

Article

Barriers of Biodiesel Adoption by Transportation Companies: A Case of Malaysian Transportation Industry

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Abstract: The need to develop an alternative fuel to fossil fuel is growing day by day, especially for the transportation industry, as the supply of fossil fuels is limited and is depleting at a rapid rate. One available resource that has emerged recently is biodiesel. However, the usage of biodiesel is very low among transportation companies. An investigation into the barriers of adopting biodiesel by transportation companies is the focus of the present study. A survey of 147 transportation companies in Malaysia was undertaken, and the data gathered were analyzed using partial least squares technique. Lack of government support, lack of environmental–commercial benefits, and lack of competitive pressure were found to be the barriers to biodiesel adoption. The results also indicated that differentiation strategy moderates the impact of lack of government support, lack of customer demand, lack of environmental-commercial benefits and lack of competitive pressure on biodiesel adoption. The results of this study could benefit policy makers by providing them key focus areas in which they can modify their strategies to actively and successfully promote the use of biodiesel among transportation companies in developing countries.

Keywords: biodiesel adoption; transportation; barriers; differentiation strategy

1. Introduction

There is now a worldwide awareness of the increasing level of greenhouse pollution that has occurred due to the use of fossil fuels. The increasing gap between the required energy of the industrialized world and the limited source of energy from such fossil fuels has caused the energy crisis. The transportation industry is widely viewed as one of the main sources of pollution among energy consumers [1]. For example, the transportation industry was the second most polluting sector in the USA in 2014 [2]. At the global level, in 2014, transportation produced 14% of the world's total pollution and was the fourth most polluting industry [3]. The substantial contribution of large transport vehicles to air pollution and other gaseous or airborne pollutants has become an important issue due to the increase in CO₂ emissions, which accelerate global warming [4]. By reducing the amount of pollution caused by the transport sector, a significant reduction in climate change and acid rain is expected [5]. Currently, fossil fuels provide around 98% of the total energy consumed in the transportation sector [6]. In this regard, the consumption and usage of alternative fuels that are environmentally friendly, such as biofuels, solar power, and fuel cells, have been proposed as

a strategy for tackling the significant effect of fossil fuel consumption on the environment. Biofuel is one of the potential alternatives to gasoline that can reduce the emission level of pollutants and has attracted both researchers' and policy makers' attention.

Biofuel refers to solid, liquid, or gaseous fuels which are made from bio-renewable feedstocks [7]. Biodiesel and bioethanol are two liquid types of biofuel that can be used as substitutes for gasoline. Biodiesel can be produced from various food crops including sugarcane, grains, corn, potatoes, and sorghum. It can also be produced directly from vegetable oils, both edible and non-edible, recycled waste vegetable oils, and animal fat [5,6]. These sources are seen as feasible alternatives of fossil fuels based on their abundance worldwide and their low cost [8,9]. Biofuel is the most attractive and practical alternative to fossil fuels due to its similarity to fossil fuels in terms of energy and chemical structure and also due to its wide range of available feedstocks and lower emission of greenhouse gases [10]. For oil importing developing countries, biofuels promise new economic opportunities for the rural population. The advantage of indigenous resources as a basis for renewable energy sources is that they can potentially provide energy services with no or very low emissions of air pollutants and greenhouse gases [11]. According to Gui et al. [12], currently, edible oil is the source of more than 95% of biodiesel. In fact, with biofuel use, both demand and prices for agricultural products would increase, thus revitalizing the economy. As such, several non-governmental organizations (NGOs) around the world have expressed harsh criticism of the use of vegetable or edible oil in the biodiesel industry at the expense of the millions of people facing hunger and starvation worldwide [13]. However, countries which adopt biofuels can reduce dependence on imported petroleum and hence lessen the associated political and economic vulnerability to the international market [10,11]. The benefits are thus far-extending to countries which opt for biofuels, including sustainability, reduction of greenhouse gases, regional development through increased use of local products, agricultural development, and finally, security of oil supply [14]. The global prominence of this issue rests on the fact that developing a clean fuel is of great importance to many countries, especially a source of energy which is easily available, healthy for the environment, and technically feasible [15,16].

