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Energy efficiency in the Japanese transport sector ☆

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HIGHLIGHTS

- We examine energy efficiency in the Japanese passenger transportation sector.
- Japan stands out for low activity and modal structure, not modal energy intensity.
- We also consider the political context of energy efficiency in Japan.
- Energy efficiency policies also rewarded important political constituents.
- Political changes are threatening transportation energy efficiency in Japan.

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ABSTRACT

We examine energy efficiency in the Japanese transportation sector since the 1970s. Comparisons with the United States and other developed economies illustrate that Japan primarily stands out due to low activity levels and modal structure rather than modal energy intensity. On-road automobile energy intensity has shown little improvement, albeit from a low base, over the past four decades. We also consider policy measures undertaken by the Japanese government. Political arrangements in Japan after World War II made it attractive for politicians to pursue energy conservation by making transportation, particularly by automobile, expensive for the average Japanese citizen. The revenues raised from various fees and taxes on automobile transportation were redistributed to core supporters of the ruling Liberal Democratic Party. These political arrangements have come under fire in recent years, calling into question Japan's traditional approach towards transportation sector energy efficiency.

1. Introduction

Japan has one of the most energy efficient economies in the world according to conventional measures such as energy intensity. The Japanese transportation sector is also among the most efficient. In this paper, we will review energy trends in the Japanese transport sector in recent years. We reveal that the low level of automobile ownership in Japan through the early 1970s was largely erased by steady growth that pulled fuel use upwards as the Japanese became more affluent and automobile ownership increased. Poor traffic hindered Japanese drivers from attaining high levels of fuel economy. Only after 2000 did these trends begin to change and even reverse. Thus, despite Japan's global reputation as an energy efficient country, energy intensities for the main mode of transport rose for most of the period after 1973.

Japan clearly stands out from other countries in transport activity and mode share. We will illustrate this point through comparison with the United States and several other developed countries. Despite economic development to a level comparable to most Western countries, Japanese travel shorter distances and are much more prone to travel by rail. After declining consistently for several decades, rail share in Japan has rebounded over the past decade. Past analyses have called into question whether Japan's transportation energy efficiency is attributable to government policy (Kiang and Schipper, 1996). We consider several non-policy

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determinants of transportation trends—geography, urban population density, demographics, and economic development—and find that Japan stands out in terms of transport activity and mode share even after considering these factors.

Turning to policy, a primarily focus in recent years has been the use of regulatory means to improve automobile fuel economy, exemplified by the Top Runner program. However, the defining feature of transportation policy in Japan is high costs imposed on automobile ownership and travel. Highway tolls in particular are extremely high compared to other developed economies. Political arrangements in Japan after World War II made it attractive for politicians to pursue energy conservation by making transportation, particularly by automobile, expensive for the average Japanese citizen. The revenues raised from various fees and taxes on automobile transportation were redistributed to rural residents and the construction industry, the core supporters of the ruling Liberal Democratic Party. These political arrangements have come under fire in recent years, calling into question Japan's traditional approach towards transportation sector energy efficiency.

2. Japan's transportation sector in comparative perspective

2.1. CO_2 emissions in the Japanese transportation sector

In this section, we will place Japan in comparative perspective through comparison with the United States. We will divide transportation into passenger transportation and freight transportation, since these subsectors tend to be driven by different economic factors (Schipper et al., 1997; Schipper and Marie-Lilliu, 1999). This omits a small amount of energy in the transport sector for off road vehicles (U.S. Department of Energy, 2010). The overwhelming bulk of the energy for domestic passenger transportation and freight transportation consist of the following vehicles:

Passenger transportation

- Cars (private vehicles like sedans, kei-cars (the smallest category for cars in Japan, length < 3.4 m, width < 1.48 m, height < 2.0 m, engine displacement < 660 cc), Sports Utility Vehicles (SUV) and Passenger Light Trucks (LT) for passenger use in the U.S. For Japan, kei-cars are included here; for the US, the share of light trucks and SUV used as household vehicles is included as these make up nearly 40% of household vehicles today (Schipper et al., 2011).
- Buses, including intercity, school, and local transit services
- Passenger air travel within the US or Japan
- Passenger rail, including both local transit and intercity services
- Passenger ships or boats for Japan. For the US, these are negligible.

