CO2 Mitigation Policy of Aviation Sector in Japan

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論 文 内 容 の 要 旨

CO_2 emissions from aviation industry have increased rapidly, and air transportation released approximately 2.8% of global fuel-combustion-based CO_2 emissions in 2019. Aircraft passenger demand has grown at a rate of 6.2% per year over the past 10 years, and Boeing and Airbus projected a rate of growth 4.6% per year and 4.3% per year over the next 20 years, respectively. On the other hand, the International Civil Aviation Organization (ICAO) has introduced a global market-based measure (GMBM) program and “carbon neutral growth from 2020” to avoid increases in CO_2 emissions from the international aviation sector after 2020. Airline industry needs to satisfy the aircraft passenger demand and at the same time to reduce CO_2 emissions from their operations. With this background, this thesis develops a new decomposition analysis framework to analyze the supply-and-demand factors for the CO_2 emissions associated with Japanese aviation industry. This thesis also analyzes the lifecycle CO_2 emissions and cost through the estimation of aircraft lifetime and aircraft replacement cycle. By using the proposed analysis frameworks, this thesis identifies the major driving factors of increasing and reducing CO_2 emissions for each supply-side and demand-side, and appropriate aircraft replacement cycle for environmental and economic objectives. Based on the results, this thesis discusses effective CO_2 mitigation policies of aviation sector in Japan. This thesis comprises five chapters.

Chapter 1 briefly provides research background, research objectives, and contributions of this thesis. This chapter illustrates CO_2 emissions from aviation industry and points out an importance of mitigating CO_2 emissions without uncertain reduction measures. This chapter also argues how CO_2 emissions reduction measures estimation with feasible measures can be useful in providing effective CO_2 mitigation policy of aviation industry.

Chapter 2 conducts a review of relevant existing articles, identifies the contributions and problems of the existing research, and describes the significance and objectives of the present study.

Chapter 3 estimated CO_2 emissions from international aviation by two Japanese major airlines, Japan Airlines (JAL) and All Nippon Airways (ANA), and identified the drivers for those CO_2 emissions using an index decomposition analysis conducted between 2005 and 2015. This chapter developed original flight database of aircraft fuel efficiency and timetable of JAL and ANA, and based on the database, estimating the CO_2 emissions from international aviation for each airline. This study found the following: (1) changes in

aircraft models and the total number of flights affected the CO_2 emissions attributable to the aviation industry most significantly, (2) introducing the more fuel-efficient Boeing 787 led to CO_2 emission reductions of 1.3 million tons by the two companies, and (3) these reductions were canceled out by the total number of flights and distances per passenger attributable to the airlines' operations. This chapter concluded that conclude that the environmental and business strategy of introducing greener aircraft with better fuel efficiency was insufficient for mitigating aircraft emissions' effects on climate.

Chapter 4 analyzes fleet dynamics and to assess whether aircraft introduction is a feasible way to meet environmental and economic objectives. Previous studies showed that the introduction of new fuel-efficient aircraft contributed to reduce CO_2 emissions. However, the effects of costs and emissions in the aircraft manufacturing and flying phases from a long-term perspective remain unclear because they did not consider the fleet dynamics. To discuss the effects of introducing new-fuel efficient aircraft on environment and economics, it is important to identify the aircraft replacement cycle. This chapter specified the lifetime distribution function for Japanese passenger aircraft, and estimated lifecycle CO_2 emissions and associated costs between 1965 and 2019. This chapter found that single-aisle aircraft followed a Rayleigh distribution with a mean of 13.42, while twin-aisle aircraft followed a normal distribution with a mean of 19.82. The reduction potential of lifecycle CO_2 emissions is 28.2 Mt over 55 years by changing aircraft lifetime. However, the cost associated with the lifecycle CO_2 emission reductions is USD 94.0 billion, and airlines need to pay USD 3.4 thousand to reduce CO_2 emissions by one unit. This chapter concluded that the introduction of new aircraft was shown to be cost-ineffective as a CO_2-reduction policy, and airlines need to switch to less costly alternatives.

Chapter 5 summarizes the analysis results obtained from Chapters 3 and 4, and presents the conclusions of this dissertation.