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AUSTRALASIAN AGRICULTURAL & RESOURCE ECONOMICS SOCIETY

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Contributed paper prepared for presentation at the 64th AARES Annual Conference, Perth, Western Australia 12-14 February 2020.

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21 October 2019

Abstract

As part of the environment-related stimulus package implemented in the aftermath of the 2008 global financial crisis, the Japanese government introduced tonnage and acquisition tax breaks as well as a subsidy programme for eco-friendly vehicles. However, there has been limited research on their economic effects. Therefore, this paper employs the event study methodology to examine not only the direct economic effects of the eco-friendly vehicle tax breaks and subsidy programme on automobile firms' performance but also their spillover economic effects on automobile parts firms' performance. Our results show that the eco-friendly vehicle tax breaks had lower positive economic direct effects and no positive spillover effects while the eco-friendly vehicle subsidy programme had more significant positive direct economic effects and positive spillover effects. The differences in economic effects between tax breaks and subsidy programme result from the differences in the implementation duration and from the differences in the preferential monetary benefits. In addition, a mixed policy that combines the eco-friendly vehicle tax breaks and the eco-friendly vehicle subsidy programme is preferable to implementing the former alone.

Keywords: event study; environmental stimulus policy; capital market; spillover effect; policy analysis.

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1. Introduction

After the 2008 global financial crisis, President Barack Obama of the United States proposed a Green New Deal policy to simultaneously address environmental or energy issues and the financial crisis. This environment-related economic stimulus policy uses instruments designed to increase employment opportunities and recover from the financial crisis through public investment in the areas of environment and energy. In Japan, the government implemented Japanese versions of the Green New Deal policies in the form of tonnage and acquisition tax breaks and a subsidy programme for the promotion of eco-friendly vehicles (hereafter, the 'eco-friendly vehicle programmes'). These programmes were economic stimulus plans aimed to encourage consumers to purchase or trade up to eco-friendly vehicles. Prime Minister Aso announced the 'Immediate Policy Package to Safeguard People's Daily Lives' on 19 December 2008. The tonnage and acquisition tax breaks for eco-friendly vehicles were included in this policy, as policy instruments to encourage the broad use of eco-friendly vehicles and to reduce carbon dioxide emissions in the transport sector. A tonnage tax break of between 50 and 100 per cent was applied to eco-friendly vehicles with vehicle inspection certificates from 1 April 2009 to 30 April 2012. Additionally, an acquisition tax break of between 50 and 100 per cent was applied to eco-friendly vehicles registered or notified from 1 April 2009 to 31 March 2012. The 'Policy Package to Address the Economic

Crisis', announced on 10 April 2009, introduced a subsidy programme for eco-friendly vehicle purchases. The eco-friendly vehicle subsidy programme granted a one-year time-limited subsidy of 50,000 to 1,800,000 yen to consumers who purchased eco-friendly vehicles from 10 April 2009 to 31 March 2010.

The eco-friendly vehicle programmes were implemented as an environment-related stimulus package. This study evaluates the economic effects of these programmes. In particular, we consider the economic effects on firms using the event study methodology to analyse how the stock prices of automobile firms responded to the programmes and to assess the spillover effects on the automobile parts industry.

This paper offers three main contributions. First, we evaluate the economic effects of the environment-related stimulus policies on financial performance. There has been limited research on the economic effects of environment-related stimulus policies in Japan as a fiscal policy response to the global financial crisis. For example, Jiménez et al. (2016), using the difference-in-difference methodology, investigate both prices and environmental effects of the environment-related stimulus policy, called Plan 2000E. However, Plan 2000E was a Spanish fiscal policy response to the global financial crisis and not that of the Japanese.[2] Alhulail and Takeuchi (2014) estimate the impacts of the eco-friendly vehicle programmes on monthly sales of 10 eco-friendly vehicles. Further,

[2] Plan 2000E is a subsidy policy for the replacement of old vehicles by new ones and aims at boosting the sale and production of vehicles, particularly of vehicles designed to pollute less.