Considering the air pollution and global warming issues, the significant role of the transportation industry in air pollution and consumption of limited fossil fuels, and biofuel importance as a clean and sustainable energy source, there has been considerable research from the engineering side on the production processes of biofuels [17,18]. Indeed, research shows that the obstacles to the development of the biofuel industry are not of a technical nature, but rather are due to non-technical problems [19,20] such as management issues.

Studies on biofuel from a management perspective can be categorized into two main streams. In the first stream of research, biofuel supply chain management has been studied [21,22]. The second stream of research has focused on the drivers of biofuel adoption [23–25]. However, these studies have investigated the drivers from the perspective of the customers and not the firm. For example, Moon et al. [23] investigated the effects of individual traits, retailer choice attributes and message framing on customers' intentions to adopt biofuel.

Europe has planned to increase the share of biodiesel in the transport sector's energy consumption to 10% in 2020 from 5.1% in 2012 [26]. As the adoption of biodiesel is relatively low in transportation industry and there is little or no research on adoption of biodiesel from a management point of view, the present study seeks to investigate the barriers of biodiesel adoption in transportation industry. The study can enable researchers to gain insight into the issues involved in the adoption of biodiesel in the transportation industry, as well as provide significant practical benefits to the transportation companies who might be encouraged to adopt biodiesel in future and to society in general.

There are various typologies in the strategy field to describe the ways in which firms compete in a specific industry [27]. The focus of all typologies [28–30] is based on two main strategies, namely cost leadership and differentiation. According to Porter [29], in order to develop a competitive advantage, firms should pursue any of these competitive strategies. Previous studies have shown that the differentiation strategy plays an important role in adopting environmental or socially-related

practices [31]. Despite its importance, little or no research exists considering how a differentiation-based strategy can moderate the impact of barriers on adoption of green practices, especially biofuel. It is important to bear in mind that strategies of companies which are focused on differentiation are totally different from the ones that compete based on cost leadership [29]. In view of a rapid rise in global competition, focusing on the role of differentiation strategy may help to highlight the importance of barriers in adopting biodiesel, especially in the key transportation industry.

Considering the abovementioned gaps in the literature, this study aims to investigate the barriers to biodiesel adoption by transportation firms by considering the differentiation strategy as a moderator. The rest of the paper is organized as follows: in Section 2, the model will be conceptualized and hypotheses will be supported by related literature. Later, the methodology of the study will be discussed in Section 3. The validity and reliability of the variables will be evaluated in Section 4 and hypotheses will also be tested in this section. Finally, the discussion and conclusions of the study will be provided in Section 5.

2. Conceptualization and Hypotheses Development

Currently, the major obstacle to the commercialization of biodiesel is apparently the high cost factor [32,33], with raw materials the main cost [34]. More specifically, the raw material cost has been estimated by Zhang et al. [35] to be from 70–95% of the total production cost of biodiesel, and from 70%–85% by Meng et al. [36]. Calculating the actual production cost of producing vegetable oil for fuel in developing countries depends on the local cost of land and labor. For example, an annual production rate of 4–5 tons of palm oil per hectare is estimated [37], however, to compare palm oil and mineral oil production in absolute economic terms is difficult given the regional variations among countries.

The importance of palm oil as the second most traded vegetable oil crop worldwide, after soy, is noteworthy. It is crucial to the economies of Malaysia and Indonesia, with over 90% of the world's palm oil exports being sourced from these two countries [38]. Mainly used in manufacturing food products, palm oil has recently emerged as an ingredient in biodiesel and as a fuel for generating electricity. With the prospect of these new uses for palm oil, a rise in its global demand is seen as very likely [39]. Malaysia depends heavily on palm oil as a source for biodiesel production. However, while crude petroleum oil prices are low, low crude palm oil prices are not a viable option in the free market economy. In addition, the Malaysian government continues to heavily subsidize fossil fuels [39], making it difficult to compete with petroleum-derived diesel in the near future [40]. According to Mohammadi et al. [41], the Malaysian government's efforts to promote the usage of biofuel and expand its market both nationally and internationally have not been successful due to the high price of crude palm oil and delays in the implementation of a biodiesel blend policy. The unfavorable market conditions of biofuel, such as its price and lack of government support, have had a negative effect on customer demand [41]. According to previous studies, government support [42,43], customer demand [42,44], environmental–commercial benefits [43,45], and competitive pressure [46,47] are important factors in motivating firms to adopt environmentally friendly practices. Hence in this study, lack of government support, lack of customer demand, lack of environmental commercial benefits, and lack of competitive pressure are proposed as potential barriers of biofuel adoption. Figure 1, illustrates the conceptual framework of the study. In addition to the four mentioned barriers, we propose that differentiation strategy moderates the impact of these barriers to biodiesel adoption. The following sections provide a brief review of the literature pertaining to each barrier. In addition, research propositions suggested by the literature are offered.

