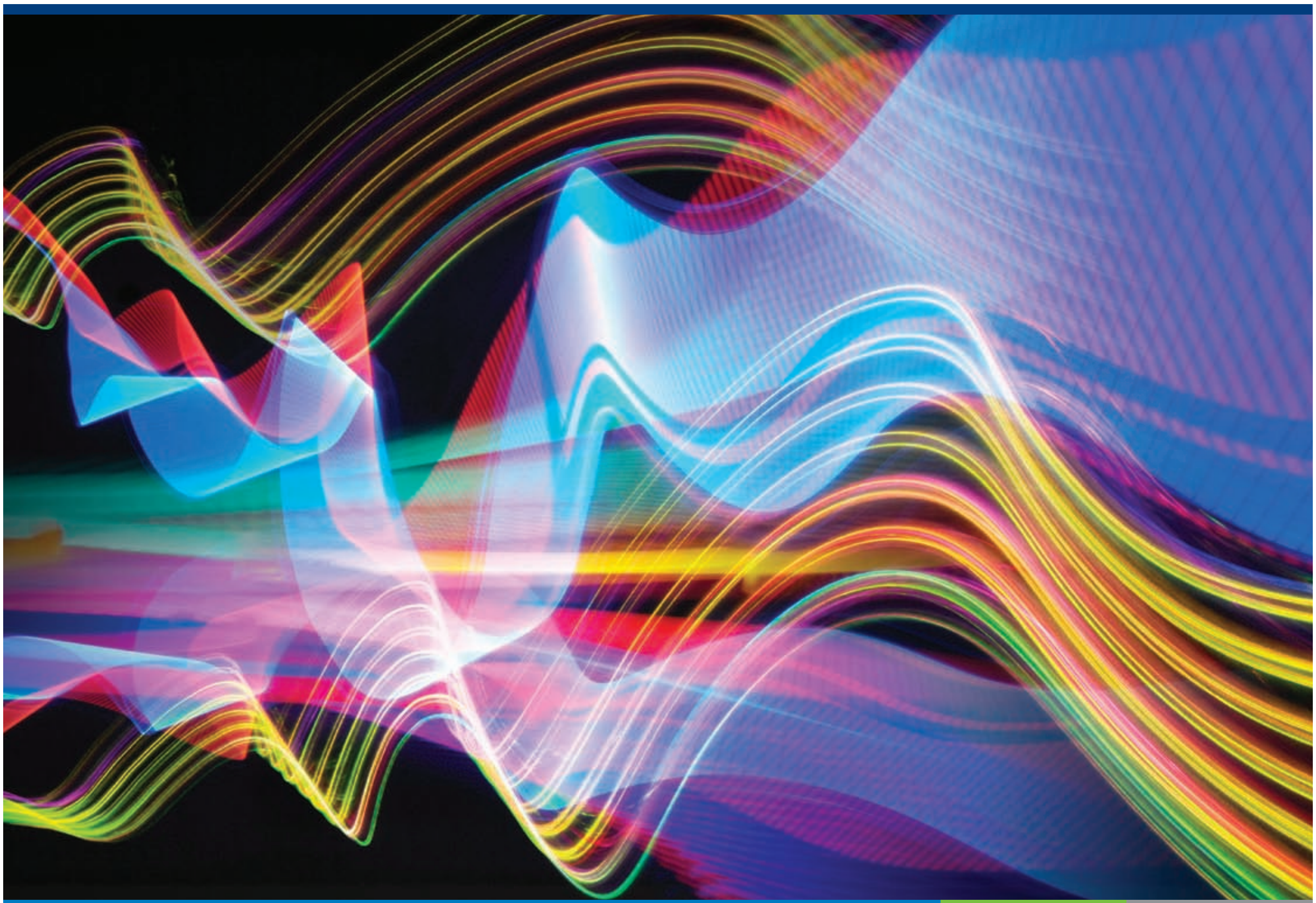
International Transport Forum



Transport Outlook

Seamless Transport for Greener Growth

2012

OECD

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2012

INTERNATIONAL TRANSPORT FORUM

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EXECUTIVE SUMMARY

Bleak short term trade and freight transport outlook

The 2008 financial crisis triggered a severe, sudden and synchronised drop in demand leading to strong reductions in global output, trade and transport volumes. The fall in trade was larger than the drop in output, and the fall in transport volumes was larger than the drop in trade volumes. The 2008 shock has accentuated and accelerated the shift of economic mass from advanced economies to emerging economies that was well underway before the crisis; a shift that is clearly reflected in the transport outlook.