Miyazaki (2016), using vector auto regression analysis, evaluates the economic effects of Japan's environment-related stimulus policies, such as the eco-friendly vehicle programmes and the eco-points programme for electrical household appliances, based on aggregated monthly data of electrical appliances and automobile production.[3]

Second, our study relates to the empirical research on the indirect economic effects, known as spillover effects, of the policy. Adda et al. (2012) evaluate the spillover effects of smoking bans on pub-holding companies in the United Kingdom. Chatziantoniou et al. (2013), using quarterly data, investigate the direct and indirect effects of monetary and fiscal policies on stock markets in Germany, the United Kingdom, and the United States. The automobile industry, being a machinery industry that assembles machines, requires various components such as automobile components, steel stock, and rubber products, for vehicle production. Since the automobile industry has a large array of supporting industries, vehicle production has significant economic effects on other industries. Moreover, the automobile industry is important in Japan. It thus follows that evaluating the spillover economic effects of the eco-friendly vehicle programmes is also required. However, related studies, such as Alhulail and Takeuchi (2014) and Miyazaki (2016), do not evaluate the spillover effects of the eco-friendly vehicle programmes.

[3] The eco-points programme for electrical household appliances is an energy efficiency rebate programme implemented as an environment-related stimulus policy in Japan. This was a time-limited subsidy where eco-points were granted to consumers who purchased energy-saving electrical household appliances such as air conditioners, televisions compatible with digital broadcasting, and refrigerators. The eco-points could be exchanged for products or services.

Our study focuses not only on the direct economic effects but also on the spillover effects.

Third, numerous empirical researches investigate whether environmental management relates with financial performance. For example, Crifo et al. (2015) examine the impact of the disclosure of corporate environmental social governance practices on equity financing. Using the event study methodology, Klassen and McLaughlin (1996) reveal that strong environmental management, indicated by environmental performance awards, results in positive financial performance in terms of stock market performance. Also employing the event study methodology, Gupta and Goldar (2005) illustrate the positive correlation between firms' environmental and financial performance. Murguia and Lence (2015) use event study analysis to show how the market reacts to firms' environmental rankings. Takeda and Tomozawa (2008) and Yamaguchi (2008), again using the event study methodology, focus on the impact of environmental management rankings on stock prices of Japanese companies. However, only one study—Tamechika and Okuda (2017) on the eco-points programme for electrical household appliances—examines the relationship between environmental stimulus policies and financial performance. Consequently, our research focuses on the under-researched impacts of the environment-related stimulus package on financial performance.

The rest of this paper is organised as follows. Section 2 describes the data and methodology used to evaluate the economic effects of the eco-friendly vehicle programmes. Section 3 reports the empirical results, and Section 4 describes robustness checks. Conclusions as well as a discussion on the policy implications derived from this analysis are provided in Section 5.

2. Materials and Methods

This analysis uses two types of daily data: daily returns for selected firms and market portfolio data. Both data sets are provided by Financial Data Solutions, Inc.

Table 1 lists the two events under the eco-friendly vehicle programmes: the tonnage and acquisition tax breaks and purchase subsidy programme for eco-friendly vehicles. We examine these two events separately. Both events involve 11 automobile firms: Nissan Motor Co., Ltd.; Isuzu Motors Limited; Toyota Motor Corporation; Hino Motors, Ltd.; Mitsubishi Motors Corporation; Nissan Shatai Co., Ltd.; Mazda Motor Corporation; Daihatsu Motor Co., Ltd.; Honda Motor Co., Ltd.; Suzuki Motor Corporation; and Fuji Heavy Industries, Ltd.

Table 1. Definition of events

Name	Event day	Definition
First event	19 December 2008	'Basic Policy for an Additional Economic Stimulus Package' was announced. The tonnage and acquisition tax breaks for eco-friendly vehicles were proposed in this policy.

Second event	10 April 2009	'Policy Package to Address the Economic Crisis' was announced. This proposed a one-year subsidy programme for purchasing eco-friendly vehicles.

In order to measure the spillover effects of the eco-friendly vehicle programmes, we examine their effects on stock prices of automobile parts firms. For this purpose, we use the stock prices of member firms of the Japan Auto Parts Industries Association. We use the event study methodology in order to evaluate these on automobile firms' and automobile parts firms' stock prices, as outlined by MacKinlay (1997). The event study methodology is supported by the assumption that capital markets are efficient in a semi-strong form, as argued by Fama (1970), and that stock prices reflect all public information. The methodology also assumes that stock prices fluctuate only as a result of unexpected information, a situation that influences a firm's future cash flow.