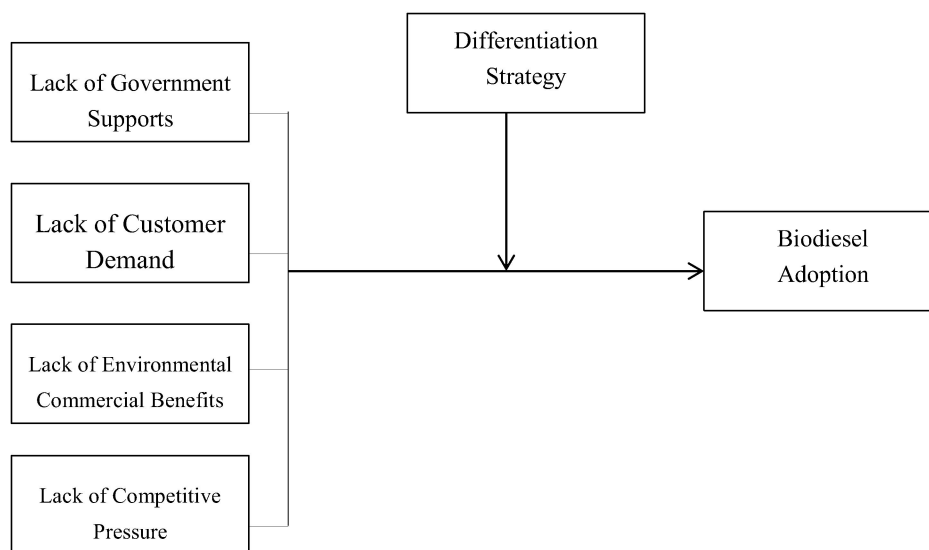


Figure 1. Conceptual framework.

2.1. Lack of Government Support

To promote the usage of biofuel, various countries have implemented legal acts to encourage its use [18]. Pukalskas et al. [48] highlighted the legal acts of the European commission as a reason for the expansion of biofuels usage in recent years. In 2006, Malaysia launched a biodiesel policy for the first time, aiming to address energy shortages and environmental issues [49]. Mandatory biodiesel blending was enforced in June 2011. Furthermore, the Malaysian government promoted an intervention plan which consisted of allocations of cash up to RM 300 million as well as various incentives to support the biodiesel program [50]. The aim of this plan was to motivate companies to use palm-based biodiesel. However, Malaysia's biodiesel policy and intervention plan were largely ineffective due to subsidies of fossil fuels leading to uneven competition for biodiesel [51]. Abdullah et al. [43] found that a lack of government support can be a demotivating factor for companies to adopt green practices. A study conducted by Johari et al. [51] suggested that the lack of subsidies for biodiesel has a negative effect on the adoption of biodiesel. According to Huang and Wu [40], the promotion of biodiesel requires establishment of an inter-ministry coordination mechanism. Based on the above, a lack of government support is seen as playing a significant role in preventing the adoption of biodiesel in the transportation industry. Therefore, the following hypothesis was developed:

H1. Lack of government support is a factor that discourages biodiesel adoption.

2.2. Lack of Customer Demand

Previous studies have found that customer demand is a driver of environmental practices [43,52]. The willingness of the customer to pay more for environmentally friendly services will secure the future demand of environmentally friendly services of a transportation company. Moreover, the lack of significant benefits that using biodiesel brings to the company will hinder transportation companies from using biodiesel as an alternative of fossil fuel. The lack of customers' responsiveness to environmentally friendly services will lead to lower propensities of transportation companies to use biofuel [53]. The transportation companies believe that if the type of fuel that the trucks and lorries use is not important for customers, thus they have no incentive to use biodiesel based on cost. Therefore, the following hypothesis was developed:

H2. Lack of customer demand is a factor that discourages biodiesel adoption.

