A Framework to Evaluate Carbon Emissions from Freight Transport and Policies to Reduce CO₂ Emissions through Mode Shift in Asia ¹

Madan B. REGMI*  
Department of International Development Engineering, Graduate School of Science and Engineering, Tokyo Institute of Technology  
2-12-1-I4-12, O-okayama, Meguro-ku, Tokyo 152-8550, Japan,  
Fax: +81-3-5734-3468  
E-mail: regmi.m.aa@m.titech.ac.jp

Shinya HANAOKA  
Associate Professor, Department of International Development Engineering  
Graduate School of Science and Engineering, Tokyo Institute of Technology  
2-12-1-I4-12, O-okayama, Meguro-ku, Tokyo, 152-8550, JAPAN  
Fax: +81-3-5734-3468  
E-mail: hanaoka@ide.titech.ac.jp

Abstract: Transport sector contributes to 23% of global CO₂ emissions and road transport share is about 75% of GHG emission from transport. Freight transport consumes 35% of all transport energy and has been growing more rapidly than passenger transport. However, current research focuses more on passenger transport. The paper reviews various methodologies used for assessing carbon emissions from freight transport and propose a framework for assessing emissions from interregional inland freight transport employing bottom-up approach. The paper looks at intermodal transport opportunities through use of dry ports and inland container depots along selected interregional freight route. Emissions reduction potentials are evaluated through use of regulatory and economic instruments to stimulate the modal shift from road towards more environmentally friendly modes such as railway and waterways. It then suggests various policy options and measures necessary to reduce emission from long haul freight transport.

Key words: Freight transport, intermodal, emissions, policies, Asia

1. INTRODUCTION

Transport sector accounts for 23% of global CO₂ emissions. The energy use in the transport sector is expected to increase by 50% in 2030 (IEA, 2009a). These days the climate change is high on global and national agenda after the conclusion of the Copenhagen Conference (UNFCC, 2009). Countries are voluntarily discussing and taking measures to reduce emissions so as to hold the increase in global temperature below 2°C. To achieve this and cut down global carbon emissions transport sector has to play a leading role.

Road transport is the largest consumer of fossil fuel among transport sector and it consumed about 79% of total fuel consumed by the transport sector within the Asia and the Pacific region in 2006 (IEA, 2008). Road transport is responsible for 71% of transport emission in Europe (EC, 2009). Its share in Asia is even higher. Road transport carries substantial share of freight and passenger volume. The share of passenger and freight transport is growing at a rate of 1.9% and 2.7% respectively (EEA, 2010).

¹ The views expressed herein are those of the authors and do not necessarily reflect the views of the United Nations.
* Corresponding Author
Many researches and initiatives on transport and climate change focus on passenger and urban transport (Kamakate et al. 2009; Han and Hayashi, 2008; Burwell, 2009; Collantes and Gallagher, 2009). Many studies look at emission reduction potential through modal shift from private mode to public transport, improvement of vehicle technology, and use of non-fossil fuels, and use of public transport. However, limited studies are available in the area of freight transport emission though the freight transport emissions are one third of total transport emission.

In this context, as accurate emission measurement is essential to evaluate different policy measure to be employed for emission reduction the paper aims to review existing emission measurement approaches and propose a framework to assess freight vehicle emissions employing bottom-up approach. Then it will look and evaluate various policy options to reduce CO\textsubscript{2} emission from freight transport focusing on model shift opportunities from road to non-road mode such as rail and intermodal transport.

The paper is structured in the following manner. Chapter 2 presents current trend of transport sector emissions and measures to reduce emissions. Chapter 3 outlines Tier 1 and Tier 2 methodologies and top-down and bottom-up approaches for emission measurement and suggest a framework for emission measurement for inland transport corridor. Chapter 4 suggests measures for emission reduction through modal shift to railways considering investment in railways and freight terminals, improvement of operational efficiency through railway reforms, regulatory and financial instruments in Asian countries. Finally, the conclusions are presented in Chapter 5.

