

# 14 A Quantitative Analysis of the Economic Effects of Patents on Industry: The Case of Japanese Automobile Industry<sup>(\*)</sup>

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*This study represents an economic analysis of an argument that Japanese firms' patents are failing to contribute to their profits. Particularly, this study focused on patents for eco-friendly technologies used for hybrid vehicles to verify the economic effects of patents on the automobile industry. Automobiles cover so many elemental technologies that it is unlikely that any single firm will own all of the patents covering one vehicle. Because the patent royalties are spread out across many different patent owners, profitability for patents of automobile technologies is assumed to be low. However, almost all eco-friendly technology patents are monopolized by a few Japanese firms, so this subcategory of patents might make more of a contribution to the profits of Japanese firms than patents generally. This study found that international applications for patents on electric motor technologies can hold down vehicle production costs, but that they do not contribute to the profits of the automobile industry due to the insufficient diffusion of vehicles powered by electric motors. It also found that patents on hybrid vehicle control technologies have failed to contribute to boosting car manufactures' new passenger car sales. This lack of an effect may be due to hybrid vehicles' limited market share even in countries with strict vehicle emissions standards, such as Japan and Germany.*

## I Introduction

According to Watanabe (2012), one of recent patent-related arguments in the intellectual property management field says, "Japanese enterprises' patents may be failing to contribute to their earnings." Given the fact that European firms and American firms with fewer patents are earning more than Japanese firms with more patents, some Japanese firms question whether a high investment in patents will yield sufficient returns.

This study examines whether patents contribute to profits for firms by employing an economic approach to verify whether patents are apt to lead to profits. Specifically, the study has had two purposes. One purpose is to verify the impacts of patent systems and patent acquisitions on the productivity of the entire industry and on individual patent acquirers with econometric models. Another purpose is to drive policy implications for patent systems that would provide incentives for the research and development (R&D) operations of enterprises and make greater contributions to invigorating the industry. Particularly, the study proposed a patent system that will boost incentives for firms' investment in research and development of socially significant eco-friendly technologies in an environment where it is very uncertain whether

patented technologies could increase profits.

Only the automobile industry is analyzed. The reason for narrowing down the target to one industry is that patents' links to earnings widely differ from industry to industry. For example, Watanabe (2012) compared the pharmaceutical and electronics industries based on a questionnaire survey by Watanabe et al. (2008) and reaffirmed that patents' contributions to earnings differ from industry to industry. The reason for choosing the automobile industry from among a number of industrial industries is that both the situations of less and more monopolized patents can be analyzed in this industry. In general, it can be assumed that less monopolized are associated with lower profits attributable to the patents, while more monopolized patents can lead to higher profits attributable to the patents. Given that automobiles cover a large number of elemental technologies including electronics, it may be difficult for any single automobile manufacture to possess all patents on its products. Therefore, patents' profitability can be generally assumed to be low in the automobile industry. However, patents on hybrid and other eco-friendly technologies are a special case. Because patents covering these technologies are more monopolized, with many held by the same Japanese firms, these patents may contribute more to profits than patents covering other

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aspects of the vehicle. The study thus focused on patents on eco-friendly technologies that are highly monopolized. Given the Japanese automobile industry's strong international competitiveness, their patents could be found to be a source for their competitiveness.

Here, eco-friendly technologies in automobile industry must be defined specifically. The study defines as eco-friendly technologies for engine technologies for hybrid electric and electric vehicles that are almost monopolized by some Japanese automobile manufactures. In general, electricity-fueled vehicles emit less nitrogen oxide, carbon dioxide and particle matters than gasoline-fueled ones and are viewed as eco-friendly cars that impose fewer loads on the environment.

In analyzing economic effects of patents the on automobile industry, the channels through which patents work to the advantage of patent holders are considered. There are three main ways that patent owners in the automobile industry may profit from their patents: 1) By collecting license fees from other firms that wish to use the patented technology; 2) By applying the patented technologies to increase production efficiency and lower production costs, thereby enhancing the firm's price competitiveness; and 3) By using the presence of the patented technology as a marketing point to attract customers. In an approach designed to cover all these channels, an econometric approach was adopted to verify the following three points:

- (A) Whether getting patents increases profits in the automobile industry
- (B) Whether patents reduce vehicle production costs
- (C) Whether patents increase the demand for new cars

