Driving to the Low-Carbon Society: the Developments of Sustainable Technologies in Japanese Automobile Industry

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1. Introduction

In the discipline of international environmental politics, the role of business actors has been drawing many scholarly attentions these days (Hurrel and Kingsbury 1992; Levy and Egan 1998; Levy 1997; Newell and Paterson 1998; Levy and Newell 2005; Newell 2008; Rowlands 2001; Clapp 1998, 2008; Falkner 2001, 2003, 2005, 2008; Pattberg 2007, 2008). The business is particularly important in the process of global environmental governance, because their activities affect the environment both *positively* and *negatively*. In other words, the business is both the stumbling block as well as the solution to the environmental governance.

This paper shed a light on the role of automobile industry in the issue of climate change. This is because, first, the industry is expected to play a key role in the global climate governance, given that the road transport sector accounts for about 16% of the total global carbon dioxide (CO_2) emissions, with expected growth from 4 gigatonnes in 2000 to more than 9 gigatonnes in 2050. Sexond, the industry operates globally with its economic significance that could potentially give a rise to their political power over the

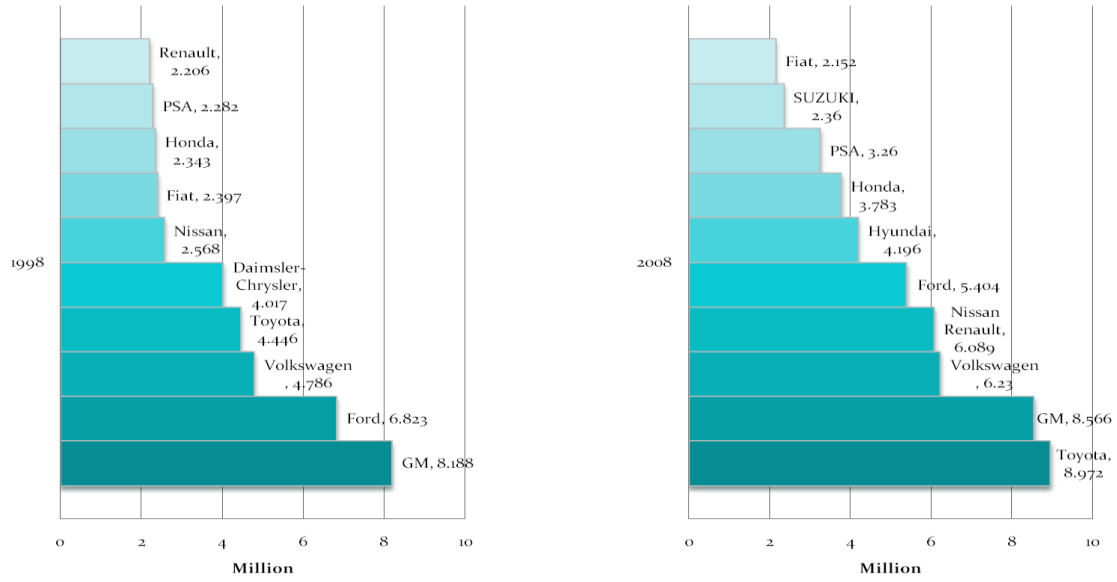
international climate negotiations. Japan in particular, is the biggest automobile manufacturing nation as well as one of the key players in the international climate negotiations, and therefore has the potential to affect changes towards more sustainable road transportation sector on a global level. Against this background, this paper asks how the automobile industry can be the driver to push towards low-carbon society, especially through their developments of the sustainable technologies. To do so, it examines how Japanese public policies and business strategies have been influenced the developments of sustainable technologies in the automobile industry.

2. Japanese public policy on auto industry

2.1 Overview

Japan is the biggest automobile manufacturing nation since 2006. Accordingly, the automobile industry is one of the key industries with about 8% of the Japanese population being employed in the industry (JAMA). The international landscape in the automobile sector has changed significantly between 1998 and 2008: the US-dominant market structure that prevailed in 1998 has changed with sales of Toyota ranking at the top in 2008 (Figure 1).

Figure 1: Changes in the sales rankings 1998-2008.



Source: Nikkei(2009) *The New era of Automobile*. Tokyo: Nikkei Publishing Inc.