2.3. Lack of Environmental–Commercial Benefits

Van Hemel and Cramer [54] found that without clear commercial benefits being gained from adopting certain environmental practices, a company is unlikely to adopt such practices. With palm oil plantations rapidly expanding in response to the fast growing demand for biodiesel, several critical environmental issues have surfaced. Firstly, deforestation has proceeded at a rapid rate to keep up with palm oil demand and this has led to the destruction of large tracts of peat land. Furthermore, the biodiversity of the local ecosystems in such areas is decreasing with the further invasion into forested areas [39]. The practice of clearing rainforests using fire is seen as releasing increasing amounts of CO₂ into the atmosphere, indeed, more than burning fossil fuels would produce [55]. As such, transportation companies have doubts on the environmental benefits of palm oil biodiesel. Furthermore, when companies perceive that environmental practices do not bring them any benefits, it is likely that environmental initiatives will be reduced in companies [43,45]. In addition to these problems, the price ratio between the palm oil and crude oil price has increased from 2006 to 2010 by approximately 65%. This fact has led to transportation companies foreseeing that biodiesel will remain less competitive than fossil fuel, and consequently customers are less likely to pay extra for their transportation services due to using biodiesel. Therefore, the following hypothesis was developed:

H3. Lack of environmental–commercial benefits support is a factor that discourages biodiesel adoption.

2.4. Lack of Competitive Pressure

Due to very high market uncertainty and price competition in the transportation industry, it is very difficult for the companies to keep the transportation service at a low cost and adopt biodiesel at the same time. Zailani et al. [56] found that over-competition exists in the Malaysian transportation industry and thus price plays an important role as customers have numerous alternative choices for shipping their products. Previous studies have shown a positive relationship between competitive pressure and environmental practices [46,47]. Using biodiesel instead of fossil fuel is costly and a lack of competitive pressure to adopt biodiesel can have a negative effect on its adoption. Thus, the following hypothesis was developed:

H4. Lack of competitive pressure is a factor that discourages biodiesel adoption.

2.5. Differentiation Strategy

There are two generic strategies used by competing firms, one is based on a differentiation strategy and the other on cost leadership [57]. A differentiation strategy in a service organization aims to create customized products and services in response to individual customer preferences and demands [58], in other words, its focus is on recognition of customer needs. A cost leadership strategy focuses on cost structure to compete with other firms or segmented targets. A differentiation strategy can generate a higher profit for a firm in comparison to the cost leadership strategy in the long term through enhancing customers' loyalty and reducing price sensitivity [59]. As the customers of transportation firms' services, such as manufacturers or retailers, are closer to the public eye, they should take responsibility for their partners' environmental performance [60]. Sancha et al. [61] found that partners' poor sustainability practices will not just damage the buying firm's reputation but also impact the operation's performance in the long run. As such, the customers of transportation firms' services encourage them to operate in an environmentally friendly manner. Using biofuel as an environmental practice is one of the ways in which transportation companies can respond to their customers' needs and consequently differentiate themselves from their competitors. A transportation company seeking to establish its uniqueness based on using biodiesel as a competitive advantage will adopt biodiesel regardless of government support, customer demand, environmental commercial benefits, and competitive pressure. Therefore, the following hypotheses were developed:

H5. *Differentiation strategy positively moderates the impacts of (a) lack of government supports, (b) lack of customer demand, (c) lack of environmental commercial benefits, and (d) lack of competitive pressure on biodiesel adoption.*

3. Research Methodology

3.1. Measure of Constructs

Content validity was ensured by adapting items from prior studies which were measured by a five-point Likert scale from “Strongly Disagree” to “Strongly Agree”. The items, lack of government support, lack of customer demand, and lack of environmental commercial benefits were adapted from Abdullah et al. [43]. The scales for lack of competitive pressure were measured using items from Zainuddin et al. [62]. The items of differentiation strategy and biodiesel adoption intention were adapted from Das and Joshi [63] and Zailani et al. [64], respectively.

3.2. Data Collection and the Sample

The population of this study consisted of all transportation companies in Malaysia. Since biodiesel adoption is the concern of this study, the target respondents should have sufficient knowledge about the barriers that their companies face for adopting biodiesel. Thus, respondents were drawn from among the top management levels including owners, CEOs, managing directors, general managers, and senior managers, and the unit of analysis was the individual firm.