2. TRANSPORT AND CO\textsubscript{2} EMISSIONS

Figure 1 shows the contribution of various sectors to the world greenhouse gas (GHG) emissions and CO\textsubscript{2} emissions by various sectors in European Union (EU). It clearly shows that the transport sector accounts for 13.1\% of world emissions (IPCC, 2007). CO\textsubscript{2} accounts for 75\% of the total GHG. Transport sector CO\textsubscript{2} emissions accounts for 23\% (IEA, 2009c). Road transport accounts for 75\% of transport CO\textsubscript{2} emissions where as the share of rail and shipping is 12.5\% and that of aviation is 12.5\% (Stern, 2007).

Figure 1: World GHG and EU CO\textsubscript{2} emissions by sector

Figure 2 shows CO\textsubscript{2} emissions by countries. Which clearly shows that USA has highest share of CO\textsubscript{2} emissions followed by China, EU share of emission is 16.3\%. Major industrialized
Asian countries China, India, Japan, and South Korea collectively accounts for 30.7% of CO₂ emissions (EC, 2009).

Figure 2: CO₂ emissions by countries

Figure 3 shows CO₂ emission by mode in EU which clearly shows that the road transport accounts for 71% of CO₂ emissions while railway has insignificant 0.6% share. This mode share clearly shows that policies and measures for emission reduction should be focused on road transport, if the transport sector has to contribute to the global GHG reduction.

Figure 3: CO₂ emissions by mode in EU

Figure 4 shows the freight modal split of inland transport in EU. The road has more than two-thirds of freight mode share in EU. In EU countries overall tonne-km increased by 34% between 1997 and 2007. Road freight increased by 43%, air freight 31% and maritime transport grew by 10% (EEA, 2010). We can see that growth in road sector is outpacing other sector. Freight transport activity in tonne-km is expected to nearly double by 2020. To contribute to the global emissions reduction transport sector needs to substantially reduce the emissions. Among transport sector as the road transport has highest share of emissions both for passenger and freight, the focus of policy interventions and actions should be targeted on reducing emissions from road transport. One of the key policy challenges would be to
increase the mode share of non-road transport modes such as railways and waterways which are more energy efficient than road mode.

**Figure 4: Freight modal split of inland transport in EU-27, 2006 (%)**

Figure 5 shows that road transport dominates inland freight transport in most European Countries. The rail transport has major share in Baltic States while the Netherlands and Germany have considerable share of water transport (EEA, 2006). Continuing increase in road transport freight share is due to flexibility and its comparative advantage over other modes.

As we see that road transport has predominant share of transport thus contributes more CO₂ emissions. If we are to reduce emissions from transport it requires specific measures to reduce emissions from road freight as well as passenger transport. Most of the eco-efficient transport development looks at two aspects: (i) Improving the energy efficiency of individual vehicles, to increase the distance traveled per unit of fuel, or (ii) Modal shift that promotes lower fuel consumption per passenger- or freight-kilometer traveled (ADB, 2006). Some suggest combining policy options like restraining the growth of travel demand with strong transport and land use planning and targeting advance technologies and fuels to the feasible subsectors (McCollum and Yang 2009).

Policy measures and initiatives like: (i) improved mass transit and urban transport; (ii) congestion charging; (iii) improving vehicle efficiency; and (iv) promotion of innovative fuels are disused in details in GTZ Module 5e (Dalkmann and Branigann, 2007). If we invest in public transport and efficient vehicles, the right kinds of research and development, technology transfers and incentives, we could achieve the critical target of CO₂ level at 450 ppm. However this will requires including new strategies for reducing per capita vehicle miles travelled (Burwell, 2009).
The share of rail transport and freight is decreasing. Historical trend and most of literatures forecast continuous growth of road freight transport. If we are to induce mode shift to non-roads mode policies in those direction are required. Modal shift is attractive options for CO₂ reduction, investment in railways and intermodal transport system is necessary (IEA, 2009). But will it be possible to reverse the current trend? Is modal shift a really feasible option? Much research focus on vehicle technology, alternate fuel and mode shift in passenger transport and promotion of mass transit. Is it because that there is much less we can do about modal shift?

