Energy Efficiency in the Japanese Transport Sector

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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. Automobile energy intensity has shown little improvement, albeit from a low base, over the past four decades. We also consider the political context of Japan’s transportation sector policymaking. 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 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.

Keywords

Japan, transportation, 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. However, past analyses have called into question whether any of this efficiency is attributable to government policy. In particular, in the mid-1990s, relatively higher energy efficiency in Japan was attributable entirely to transport levels and modal structure rather than modal energy intensity (Kiang and Schipper 1996). Japanese transportation may be more efficient in part because of factors that have very little to do with government conservation efforts, such as demographics, geography, and higher energy costs.

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 efficiency 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 particularly through comparison with the United States. Despite economic development to a level comparable to most Western countries, Japanese travel shorter distances and are much more likely to travel by rail. Remarkably, after declining consistently for several decades, rail share in Japan has rebounded over the past decade.
Turning to policy, Japan stands out for some innovative policy measures that could be successfully adopted elsewhere – in particular, aggressive automobile fuel economy standards based on its Top Runner program. However, the overall prognosis for Japanese transportation policy is not favorable. Because Japan has already achieved a high level of efficiency, Japanese policymakers concede that further improvements are unlikely to prove dramatic. Long-term political changes have also unsettled Japanese transportation policy – existing arrangements that contributed to energy efficiency have been called into question amidst a historic political transition. The Great Tohoku Earthquake of March 11, 2011, has renewed attention on energy conservation, but the primary positive impact so far has been avoidance of a potentially harmful outcome: plans to eliminate highway tolls have been rolled back.

2. Japan’s Transportation Sector in Comparative Perspective

2.1 CO2 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, mini-cars (the smallest category for cars in Japan, length<3.4m, width<1.48m, height<2.0m, engine displacement<660cc), Sports Utility Vehicles (SUV) and Passenger Light Trucks (LT) for passenger use in the U.S. For Japan, mini 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

Figure 1 gives the breakdown of per capita energy use for travel and freight in the two countries by mode. Figure 1 shows that passenger cars and freight trucks, both in Japan and the U.S.A., comprise almost 85% of the CO₂ emission from transportation in the two countries. Thus, any
significant improvement in CO₂ emissions in the transportation sector has to include improvements in efficiency and changes in usage of passenger cars and freight trucks. Japan’s CO₂ emissions from the whole transportation sector (passenger and freight) were about 244MtCO₂ 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 CO₂ emissions. Comparison of Japan’s freight emissions with other countries (including Korea) can be found in Kamakate and Schipper (2009) and Eom, Schipper and Thompson (2011).

Fig. 1
2.2 Analysis of Passenger Transportation Patterns and Trends in Japan

In this section, we will provide an analysis of CO\textsubscript{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, Marie and Gorham (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\textsubscript{2} emission per activity (pkm), which is the product of the energy intensity I times the CO\textsubscript{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\textsubscript{2} emission is calculated from the aggregation of CO\textsubscript{2} emissions in each mode calculated from the formula shown below.

\[
CO_2\text{ emission (tCO}_2\text{)} = G = \Sigma A*S*I*F = \Sigma A*S*C. \tag{1}
\]

Each factor (activity, structure (mode), intensity) will be analyzed with respect to CO\textsubscript{2} emissions.

As Equation 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\textsubscript{2} intensity of each fuel (or electricity) gives the CO\textsubscript{2} intensities of travel, and for Equation 1, total CO\textsubscript{2} emissions for travel.

2.3 Transport Activity

Figure 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, passenger activity (travel) per capita increased steadily in both the U.S. and Japan because of economic growth. With increases in population, the result was even greater growth in total travel. Controlling for population trends, in the U.S., pkm/capita increased by 1.1% per year from 1973 to 2008 while the pkm/capita in Japan increased by 1.4% per year. The difference in growth rate between the two arose because Japan started at a lower level than the US, and the share of automobile travel itself was much lower in the total. As we will see, the growth in Japan was driven principally by the subsequent growth in automobile ownership and use.