Domestic institutional environments, especially governmental regulations on the fuel economy of vehicles have strongly influenced in directing the sustainable technological innovations in the industry. Japanese fuel economy regulation was triggered by domestic and international events. Domestic events included the growing concerns about air pollution and accompanying damage to health that eventually led to the Air Pollution Control Law of 1968, which in turn formed the basis of environmental technology improvements of the Japanese automobile industry; the second was the oil crisis in the 1970s and the creation of the Law Concerning the Rational Use of Energy (Energy Conservation Act) in 1976, which encouraged energy savings in factories, transportation, and buildings. The Amendment of the Energy Conservation Act in 1979 included the use of vehicles, and therefore set the first Japanese automobile fuel economy standard. Japanese fuel economy regulation was thus originally driven by the rationale of energy savings.

With the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, Japanese fuel economy regulations have been motivated not only by energy-savings but also by concerns about climate change (Miyoshi and Tanishita, 2008). In the following years, a new fuel economy standard for gasoline vehicles was introduced with the target year 2000. After the Kyoto Protocol was adopted in 1997, the Guideline of Measures to Prevent Global Warming was announced in 1998 by the newly established Global Warming Prevention Headquarters under the Cabinet. This guideline largely revised the Energy Conservation Act in 1998, with the introduction of the 'top runner method'. In the next year, fuel economy standards were largely tightened by the top runner method, requiring 22.8% improvement for gasoline vehicles as compared to 1995 levels by 2010 (15.1km/L), and 14.9% improvement for diesel vehicles by 2005. Notably, Japanese automobile manufactures achieved the 2010 fuel economy target of gasoline vehicles already by 2007. As a result, a stricter 2015 standard, which requires 16.8 km/L that is equal to a 23.5% improvement against the previous standard, was introduced in 2007 for both gasoline and diesel vehicles.

Currently, the new Japanese 2020 fuel economy standard for passenger vehicle is under the discussion. The Japan's 16.8 km/L standard is in fact slightly stricter than the EU's 130g-CO_2/km target (120g-CO_2/km, by

including complementary measurers such as the increased use of bio-fuels, traffic road-safety management, fuel-efficient tyres and air conditioning, and changes in driver behaviour) which was set in December 2008 by the EU law. One of the resulted outcomes of these efforts is that Japanese auto industry is the most fuel efficient industry among the major automobile manufacturing countries (table 1).

Table 1. Comparison of actual GHG emission fleet average performances

Year/ gCO2/km	US	California	Canada	EU	**Japan**	China	South Korea
2002	261	261	244	166	**157**	213	
2003	259		239	164	**156**		232
2004	262		239	162	**154**		218
2005	253		237	161	**153**		214
2006	249		227	160	**149**	188	213
2007	243			158	**147**		207
2008	240	239		154	**141**	185	198

Source: ICCT (2010), modified by author.

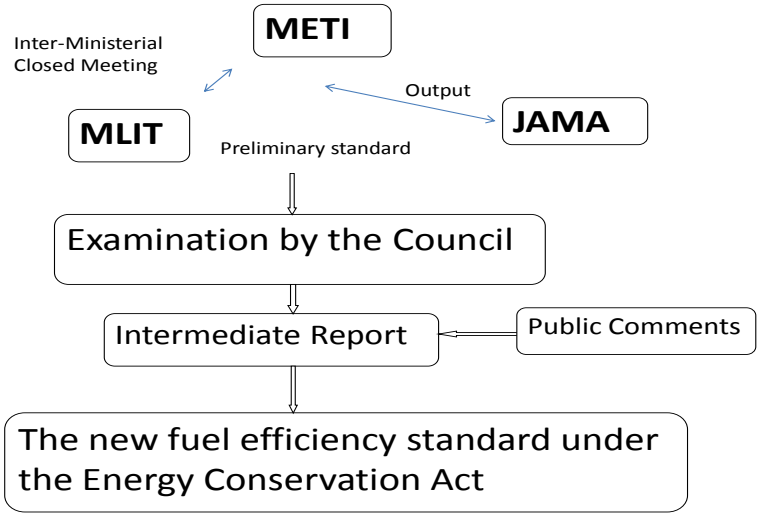
2.2 Decision-making process

In the process of fuel economy regulation, the Japanese Ministry of Land, Infrastructure, Transport (MLIT) and the Japanese Ministry of Economy, Trade and Industry (METI) are responsible for the decision-making. MLIT is the official governmental body responsible for transport matters. METI, which is originally responsible for economic activities, is responsible for the fuel economy regulations due to its authority conferred to it by the Energy Conservation Act.