But conditions for strong long term growth in freight and passenger transport

The macroeconomic outlook and with it the expectations for trade and transport in the near term remain rather bleak. Growth rates in emerging economies, though still high, have slowed. Recent updates on the outlook for the OECD are cautiously more optimistic for the USA but on the whole downside risks dominate, including the effects of high and volatile oil prices. In the longer run, governments will have to complete a difficult balancing act between reducing debt ratios while maintaining long term growth potential and avoiding policy-induced slowdowns in the nearer term. The impacts are most clearly felt in the near term outlook for freight transport. The conditions for returning to growth do exist, however, and pessimism about a prolonged slump does not need to extend to the longer run.

Passenger volumes may double, freight may quadruple

Our mobility projections are therefore based on continued long run global economic growth. The impact of the current economic crises could well be a permanent loss of output rather than a direct return to pre-crises growth paths but global passenger transport volumes could grow to be as much as two and a half times their 2010 level by 2050. Freight volumes could grow by a factor of four.

The near term prospect for transport for trade

Emerging economies engine of growth

Maritime and air cargo transport flows between large trading blocks move in close correlation with the rate of growth of the world economy and global trade, but variations in transport flows are larger than those in trade which in turn are larger than those in output.

Since approximately 2002, output, exports and imports have grown considerably faster in emerging economies than in advanced economies. Flows in emerging economies have recovered from the 2008 shock more rapidly and more robustly. Imports in emerging economies have functioned as engines of economic recovery since 2008.

But trade now slowing again

Recovery of external trade and the associated transport flows slowed down in the second half of 2011 in advanced economies. The volumes of EU and USA seaborne imports in particular have not attained pre-crisis levels and began to decline again near the end of 2011.

The near term outlook for trade and transport is highly uncertain, more so than for overall output. Uncertainty over the growth of domestic demand is large in the Euro zone and the USA, though prospects are somewhat better in the USA. The evolution of exports is also increasingly uncertain, given signs of weakening growth in some major emerging economies.

Mobility projections for 2050

Our long run mobility projections are embedded in a framework of:

a. Continued economic growth, per capita and overall, with fast growth outside the OECD. We consider the possibility that the 2008 crisis translates into a permanent loss of output.

b. Continued population growth, particularly outside the OECD.

c. Continuing urbanization, with fast-paced change outside the OECD.

Higher per capita incomes and larger populations increase mobility volumes; urbanization tempers mobility growth.

Patterns of urban development critical to passenger transport trends

For passenger transport, we distinguish between a case where the urbanization effect is moderate, in the density of the urban development that results and in the overall effect on mobility (as has been the case in the OECD in the past), and where it is strong (as may be the case if public policy steers in the direction of agglomeration and densification). The cases give a high and low scenario for the development of passenger mobility. The low scenario (strong urbanization effects) is plausible but keeping mobility growth near it requires a strong and enduring policy commitment.

Freight transport growth to be more intensive than often projected

For freight transport, we consider a case where freight volumes grow in line with output and one where they grow more slowly ("decoupling"). For the near to medium term and in particular for emerging economies, the high freight growth scenario appears more plausible.

The extent to which more mobility translates into higher emissions of CO_2 depends on the modal composition of mobility and on the evolution of technologies embedded in vehicle fleets.

Key results are summarized in the accompanying table and discussed below. Ranges for the projected transport volumes are large, but this is to be expected given the very long time horizon (40 years) and the nature of the exercise in developing scenarios that test the bounds of projections in relation to plausible changes in assumptions and policy developments.

Moderate transport growth in OECD countries

- Transport flows are expected to grow strongly throughout, driven by higher GDP and larger populations.
- In the OECD passenger transport volumes in 2050 are expected

to be 10% to 50% higher than in 2010. Freight transport is expected to grow by 50% to 130%.

Strong growth outside the OECD area

- Growth is expected to be much higher outside the OECD, where passenger transport flows would be around three times as large in 2050 as in 2010, and freight flows two-and-a-half to five-and-a-half times as large.