If we examine the increase in recent years, the growth in passenger activity per capita in Japan seems to have finally stopped and started to decrease in 2003. A similar plateau in the US and other countries is evident, even as GDP continued to grow (Millard-Ball and Schipper 2011). However, in each country, travel has generally increased with GDP/capita, which raises the issue of whether that couple will be relaxed or even reversed as GDP continues to grow. Figure 3 shows that the travel activity per unit of GDP in the U.S. is more than twice that in Japan. Uncovering the reasons behind this difference is crucial to understand whether either nation’s level will stabilize or even decline. The most obvious difference is geography – Japan is more densely populated, with the major urban centers of Tokyo, Osaka, and Nagoya in close proximity to one another. Destinations are close in dense Japan than in the US, and traffic is slower, so the cost in time of a journey is higher. Some policy measures may also account for the difference, as we explain in subsequent sections.
Transport activity per capita, Japan and the US

Fig. 2
2.4 Structure (Mode)

The breakdown of passenger activity in Japan (Fig. 2) over time showed that the biggest contributor was cars, which accounted for 55.8% of all passenger activity in 2008. It is striking that the share of rail in Japanese passenger activity is 30.9% - very high compared to 0.6% in the U.S. and about 10% for major Western European countries. That of buses is also much higher in Japan than in the US - in fact, per capita travel for bus and rail in Japan come close to that of per capita air travel in the US! Both of these differences are consistent with what is observed around the world – denser countries have both lower total per capita travel and a higher share of that travel in collective ground modes. These tend to lose importance as income grows, but we can see Japan’s collective level today is still well above that of even European countries (Millard-
Ball and Schipper 2011; Webster and Bly 1981). Japanese move far less and less in cars than Americans (or Europeans).

As with other countries, the biggest increase in passenger activity in Japan over time came from cars. Cars excluding mini-cars increased from 235 billion pkm in 1975 to 559 billion pkm in 2008. Mini-cars increased from 28.0 billion pkm in 1975 to 216.2 billion pkm in 2008.² Airplane passenger activity in Japan increased rapidly from 19.1 billion pkm to 81.0 billion pkm in 2008. Although this represents 6.6% of total passenger activity, it is still less than half that of that in the U.S. and only about a third of the U.S. per capita value. If foreign travel were counted, however, Japan would doubtless close some of the gap with the U.S. Note that our U.S. figures include travel in the over 80% of light trucks and SUVs that were used as household vehicles in the 2000s, a figure that rose from under 30% (of a much smaller number) in the early 1970s (Schipper et al. 2011). It is ironic perhaps that while Japan’s individual mobility has been boosted by small cars with an engine capacity under 660 CC, that of the US comes from vehicles with six times or more the engine capacity. We will discuss the policy measures that likely contributed to this difference in Section 4.

As for bus and rail, these were almost insignificant in the US and their shares or per capita values changed little from the 1970s to 2008. By contrast, the shares of bus travel in Japan fell sharply as car use grew, and the per capita values of bus travel in 2008 were lower than in 1975. Rail travel in 2008, however, was close to its peak of the early 1990s of over 3100 pass-km/capita, most likely because of the success of the Shinkansen. Given the modest resurgence in rail travel, which nearly reached its early 1990s peak again in the late 2000s, we surmise that the Shinkansen both boosted rail travel and encouraged significant switching of air travelers to rail in

² Neither EDMC nor ML2 list passenger travel for min cars from before 1987. Following Schipper and Kiang (1996) we extrapolate travel to these previous years by the product of each year’s mini-car distance driven times the average number of people per mini-car in 1987.
competitive markets (Shibahara et al. 2011).

In summary, Japan’s per capita travel and modal structure have evolved as expected over time as per capita GDP rose. Yet, they still differ significantly from those of the U.S. and Europe as marked by a significantly lower level of total domestic travel (well under one-half of the US per capita level), and a much lower share of car travel (less than 65% vs. typically 85% in Europe and 88% in the U.S.).

2.5 Energy Intensity by Mode

Energy intensity of car travel (including mini-cars) and air in Japan is around 2.0MJ/pkm, that of Buses, at about 0.7MJ/pkm, is less than half of them; and that of Rail (about 0.4MJ/pkm calculated from primary energy; 0.2MJ/pkm calculated from electricity kwh) is substantially lower than the others. The energy intensities of travel modes in Japan vary considerably in relation to the United States. As Figure 4 shows, those of bus or rail travel are low, even including the primary energy required to make electricity for rail. On the other hand, the energy intensity of air and automobile travel was historically below levels in the U.S., but in recent years, this relationship has reversed. In 2008, the energy intensity of car travel in Japan was about 10% higher than that in the U.S.