The sample size of this study was calculated through G-power at 80% power and 0.15 effect size as suggested by Cohen [65]. As there were nine predictors (four barriers, one moderator, and four interactions), a minimum sample of 114 was needed for testing the model. In order to reach a wide geographical area in a short period of time and at minimal cost, mail questionnaires were used [66]. The addresses of transportation companies were obtained from the Malaysia Logistics Directory. Out of 400 questionnaires distributed, 156 were returned. However, questionnaires which were largely incomplete were excluded from the survey, leaving 147 questionnaires for the subsequent analysis; in other words, the response rate was 36.8%. Most of the companies had been established for more than a decade, and 74% had fewer than 150 employees.

In order to check for non-response rate bias due to the low response rate, procedures were followed as recommended by Armstrong and Overton [67]. It was assumed that the last one-quarter respondents would be the most similar to non-respondents based on the long time and most effort to obtain their replies. However, when the last quartile was compared to the first three quartiles, no differences could be found between the ‘early’ and ‘late’ respondents at the 5% significance level, and therefore it was concluded that non-response bias was not an issue with regard to the data collected.

3.3. Analysis

Given the exploratory nature of the study [68], the Smart PLS version 3.0 was used to test the measurement model utilizing the partial least squares (PLS) technique. In the first step, the measurement model was tested to validate the questionnaire, and in the second step, the structural model was tested to evaluate the hypotheses.

4. Results

4.1. Measurement Model Results

Factor loading, average variance extracted (AVE) and composite reliability (CR) were used to determine convergent validity [69–72] Table 1 shows that the CR of all constructs was higher than 0.7, the factor loadings were above 0.4, and the values of AVE were above 0.5. These findings indicated a satisfactory convergent validity [73].

Table 1. Measurement model evaluation.

Constructs	Items	Factor Loading	CR	AVE
Lack of Government Supports (LGS)	Inadequate enforcement of environmental regulations by government officers for adopting biodiesel.	0.894	0.926	0.806
	Inadequate subsidies for adopting biodiesel.	0.852		
	Inadequate tax reduction for adopting biodiesel.	0.945		
Lack of Customer Demand (LCD)	Caring for the environment is an important consideration for our customers.	0.704	0.921	0.700
	Our customers require my firm to adopt biodiesel.	0.876		
	Our customers encourage my firm to adopt biodiesel.	0.880		
	Our customers would withhold a contract if my firm did not adopt biodiesel.	0.888		
	Our customers reject our transportation services if my firm does not adopt biodiesel.	0.821		
Lack of Environmental Commercial Benefits (LEB)	There would be little environmental benefits by using biodiesel.	0.884	0.904	0.759
	My firm has experienced that customers are not willing to pay extra for using biodiesel.	0.892		
	My firm has perceived that green benefit is little but cost is high	0.837		
Lack of Competitive Pressure (LCP)	In transportation industry, a large number of firms adopt biodiesel.	0.743	0.861	0.609
	In transportation industry, our competitors use biodiesel.	0.752		
	My firm has experienced competitiveness pressure to adopt biodiesel.	0.821		
	My firm has realized competitiveness pressure to adopt biodiesel.	0.802		
Differentiation Strategy (DS)	My firm introduces more services than its major competitors.	0.854	0.874	0.635
	My firm focuses on building brand identification for its services	0.751		
	My firm emphasizes being the industry leader in offering new services	0.804		
	My firm introduces services to the market faster than the competition.	0.774		
Biodiesel Adoption (BA)	My firm's willingness to use biodiesel is very high.	0.888	0.885	0.794
	My firm has high intention to use biodiesel.	0.894		

As suggested by Henseler et al. [74], the heterotrait-monotrait ratio of correlations (HTMT) was used to evaluate the discriminant validity [75]. The values of HTMT were less than 0.85 (Table 2) which confirmed the discriminant validity of all constructs [76].

Table 2. Heterotrait-monotrait (HTMT).