The procedures and results of the econometric analysis in this study are summarized the following: First, production functions are estimated to verify (A) whether the acquisition of patents leads to boosting profits in the automobile industry. The verification covered the three channels comprehensively. The verification found that getting the patents concerning the electric motor technologies reduced earnings in the automobile industry even though these technologies were highly monopolized by some firms. As earlier assumed, it also found that the acquisition of patents on other major technologies has little impact on earnings in the automobile industry. Next, it was verified whether production costs or sales aspects

are responsible for leading to the acquisition of patents on electric motor technologies to lower earnings. A production function was estimated to verify (B) whether patents reduce vehicle production costs. The analysis found that patented electric motor technologies that are part of eco-friendly technologies can reduce labor and capital input per vehicle to lower overall production costs. It also found that the acquisition of patents on hybrid engine technology can increase production costs instead of lowering them. As for sales, a demand function was estimated to verify (C) whether patents increase the demand for new cars. The analysis found that patents do not increase new car sales. It also found that patents on hybrid vehicle control technologies as part of eco-friendly technologies fail to lead to expanding demand for new cars. This may be because the market penetration rate for hybrid vehicles is still low.

## **II An analysis of some impacts of patents on productivity of the Japanese automobile industry**

Chapter II first verified whether the acquisition of patents leads to boosting earnings in the automobile industry. As it is difficult for any single automobile manufacture to possess all patents on a car consisting of a large number of elemental technologies, it is expected that it would be difficult for patents to lead to boosting earnings. As some Japanese enterprise exclusively possesses patents on eco-friendly technologies for hybrid and electric vehicles and almost monopolizes the hybrid and electric vehicle market, there is a possibility that the acquisition of patents on these technologies could contribute to earnings in the Japanese automobile industry.

Production functions are employed for the verification. First, a stochastic frontier production function was estimated. In the stochastic frontier production function, the inefficiency terms added to a usual translog production function to control differences in country-by-country automobile industry production efficiencies. Next, ordinal least square models are employed to check impacts that patents exert on the value of inefficiency determined through the estimated stochastic frontier production function.

Data on 14 of the 15 major vehicle-producing countries between 1990 and 2010, excluding Sweden whose data were unavailable, were used for estimation. The 14 are Japan, the United

States, Canada, Germany, the United Kingdom, France, Italy, Spain, Australia, South Korea, Brazil, Russia, India and China. The number of samples stood at 196 (14 countries over 14 years). Data on country-by-country automobile industry was drawn from GMID Passport Academic (Euromonitor International) and patent data -- PCT (Patent Cooperation Treaty) applications by major technology category in the automobile industry -- from the OECD iLibrary. Value added in the automobile industry was defined as output and capital and labor as input.

The verification found that patents fail to lead to boosting earnings in the automobile industry. Even patents on eco-friendly technologies that are highly monopolized by some enterprise were found to make little contribution to earnings. The finding is identical to the earlier study conclusion that Japanese enterprises' patents have failed to contribute to their earnings.

Next, Chapter II confirmed whether production side is responsible for the failure of patents on highly monopolized eco-friendly technologies to contribute to earnings. Because the frontier model was rejected as an estimation result of stochastic frontier production function estimation, patents were added as an independent variable for the trans-log production function without the inefficiency term to examine the impacts of patents on productivity.

Data on 14 of the 15 major vehicle-producing countries between 1990 and 2010, excluding Sweden whose data were unavailable, was used. The 14 are Japan, the United States, Canada, Germany, the United Kingdom, France, Italy, Spain, Australia, South Korea, Brazil, Russia, India and China. The number of samples stood at 196 (14 countries over 14 years). Data on country-by-country automobile industry was drawn from GMID Passport Academic (Euromonitor International) and patent data -- PCT (Patent Cooperation Treaty) applications by major technology category in the automobile industry -- from the OECD iLibrary. Output was defined as the number of vehicles produced and inputs were defined as capital and labor.

In this section, supply sides measurements were investigated to verify whether the acquisition of patents leads to lowering automobile production costs. The verification found that patents on electric motor technologies among eco-friendly technologies can reduce production costs while patents on hybrid technologies can increase automobile production

costs. Japan monopolizes patents on both electric motor and hybrid technologies. Therefore, the two categories of patented technologies are assumed to have offset each other's impacts on production costs. Therefore, demand side rather than production side is assumed to be responsible for the failure of patents on highly monopolized eco-friendly technologies to contribute to.

### **III An analysis of some impacts of patents on the sales of Japanese passenger cars in the Japanese and foreign markets**

Chapter III confirmed whether demand side is responsible for the failure of patents on highly monopolized eco-friendly technologies to contribute to earnings. The explanatory variable assumed to be responsible demand factors are income from licensing of patented technologies and income from sales of products using patented technologies. However, licensing income was excluded from my analysis, because the licensing of patented technologies in the automobile industry takes place mainly between automakers and their subsidiaries.