It may seem surprising that car travel in the U.S. and Japan have nearly the same energy intensities. In terms of new auto fuel economy, the Japanese fleet uses about 15% less fuel/km than that in the U.S. – Japanese cars are considerably smaller and less powerful (Fig 5 and Fig 6). Congested traffic appears to be the reason for the surprising near-equivalence of energy intensities. A stock-wide model of the Japanese fleet suggests these would obtain 6.2 l/100 km
using the standard 15-mode test (IEE 2010). Raising this aggregate number by 33% to reflect real traffic gives a much closer fit to the on-road fleet fuel economy figures. For reference, the US EPA uses a corresponding adjustment of around 25% to raise tested vehicle fuel economy to what would be expected in real traffic. The fact that there are so many mini-cars in Japan, usually occupied by single-drivers, may further lower the average occupancy of cars and therefore raise average fuel use/passenger-km. In contrast, the low energy intensities of bus and rail travel in Japan can be attributed to high load factors, i.e., full vehicles.

The average car on the road in the US in 2008 used 30% less fuel than one in 1973. Trends in the fuel intensity of new Japanese cars have been mixed. Between the mid 1980s and until late 1990s, consumers were favoring more luxury, sporty, powerful cars with more capacity and torque. As a consequence, the share of the largest cars among new vehicles grew steadily, and with that growth, energy use per veh-km or pass-km for cars grew, raising energy intensities of aggregate transport until a peak in 2001/2, in contrast to a large sample of European countries or the US (Millard-Ball and Schipper 2011). Aggregate intensity in the US, while much higher, fell slowly during the same period, as Figure 5 shows.

The energy intensity of mini-cars in Japan increased 28% from 1.63MJ/pkm in 1975 to 2.08MJ/pkm in 2006. This can be attributed to changes in regulation. The maximum displacement of mini-cars was raised from 550cc to 660cc in 1990, which resulted in greater demand for these vehicles as well as a change in the types of vehicles classified in this category. Immediately following the 1990 reform, mini-car activity and energy consumption increased rapidly. Mini-car energy consumption increased more rapidly than activity after this reform, hence increasing energy intensity. We will return to the policy context surrounding mini-cars in Section 4.
Energy/passenger-km by mode, Japan and the US

Fig. 4
Fig. 5

Fig. 6
2.6 Analysis

The absolute values of energy use in passenger transportation in Japan increased by 149% (3.6% increase per year on average) from 1,001PJ in 1975 to 2,490PJ in 2001. The decomposition of the factors in Equation 1 shows that this was driven upward primarily by increased travel, driven in turn mostly by growth in car travel. However, after 2001, energy consumption decreased by about 9% to 2,267PJ in 2008. The decline occurred both because of a flattening in total travel, most markedly of car use, as well as a decline in the energy intensity of car use.

The Japanese population increased by 14% from 1975 to 2008, while transportation energy consumption increased 126%. Thus, energy consumption per capita in Japan increased by 97% from 9.0GJ/capita in 1975 to 17.7GJ/capita in 2008, driven mostly by the increase for cars. This is quite different from the U.S., where almost no change was experienced because even as early as 1975, car ownership (in cars/1000) was almost as high as it was in Japan in 2008. Hence, this important driver of growth showed much less influence in the U.S.

Since oil products dominate the fuel mix, Japan’s transportation CO₂ emissions are also very similar to Japan’s energy consumption. As a consequence of passenger activity, structure (mode) and CO₂ intensity, the CO₂ emission of passenger transportation in Japan increased 146% (3.5% increase per year on average) from 71MtCO₂ in 1975 to a peak of 175MtCO₂ in 2001, and decreased to 156MtCO₂ in 2008. U.S. CO₂ emission per capita in 2006 was 4.31tCO₂/capita, which was about 3.5 times of that in Japan (1.24tCO₂/capita). Considering CO₂ emissions per GDP, in the U.S. it decreased 43% from 201kgCO₂/GDP in 1975 to 114kg CO₂/GDP in 2006, while in Japan it remained fairly constant (46kg CO₂/GDP in 1975 and 45kg CO₂/GDP in 2006). U.S. CO₂ intensity per GDP is still about 2.5 times of that in Japan but the gap has been
narrowing over the thirty year period.