The event window is set at three trading days, consisting of the event day and one day prior to and after the event day. Thus, the event day is τ_0, the initial day of the event window is $\tau_1 = -1$, and the final day of the event window is $\tau_2 = +1$. Specifically, the event windows are from 18 December 2008 to 22 December 2008 for the first event and from 9 April 2009 to 13 April 2009 for the second. Each estimation window is defined as 120 trading days prior to the event window. We apply the following market model for each event:

$$R_{i\tau} = \alpha_i + \beta_i R_{m\tau} + \varepsilon_{i\tau}, \quad (1)$$

where subscript i denotes the i-th firm and τ the day; R_i is the rate of return on the i-th firm's stock price; R_m indicates the rate of return for the market portfolio; and $\varepsilon_{i\tau}$ represents the error term, with $E(\varepsilon_{i\tau}) = 0$ and $Var(\varepsilon_{i\tau}) = \sigma_{\varepsilon_i}^2$. Equation (1) is estimated with data for the estimation window using ordinary least squares. Given the estimated parameters $\hat{\alpha}_i$ and $\hat{\beta}_i$, the abnormal return (AR) of firm i in period τ in the event window is

$$AR_{i\tau} = \alpha_i - \left(\hat{\alpha}_i + \hat{\beta}_i R_{m\tau}\right). \quad (2)$$

The cumulative abnormal return (CAR) is calculated by adding ARs over the event window as follows

$$CAR_i(\tau_1, \tau_2) = \sum_{\tau=\tau_1}^{\tau_2} AR_{i\tau}. \quad (3)$$

Averaging CARs and their variances $\sigma_i^2(\tau_1, \tau_2)$ across N firms gives the average CAR ($\overline{CAR}$) and its variance $\bar{\sigma}_i^{\,2}(\tau_1, \tau_2)$. Therefore,

$$\overline{CAR}(\tau_1, \tau_2) = \frac{1}{N}\sum_{i=1}^{N} CAR(\tau_1, \tau_2), \quad (4)$$

$$Var[\overline{CAR}(\tau_1, \tau_2)] = \bar{\sigma}^2(\tau_1, \tau_2) = \frac{1}{N^2}\sum_{i=1}^{N} \sigma_i^2(\tau_1, \tau_2). \quad (5)$$

On the assumption that neither event affects the mean or variance of the returns, we test the null hypothesis that the average CAR is equal to zero, using the following J_1-statistic:

$$J_1 = \frac{\overline{CAR}(\tau_1, \tau_2)}{\sqrt{\bar{\sigma}^2(\tau_1, \tau_2)}} \sim N(0,1). \quad (6)$$

We also test the null hypothesis that the event has no effect on each firm's stock

price, using the following J_2-statistic:

$$J_2 = \frac{CAR_i(\tau_1,\tau_2)}{\sqrt{\sigma_i^2(\tau_1,\tau_2)}} \sim N(0,1). \quad (7)$$

3. Results

Tables 2 and 3 report the average CARs of the automobile firms as a whole and the CARs of individual automobile firms, respectively, as well as their statistical significance, for the two events with the 120-day estimation window.

Table 2. Average CARs with estimation window of 120 days: Direct effects

Event	First event		Second event	
	CAR	J_1-statistic	CAR	J_1-statistic
	0.983	4.763***	4.220	22.355***

Note: *** denotes statistical significance at the 1% level.

Table 3. CARs with estimation window of 120 days: Direct effects

Firm	First event		Second event	
	CAR	J_2-statistic	CAR	J_2-statistic
Nissan Motor Co., Ltd.	0.532	2.544**	7.091	41.033***
Isuzu Motors Limited	6.575	43.030***	22.227	171.133***
Toyota Motor Corporation	-5.867	-18.829***	-0.219	-0.808
Hino Motors, Ltd.	6.012	30.928***	9.147	50.009***
Mitsubishi Motors Corporation	0.453	2.273**	-1.673	-7.749***
Nissan Shatai Co., Ltd.	-4.204	-16.409***	-3.104	-11.443***
Mazda Motor Corporation	3.665	24.569***	11.875	90.174***
Daihatsu Motor Co., Ltd.	-0.083	-0.470	4.169	23.238***
Honda Motor Co., Ltd.	-0.634	-3.173***	-4.035	-22.271***
Suzuki Motor Corporation	5.906	26.158***	-1.775	-9.426***
Fuji Heavy Industries Ltd.	-1.546	-7.965***	2.711	17.811***

Note: ** and *** denote statistical significance at the 5% and 1% levels, respectively.