In order to devise policies for emissions reduction we should know the clear information about the current level of emissions and future trends. The next chapter discusses various approaches to emission measurement.

3. MEASURING TRANSPORT EMISSIONS

3.1 Intergovernmental Panel on Climate Change (IPCC) Methodology
Vehicle emissions can be estimated using different approaches and accuracies. Various methodologies to be used for measuring emissions are outlined IPCC Guidelines (IPCC, 2006). Countries follow the prescribed method to report national emission to the United Nations Framework Convention on Climate Change (UNFCCC). Depending on degree of accuracy required three Tier approach is used. The level of complexity also increases with Tier. CO₂ emissions are best calculated on the basis of amount and type of fuel combusted and its carbon content.
3.1.1 Tier 1 and Tier 2 Methodologies
The ‘Tier 1’ approach is a simple method to calculate CO₂ emissions by multiplying estimated fuel sold with a default emission factor. The general Tier 1 equation for CO₂ emissions from road transport is:

\[ \text{Emission} = \sum \left[ \text{Fuel}_a \times \text{EF}_a \right] \]  

(1)

Where:
- \( \text{Emission} \) = Emission of CO₂ in (kg),
- \( \text{Fuel}_a \) = fuel sold (TJ);
- \( \text{EF}_a \) = emission factor (kg/TJ)
- \( a \) = type of fuel (petrol, diesel, natural gas, LPG etc)

Tier 2 approach is similar to Tier 1 but the default emission factors should be replaced by country-specific carbon contents of the fuel sold in road transport are used. The Tier 2 approach considers the fuel used by different vehicle categories and their emission standards. Equation (1) can be used for tier 2 method as well. EMEP/EEA Guidebook (EEA, 2009) provides a different equation containing number of vehicles and annual distance travelled:

\[ \text{E}_{i,j} = \sum (N_{j,k} \times M_{j,k} \times \text{E}_{f},j,k) \]  

(2)

where,
- \( \text{EF}_{i,j,k} \) = technology-specific emission factor of pollutant \( i \) for vehicle category \( j \) and technology \( k \) \([\text{g/veh-km}]\),
- \( M_{j,k} \) = average annual distance driven per vehicle of category \( j \) and technology \( k \) \([\text{km/veh}]\),
- \( N_{j,k} \) = number of vehicles in nation’s fleet of category \( j \) and technology \( k \).

Methodologies for estimation of emissions from railway locomotives are similar for three Tiers and they only have variation of the same equation:

\[ \text{Emissions} = \sum (\text{Fuel}_j \times \text{EF}_j) \]  

(3)

where,
- \( \text{Emissions} \) = emissions (kg),
- \( \text{Fuel}_j \) = fuel type \( j \) consumed (as presented by fuel sold) in TJ
- \( \text{EF}_j \) = emission factor for fuel type \( j \) (kg/TJ),
- \( j \) = fuel type (diesel, gas oil).

For Tier 1, emissions are estimated using fuel-specific default emissions factors, assuming that for each fuel type the total fuel is consumed by a single locomotive type. Tier 2 uses the same equation with country-specific data on carbon content of the fuel.

3.1.2 Tier 3 Methodology
Tier 3 is more detailed than Tier 2 methodology based on activity data and emission factor but with a greater disaggregation of activity data and emission factors. When a more accurate estimation of the relevant emissions is required Tier 3 methodology is used. It considers hot and cold start emissions as well as different driving situations like urban, rural and highways. However, for CO₂ emission measurement IPCC Guidelines recommends using only Tier 1 and Tier 2 methodologies and for railways there is no advantage of using Tier 3 methodology (Eggleston et al., 2006).
3.2 Top-down and Bottom-up Approaches
The emission factors proposed are aggregated and averaged over a large number of driving cycles and due to method employed to estimate emissions factors and disaggregation of emissions they may not reflect emissions of vehicles driven under actual conditions.