If all the factors in Equation 1 are considered, the changes in Japan’s CO2 emissions for travel can be summarized by a Laspeyres decomposition. Laspeyres indices decompose changes in passenger transport energy use into several underlying factors (Schipper et al. 1992). They allow us to evaluate the hypothetical impact of activity, modal structure, and modal energy intensity as if only each of those factors changed and the others were held constant at base year values. A more detailed overview of the methodology and applications to other contexts is available elsewhere (Ang and Zhang 2000; Ang 2005; Millard-Ball and Schipper 2011).

Table 1 shows annual average changes by decade since 1970 for Japan. The “Actual” column represents the change in total energy use for passenger transportation. Transport energy use in Japan grew at a very high rate in the 1970s, averaging about 7.8%, but growth slowed down in subsequent decades and turned negative in 2000-2008. Japan is fairly exceptional in this regard – of six developed countries analyzed by Millard-Ball and Schipper (2011), the only other country to record a decline in passenger transport energy use in recent years is the United Kingdom.

The “Activity” column depicts the hypothetical case where modal structure and intensity are held to base year values, while total travel activity is allowed to change. As Table 1 shows, transportation activity in Japan flattened out in recent years after three decades of consecutive

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3 Formally, we calculate energy use $E^A$ as a percentage of total energy use in the base year as follows:

$$E^A = \frac{A_t}{A_{io}}.$$  

$A_t$ is total activity for country $i$ in year $t$ and $A_{io}$ is total activity in the base year. We then calculate annual average change according to the following formula:

$$\bar{\partial}_{a,b}^A = \exp^{\frac{\log E^A_{tb} - \log E^A_{ta}}{b-a}} - 1,$$

where $\bar{\partial}_{a,b}^A$ is the average change for the country between years $a$ and $b$. 

17
growth. This may be due in part to demographics – Japan’s population peaked in 2006 and has been essentially flat during the first decade of the 21\textsuperscript{st} century.

The “Structure” column shows the hypothetical case where the modal share of cars, bus, rail and air is allowed to change while holding activity and intensity constant.\textsuperscript{4} Mode share has generally been constant in developed economies over the past several decades (Millard-Ball and Schipper 2011). In this regard, Japan is somewhat exceptional in that there was a shift away from public transportation, particularly rail, towards automobile transportation in the 1970s and 1980s. However, in recent years, the share of bus and rail has begun to rise again, contributing to the decline in transportation energy use.

The “Intensity” column shows the case where modal intensities are allowed to change while holding activity and structure constant.\textsuperscript{5} The figure shows that there have been important swings in the energy intensity of travel in Japan over the past four decades. Intensity grew during the 1970s and 1990s but fell in the 1980s and 2000s. This likely reflects policy responses undertaken after the oil shocks of the 1970s and the Kyoto Protocol. As discussed earlier, the energy intensity of car use in Japan increased in the 1990s due to consumer preferences and tax changes favoring larger automobiles. Overall, this mixed pattern has meant that energy intensity

\textsuperscript{4} Formally, we calculate the following formula, where $E^S$ is energy use analogous to $E^A$ in the prior footnote:

$$E^S_{it} = A_{i0} \sum_m S_{mit} I_{mit} E_{i0},$$

where $S_{mit}$ is the share of each mode m in country i in year t, $I_{mit}$ is the energy intensity for each mode in country i in the base year, and $E_{i0}$ is total energy use in the base year for country i. Annual average changes are calculated in the same way we calculated $\hat{\theta}^A_{a,b}$ in the previous footnote.

\textsuperscript{5} Formally, we calculate:

$$E^I_{it} = \sum_m I_{mit} A_{mit} E_{i0},$$

where $I_{mit}$ is the energy intensity for each mode m in time t for country i, $A_{mit}$ is the activity of each mode m in the base year for country i, and $E_{i0}$ is total energy use in the base year for country i. Annual average changes are calculated in the same way we calculated $\hat{\theta}^A_{a,b}$ in the footnotes above.
of travel in Japan has been roughly flat during the past four decades, unlike other major economies, where there has been a downward trend (Millard-Ball and Schipper 2011).