Table 2 shows that the J_1-statistic for the first event is statistically significant at the

1% level. Additionally, the average CAR for the first event is statistically significant and has the expected positive sign, indicating that the eco-friendly vehicle tax breaks positively affected automobile firms' stock prices. Furthermore, Table 3 shows that the CARs for the first event are statistically significant at the 5% level for most automobile firms and positive for more than half of them (six out of 11). These results indicate that the eco-friendly vehicle tax breaks generated positive direct economic effects.

Regarding the second event, Table 2 shows that the average CAR is also statistically significant at the 1% level and has the expected positive sign. Furthermore, Table 3 shows that six out of 11 CARs are statistically significant and positive. These results indicate that the eco-friendly vehicle subsidy programme also generated positive direct economic effects.[4]

Both events, namely the eco-friendly vehicle tax breaks and the eco-friendly

[4] The Japanese Cabinet endorsed the 'Emergency Economic Countermeasures for Future Growth and Security' on 8 December 2009 and extended the eco-friendly vehicle subsidy programme for six months. We also carry out an event study on the extension of the eco-friendly vehicle subsidy programme. The results show that the extension of the eco-friendly vehicle subsidy programme did not affect stock prices. This event was a subsequent extension, while the 'Policy Package to Address the Economic Crisis', announced on 10 April 2009, was the initial introduction of the eco-friendly vehicle subsidy programme. The economic effects of the eco-friendly vehicle subsidy programme decreased during the extended period. Vehicles targeted by this programme are high-cost durable goods purchased infrequently. Specifically, consumers do not repurchase if they have bought vehicles in the recent past. Thus, many consumers who had purchased vehicles during the first period did not purchase vehicles again during the second period of the programme. Moreover, the 'Emergency Economic Countermeasures for Future Growth and Security' was also the announcement of the termination of the eco-friendly vehicle subsidy programme. According to the results, the extension of the eco-friendly vehicle subsidy programme did not affect stock prices.

vehicle subsidy programme, generated positive economic effects on automobile firms. However, the second event had a larger impact than did the first event. The eco-friendly vehicle tax breaks were scheduled for implementation over three years, a longer duration than the implementation period of the eco-friendly vehicle subsidy programme. Therefore, the eco-friendly vehicle tax breaks induced fewer consumers to purchase or trade up to eco-friendly vehicles than did the eco-friendly vehicle subsidy programme, a one-year time-limited subsidy plan included in the supplementary budget. Since consumers considered themselves to be entitled to the subsidy only if they purchased eco-friendly vehicles during the scheme's one-year validity period, the eco-friendly vehicle subsidy programme encouraged more consumers to purchase or trade up to eco-friendly vehicles. Furthermore, the preferential monetary benefits differed between the two events. For example, consumers who purchased a Toyota Prius between 10 April 2009 and 31 March 2010 at a cost of 1.95 million yen benefited from both the tonnage and acquisition tax breaks for eco-friendly vehicles (i.e. they were exempt from the tonnage and acquisition taxes) and the subsidy programme for purchasing eco-friendly vehicles. That is, they were given a tonnage tax break for eco-friendly vehicles up to 56,700 yen and an acquisition tax break up to 87,700 yen. Thus, the total tax breaks amounted to 144,500 yen. They could also receive a subsidy payment equal to 100,000–250,000 yen. Since the preferential monetary benefit for the subsidy was

originally larger than that for the tax breaks, the eco-friendly vehicle subsidy programme possibly encouraged more consumers to purchase or trade up to eco-friendly vehicles. Moreover, aggregating the tax breaks and subsidy payments yields a discount of 244,500–394,500 yen. That is, whereas the tonnage and acquisition tax breaks for eco-friendly vehicles alone granted consumers a 6.90% price reduction, the tax breaks combined with the subsidy reduced the price by 11.67–18.84%. In short, the second event provided larger preferential monetary benefits, and therefore, generated greater economic effects on the automobile industry.

Table 4 reports the average CARs of the automobile parts firms and their statistical significance for the two events with the 120-day estimation window. Table 5 reports the total number of automobile parts firms and the number of positive as well as significantly positive CARs of the firms as a whole for the two events with the 120-day estimation window.