- The lowest numbers for passenger transport assume lower GDP and a less car-intensive development of mobility. The lowest numbers for freight transport assume lower GDPs and a less freight-intensive development of the economy.

Fuel efficient engines limit CO_2 growth to 1.5—2.4 times 2010 levels

- Emissions grow more slowly than transport volumes because technologies become less CO_2-intensive. This is mainly because traditional internal combustion engines become more efficient and because of penetration of hybrid vehicles in the fleet, not so much because of large scale uptake of alternative technologies such as electric vehicles. Total CO_2 emissions from freight and passenger transport combined, world-wide, would grow to 1.5 to 2.4 times 2010 levels by 2050.

Index of GDP, GDP per capita, Transport volumes and CO_2-emissions in 2050 (2010=100) highest and lowest estimates

Highest: high GDP growth and high car ownership rates
Lowest: low GDP growth and lower car ownership rates

	Passenger transport (passenger-km)			Freight transport (tonne-km)		
	OECD	Non-OECD	World	OECD	Non-OECD	World
GDP	210 – 230	440 – 520	300-350	210 – 230	440 – 520	300-350
GDP per capita	185 – 210	320 – 370	230-270	185 – 210	320 – 370	230-270
Transport volume	110 – 150	240 – 360	170-260	150 – 230	250 – 550	200-380
CO_2-emissions	80 – 110	240 – 450	130-220	100 – 165	260 – 450	170-300

Car use to grow 2.4 to 3.6 times outside OECD

If car ownership and use continues to develop along patterns observed in the past, mainly in the OECD, then passenger transport volumes outside the OECD would be around 3.6 times as high in 2050 compared to 2010. If car ownership growth is lower, more in line with past patterns in the major cities of Japan, the increase is about 2/3 as large. The difference provides a rough indication of what conceivably can be achieved through policies to discourage car ownership and use.

Motorbikes will be a major factor in urban mobility

Discouraging car ownership and use reduces mobility growth and also diverts mobility to two-wheelers and to public transport. Our "low car ownership" scenario indicates that outside the OECD two-wheeler use allows mobility to develop as quickly as in the "high car ownership" scenario at moderate income levels. As incomes continue to rise, however, high car ownership means more mobility, and the pressure to own and use cars ultimately mounts in the low car ownership scenario as well. Maintaining low car ownership rates requires enduring policy commitment.

Oil prices, taxes, and charges for using cars critical factor

Prices matter. If crude oil prices were to rapidly increase to around $200/barrel and remain at that level, then average car use per capita would actually be lower in 2050 than in 2010. Mobility growth would be constrained, but still strong because of higher car ownership and larger populations. Higher fuel or mileage tax levels outside the OECD could have a similar effect in constraining mobility growth and especially car use in those regions.

Car use levelled-off in OECD but trend may not be permanent

The mobility projections for the OECD assume that passenger transport grows more slowly than GDP. This is consistent with evidence on the evolution of car passenger-kilometres driven in the OECD over the last decade, where there are signs of zero or even negative growth in some countries, despite higher GDP. It is, however, not entirely clear if this is a permanent or transitory event and what its real causes are. It is too early to conclude that passenger car travel in advanced economies is past its peak.

Aviation is to grow very strongly over the coming decades. Technological progress can help mitigate CO_2-emission growth, but potential is limited as the emission characteristics of the 2050 fleet will be determined largely by technologies that already exist.

Mobility, funding, and Green Growth

Technological change key for greener growth

The transport sector has an important part to play in achieving Greener Growth. Modifying mobility patterns is possible and arguably useful, but the upward pressure from higher incomes and larger populations on the demand for mobility is very large. This makes technological change the key for reducing emissions even if changes in patterns of mobility are an essential part of achieving many other development goals.

Public and private funding both squeezed

More mobility will require more infrastructure. Prospects for attracting private capital to step in when public funds are scarce are limited. Potentially appealing private investment opportunities in transport exist but competition with projects in other sectors in need of increased expenditure is likely to be severe and the abundance of private savings may well decrease in the coming years with demographic change and a reorientation of economic development towards domestic demand in developing countries. Identifying priority projects will become increasingly important, for funding in ways that fit specific circumstances.