	LGS	LCD	LEB	LCP	DS	BA
LGS						
LCD	0.568					
LEB	0.684	0.812				
LCP	0.587	0.776	0.768			
DS	0.165	0.283	0.430	0.456		
BA	0.682	0.585	0.831	0.719	0.576	

4.2. Structural Model

Explained variance proportion was used to determine the accuracy of the model's predictions [77–79]. In the present study, the R^2 value of biodiesel adoption was 0.551. Additionally, in order to measure the predictive relevance, the Stone-Geisser Q^2 (cross-validated redundancy) value was used. A model is deemed to display predictive relevance if Q^2 is more than zero [80], which was achieved in the current research where Q^2 was 0.407. In brief, therefore, the model achieved high predictive relevance and an acceptable fit.

In order to test the structural model, non-parametric bootstrapping was applied [81] with 2000 replications (Table 3). The results indicated that lack of government support ($\beta = -0.276$ and $p < 0.001$), lack of environmental commercial benefits ($\beta = -0.371$, and $p < 0.001$) and lack of competitive pressure ($\beta = -0.160$ and $p < 0.05$) have negative effects on biodiesel adoption. Thus, it was found that H1, H3 and H4 were clearly supported, leaving only H2 unsupported. In order to create an interaction construct, the product indicator approach (standardized) was used [82–84]. The results indicated that differentiation strategy moderates the impact of all proposed barriers on biodiesel adoption. As such, H5a to H5d were supported.

Table 3. Path coefficient and hypothesis testing.

Hypotheses	Relationships	Path Coefficient	t-value	Decision
Main Model				
H1	LGS -> BA	-0.276	3.973***	Supported
H2	LCD -> BA	0.093	0.975	Not Supported
H3	LEB -> BA	-0.371	3.403***	Supported
H4	LCP -> BA	-0.160	1.863*	Supported
Moderating Effect				
-	DS -> BA	0.239	3.792	-
H5a	DS*LGS -> BA	0.126	2.440**	Supported
H5b	DS*LCD -> BA	0.135	2.150*	Supported
H5c	DS*LEB -> BA	0.087	1.859*	Supported
H5d	DS*LCP -> BA	0.107	1.902*	Supported

Notes: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Figure 2 illustrates that lack of government support and lack of competitive pressure have no apparent negative effect on biodiesel adoption among the transportation companies that pursue differentiation strategy. Although the differentiation strategy moderates the relationships between lack of environmental commercial benefits and biodiesel adoption, it can still be considered a barrier to the adoption of biodiesel even among companies that pursue the differentiation strategy. The companies which want to differentiate their market from competitors found that a lack of market demand was a positive determinant of biodiesel adoption.