Table 4. Average CARs with estimation window of 120 days: Spillover effects

Event	First event		Second event	
	CAR	J_1-statistic	CAR	J_1-statistic
	-2.7e+00	-14.01094***	5.036072	29.75498***

Note: *** denotes statistical significance at the 1% level.

Table 5. CARs with estimation window of 120 days: Spillover effects

Firm	First event	Second event
Total number of firms	121	122

Number of significantly positive CARs	26	85
Number of positive CARs	28	88

Table 4 indicates that the average CAR of automobile parts firms for the first event is statistically significant at the 1% level but has a negative sign. From Table 5, only 26 out of the 121 CARs of automobile parts firms are positive and statistically significant for the first event. These results indicate that the eco-friendly vehicle tax breaks had no positive spillover effects on automobile parts firms. The average CAR of automobile parts firms for the second event, shown in Table 4, is statistically significant at the 1% level and has the expected positive sign. In addition, Table 5 shows that 85 out of the 122 CARs of automobile parts firms are positive and statistically significant for the second event. These results indicate that the eco-friendly vehicle subsidy programme had positive effects on many automobile parts firms' stock prices, i.e. the eco-friendly vehicle subsidy programme generated positive spillover effects.

Since the eco-friendly vehicle tax breaks scheme was implemented for a longer period of three years and its preferential monetary benefits were lower, the scheme had relatively small economic effects on automobile firms. Consequently, the eco-friendly vehicle tax breaks did not generate positive spillover effects on automobile parts firms. Since the eco-friendly vehicle subsidy programme was implemented for a shorter period of one year and its preferential monetary benefits were higher, the eco-friendly vehicle

subsidy programme had a larger economic impact on automobile firms. Therefore, the eco-friendly vehicle subsidy programme had positive spillover effects on automobile parts firms.

4. Robustness Checks

We conduct estimations using the 150-day estimation window to verify the robustness of the results. Table 6 reports the average CARs of automobile firms for the two events with the 150-day estimation window and their statistical significance, showing that the average CARs for the first and second events are positive and statistically significant at the 1% level. Table 7 reports the CARs of the individual automobile firms for the two events with the 150-day estimation window. Table 7 shows that out of the 11 automobile firms, five firms in the first event and six firms in the second event have positive and statistically significant CARs.

Table 6. Average CARs with estimation window of 150 days: Direct effects

Event	First event		Second event	
	CAR	J_1-statistic	CAR	J_1-statistic
	0.662	3.002***	4.540	23.504***

Note: *** denotes statistical significance at the 1% level.

Table 7. CARs with estimation window of 150 days: Direct effects

Firm	First event		Second event	
	CAR	J_2-statistic	CAR	J_2-statistic
Nissan Motor Co., Ltd.	0.416	1.826*	7.309	39.010***
Isuzu Motors Limited	6.094	36.592***	22.554	165.137***
Toyota Motor Corporation	-5.850	-17.304***	-0.114	-0.393

Hino Motors, Ltd.	5.513	26.301***	9.548	51.225***
Mitsubishi Motors Corporation	0.033	0.157	-1.357	-6.721***
Nissan Shatai Co., Ltd.	-4.490	-17.208***	-2.747	-10.574***
Mazda Motor Corporation	2.830	17.975***	12.394	90.521***
Daihatsu Motor Co., Ltd.	0.006	0.032	4.733	26.903***
Honda Motor Co., Ltd.	-0.973	-4.543***	-3.727	-19.621***
Suzuki Motor Corporation	5.802	23.844***	-1.461	-7.404***
Fuji Heavy Industries Ltd.	-2.105	-10.473***	2.808	17.177***

Note: * and *** denote statistical significance at the 10% and 1% levels, respectively.

Table 8 reports the average CARs of automobile parts firms for the two events with the 150-day estimation window, and their statistical significance. Table 9 reports the total number of automobile parts firms and the number of positive as well as significantly positive CARs of the automobile parts firms as a whole for the two events with the 150-day estimation window.

Table 8. Average CARs with estimation window of 150 days: Spillover effects

Event	First event		Second event	
	CAR	J_1-statistic	CAR	J_1-statistic
	-2.9e+00	-14.37052***	5.126855	29.80231***

Note: *** denotes statistical significance at the 1% level.