Thinking seamless makes for smart investment and greener growth

Adopting a seamless transport system view, with its focus on end-to-end journeys, helps to identify investment options that provide good value for money. This view also tends to favour a more balanced transport system, less strongly geared towards car reliance. Highlighting seamlessness is not trivial as it focuses on improving the network and system characteristics of transport where pay-offs for modest investments can be large. Such a perspective can help identify new and effective design and investment opportunities. "Thinking seamless" helps make smart investment choices that go beyond just providing better service and is an important factor in aligning mobility aspirations with aspirations for Greener Growth.

INTRODUCTION

The ITF Transport Outlook 2012 consists of three chapters. Chapter 1 has a short- and near-term focus. It discusses the impact of the 2008 macroeconomic shock on transport flows and a qualitative evaluation of near-term prospects for the sector. Recovery post-2008 has slowed down in advanced economies, and the most probable near-term scenario is one of tepid growth and mainly downside macroeconomic risks. Emerging economies continue to grow quickly but the pace is a bit slower than previously expected. Developments in trade and transport flows align fully with the broad macroeconomic picture, although swings in trade flows are larger than those in GDP, and transport volume changes have larger amplitude than those of trade.

Chapter 2 presents long run scenarios based on modelling work with a 2050 horizon. Passenger transport flows in the OECD could grow by around 30% between 2010 and 2050. Outside the OECD, they could triple. If freight volumes develop in line with GDP, then global flows in 2050 would be more than three times as large as they are now.

The general overview is followed by a discussion that focuses on scenarios for private vehicle ownership (light-duty vehicles and two-wheelers). The stock development model underlying the scenarios has been completely revised compared to earlier editions of the Outlook, updating it on the basis of recent research results and expanding the modelling scope. The analysis shows that overall passenger mobility using light-duty vehicles and two-wheelers is to increase very strongly in non-OECD economies. We distinguish between a scenario where car ownership develops mostly according to patterns observed in the OECD at comparable levels of income, urbanization, and density, and a scenario where car ownership is more restricted for cost and policy reasons. In addition, we consider the possibility that two-wheeler ownership rises strongly in the near future (resulting in lower car ownership levels throughout the period as well as a later takeoff of growth in car ownership). A discussion of the impact of taxes and oil prices is also included, and the impacts on energy use and on greenhouse gas emissions are discussed. Sustained high crude oil prices can slow down the growth of global mobility considerably, and aligning fuel tax levels outside the OECD with levels now prevailing in OECD Europe would slow down transport growth in that region, but not bring it to a halt.

Chapter 3 brings together themes of the previous Chapters. It reflects on how low growth and high debt in many countries affect the future funding situation of the transport sector. Evidence suggests that expectations for replacing ever scarcer public funds by private funds should not be set too high, unless private involvement is a lever to introduce user charging where that is appropriate. With respect to the climate change challenge, it is obvious that there are no easy solutions and some suggestions are made on how to balance technology-oriented and mobility-oriented policies to ensure the biggest probability of success.