The emission factors estimation are based on either ‘top-down’ or ‘bottom-up’ approaches. In the top-down approach, total annual road traffic emissions are disaggregated first spatially and then temporally over the area, using traffic load and speed variation in a dimensionless form. In the bottom-up approach, emissions are calculated on the basis of the available traffic patterns and then summed. Emissions are calculated for each street or road of the area under simulation, and on an hourly basis. The patterns of traffic flow, and the variation of average speed with time, should be used to calculate the temporal variation in emissions. This means that traffic counts and speed measurements (or estimates) should be available for the modelled area. Clearly, the bottom-up approach attempts to simulate reality more accurately, and requires more effort than the top-down method, although it is not yet clear whether such a degree of sophistication results in more reliable emission estimates, and consequently better air quality simulations (EEA, 2009).

In principle, the top-down and bottom-up estimates of motor vehicle emissions are carried out independently. In each case the most reliable information (such as traffic counts, statistics of vehicle registrations and measured emission factors) form the basis of the calculation.

Bottom up approach is useful to calculate emissions for specific conditions and vehicle type that can be aggregated. Bottom-up approach provides more clue than top-down, can provide more information to policy makers to assess driving force behind the increasing emissions. However the bottom-up approach needs more and reliable data that can be compared with top-down estimates (Kumari et al, 2005; Ravindra et al. 2006)

Bottom-up focuses on technology and their characteristics, while top-down focus more on process within economy of energy system and historical behavior. Bottom-up approach suits to evaluate policy instruments and both approaches are comparable for transport sector (van Vuuren et al., 2009; Hoogwijk et al. 2010).

For measuring emissions from road transport EMEP/EEA Guidebook (EEA, 2009) recommends using Tier 2 or Tier 3 methods. These are usually called bottom-up approach While Tier 1 which uses average emissions factors and fuel sold or consumed is referred at top-down approaches. IPCC guideline also recommends using Tier 1 and Tier 2 for carbon emissions.

3.3 Emission Factors
The emission equations require emission factors for emission estimation. Vehicle emissions largely depend on type of vehicle, engine capacity, speed, actual driving pattern, condition of road, load factor etc. In case of train it depend on engine capacity and traction used whether it is electric, diesel or coals driven, load factor, speed, track condition. These data are aggregated and averaged. Variation on emission factors are found based on different sources. There are many data and research available in IEA countries. IEA used top-down approach for emission calculation. Table 1 presents CO₂ emission factors complied for LDV, HGV and freight trains (DECC, 2009).
Table 1: Emission factors of various transport modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>DEEC g/tonne-km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road LGV</td>
<td>400.1</td>
</tr>
<tr>
<td>HGV</td>
<td>118.6</td>
</tr>
<tr>
<td>Rail</td>
<td>28.3</td>
</tr>
<tr>
<td>Small tanker</td>
<td>20</td>
</tr>
<tr>
<td>Large container</td>
<td>13</td>
</tr>
</tbody>
</table>

IPCC Guidelines suggest that CO₂ emission factors should be within a range of ±5%. It is good practice to ensure that default emission factors reflect local fuel quality and composition.

### 3.4 Review of Methods for Measuring Vehicle Emissions

Many computer and emissions models are available for emissions measurement. US Environmental Protection Agency’s Mobile and MOVES, European Environment Agency’s COPERT 4, International Vehicle Emission (IVE) Model, International Energy Agency’s Mobility Model (MoMo) are some frequently used models. Review of some emission models used in countries can be found in OECD (2002). Recently developed emission model Changer (IRF, 2009) can estimate total carbon footprint of road construction, maintenance, rehabilitation.