Freight transportation

- Trucks and trucking
- Freight rail
- Domestic freight ships or boats
- Domestic air freight

Fig. 1 gives the breakdown of per capita energy use for travel and freight in the two countries by mode. Fig. 1 shows that passenger cars and freight trucks, both in Japan and the U.S.A., comprise almost 85% of the CO_2 emission from transportation in the two countries. Thus, any significant improvement in CO_2 emissions in the transportation sector has to include improvements in efficiency and changes in usage of passenger cars and freight trucks. Japan's CO_2 emissions from the whole transportation sector

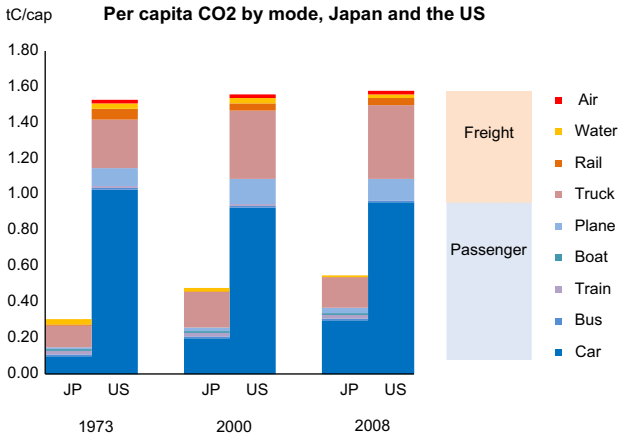

Fig. 1. Per capita CO_2 by mode, Japan and the US.

(passenger and freight) were about 244 $MtCO_2$ in 2008. About sixty percent of that came from passenger transportation and forty percent came from freight transportation.

In the subsequent analysis, we will focus on passenger transportation to disentangle the sources of CO_2 emissions. Comparison of Japan's freight emissions with other countries (including Korea) can be found in Kamakate and Schipper (2009) and Eom et al. (2011).

2.2. Analysis of passenger transportation patterns and trends in Japan

In this section, we will provide an analysis of CO_2 emissions and trends in passenger transportation in Japan. To provide comparative perspective, the trends will be compared with those in the United States. In this research, we will use an analytical framework based on Kiang and Schipper (1996) and developed more fully by Schipper et al. (2000), which consists of the components shown below:

A. Activity: volume of transportation measured in passenger-kilometers (pkm)

S. Structure: modal shares in total activity

C. Intensity: CO_2 emission per activity (pkm), which is the product of the energy intensity I times the CO_2 content of the fuel F. Since F is overwhelmingly dominated by oil (despite the important share of electric rail in travel), we keep I and F separated and focus primarily on I.

Then, CO_2 emission is calculated from the aggregation of CO_2 emissions in each mode calculated from the formula shown below.

$$CO_2\ emission\ (tCO_2) = G = \sum A \times S \times I \times F = \sum A \times S \times C.$$
$$total\ activity\ (\text{pkm})\ \text{X}\ structure(=mode)\ (\%)\text{X}\ CO_2\ intensity\ (tCO_2/\text{pkm}) \quad (1)$$

Each factor (activity, structure (mode), intensity) will be analyzed with respect to CO_2 emissions.

As Eq. (1) implies, energy use for travel is the product of total travel, the modal shares, and the energy intensities of each mode. Combing the energy intensity of each mode with the CO_2 intensity of each fuel (or electricity) gives the CO_2 intensities of travel, and for Eq. (1), total CO_2 emissions for travel.

2.3. Transport activity

Fig. 2 shows the per capita breakdown of travel activity from 1973 to 2008 in each country. Passenger travel per capita in the United States is about 2.5 times greater than in Japan. Historically,