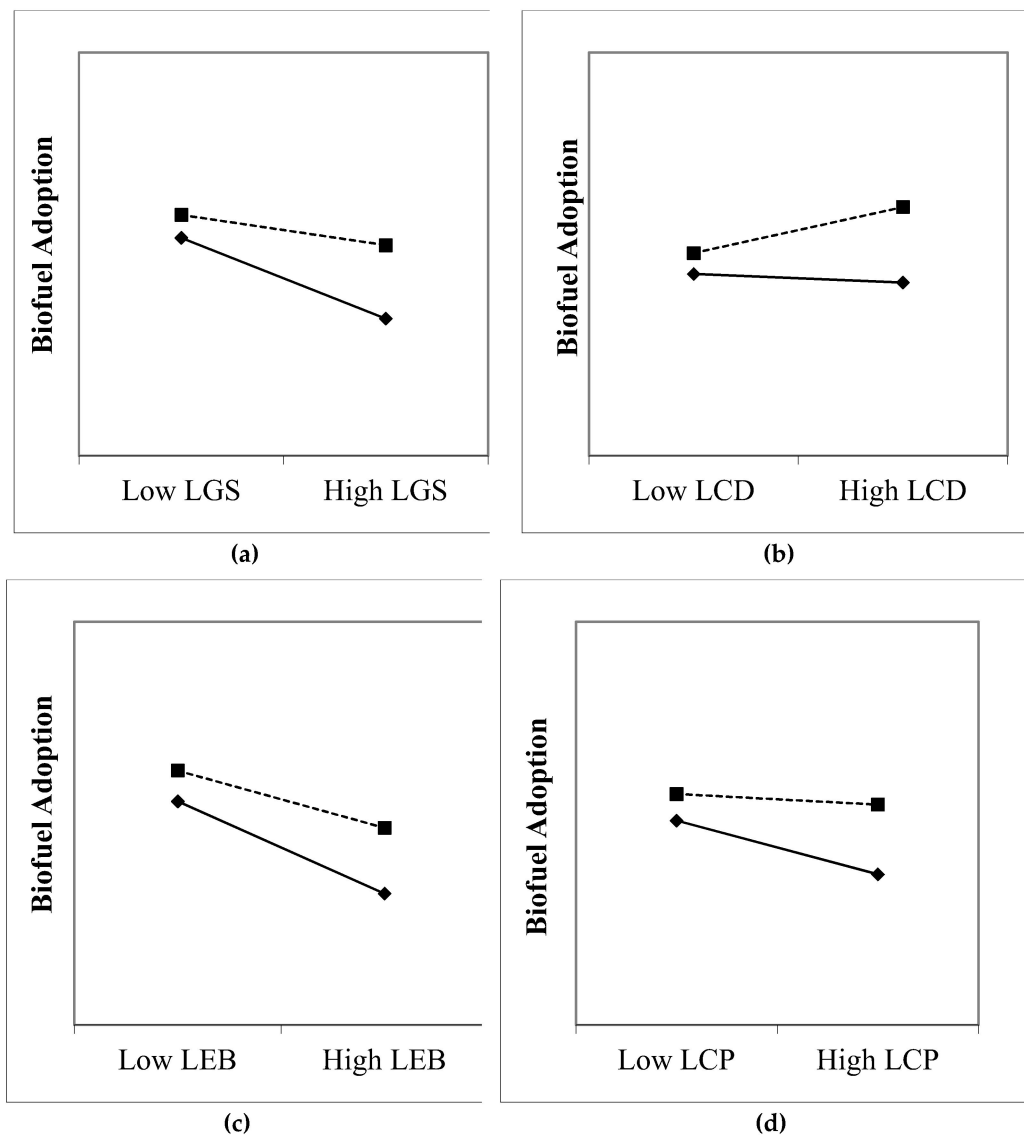


Figure 2. Interaction effect of barriers and differentiation strategies. (a) Interact with lack of government supports; (b) Interaction with lack of customer demand; (c) Interaction with lack of environmental commercial benefits; (d) Interaction with lack of competitive pressure

5. Discussion and Conclusions

Due to the energy crisis and global air pollution, biodiesel as a feasible alternative of fossil fuel has received considerable attention in the past decade. Malaysia is a country which is very rich in palm oil as a source of biodiesel. Palm oil-based biodiesel may offer many benefits including the reduction of air pollution, the creation of new employment opportunities especially in rural area, and the reduction of a dependency on fossil fuel. Nevertheless, several barriers will have to be overcome in order to raise market penetration as well as the acceptance of biodiesel. This study sought to address this critical area by investigating the barriers to biodiesel among transportation companies. The findings show that lack of government support, lack of commercial environmental benefits, and lack of competitive pressure are the main barriers of adopting biodiesel. Furthermore, the negative impact of these barriers is less among the transportation companies that adopt a differentiation strategy in comparison to the ones that adopt a cost leadership strategy.

The results show that government support has a negative effect on the adoption of biodiesel which is consistent with the findings of Johari et al. [51]. As in other developing countries, financial support and enforcement by government officers to adopt biodiesel are crucial for promoting biodiesel.

Currently in Malaysia, government incentives as well as financing mechanisms are insufficient to motivate transportation companies to adopt biodiesel [51]. Generally speaking, the most critical barrier to taking pro-environmental action is lack of financial support [85]. However, companies will accept such actions if they do not risk losing profits [86]. Therefore, the Malaysian government could do much in this regard if it provided financial incentives in different forms (subsidy, tax exemption, low interest loan, specific funds for using biodiesel, etc.) and enforce companies to use biodiesel in the interests of the environment and society.

The results also show that lack of customer demand has no significant effect on adoption of biodiesel, which is not consistent with the finding of Silva and Leitao [53] who found that lack of customer responsiveness to environmentally friendly services was a barrier to adopting biofuel in the transportation industry. The potential reason for the insignificant effect of lack of market demand is that biodiesel in Malaysia is still in the initial stage and transportation companies are not certain about the potential demand for using biodiesel. The companies believe that the price of transportation service is the main factor in determining customers' decisions, and using biofuel can only be seen as a practice to differentiate service from competitors. As such, a lack of demand for adopting biodiesel has no effect on their decision to use biodiesel.