Schipper et al. (2009) outlines simple activity based approach called ASIF to calculate emissions.

\[ G = A \times S_i \times I_{i,j} \times F_{i,j} \]  

(4)

Where,

- \( G \) = carbon emissions form transport
- \( A \) = Total activity (passenger or freight travel)
- \( S_i \) = Modal structure (travel by mode)
- \( I_{i,j} \) = Modal energy intensity
- \( F_{i,j} \) = Carbon content of fuel

Measuring carbon emissions is important. However, there are several data gaps in Asia. Most of the emissions data referred to are from developed countries OECD, EEA, and IEA. It is difficult to find vehicle activity data therefore initiatives are required to collect and collate emissions data in Asia.

### 3.5 Proposed Framework for Measuring Freight Emissions

Most of the above vehicle emission models are centered on emission factors and fuel consumption for particular type of vehicles. The emission factor considered is also aggregated and averaged at national level which may differ from actual field condition. These all models give figures for comparisons which at cases may be far less than actual emissions. There is wide variation in value of emission factors depending on source being used. Fuel consumption also may not take account of air conditioning, lights used during driving etc. At time the estimates could understate the emissions by 25% (OECD, 2002).

Therefore, it is proposed to measure emission on actual transport corridor where there mode
choice options are available and are in operation. The emission factors corresponding to the country and that area will be taken. It is envisaged to look at the effect of mode shift on overall CO$_2$ emission. This approach is similar to the emission measurement approach taken by Schipper et al. (2009). Equations (1) and (3) are combined to estimate total emission from road vehicle and rail. The combined equation is:

$$\text{Emissions} = \sum (\text{Fuel}_a \times \text{EF}_a) + \sum (\text{Fuel}_{nm} \times \text{EF}_f)$$  \hspace{1cm} (5)$$

Introducing an average vehicle kilometer and number of vehicle, the equation (5) can be written for a land transport corridor:

$$\text{Emissions} = \sum \text{FV}_j \times \text{VTKm}_j \times \text{EF}_{i,j} + \sum \text{FT}_j \times \text{TTKm}_j \times \text{EF}_{i,t}$$  \hspace{1cm} (6)$$

FV- Freight vehicle
VTKm- Average vehicle Ton-km
EF$_{i,j}$=emission factor of fuel i for vehicle j (g/veh-km)
FT= Freight Train,
TTKm= Average train Ton-km,
EF$_{i,t}$=emission factor of fuel i for locomotive t (g/train-km)

The above equation will be used to evaluate various factors that can stimulate modal shift from road to rail. Also, it will be used to evaluate various emission reduction scenarios. Figure 6 shows the emission reduction options on a 5000 km transport corridor carrying 100,000 Tons freight. Initially the mode share of railway is assumed to be at 20% and that of road 80%, then with policy and other efforts its rail mode share gradually increases to 50% which would reduce emission by 27%.

![Figure 6: Effect of rail mode share on Total CO$_2$ emissions](image)

The following chapter outlines various policy options that could induce modal shift from road to other modes.
4. POLICIES TO REDUCE CO₂ EMISSIONS FROM FREIGHT TRANSPORT

The emission factors of various modes show that there are clear benefits of moving the freight from road to non-road mode. Even though inland water transport mode being more energy efficient than railway for per tonne-km, there are very limited inland water transport (IWT) routes available in Asia. Navigable Rivers like Mekong, Ganga, and Padma are to name few and they have limited use for freight, mostly IWTs are being used in traditional way for passenger transport. The revival of water transport rather than just using in limited manner could also take some share from road transport and reduce emissions to some extent. Revival and improvements of canals and rivers routes through channeling, dredging, widening to increase capacity, additional of river ports are some of work required. Maritime transport has already taken major share of international transport. There is further potential of modal shift through coastal shipping. However, some inland routes like Euro-Asia land routes offer much less travel length than traditional maritime routes. Uses of these inland routes for intermodal transport are also feasible options.