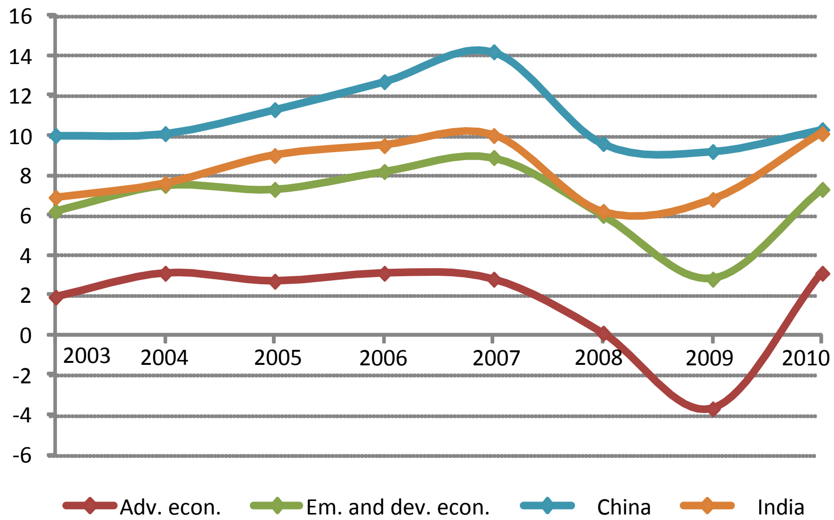
CHAPTER 1. THE IMPACT OF THE 2008 SHOCK ON TRANSPORT AND NEAR TERM PROSPECTS

1.1. The 2008 shock and its immediate aftermath

The 2008 financial crisis triggered a severe, sudden and synchronised drop in demand leading to strong reductions in global output, trade and transport volumes. The fall in trade was larger than the drop in output, and the fall in transport volumes was larger than the drop in trade volumes. A comparison of Figures 1a and 1b shows that the drop in volumes in the imports and exports of goods was considerably larger than the volume reduction in overall output. Regions have fared differently, with many OECD economies experiencing a "Great Recession" whereas emerging economies have managed to limit the damage to varying degrees of slowdown in their high pace of output growth, see Figure 1a.

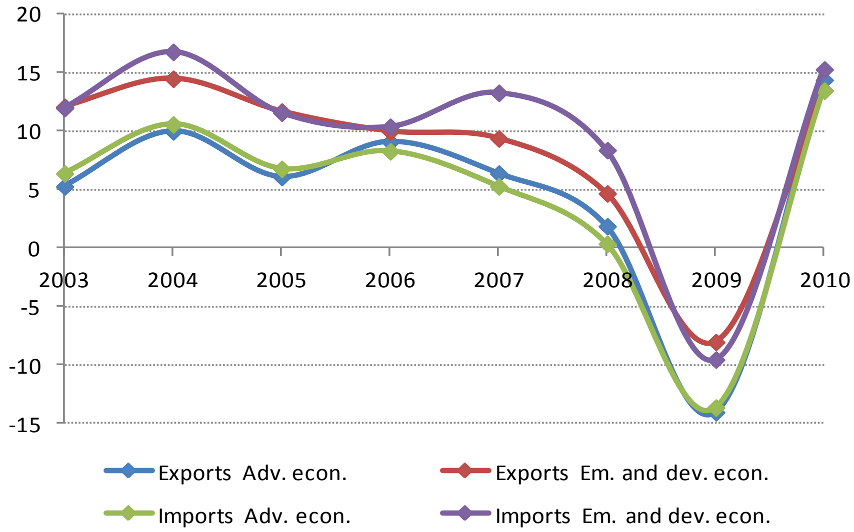
The 2008 shock has accentuated and accelerated the shift of economic mass from advanced economies to emerging economies that was well underway before the crisis. This shift is illustrated by difference in growth rates in Figure 1a. It also shows in differing growth patterns of import and export volumes, as can be seen in Figure 1b and Figure 2. Figure 1b illustrates that annual growth rates of imports and exports in emerging economies have exceeded those in advanced economies since 2003, and that the drop following the 2008 shock has been somewhat more limited. The trade volume index in Figure 2 provides a longer run perspective, and shows that the growth rate of imports and exports in emerging economies accelerated and rose above that of advanced economies in the first decade of the 21st century. Exports and imports in advanced economies continued to grow up to 2008 as well, but at more or less the same pace as in the 1990s.

Figure 1a. **Annual % growth of real GDP, 2003 – 2010, Advanced economies, Emerging and Developing economies, China, India**



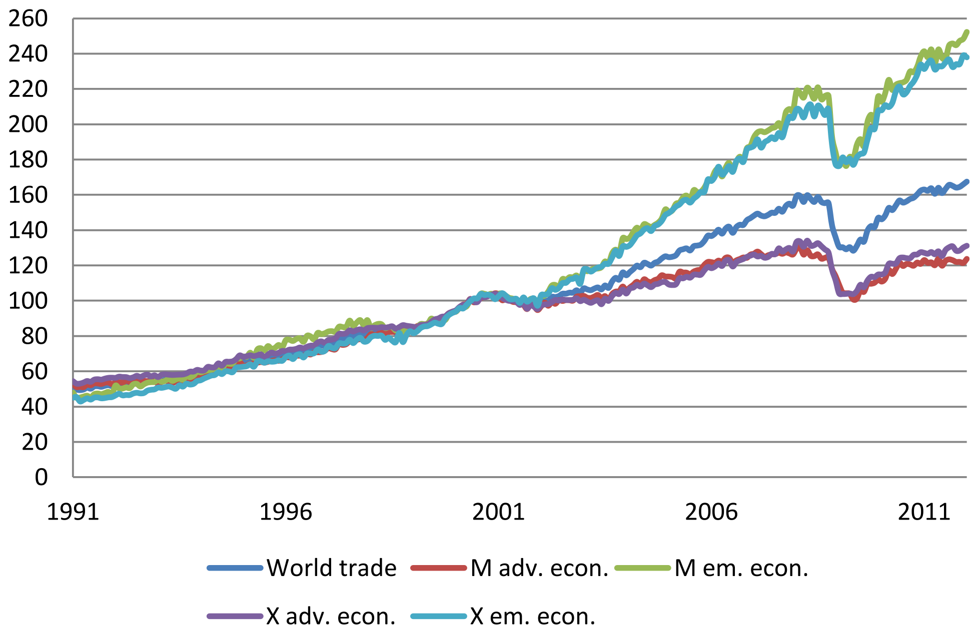
Source: Table A.1 of the IMF World Economic Outlook September 2011.

