt; ENP</td>
<td>0.535</td>
<td>0.101</td>
<td>5.325***</td>
<td>Supported</td>
</tr>
<tr>
<td>GII -&gt; SP</td>
<td>0.484</td>
<td>0.077</td>
<td>6.268***</td>
<td>Supported</td>
</tr>
</tbody>
</table>

Control Variables

<table>
<thead>
<tr>
<th>Relationships</th>
<th>Path Coefficient</th>
<th>Std. deviation</th>
<th>t-value</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm Size -&gt; GII</td>
<td>-0.027</td>
<td>0.068</td>
<td>0.395</td>
<td>-</td>
</tr>
<tr>
<td>ISO -&gt; GII</td>
<td>-0.142</td>
<td>0.078</td>
<td>1.816*</td>
<td>-</td>
</tr>
<tr>
<td>Ownership -&gt; GII</td>
<td>0.011</td>
<td>0.074</td>
<td>0.147</td>
<td>-</td>
</tr>
</tbody>
</table>

* t values are computed through bootstrapping procedure with 153 cases and 5000 samples
** *p<0.05, **p<0.01 (one tail)

5. Discussion and implications

According to a literature review, the Malaysian automotive supply chain is still in its developing stages and has significant negative environmental impacts. Therefore, GII should be pursued aggressively to accommodate the current environmental situation. Green innovation is a good approach for the automotive supply chain to adopt. Understanding the determinants of GII is essential to automotive supply chain firms. Some studies have examined the motivation and driving forces of GII but do not focus on the automotive supply chain industry. Thus, this study investigates the determinants of GII. The benefits of adopting GII in manufacturing firms have been explained to some extent. However, some managers remain unconvinced in adopting green innovation. Thus, this study determines the potential positive effects of GII on simultaneous firm economic, social, and environmental performances. Several motivations drive automotive supply chain companies to adopt green innovation. Environmental regulations, marketing demands, and firm internal initiatives are the major factors that positively affect the adoption of green innovation by Malaysian automotive supply chain firms.
Our findings on the relationship between environmental regulation and GII are consistent with those of Fergusson and Langford (2006) and Qi et al. (2010), who found that stringent environmental regulations may promote green innovation. The Malaysian national automotive policy has not taken action with regard to the environmental impact of the automotive industry development. Directives or legislations on end-of-life vehicles for the automotive industry have yet to be established (Amelia et al., 2009). Therefore, the Malaysian government should set environmental regulations with stringent standards for the automotive industry. Market demand is also an important factor for green innovation adoption, a finding that agrees with that of Lin et al. (2014); a positive relationship exists between market demand and GII for automotive companies in Taiwan. Malaysian customers’ concern about environmental issues has increased dramatically. In addition, with the increasing petrol prices in Malaysia, petrol consumption will play an important role in the selection of a new vehicle. Automotive companies that align these requirements with innovative green products and processes meet customer demand well and outperform their competitors. The internal initiatives of firms are also significantly related to GII. The successful implementation of GII is assured with adequate technology, human capital, environmental management systems, practices, and tools to support green innovation.

The results also showed that firms support the principles of institutional theory and respond to external influences, such as regulations and market demand, in their adoption of GII, although they do so in different manners. Overall, the study found that coercive pressure (regulations) influences, more than normative (market demand) ones, suggest that more stringent environmental regulations improve the adoption of green innovation initiatives. Generally speaking, this finding is consistent with a previous study on the importance of environmental regulation (especially monitoring and enforcement) in GII (Qi et al., 2010; Kammerer, 2008, 2009; Eiadt et al., 2008). Among the three determinants, the internal initiative of firms has the greatest effect on GII. Internal resources significantly induce firms to initiate green innovation and gain advantage over other firms. Market demand and environmental regulations do not promote GII without adequate internal initiatives. A company with high-quality professional development, such as better education or training, will be more capable of green innovation (Lin and Ho, 2008).

The literature highlights several benefits that can arise from integrating green innovation into product development and business processes: increased efficiency in the use of resources, return on investment, increased sales, development of new markets, improved corporate image, product differentiation, and enhanced competitive advantage (Fraj–Andre et
Chen et al. (2006) found that the performance of both green product and green process innovation is positively correlated to competitive advantage. The present study observed that GII significantly affects the environmental, economic, and social performance of automotive companies. This finding indicates that the adoption of green product and process innovation allows Malaysian automotive supply chain companies to improve their economic, social, and environmental performance. The results suggest that GII may lead to a win-win situation so that the environmental, social, and economic performances of firms improve simultaneously. Companies should design green innovative products and adopt green innovative processes to achieve sustainable development. The implication of this finding for automotive firms’ managerial groups is the discovery that the practice of green innovation in the firms’ environment can obtain an economic advantage for the firms. This condition will help to improve the competitive advantage of the firms in the market and at the same time contribute to their environmental and social performance, which will further help to improve the image and reputation of firms.