In the case of the 2015 fuel economy regulation, these two Ministries held a series of closed meetings from 2004 until 2006, and invited the Japanese automobile industry to participate in these meetings (Iguchi, 2009a; 2009b). It is important to note here that the industry participated in this decision making process through the 'Japan Automobile Manufacturers Alliance' (JAMA), which has been the central industry network for the Japanese automobile industry. In fact, Keidanren (the central Japanese

business network) does not have a role in the fuel economy regulation in this process. After a certain agreement has been reached in these closed meetings, their agreements are passed to the Council for examination. The member of the Council is generally chosen from Japanese academia. Their role is to discuss the appropriateness of the new standard, by examining the Japanese auto industry's technological potential. Therefore, once the standard has been agreed in the Council, it implies that the certain legitimacy has given upon the standard. After being examined by the Council, the agreements are published as an 'intermediate report', and open to the public in order to reflect their comments. If there is not much dissenting opinion, it becomes the new fuel economy standard under the Energy Conservation Act (Figure 2).

Figure 2. The decision-making process of Japanese fuel economy regulations



3. Business strategies in pushing for the sustainable technological innovation

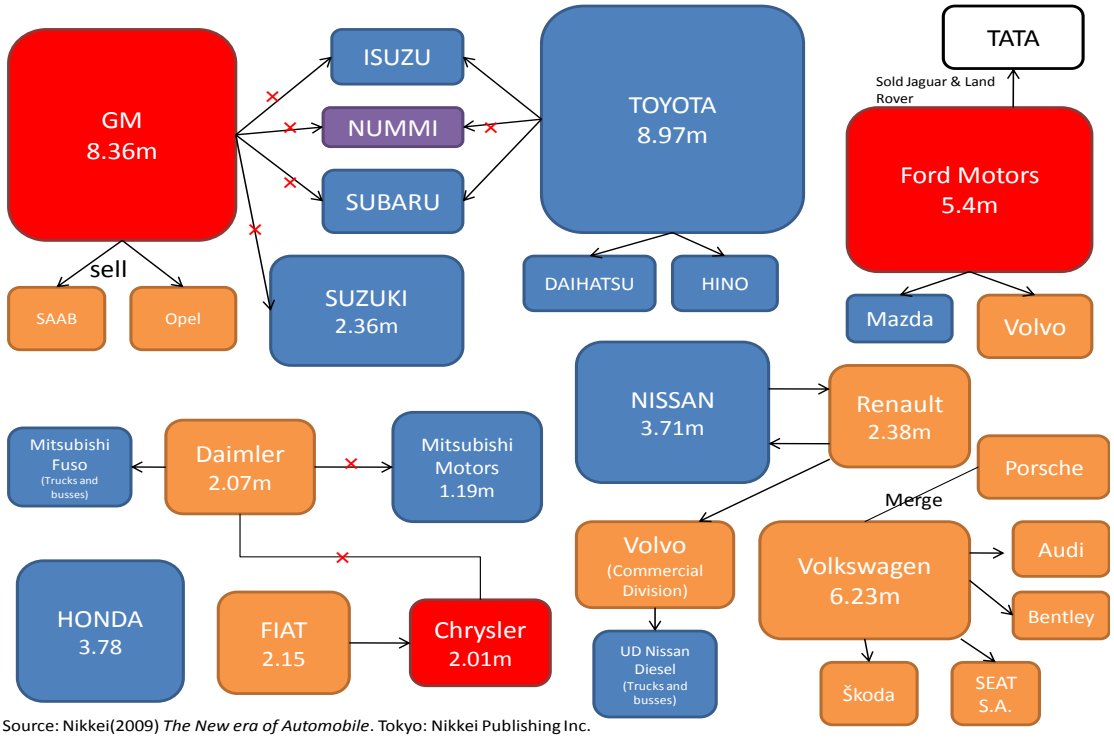
3.1 Environmental standards of exporting countries

As one of the major automobile manufacturing countries (see Figure 3), Japan has exported great numbers of automobiles. In doing so, Japanese automobile companies have been investing considerable amounts in research and development (R&D), in order to clear the environmental regulations of the importing countries, which are sometimes more stringent than the

standards at home, but also for the purpose of gaining the first mover advantage. This is one of the ways in which the technological innovation emerges.