**Table 1: Laspeyres Decomposition of Passenger Transport Energy Use in Japan**

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Actual</th>
<th>Activity</th>
<th>Structure</th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-1980</td>
<td>7.8%</td>
<td>2.6%</td>
<td>1.7%</td>
<td>3.1%</td>
</tr>
<tr>
<td>1980-1990</td>
<td>2.7%</td>
<td>3.4%</td>
<td>1.1%</td>
<td>-1.8%</td>
</tr>
<tr>
<td>1990-2000</td>
<td>3.6%</td>
<td>1.5%</td>
<td>0.9%</td>
<td>1.2%</td>
</tr>
<tr>
<td>2000-2008</td>
<td>-0.9%</td>
<td>-0.1%</td>
<td>-0.3%</td>
<td>-0.7%</td>
</tr>
</tbody>
</table>

Note: Actual refers to the actual annual average change in energy use in Japan during the specified decade. Activity is the hypothetical annual average percentage change in energy use if only activity had varied, with modal structure and modal energy intensities held at 1990 levels. Structure is the hypothetical annual average percentage change in energy use if only modal structure varied, with activity and modal energy intensities held at 1990 levels; Intensity is the hypothetical annual average percentage change in energy use if only modal energy intensities varied, with activity and modal structure held at 1990 levels.
3. Japanese Government Policy Measures Related to Transportation Efficiency

This section focuses on the political and policymaking context for Japanese passenger travel.6 Perspectives on the U.S. can be found in Schipper (2009) and Morrow et al. (2010). A more historical overview of Japan’s transportation sector energy policies is available in Hayashi (2001), MLIT (2002), Furukawa (2007, 2008, 2009), and Lipsy (2011a, 2011b).

The Japanese government has generally viewed energy efficiency as a high priority since the oil shocks of the 1970s, which revealed the vulnerability of the economy to energy supply disruptions. In more recent years, energy efficiency has been promoted as an important mechanism to achieve CO2 emissions reductions to address global warming. In the transportation sector, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been primarily responsible for developing efficiency policies in coordination with the Ministry of Economy, Trade, and Industry (METI) and the Ministry of the Environment.

A primary focus of Japanese efficiency policy in the transportation sector is automobile fuel economy standards. MLIT officials justifiably see reduction of emissions from cars as critical for reducing CO2 emissions in the transportation sector. In turn, increasing fuel economy is viewed as the most effective way to reduce emissions from cars. Cross-nationally, Japan adopted stringent fuel economy standards very early, in 1979 – the E.U. only adopted fuel economy standards in 2005 and made them mandatory in 2008, and although U.S. CAFE standards have been in place for a comparable period, they have been considerably less stringent.

A major Japanese innovation in recent years is the “top-runner” program. The top runner program was introduced under the Energy Conservation Law in 1998, and it has been applied to

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6 This section is based on interviews with officials in the Japanese Ministry of Economy, Trade, and Industry, Ministry of Foreign Affairs, Ministry of Land, Infrastructure, Transport and Tourism, the Democratic Party of Japan, and the Liberal Democratic Party.
a range of areas including fuel economy standards. The program is designed to automate improvements in efficiency over time by setting target improvements based on the current highest-efficiency product in each sector. In 2004, a detailed labeling standard was implemented to inform consumers about the efficiency of a particular product against the standard (IEEJ 2007).

Japanese government officials indicate one motivation for the top-runner program was to reduce the scope of industry lobbying, which tends to dilute or distort efficiency measures. Under the program, standards are based strictly on the most efficient technologies available. There is therefore not much room for lobbying to massage standards or carve out advantages that benefit some firms asymmetrically. In practice, the policy is implemented in an automatic, incremental manner and without a great deal of political interference.