Emission reduction policy measures that are being pursued for passenger transport are also applicable to the freight transport. Improvement of vehicle technology benefits road freight through fuel savings. Likewise improvement in efficiency and technology of rail traction will benefit rail freight transport. However there are some initiatives which are applicable to freight transport only. Therefore these measures are broadly categorized in two categories- (a) common policy measures that are applicable to both passenger and freight transport; and (b) measures focusing on freight modal shift from road to non-road mode. Modal shift policies have usually been weak and can only be effective when well treated and integrated with demand management measures.

There are many policy initiatives and measures that have been successful in the developed world or other part will also be beneficial to induce freight model shift in Asia. Following measures will be discussed at some length:

(i) Investment in Railways;
(ii) Investment for freight terminals and consolidation centres;
(iii) Fiscal measures
(iv) Improvement of operational efficiency of railways; and
(v) Regulatory measure;

The inland freight transport can be domestic, international and interregional in nature. Additional issues like customs clearance, border-crossing and security need to be considered when the freight is international and destination is other country than country of origin.

4.1 Common Policies Measures

Many studies cover the issue of vehicle technology and suggest that this is the most viable option for vehicle emissions reduction. Wang et al. (2007) have evaluated three policy scenarios for estimating CO₂ reduction from road transport in China. They suggest that adopting vehicle technology is most effective way to reduce carbon emissions which could achieve nearly 96% emissions reduction by 2020 compared to 2000 base case scenario. Heywood (2008) predicts that 30-50% emissions reduction possible in 20-40 yrs through improvement of vehicle technology such as improved engine, weight and drag reduction, hybrid technology.
The fuel consumption also depends on driving patterns and sensible driving can save fuel consumption. Driver training, controlled speed and proper maintenance of engine and tire pressure of freight vehicle can reduce fuel consumption and emissions. Construction of city by pass helps to avoid congestion. Driver training can result up to 18% savings in fuel consumption (Wisetjindawat, 2010). Congestion pricing was introduced in London in 2003 and the programme achieved 30% reduction in congestion, a 20% reduction in traffic and 16% reduction in CO2 emissions (EEA, 2008).

Some researcher argues that reducing travel demand also an option. However, this may not be a feasible option as travel is related to economic activities. Initiatives to reduce travel demand through integrated planning and optimizing location of factory and markets or rationalizing freight trips through consolidation and distribution centers can be effective.

4.2 Policy Measures to Promote Modal Shift

4.2.1 Investment in Railways

Firstly to consider a modal shift mode choice options should be available on a route or corridor being considered. Although Asia house major countries like having extensive railway network there are some missing links in the railway routes. China, India and Russia have 77,966 km, 63,465 Km and 86,660 km of railway network respectively. There are about 8,000 km of missing links that need to be constructed to provide uninterrupted railway connectivity along the Trans-Asian Railway requiring US $ 23 billion (ESCAP, 2010). In addition, there are certain routes which lack capacity and maintenance- therefore considerable railway investment has to be made. The recent development trend shows heavy focus on highway development in Asia like India’s National Highway Development Programme and China’s Expressway development programme.

Railway was first invented as a freight carrier and now can run in clean form of energy (Smith, 2003). The energy intensity and long life cycle of rail cars, new speed innovation- can take major share of growing transport demand (freight and passenger). Efforts from policies and railway operators are necessary to maintain railway’s environmental superiority among other modes of transport. Relative cost, relative time and relative comfort are the common factors likely to influence modal choice (Chaudhury, 2005).

In addition to above considerable investment will be required for maintenance and improvement of railway network. There are not many studies that have looked at cross-elasticity of railway investment on modal shift- how the investment in railway would change the freight share of road.