Table 9. CARs with estimation window of 150 days: Spillover effects

Firm	First event	Second event
Total number of firms	121	121
Number of significantly positive CARs	22	89
Number of positive CARs	27	92

Table 8 shows that the average CAR of automobile parts firms for the first event is

statistically significant at the 1% level but has a negative sign. As shown in Table 9, only 22 out of the 121 CARs of automobile parts firms are positive and statistically significant for the first event. Table 8 shows that the average CAR of automobile parts firms for the second event is statistically significant at the 1% level and has the expected positive sign. Additionally, Table 9 shows that 89 out of the 121 CARs of automobile parts firms are positive and statistically significant for the second event.

As Tables 6–9 show, the results are similar between the 120- and 150-day estimation windows. Therefore, we conclude that the results in Tables 2–5 are robust.

5. Conclusions and Discussion

This study analyses the economic effects of the Japanese eco-friendly vehicle programmes announced after the financial crisis of 2008. Research on the economic effects of environment-related stimulus policies is limited. We use the event study methodology to evaluate the direct and indirect effects of the eco-friendly vehicles' tonnage and acquisition tax breaks and purchase subsidy programme, respectively. Our results indicate that the tonnage and acquisition tax breaks for eco-friendly vehicles had positive direct economic effects, but their size was smaller, and no positive spillover effects. We also find that the subsidy programme for purchasing eco-friendly vehicles had positive direct economic effects, and their size were larger, and positive spillover effects. Overall, the eco-friendly vehicle programmes aided the recovery from the 2008

financial crisis. The results of the eco-friendly vehicle programmes differed for the following two reasons. First, the duration of application differed between the two eco-friendly vehicle programmes. The eco-friendly vehicle subsidy programme was implemented for one year while the eco-friendly vehicle tax breaks were implemented for three years. Therefore, the former induced more consumers to purchase eco-friendly vehicles than the latter. Second, the preferential monetary benefits differed between the eco-friendly vehicle programmes. The preferential monetary benefits were originally larger for the eco-friendly vehicle purchase subsidy programme than for the tax breaks. Furthermore, since the eco-friendly vehicle tax breaks were also implemented during the eco-friendly vehicle subsidy programme period, the combined preferential monetary benefits for the second event were substantial.

Two policy implications can be discussed based on this analysis. First, in order to implement an economic-stimulus policy aimed at encouraging vehicle consumption and to promote the diffusion of eco-friendly vehicles, it is desirable to adopt not only tax breaks but also a subsidy programme. Since a vehicle is a high-cost good, the decrease in the price of vehicle caused by tax breaks alone is small; therefore, tax breaks alone provide a lower incentive to consume vehicles. Furthermore, eco-friendly vehicles which incorporate new technologies are much more expensive than CO_2 emission-intensive vehicles (conventional vehicles), which incorporate conventional

technologies. Reducing the considerable price differential between eco-friendly and conventional vehicles encourages consumers to purchase or trade up to eco-friendly vehicles, thereby resulting in the diffusion of eco-friendly vehicles. However, the reduction of the price differential by tax breaks alone is insufficient; such reduction of price differentials requires the implementation of both tax breaks and of a subsidy programme. Especially, promotion of high-cost goods such as vehicles needs the adoption of both tax breaks and of a subsidy programme.

Second, the economic-stimulus policy needs to be designed to have a large spillover effect, i.e. the implementation of the economic-stimulus policy should be targeted at the industry that has large impacts on the production of other industries, thereby having the potential for larger positive economic effects. The automobile industry targeted by eco-friendly vehicle programmes is the assembly industry, which requires large amounts of intermediate inputs such as automobile components and raw materials. In other words, production in the automobile industry has larger effects on production in other industries. Therefore, an economic-stimulus policy targeted at the automobile industry has positive economic impacts on both the automobile industry and on other industries, thereby being more effective in reviving the economy. In this sense, adoption of the economic-stimulus package for the promotion of houses is also desirable.

A mixed policy that combines the eco-friendly vehicle tax breaks and subsidy programme is a stronger policy instrument to encourage a broader use of eco-friendly vehicles than the eco-friendly vehicle tax breaks alone. However, the subsidy programme for purchasing eco-friendly vehicles must not be reintroduced, because vehicles are durable goods and few consumers who have recently bought them would repurchase a second time.

Acknowledgements

This work was supported by the Japan Society for the Promotion of Science [Grant-in-Aid for Young Scientists (B) No. 15K17054].

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