The Japanese emphasis on regulatory policies, such as the top-runner program, can be traced to several political factors. Regulation is well suited to the Japanese political environment, in which bureaucratic officials design policies in close consultation with private sector actors (Samuels 1987; Okimoto 1990). Compared to more legalistic, arms-length political systems, regulations are less likely to be unrealistic or accompanied by inadvertent consequences. Relatively speaking, energy taxation has been more politically controversial and difficult to sustain. Japanese transportation officials perceive taxes as being problematic due to their negative social implications – the burden falls disproportionately on low income citizens. Rural residents also tend to be intensive users of energy resources (Broz and Maliniak 2009), and they have been an important constituency for the Liberal Democratic Party (LDP), which was the dominant Japanese political party until very recently. In addition, more stringent regulations are also compatible with the interests of important private actors in Japan. Unlike the United States, where the domestic auto industry generally lobbies against tough fuel economy standards, Toyota
and Honda tend to be relatively supportive of Japanese regulation, as they specialize to a greater degree in energy efficient models. Finally, although Japanese government officials deny that this is a primary motivation, detailed regulations implemented primarily in consultation with domestic automobile producers can operate as a nontariff barrier against foreign competitors.

As illustrated by fuel economy standards, transportation efficiency policy in Japan has historically been designed to conform to the Japanese political and economic environment. However, as we illustrated in the previous section, the main factors that differentiate Japan are transport activity and mode share rather than energy intensity by mode. There are several Japanese policy measures that have likely contributed to low overall travel distances and high rail share. However, these policies are generally not recognized as energy efficiency measures as they emerged from an opaque policymaking process that attempted to achieve multiple goals, only one of which was energy efficiency.

Government officials in Japan have often sought to build support for efficiency-enhancing measures by making use of popular policies initially intended for other purposes. For example, the vast Japanese *shinkansen* bullet train network predates concerns about energy efficiency, but in recent years, extension of the network has been justified as a measure to shift passenger volume from less efficient air and automobile travel. Expansion of the *shinkansen* is not motivated primarily as a CO₂ reductions measure – there are political considerations such as the interests of the construction and rail industries and the overall goal of expanding the transportation network. However, CO₂ reductions are an important externality and justification for further expansion.

Another illustration of this strategy concerns *keijidosha*, or mini-cars. Mini-cars are defined by restrictions on engine displacement and car size, and are subject to a variety of
incentives such as lower taxes and insurance costs. The mini-car program was initially implemented in Japan immediately after World War II as a means to advance motorization. However, the program has continued and expanded even after Japan became one of the largest automobile markets in the world. Mini-cars, because they tend to be lighter and smaller than regular cars, have been emphasized by Japanese government officials as a means to encourage automobile fuel efficiency. In addition, the mini-car program is politically popular, particularly in rural areas where public transportation is limited and households often purchase a mini-car as a second vehicle. Surveys of mini-car ownership find disproportionately high shares of ownership among rural residents, housewives, and the elderly (Ozeki 2009). Several incentives associated with mini-cars are only available in rural areas, most importantly the waiver on requirement to register a parking space and a discount on highway tolls (Lipscy 2011a).

Compared to other countries, Japan maintains abnormally high tolls on highway usage. When Japan completed its first highway, the Meishin Expressway in 1958, tolls were levied with the specific purpose of paying off the World Bank loan used towards its construction (Japan Automobile Manufacturers Association 2006). According to these initial plans, Japan’s major highway routes, connecting the metropolitan areas of Tokyo, Nagoya, and Osaka, should have become free of tolls by the early 1990s. However, during the oil shocks of the 1970s, LDP Prime Minister Tanaka Kakuei implemented a policy of pooling highway tolls in order to support construction of infrastructure in rural areas (Sugimoto 2004). Instead of being eliminated, tolls on the main urban routes were repeatedly raised, imposing an onerous cost on long-distance automobile travel. For example, automobile travel from Tokyo to Osaka, about a 510km (315 mile) trip, costs 13,500 yen, or $180.\textsuperscript{7} The revenues from these profitable urban routes were

\textsuperscript{7} As of 2011, assuming weekday travel and a standard fare, which would have been typical in the earlier period before recent political developments to be discussed later in this section.
used to subsidize road construction and maintenance in rural areas, benefiting two key constituents of the LDP – the construction industry and rural residents. The tolls on intra- and inter- urban highway routes have made public transportation, particularly energy efficient rail travel, highly competitive.  

Across these policies, an important consideration for efficiency measures has been compatibility with the support base or core constituency of the LDP – e.g. rural residents, the transportation industry, and the construction industry. In recent years, because of several important political changes, Japanese transportation efficiency policy has entered a new, more uncertain period. First, electoral reform in 1994 replaced the old system based on a single nontransferable vote (SNTV) with a mixed system placing greater emphasis on plurality voting in single-member districts. This has shifted the electoral strategy of politicians away from narrow appeal to interest groups – e.g. the construction industry – towards broader appeal to the median voter (Cox et al. 1999; Rosenbluth and Thies 2010). Second, the Democratic Party of Japan (DPJ), which has a more urban support base, emerged as a serious competitor to the LDP and finally took over control of the government in 2009.  