The result confirms that lack of environmental commercial benefits have negative effect on adoption of biodiesel which is in line with the finding of van Hemel and Cramer [54] and Woolman and Veshagah [45], who stated that few environmental commercial benefits may be reduced green practices in firms. This is because managers view environmental practices as placing limitations on profits due to burdensome regulations and other constraining factors. Given this situation among firms, the government can play an important role in reducing this negative image by establishing and enforcing rules for protecting biodiesel against of fossil biodiesel by providing subsidies and tax exemptions for using biodiesel. These and other types of protection can promote biodiesel as a competitive source of fuel.

The results indicate the significant relationship between lack of competitive pressure in using biodiesel and adoption of biodiesel. Due to competition over price in the Malaysia transportation industry, companies need to keep the price of their transportation service low. With the current unequal subsidies on petroleum-derived diesel and biodiesel, it is very difficult to use biodiesel and provide transportation within competitive prices. The negative effect of the lack of competitive pressure also highlights the role of government in protecting biodiesel.

As mentioned by Porter [57], companies' competition strategies are different. Some companies compete on price and others try to differentiate themselves from others. Although using biodiesel as an alternative to fossil fuel can be practiced as a differentiation strategy, it is costly. Thus, this study predicted that the existence of a differentiation strategy as a moderator would reduce the negative effect of barriers to the adoption of biodiesel. The results show that a differentiation strategy moderates the relationships between all tested barriers and the adoption of biodiesel. This result implies that the transportation companies that make use of a differentiation strategy have a higher intention to use biodiesel as a practice to differentiate their service from that of competitors regardless of existing barriers. It is worthy to highlight that the lack of government support and lack of competitive pressure are not important factors for adopting biodiesel among the transportation companies which consider using biodiesel as adding value to differentiate their transportation service. Although the negative impact of a lack of environmental commercial benefits on adoption of biodiesel is significantly less among these companies, there is still a negative effect. This means if managers believe that there would be few environmental benefits by using biodiesel and customers are not willing to pay extra for using biodiesel, then they have no incentive to adopt biodiesel. It is interesting that a lack of market demand has a positive effect on adopting biodiesel among transportation companies that pursue differentiation strategies. The potential reason for this is that these companies believe that a demand for using biodiesel is growing and they foresee a large market for it in future, so they consider a lack of current demand as an opportunity to be first mover.

The findings of this study have implications for policymakers and managers as well as shareholders of transportation companies with an interest in the use of biodiesel. By diagnosing the dominant barriers for the adoption of biodiesel, the government will hopefully take a stand on doing away with inappropriate, inconsistent, and inadequate policies which favor fossil fuels over biodiesel. The results, however, reveal a current lack of government support, a lack of environmental commercial benefits, and a lack of competitive pressure which act as barriers to adopting biodiesel. On the other hand, the government can refocus its attention on eliminating these three barriers by establishing and enforcing proper rules for protecting biodiesel and by providing appropriate subsidies.

By diagnosing the main barriers for the adoption of biodiesel, the fear of adopting biodiesel can be eliminated. This also would lead to a higher usage of biodiesel in the transportation industry, which would then reap benefits such as lower dependency on fossil fuel, lower air pollution, and employment opportunities for Malaysians and other countries that have palm oil. This study also contributes to the literature by empirically testing the findings of previous studies, including that of Johari et al. [51], who studied the challenges of palm oil based biodiesel in Malaysia, and Mathiyazhagan et al. [87], who investigated the barriers of implementing green practices. The cross-sectional design of this study helps to empirically test the results of these studies and consequently generalize the results.

The main purpose of the present study has been successfully achieved; however, in order to lay the groundwork for future studies, the limitations must also be considered. Firstly, this study was limited to a survey sample among the transportation companies in Malaysia. Therefore, future studies would do well to test the research model in other countries to compare their results with those of the current study. This would add valuable insight into how regulations and their enforcement, market demand for biodiesel, and completion level create similar or differing circumstances for the adoption of biodiesel when compared to those in the present study. Secondly, since the focus of this study was on external barriers, future studies should test the impact of internal barriers such as technical barriers and lack of top management support.

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