A good example of how foreign regulation influenced Japanese automobile industry strategies is provided by the US Air pollution Act of 1970 (also known as the 'Muskie Act'), which set considerably high standards for every automobile manufactures to fulfil. By doing so, it encouraged technological innovation by the Japanese automobile manufacturer Honda in inventing Compound Vortex Controlled Combustion (CVCC) engine that made Honda to be the first automobile company to fulfil the regulation (Honda), and thus led the reputation of the sustainable technologies of Japanese automobile industries.

Figure 3: Major automobile industry with number of sales



Source: Nikkei(2009) *The New era of Automobile*. Tokyo: Nikkei Publishing Inc.

Among Japan's main automobile exporting countries, the environmental standards of U.S. and E.U. are particularly important in encouraging Japanese auto industry's sustainable technological innovations. U.S. is the Japan's biggest automobile exporting country with 30.7% of the total numbers of four-wheels vehicles has been exported in 2008, while Europe is the second biggest market that shares 23.6% (JAMA, n.d.a).

Furthermore, both U.S. and Europe are also the major bases of local vehicle production of Japanese auto industry. In 2008, about 25% of Japanese vehicles were produced in US (31% in North America) and around 15% in Europe, although Asia shares about 42% and this trend is on the rise.

The best example of how the exporting market's stringent regulations on the automobile is California's low-emission vehicle (LEV) regulation in 1990 that required U.S. and Japanese auto manufactures to include zero-emission vehicles (ZEVs) as a small percentage of their total sales. Although the regulation had gradually weakened by few amendments as a result of industry's lobbying efforts, it mandated the industry to include 2% of ZEVs in 1998 and 10% in 2003, including advanced-technology partially zero-emission vehicles (AT-PZEVs) such as hybrid vehicles. According to Yarime *et al.* (2008), this rigorous regulation has pushed the Japanese auto industry's technological innovations over hybrid and fuel-cell vehicles. After the California's ZEV regulation was introduced in 1990, the number of Japanese patent applications on EVs and hybrid vehicles sharply increased (Yarime, Shiroyama and Kuroki in Mytelka and Boyle, 2008).

In Europe, the strict 120g-CO_2/km target, which is almost equivalent to Japan's 2015 fuel economy target, was already proposed by European Commission in 1995. In 1998, *voluntary* target between ACEA and the European Commission (1999/125/EC) was agreed with the target of 140g-CO_2/km by 2008, and by 2009 for Japanese and Korean auto manufactures. As a result, this target may have worked as one of the driving forces that pushed Japanese auto industry to achieve the average CO_2 emission of 149g-CO_2/km in 2006. On the other hand, the average fuel economy of the European automobile industry in 2006 was only 160g-CO_2/km, which is far from the voluntary target of 140g-CO_2/km (T&E, 2007). It is notable that the Japanese auto industry's average CO_2 emission of vehicles significantly improved from 147g-CO_2/km in 2007, when the Commission announced for the mandatory regulations, to 141g-CO_2/km in 2008. Despite the fact that the mandatory CO_2 emission regulation on vehicles was only reached in December 2008, the average CO_2 emission of vehicles produced by Japanese auto manufactures in the European market were lower than US or Japanese markets. This suggests that Japanese auto industry took proactive strategies against the stringent (yet voluntary) CO_2 emission regulations in Europe. The table 2 compares the average CO_2

emission by nationality and territory in 2002.

Table 2. Average CO_2 emission by nationality and territory in 2002 (g-CO_2/km)

	Territory where cars are sold		
Nationality of Manufacturer	US	Europe	Japan
Average of EU Manufacturers	237.67	177.00	185.00
Average of US Manufacturers	290.00	203.67	195.00
Average of Japanese Manufacturers	**233.67**	**171.00**	**186.33**
Average per territory	253.78	183.89	188.78

Source: Austin *et al.* (2003) in Mikler (2009), modified by author.

3.2 Differing trends of technological innovations

Differing trends in technological innovations in other major automobile producing countries – namely Europe and the United States – can also be identified as an important factor that spurred technological innovation in the Japanese automobile industry. For instance, European automobile manufacturers have concentrated on the development of clean diesel vehicles, while the so-called 'US big three' (GM, Ford, Chrysler) are more focused on developing flexible fuel vehicles (FFVs), although hybrid electric vehicles (HEVs) are increasingly popular choices in the market strategies.