4.2.2 Investment in Freight Terminals Development

Railways alone can not provide door to door freight service. In order provide door-to-door service railway has to be integrated with existing logistical networks. Interfaces between railways and other transport modes are essential to encourage modal shift. Therefore planning and development of freight terminals, freight villages, dry ports, ICDs has to be considered to extend the reach of the rail mode through intermodal services. Rail-based intermodal freight transportation systems are more environmental friendly than truck-only freight systems in Europe, particularly for long-distance haulage and in terms of CO2 emissions (Kim and Van Wee, 2009). Still the rail freight share is not growing faster compared to road.
Although not directly related to mode shift, construction of consolidation centers near urban and strategic location can also help reduce number of freight trips. One such example is the Freight Construction Consolidation Centre in London which was established to consolidate construction freights and was able to minimize construction traffic for building and development resulting in fewer freight trucks and 75% of CO₂ emission reduction (TfL, 2007).

The British Airports Authority has developed consolidation centre at Heathrow Airport in order to reduce goods vehicle movement and improve delivery system. The goods to be delivered to Terminals 1-4 are delivered to the centre first rather than directly to the shops. This hub and spoke approach was able to reduce 70% of vehicle trips (Browne et al, 2007). CO₂ emissions from LGV are much higher than HGV; plan to reduce number and trip length of LGV freight trips through establishment of consolidation centers need to be considered. HGVs make longer trips to the consolidation centers and then LGVs delivering to the inner cities.

There are new concepts emerging in freight transport such as development of dedicated freight corridors in India and underground freight corridor in Netherlands. Freight trains are carrying double stack of containers to improve operational efficiency. Certainly these will help to take some share of road freight and contribute to reduce emissions. Some other options are coastal shipping and other eco-efficient urban freight options (Wisetjindawat, 2010). Replacing long haul truck to intermodal transport can reduce emissions effectively. Activity-based emissions modeling made comparison of intermodal transfer point in north Taiwan and utilizing coastal shipping and trucks rather than distributing by only trucks showed 60% less emissions due to efficiency of coastal shipping (Liao et al. 2009). A study of freight emissions in London revealed that consolidation and distribution centres have combined 25.7% emissions reduction (Zanni and Bristow 2009).

Some researches suggest let the transport market work, rather than pushing modal shift policies that distort transport market. Consider creating efficient interfaces between the modes- the rail, road, shipping and inland water transport so that they can compete with modes (NTC, 2008). Modal shift can happen only if it fulfills shipper’s logistical requirements, and fit in their logistical chain (Blauwens et al. 2006) and combination of policies can lead to modal shift. The freight and consolidation centers have also potential to reduce the empty truck trips – which amount to about one third of total freight truck trips.

**4.2.3 Fiscal Measures**

Railway infrastructure has high capital cost than road. Therefore, government support in form of various fiscal incentives to improve railway increases competitiveness of railway with other modes. There are examples of incentive being provided in Britain in the form of Freight Facility Grants, Track Access Grants at rail privatization, and Company Neutral Revenue Support grant was introduced targeting intermodal flows, sustainable distribution funds and new transport innovation fund (Woodburn et al., 2007). But among these halving the track access fee was more effective. There are also example of subsidies being provided to rail freight in Europe and introduction of toll on highways in Germany induced modal shift to railways.

Asia still may not be in a position to offer subsidies to the railways. However, policies geared towards encouraging private sector investment in railways, privatization and commercialization of some routes and improving railway operation and efficiency are important to attract freight.
4.2.4 Improvement of Operational Efficiency of Railways

Most of railway routes operation in Asia is still handled by public sector railway companies having overall government control. Quality of operation is the single most significant problem in railways freight operation. Therefore, in order to attract more freight share the quality of service and reliability has to be improved and punctuality of freight service train has to be maintained. This requires reform on existing railway operation system and new approaches to railway marketing. If private-sector freight forwarders can provide quality services railway sector should also be able to improve their services. Service quality and price are important aspects to change modal shift (Buehler et al., 2005).