These changes have introduced considerable uncertainty for Japanese energy efficiency policy. One illustration is the status of gasoline taxes and highway tolls. Revenue from these sources has been historically earmarked for road construction. These policies were designed to serve a dual purpose: the taxes and tolls contributed to energy efficiency by raising the cost of automobile fuel consumption, while also benefiting important political supporters of the LDP, the incumbent political party. As a minority party, the DPJ sought popular appeal by portraying these measures as wasteful giveaways, and it made elimination of gasoline taxes and highway tolls a core campaign platform. At the same time, with a relatively urban support base, the DPJ
has also advocated for pro-environmental policies, including significant reductions in CO₂ emissions. This put the DPJ in the awkward position as it ascended to power. In 2008, the gasoline tax briefly expired due to a political showdown as the DPJ-controlled upper house refused to approve an extension. Upon taking power in 2009, the DPJ gradually moderated its stance, choosing to eliminate tolls only selectively and backtracking on elimination of the gasoline tax. However, these traditional policies, which raise the costs of transportation for a large segment of Japan’s population, have become more difficult to sustain under the incentives created by Japan’s new electoral system (Lipscy 2011b) – Japanese politicians can no longer win elections by narrowly targeting pork to a small segment of the population.

Besides these political challenges, Japan faces the more practical difficulty of diminishing returns. Because Japan has already achieved relatively high levels of overall energy efficiency in the transportation sector, incremental improvement is expensive and sometimes impractical. For example, one initiative MLIT has been working on is shifting commercial freight from trucks to railroad. However, as a practical matter, further improvements have proved challenging. This is for the following reasons: First, because Japan has already achieved high capacity utilization on existing rail tracks, there is little spare capacity open for commercial use. This is a particularly difficult problem once freight trains arrive in major metropolitan areas such as Tokyo and Osaka. Trucks are seen as more convenient by most commercial users, particularly smaller businesses. Second, in Japan, passengers are prioritized over commercial traffic on rail. This is because of high passenger volumes and relatively little idle capacity on the rail network, particularly in urban areas. Commercial trains therefore need to move in between passenger trains. This poses some difficulties – e.g. in urban areas, there is no idle capacity during peak hours in the morning and evening, so commercial trains must stop. This is not just
an issue in final destinations such as Tokyo and Osaka. Between Tokyo and Osaka, trains must pass through several urban areas – moving through these areas without delay is quite difficult. There are also concerns about the effect of heavy freight on the rails used for passenger transportation. Third, because land is scarce in Japan and population densities in urban areas are very high, further expansion of the capacity of the rail network will take a long time. As a practical matter, a shift from truck to rail freight in Japan in the near future is highly unlikely.

Japan will likely continue to pursue aggressive improvement of automobile fuel economy through regulation and tax incentives. However, policies to achieve meaningful improvement of energy efficiency in other areas face problems. One of the DPJ’s signature initiatives has been a new CO_2 tax, to be implemented beginning in 2011 over a three year period. However, due to concerns about the burden of higher taxes, the tax is designed to only have a limited impact. The CO_2 tax is being implemented to effectively replace the gasoline tax. However, gasoline prices are projected to rise only by about 0.76 yen per liter (about 3 cents per gallon), and the expected reduction in CO_2 emissions associated with the tax is only about 1% by 2020 (Mainichi, 2010). There is no clear political constituency for a CO_2 tax in Japan, save the Ministry of Finance, which sees the tax as a potential revenue source. Surveys indicate that support for the tax has ranged between about 25% and 40% in recent years (Japanese Cabinet Office, 2005; 2007).