Figure 1b. **Annual % growth of Goods Import and Goods Export volumes, 2003 – 2010, Advanced economies, Emerging and Developing economies**



Source: Table A.9 of the IMF World Economic Outlook September 2011.

Figure 2. **Index of trade volumes: global, imports (M) and exports (X) for emerging and advanced economies, 1991 – January 2012, 2000 = 100**



Source: Central Planning Bureau, The Netherlands, World Trade Monitor January 2012.

Table 1. **Growth in global GDP and global trade, observations 2010-2011 and projections 2012-2013, IMF and OECD (annual % change)**

	Growth of global GDP (%)			
	2010	2011	2012	2013
IMF, January 2012	5.20	3.80	3.30	3.90
IMF, September 2011	5.20	3.50	4.00	4.50
OECD, November 2011	5.00	3.80	3.40	4.30

	Growth of global trade (%)			
	2010	2011	2012	2013
IMF, January 2012	12.70	6.90	3.80	5.40
IMF, September 2011	12.70	6.96	5.80	6.40
OECD, November 2011	12.60	6.70	4.80	7.10

Source: IMF and OECD Economic Outlooks (see footnotes 2 and 3).

1.2. Mounting pessimism on the pace of recovery

While the sentiment among observers of the condition of the global economy in early 2011 ranged from concern over fragility of the recovery[1] to guarded optimism[2], the mood in early 2012 decidedly is broadly shared pessimism regarding the prospects of near-term recovery. For example, both the OECD Economic Outlook of November 2011[3] and the IMF Update to the World Economic Outlook of January 2012[4] feature downward revisions of global growth expectations, with the recovery grinding to a halt in many advanced economies, a mild recession in large parts of Europe, and a slowdown of growth (but starting from high levels) in key emerging economies. Table 1 provides an overview of output and trade growth performance in the recent past and expectations for the near future.

There are major macroeconomic challenges, not least the policy challenge of finding a reasonable balance between reducing debt on the one hand and maintaining near-term aggregate demand and growth potential in the long run. The crisis and responses to it are increasingly seen to be accelerating trends towards an increasingly unequal distribution of income and wealth, in advanced economies. Views on what to do and concrete policy approaches differ widely, leading to poorly coordinated policy responses and weak and declining levels of confidence among consumers and businesses, which in turn feeds back negatively on the recovery. The economic outlook is particularly pessimistic in Europe, where perceptions of unsustainable sovereign debt continue to cause turmoil and instability. Expectations in the USA are somewhat more optimistic.

1. See e.g. the ITF Transport Outlook 2011, http://www.internationaltransportforum.org/Pub/pdf/11Outlook.pdf.
2. See e.g. the IMF World Economic Outlook of April 2011, which sees solidification of the recovery, http://www.imf.org/external/pubs/ft/weo/2011/01/.
3. http://www.oecd.org/document/18/0,3746,en_2649_33733_20347538_1_1_1_1,00.html.
4. http://www.imf.org/external/pubs/ft/weo/2012/update/01/index.htm.

In recent weeks concerns have risen over negative impacts of high oil prices. At the end of March 2012 the spot price of crude oil had risen to $125 per barrel from about $105 in January 2012. Future prices for December 2018 over the same period increased by $1 to $95 per barrel. This very large spread indicates that the concern is over geopolitically driven supply side disruptions in the short run more than over long run supply, but short term oil price spikes can have large effects in a fragile macroeconomic context. The discussion in Section 2.2.2 suggests that oil price rises can have considerable effects on the development of mobility. The scenario analysis does not consider knock-on effects on economic performance, but there is clear evidence that such effects exist.