One important consideration is to integrate railway with other modes in supply chain. Railway should consider offering door to door service through intermodal services through integration with other modes. Improved logistics organization, coordination, and route planning can reduce up to 10-20% emissions (OECD, 2010). Railway privatization has worked in UK, through promotion of rails for certain leg in their chain (Woodburn et al., 2008). The turnaround of Indian Railway is often cited example of railway reforms and case where the top-down policy direction has worked. The loss making Indian Railway was turned to second best public company in India (Raghuram, 2007). The Indian railways XI five-year plan includes three priorities related to freight like development of dedicated freight corridors and freight villages.

Another issue that needs to be tackled to attract freight to railway is give equal priority to freight trains. In railway operation usually the passenger rail get priority over freight. To ensure reliability of freight delivery scheduling is important. Once the schedules are reliable, railway will get more share of freight. The reliability of Sky train and Subway in Bangkok compounded with congestion of the roads has prompted freight forwarders and logistics service providers to use these urban trains to ensure delivery of parcel and packets. These are few examples that can attract freight to railways.

Many countries have different institutions to manage different modes, as well as at national, local, regional, district levels which makes implementation of integrated polices difficult. Reforms on transport governance are important. It may be necessary to integrated management of all modes by one institution.

4.2.5 Regulatory Measures

Infrastructure development policy, improving interconnectivity and pricing are major regulatory policy measures that can improve railway infrastructure and service and influence modal shift (van Essen, 2009). European polices related to Liberalization and development of, and access to, Trans-European Rail Freight Corridors facilitation of international borders in Europe and priority given to the development of Trans-Asian Railway in Asia are examples of some policy measures. While rail freight is liberalized road transport is highly regulated such as control of driver’s hours, speed limit, axle loads, and gross vehicle weight controls. Despite this efforts railway has not been able to attract more freight.

Sometimes the regulatory measures alone do not work. France introduced new links and reduced rail freight tariff and Switzerland introduced 28 ton weight limit for trucks to promote rail freight. But these measures were not effective, the international road freight bypassed
Switzerland (OECD, 2002) due to weight limitation. Despite these measures road freight continued to grow considerably.

4.3 Discussion
This chapter showed the importance of investment in railway and freight terminals, fiscal and regulatory measures, improving operational efficiency of railways and overall reforms of the railway sector in order to attract more freight to the railway thereby contributing to overall emissions. It shows that there is no one solution for all solution to promote model shift. The application, usefulness and effectiveness of these policy initiatives have to be evaluated and successful policies replicated to other corridors. It will be good to further evaluate and quantify the impacts of these initiatives to the modal shift some way. This is one area that needs to be explored in later phase of the research.

5. CONCLUSIONS
Transport sector accounts for 23% of global CO₂ emissions. Current modal split heavily favors road transport and it consumes 79% of fossil fuel used in transport sector in Asia. Emissions for moving one ton-km freight are almost four times than moving the same freight by railways. Policies and initiatives are required to encourage freight modal shift from road to energy efficient non-road mode. Modal shift to energy-efficient modes can substantially help to reduce carbon emissions from freight transport. A simple framework employing bottom-up approach is proposed for emissions measurement of transport corridors that incorporates both road and rail mode.

Rail freight had not been able to compete with road due to flexibility, cost effectiveness, and reliability of road transport. Proposals are made to increase investment in development of railways and freight terminals, to improve railway operation through railway reforms so as to attract freight to railways. Some fiscal and regulatory measures to induce model shifts are also outlined. As railways in Asia are managed by public sector management reforms would help to improve their services and competitiveness. Intermodal transport is gaining prominence, therefore railway has to be integrated in logistic chain, improve coordination and services and develop intermodal land transport routes through construction of freight stations and consolidation centres.

This paper looked at modal shift options from road to railway. In terms of energy intensity water transport is most energy efficient. Even though there are limited inland water transport routes in Asia- it is necessary to revive this routes, add related infrastructure to revitalize the inland water transport in Mekong, Ganga, Padma and many more navigable rivers.

There is much to be done on quantification of emission saving due to model shifts and to postulate optimal model share for an intermodal corridor, which is an area that need to be further explored.

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