In terms of theoretical contribution, this study is the first to investigate the determinants of GII in the Malaysian automotive supply chain industry. This sector is particularly important because it is a fast-growing industry with a significant effect on the environment. Although a few studies have explored the effect of GII on environmental and economic performances of automotive companies, the effect of GII on social performance has rarely been investigated. Social image is essential to companies to improve their market position, affirm the reputation of their brand, and attract customers.

This study provides several implications for policymakers and managers in the automotive supply chain industry. Recognizing the determinants of GII will help policymakers to understand the factors that lead to green innovation adoption in the automotive supply chain industry. Consequently, they could adjust their strategies and policies to motivate automotive company managers to adopt green innovation. Moreover, this understanding can help managers successfully promote GII in their companies. This study also identifies the significance of the effect of GII on sustainable performance. Thus, the study advances knowledge on the benefits of GII adoption for managers of automotive companies.
6. Limitations and future studies

This study has certain limitations that should be taken into account prior to generalizing its results. First, the study tested and verified the hypotheses using a questionnaire survey but provided only a cross-section of the study in nature. Therefore, this approach limits the ability to imply causality in the relationships among variables. Thus, the survey results are affected by the fact that this study cannot observe the dynamic changes of green innovation in the development process of the automotive logistic industry in Malaysia. A longitudinal study that examines the relationships for an extended period of time should be performed to provide precise results. Furthermore, the sample population is limited to the automotive supply chain. Other industries that wish to apply the findings of this study should be conscious of the effect of determinants and performances, which may vary with the types of industries. This study also used a survey sample limited to the Malaysian automotive supply chain. However, the maturity of a certain technology and decision process for adopting a technology may vary between countries. Future research should test the research model in different industries and countries. The study should also be conducted in different regions of the country for data comparison and to obtain additional information.

References


Engels, S., 2008. Determinants of Environmental Innovation in the Swiss and German Food and Beverages Industry - What Role does Environmental Regulation Play?. ETH Zurich, Zurich, Switzerland.


Seijas-Nogareda, J., 2007. Determinants of Environmental Innovation in the German and Swiss Chemical Industry - With Special Consideration of Environmental Regulation. ETH Zurich, Zurich, Switzerland.


Appendix I
Summary of literature on determinants for Green Innovation Initiatives.

<table>
<thead>
<tr>
<th>No</th>
<th>Author</th>
<th>Year</th>
<th>RG</th>
<th>MD</th>
<th>FII</th>
<th>TC</th>
<th>CA</th>
<th>CT</th>
<th>CB</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Qi et al.</td>
<td>2010</td>
<td></td>
<td></td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>Kammerer</td>
<td>2009</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Oltra and Saint Jean</td>
<td>2009</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Chen</td>
<td>2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Kammerer</td>
<td>2008</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Eiadat et al.</td>
<td>2008</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>7</td>
<td>Horbach</td>
<td>2008</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
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</tr>
<tr>
<td>8</td>
<td>Ibrahim et al.</td>
<td>2008</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Lin and Ho</td>
<td>2008</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Triebswetter and Wackerbauer</td>
<td>2008</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Beerepoot and Beerepoot</td>
<td>2007</td>
<td></td>
<td></td>
<td>√</td>
<td></td>
<td></td>
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<tr>
<td>12</td>
<td>Frondel et al.</td>
<td>2007</td>
<td>√</td>
<td>√</td>
<td>√</td>
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<tr>
<td>13</td>
<td>Bernauer et al.</td>
<td>2007</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
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<td>14</td>
<td>Chen et al.</td>
<td>2006</td>
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<td></td>
<td></td>
<td>√</td>
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<td>2006</td>
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<td>√</td>
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<td>16</td>
<td>Lee et al.</td>
<td>2006</td>
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<td></td>
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<td>17</td>
<td>Rehfeld et al.</td>
<td>2006</td>
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<td></td>
<td></td>
<td></td>
<td>√</td>
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<tr>
<td>18</td>
<td>Fagerberg et al.</td>
<td>2005</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>19</td>
<td>Roediger-Schluga</td>
<td>2004</td>
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<tr>
<td>20</td>
<td>Del Brío and Junquera</td>
<td>2003</td>
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<tr>
<td>21</td>
<td>Scupola</td>
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<tr>
<td>22</td>
<td>Jaffe et al.</td>
<td>2002</td>
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<tr>
<td>23</td>
<td>Dyllick and Hamschmidt</td>
<td>2000</td>
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<td>24</td>
<td>Kemp et al.</td>
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<table>
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<tr>
<th>Number of Occurrences</th>
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<th>11</th>
<th>5</th>
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<tr>
<td>Overall Occurrences Percentage (%)</td>
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<td>40</td>
<td>44</td>
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<td>8</td>
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</tbody>
</table>

Note: “√” indicates the study have mentioned directly or indirectly the usage of Green Innovation Initiatives. Determinants: RG=Regulations; MD=Market Demand; FII=Firm Internal Initiative; TC=Technology Capabilities; CA=Competitive Advantage; CB=Customer Benefit