The analysis in Chapter III examines the Japanese and German automobile markets. This study examines both a foreign market and the domestic market because Japanese automobile manufactures' economic activities cannot be differentiated from those of their foreign counterparts in the Japanese automobile market, given that imported vehicles are primarily those of foreign automobile manufactures in Japan. The reason for choosing the German market as a foreign market subject to the analysis is that both Japanese and German automobile manufacturers are apt to file more patent applications. Comparison of patents acquired by Japanese and German automobile manufactures indicates that both Japanese and German automobile manufacturers are apt to acquire patents in their respective home countries. But there is a difference between them. German automobile manufacturers have acquired fewer patents than Japanese automobile manufactures in Japan, while Japanese automobile manufacturers have acquired as many patents as German automobile manufactures in Germany. A breakdown of patents on hybrid vehicle control technologies among eco-friendly technologies found that Toyota Motor Corp. has acquired a remarkably large number of such patents both in Japan and Germany, indicating Toyota's monopolistic

possession of hybrid vehicle control technology patents.

The verification was implemented through the estimation of a demand function for new vehicles. In line with Berry et al (1995, 1999), Goldberg and Verboven (2001), Pertin (2002), and Ohashi and Toyama (2012), I used vehicle prices, income and vehicle performances as independent variables influencing vehicle demand in the analysis. Then, the number of patents owned by automakers was added as one of variables representing vehicle performances to verify the impacts of patents on demand. The reason for treating the number of patents as a variable representing vehicle performances is that major patented automobile technologies are expected to improve overall vehicle performances by increasing fuel efficiency and reducing emissions.

To estimate a demand function for new passenger cars in the Japanese market, this study used data on model-by-model sales for Japanese passenger cars between 2003 and 2010. Data are unbalanced and data for the period are not necessarily available for all models. Information on the number of effective patents for each automobile manufacture was taken from data provided by the Japan Patent Office. When analyzing the impacts of hybrid vehicle control technology patents on car demand, however, model-by-model data between 2006 and 2010 was used. This is because data in and before 2005 are unavailable, given that no one is allowed to access patents on hybrid vehicle control technologies in and before 2005 through the IPC (International Patent Classification). For estimating a new vehicle demand function in the German market, I used model-by-model sales data for passenger cars between 2009 and 2011. Data are unbalanced and data for the period are not necessarily available for all models.

This section analyzed demand side and examined whether patents contributed to increasing demand for new cars. The verification found that patents are not associated with an increase in car sales in either the Japanese or German market. Patents on eco-friendly technologies were also not associated with an increase in sales. This means that hybrid vehicle control technology patents failed to boost demand for cars even though the Japanese government has provided tax cuts and subsidies to expand demand for eco-friendly cars since fiscal year 2009. Hybrid and electric vehicles accounted for about 20% of the Japanese new vehicle market in fiscal year 2012. In Germany, the market

penetration rate for hybrid and electric vehicles was limited to less than 1%. Production and demand aspect analyses apparently indicate that even patents on highly monopolized eco-friendly technologies failed to contribute to earnings because hybrid vehicles and electric vehicles using eco-friendly technologies have yet to sufficiently spread in the market.

## IV Conclusion

This study used an econometric approach to examine whether patents lead to an increase of profits in the automobile industry. The verification found that neither less monopolized general patents nor highly monopolized eco-friendly technology patents have increased profits in the automobile industry. Next, this study examined whether supply side or demand side are responsible for the failure of patents on highly monopolized eco-friendly technologies to contribute to earnings. Analyses on production and demand side found that a small market share for vehicles using eco-friendly technology patents is mainly responsible for the failure of patents on highly monopolized eco-friendly technologies to contribute to profits.

In the Japanese market, hybrid vehicle control technology patents failed to boost demand for cars even though the Japanese government provided tax cuts and subsidies to expand demand for eco-friendly cars starting in 2009. This means that even if an enterprise monopolizes technologies that are recognized as socially useful, patents on these technologies fail to lead to earnings unless products using these technologies sufficiently spread in the market. This indicates uncertainties of profits. In the automobile industry, an automobile manufacture that monopolizes patents on hybrid vehicles may expire before patent-owning automobile manufactures can profit from these patents. In this way, an automobile manufacture that has developed a technology could be defeated by rivals in a price-cutting race after the expiration of a patent on the technology, thus failing to sufficiently recover research and development investment. Unless patents on new technologies are expected to lead to earnings, enterprises may choose to keep new technologies secret or may lose incentives for research and development.

Eco-friendly technologies can reduce load on the environment, thus making great social contributions. If priority is given to promoting research and development (R&D) of eco-friendly

technologies, the government should design the patent system to allow the term for patents on eco-friendly vehicles to be extended in line with eco-friendly vehicles' penetration into the market. This measure is intended to reduce uncertainties of earnings from patenting of eco-friendly technologies and keep incentives for enterprises to research and develop these technologies.

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