For instance, the diffusion of diesel vehicles are heavily depends on the air pollution regulations on automobiles in each countries. In Japan and the U.S., where the air pollution acts have been progressively evolved, the share of diesel vehicles is rather small. Japan had introduced the Air Pollution Control Law in 1968 (amended in 1996), which placed firm air pollutant emission regulation on automobile industry. In contrast to Japan and U.S., the European air pollutant regulations have been rather weak until 1980s and tightly progressed from 1990s onwards (Shiroyama, 2006), while CO_2 regulations on the automobile have been stringent. As a result, the diesel vehicles which emit less CO_2 compare to petroleum ICE vehicles, had become mainstream vehicle technology path for European manufactures - more than 50% of new passenger cars are now clean diesel vehicles.

Another example is FFVs, that is ICE engine vehicles running on gasoline blended with either ethanol or methanol fuel. FFVs require the

stable and large scale provisions of alternative fuels. In the U.S., the fuel economy regulation takes energy-savings driven approach, which has a strong link with its renewable energy policies. For example, the former President Bush's twenty-in-ten initiative aimed to improve vehicle fuel economy and increase alternative fuels, while reducing U.S. gasoline usage by 20% by 2017. Therefore, the U.S. has been the main market for the FFVs, along with Brazil and to an extent Canada and Sweden.

Japanese automobile industries has been benefiting from concentrating on the development of hybrid vehicles. Toyota has introduced hybrid technologies to 12 line-ups, with more than 1,700,000 HEVs are being sold up until now. Honda, which introduced hybrid technologies to 4 line-ups (Insight, Civic, CR-Z, Accord), is also the market leader of HEVs. If we trace back in 1990s, it was the year 1997 when Toyota released the hybrid vehicle 'Prius', with the fuel economy of 28.0km/L. Two years later, Honda released the hybrid vehicle 'Insight', with the fuel economy of 35.0km/L. Nissan, which forms alliance with French auto maker Renault, also introduces HEVs to 2 line-ups (Tino and Altima). Beside of Japanese auto manufacturers, the U.S. and European producers have also produced HEVs, for instance GM produces more than 4 line-ups, Ford with 2 line-ups (Escape and Mercury), and Chrysler with 2 line-ups (Aspen and Durango). Mercedes Benz is now announced to produce its first HEV, S-Class.

For any manufacturers producing HEVs, battery technology is at the heart. What is interesting is that most of the battery for HEVs are provided by Japanese battery manufactures. This is how the strategy of the Japanese auto industry enables themselves to be the market leader in HEVs. For instance, Toyota and Panasonic (Matsushita Battery Industry) has created a joint venture, Panasonic EV Energy in 1996 in order to provide both lithium-ion and nickel batteries for Toyota's HEVs. Honda has also created joint venture called Blue Energy, together with GS Yuasa in providing lithium batteries. Nissan-Renault alliance has also established Automotive Energy Supply with NEC Group that provides lithium-ion batteries to these manufactures. Furthermore, Volkswagen receives both lithium-ion and nickel batteries from Sanyo Electric, which has been purchased by Panasonic. Hitachi Group provides lithium-ion batteries to GM, through its venture Hitachi Vehicle Supply, and Daimler receives the battery from ENAX.

4. Concluding Remarks

So what are the implications to social dimensions environmental change and governance? First, the paper offered one example of governance arrangement that affect the sustainable technological innovations in automobile industry, namely, domestic fuel economy regulations which can be characterised as 'co-regulation' between the government and the industry. This finding would be useful in designing the domestic institutional arrangements addressing fuel economy of vehicles in developing countries, where the GHG emissions from road transport sector is significantly growing accompanying with their economic growth. This leads to the need for exploring more empirical case studies to compare and contrast different governance arrangements in this area, such as Japan, Europe, the United States, China and India on the one hand, and the more analysis on societies of developing countries in categorizing which types of governance arrangements might best fit to reduce emissions from this sector.

Second, the paper pointed out environmental standards of importing countries, as well as differing trends in technological innovations in Europe and United States have encouraged technological innovation in the Japanese industry. This links to the second implication, that there is need for more international governance that would further encourages the business competition for sustainable technologies amongst the major automobile manufacturing nations, in order to push for the low-carbon society at the global level. One way of doing this would be to coordinate efforts among the major automobile manufacturing countries to share the common (or more or less similar) standards of fuel economy of vehicles. This is not totally be impossible, given that we are witnessing the global trends of deepening fuel economy regulations everywhere in the world - where the Chinese fuel economy regulation is actually stricter than those of the U.S. and, the U.S. is now moving for the further target with the emergence of Obama Administration. These trends will no doubt push every automobile industry to foster their sustainable technological innovations, no matter what country they based at.

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