Government officials indicate that ambitious CO_2 targets, such former Prime Minister Hatoyama’s proposal to achieve 25% reductions from 1990s levels, are highly unrealistic. In the worst case, it is possible that future policy initiatives will become a net hindrance to efficiency improvements as old policies are replaced with measures that prove politically unpopular and unsustainable. Japanese politicians and diplomats have recently adopted a highly pessimistic attitude towards global climate change negotiations, particularly concerning extension of the
Kyoto Protocol. Many Japanese officials view the initial Kyoto agreement as a diplomatic failure, in which Japan was persuaded to swallow an aggressive CO₂ reduction target to match an aggressive US commitment, only to see the US fail to ratify the treaty. Officials in charge of designing Japanese climate change policies argue that the UNFCCC process was based too much on a European, top-down model, and alternative mechanisms need to be designed based on technology transfers and regional or bilateral cooperation among concerned countries.

The March 11, 2011 Tohoku Earthquake, which devastated Northeast Japan and led to a nuclear crisis at the Fukushima Dai Ichi plant, has also led to some rethinking of Japan’s overall energy policies. Most importantly for the transportation sector, plans to eliminate highway tolls have been cancelled in order to raise revenues for reconstruction – the only exception is disaster-affected regions. MLIT is also planning to accelerate several measures to improve automobile energy efficiency, namely: 1. More aggressive encouragement of eco-driving; 2. Greater use of biofuels, and 3. Enhanced V2G connection between electronic vehicles and renewable energy through the smart grid. However, these measures are mostly incremental and are unlikely to have a dramatic impact on energy usage. The nuclear crisis and subsequent electricity shortages have led some within Japan to question the feasibility of automobile electrification, but these concerns should be manageable by using regular plugs to recharge the vehicles during off peak hours at night.
4. Conclusion

Our analysis shows that the primary difference between Japan and the United States – as well as other countries – is low total per capital domestic travel, followed by low automobile share. Another positive factor in Japan is low energy intensities of bus and rail travel, attributable to high load factors. Perhaps counterintuitively, Japan does not differ significantly from the U.S. in terms of the energy intensity of automobiles. Despite superior fuel economy, traffic congestion brings the realized energy intensity of cars in Japan to a level about comparable to those in the U.S. It is also striking that, while the energy intensity of U.S. passenger automobiles have improved continuously over the past three decades, Japan showed no improvement, albeit from a low base.

One irony, therefore, is that policy measures often highlighted by Japanese policymakers and foreign observers, such as the top-runner program, are not the main source of Japan’s low energy use for transportation. Insofar as policies mattered, pork-barrel politics probably played a much larger role. After the oil shocks of the 1970s, the Japanese government raised various taxes and fees that made automobile travel expensive. The LDP, Japan’s dominant political party at the time, redistributed the revenues to political supporters, primarily rural residents and the construction industry. Various automobile taxes and expensive highway tolls have made bus and rail travel highly competitive in comparison. Subsidies for mini-cars rewarded rural residents, who tend to be heavy users, while also improving the energy efficiency of rural transportation.

In these respects, contrary to the predictions of Kiang and Schipper (1994), Japan’s transportation sector has not converged towards the structure of systems in other industrialized countries. Despite economic development on par with the West, Japanese continue to travel
shorter distances and are less likely to travel by car. Some of this difference is surely due to factors such as geography and urbanization, but we have also raised several policy measures that likely contributed to this outcome: high highway tolls, high overall taxes on automobiles, and aggressive promotion of the *shinkansen* as an alternative to air and automobile transportation. More research is necessary to understand just how much of this difference is due to policy measures. Some recent policy changes, such as the temporary suspension of gasoline taxes in 2008 and various changes to highway tolls implemented in 2008-2011, offer opportunities to examine this issue in greater detail.

In the long-term, there are some trends in Japan that will likely have a beneficial impact on energy efficiency and CO₂ emissions. Japan’s demographic profile – an increasingly older and smaller population – is often cited as a negative factor for its economy and international standing. However, Japan’s demographics are helpful when considering energy use and CO₂ emissions. A shrinking population will require less energy over time. The elderly tend to drive less than the young. The continuing movement of people into densely populated urban areas, such as Tokyo, means greater use of more energy efficient public transportation. In addition, “*kuruma banare* (moving away from cars)” among young Japanese is frequently reported by the media, and government surveys indicate that ownership of automobiles by Japanese below the age of 40 has declined sharply in recent years (Ministry of Internal Affairs and Communications, 2010). There are therefore some important factors, largely unrelated to efficiency policy, that are moving Japan towards less emissions and greater energy efficiency.
References


