

Role of Vehicle Lifetime in Climate Change

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論 文 内 容 の 要 旨

Achieving the Paris Agreement goals as adopted at COP21 will require highly transparent climate change countermeasures. Looking at the worldwide greenhouse gas (GHG) emissions by sector for 2010, the transportation sector, at approximately 14% bears much of the responsibility for emissions. The automotive sector is of particular concern. Automotive CO₂ emissions come both directly, from driving vehicles, and indirectly, from various industries in each country through a massive global supply chain of the materials and parts required for automotive manufacturing. Each country has an obligation to lead initiatives mitigating the human contributions to climate change by reigning in the CO₂ incidental to vehicle life-cycles: the carbon footprint of vehicles. Given the above situation, in Japan, for example, technological breakthroughs in the internal combustion engine, development of next-generation vehicles, and distribution streamlining are driving down CO₂ emissions from vehicle driving. The world greatly needs a shift to circular economies. In action plan for the circular economy, EC are getting more attention in closing supply chains and resource efficiency. With this kind of background, it is essential in debating policy on this shift to analyze CO₂ emissions for the entire product life-cycle, from resource mining to vehicle disposal, and not just the product usage phase. There is particularly great interest in how product lifetime extension would impact CO₂ emissions across the full product lifecycle. Previous studies on Switzerland and Japan have concluded that extending vehicle lifetime will reduce overall life-cycle CO₂ emissions and be beneficial for the environment. Generally, a longer product lifetime means that consumers buy new products less often, in turn helping to reduce the CO₂ incidental to manufacturing new products. However, slowing the pace of product replacement will leave many older, less energy-efficient products in society, which will increase CO₂ emissions incidental to product usage. If we were to achieve higher standards in energy efficiency, maybe disseminating a larger numbers of energy-efficient new products by shortening product lifetime would make the CO₂ reduction effects for product usage exceed the CO₂ increasing effect from product manufacturing. This thesis analyzed the role of the vehicle lifetime of countries in CO₂ emissions at globe. This thesis comprises six chapters.

Chapter 1 presents research background, research objectives, and contributions of this thesis. This chapter explains about why the circular economy is important in establishing low-carbon and sustainable development of the economy. This chapter points out that it is important to shed light on the ‘closing-loop’ of the product life-cycle through designing products with longer lifetimes and achieving greater re-use and recycling. Such circular strategies for products have impacts on both the economy and the environment

through the global supply chains of the products. Thus, it is crucial to analyze the carbon footprint (CF) for the entire product life-cycle.

Chapter 2 provides a comprehensive 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 spatially extended the vehicle life-cycle analysis of a single country and developed a new method for vehicle life-cycle analysis by combining a 15-country automotive stock-flow model based on the 15-country automotive lifetime distribution with global multi-regional input-output analysis. From the results, considering that ten of the 15 countries had vehicle lifetimes shorter than the average of 15.8 years: Austria, Canada, Germany, France, the U.K., Ireland, Italy, Japan, South Korea, and the Netherlands, we found that by increasing the average vehicle lifetimes of these 10 countries to the global average of 15.8 years, a reduction of 17 Mt-CO₂-eq. from the carbon footprint of the 10 countries could be achieved. In addition, we also revealed that roles of changes in vehicle lifetime and fuel efficiency on global CO₂ emissions are vastly different between countries where vehicle lifetimes are longer and those where lifetimes are shorter.

Chapter 4 estimated the carbon footprint associated with the global final demand of automobiles and auto-related petroleum of the U.S.A., Germany, and Japan, which account for 31% of the stock of passenger cars in the world in 2009, during 1995 to 2009. This chapter further developed a comprehensive new method that offers a deeper understanding of the structural change in the global final demand of automobiles and discussed how the lifetime of automobiles of a specific country has contributed to their CFs. While environmentally conscious automobile manufacturing through technological innovation has advanced globally, the industry's production structure runs counter to carbon reduction and completely canceled out the effects of technological changes in emission intensities. Suppressing demand for new cars through lifetime extension greatly reduced carbon footprint, and had a similar or greater effect than technological changes in emission intensities of suppliers directly and indirectly involved in automotive manufacturing.

In 1951, the Japanese government introduced a vehicle safety inspection system and this system has an effect of shortening the 'economic' lifetimes of automobiles and increasing CO₂ emissions associated with vehicle lifecycle. Chapter 5 developed an integrated assessment framework by combining dynamic discrete choice analysis with life-cycle environmental accounting analysis based on a dynamic stock model. From the empirical results, we found that (1) the economic lifetime of a Prius in the benchmark model is surprisingly short, 5.07 years, due to the strict car inspection system, and this replacement cycle has contributed to increasing CO₂ over time; and (2) abolishing car inspections at the third and fifth years would considerably contribute to reducing life-cycle CO₂ emissions associated with Prius sold during the study period, 1997 to 2016, accounting for approximately one million tons-CO₂ eq. over 20 years. Thus, we conclude that modifying the regulation policy with a focus on the car inspection system to induce car owners to keep their automobiles longer would have environmental benefits.

Chapter 6 summarizes the analysis results obtained from Chapters 3, 4, 5 and presents the conclusions of this dissertation.