Weaker output growth expectations translate into downward revisions for the growth of global trade. The slowdown in growth hits trade-intensive sectors particularly hard as weak prospects in advanced economies dampens the demand for exports from emerging economies. The proportional reduction in world trade will likely be larger than the overall effect on output. This is illustrated by a comparison of the November 2011 and January 2012 expectations from the IMF, see Table 1. The trade volume index shown in Figure 2 shows that trade growth has started to slow down after the initial quick recovery after the 2008 shock. Trade growth has nearly stopped in advanced economies, and exports from emerging economies have stagnated as well. What trade growth is left is driven by rising imports by emerging economies. This could be seen as rebalancing, although it is rebalancing driven by the weak performance of advanced economies rather than by structural change in the relations among healthy economies. It is noteworthy those global trade volumes at the end of 2011 exceed pre-crisis levels, and that this is because of the quick post-2008 growth in emerging economies, whereas in advanced economies import volumes remain below pre-crisis levels.

1.3. Freight transport and the macro economy

In order to track the relation between trade and transport, the International Transport Forum gathers data on tonnes imported and exported between large trade blocks. Figure 3 provides an overview of the main trends since June 2008, at which time transport volumes peaked. The transport trends mirror observations made above and provide some further insight. In December 2011, tonnes shipped over sea to and from the EU-27's were 5% below their pre-crisis peak. Imports remained 13% below the pre-crisis peak level, while exports were 16% higher. Furthermore, imports were once more on a path of decline in the most recent months measured. Exports, on the contrary, were on the rise. The pattern is consistent with the picture of weakening demand in the EU-27.

A geographical breakdown of the data (not shown) shows that the increase in maritime exports from the EU-27 reflects larger demand from emerging markets. Tonnes shipped to Asia are up by 51% and those to BRICs by 58%, whereas exports in tonnes over sea to the USA are down by 21% compared to the pre-crisis peak. Tonnes exported over sea to China are up by 75% in December 2011 compared to July 2008, and tonnes imported are down by 23%.

The broad pattern for the USA is similar to that of the EU. Tonnes shipped by sea to and from the USA are below pre-crisis peak levels by 3%, but the downward path observed in the Fall of 2011 was turned around in the most recent months for which data are available. Exports are higher than they were before the crisis (+17%) and imports are lower (-15%), with maritime export growth over pre-crisis levels mainly driven by Asia (+29%) and BRICs (+68%).

Fluctuations in air cargo transport correlate closely with the business cycle, and we see evidence that they are usually pro-cyclical. The patterns for air freight imports and exports from the EU-27 shown in Figure 3 therefore do not bode well. Import by air into France and the UK is below pre-crisis levels and has been declining. German imports remain well above pre-crisis levels but have declined in the most recent months for which data are available. Exports are on the decline as well. Import demand in the USA is down, but air cargo exports are holding up.

International trade has been subject to some restrictive trade policy measures in the wake of the crisis.[5] Fears of job losses at home have led to the imposition of an array of trade restrictions, including behind-the-border measures. Such policies have been adopted by many large developed and developing countries and as such affect a large share of international trade. Trade can act as a catalyst for growth, so trade restrictions may prolong the crisis. Less evident but nonetheless harmful is postponing trade policy reforms during the crisis.[6] Additionally, measures imposed as a response to the crisis may be difficult to lift at a later point in time once they have taken root.

Summing up, the macroeconomic outlook and with it the expectations for trade and transport in the near term remain rather bleak. Recent updates on the outlook for the OECD are cautiously more optimistic for the USA[7], an issue not picked up in our transport data given that they run only to December 2011. Other sources, however, report strong increases in exports from the Port of Los Angeles, while imports remain low and this is attributed to low domestic consumer demand.[8] On the whole, downside risks dominate, including the effects of high and volatile oil prices. In the longer run, governments will have to complete a difficult balancing act between reducing debt ratios while maintaining long term growth potential and avoiding policy-induced slowdowns in the nearer term. The conditions for returning to growth do exist, and (mitigated) pessimism about a prolonged slump does not need to extend to the longer run. This is why our mobility projections in the next Chapter are based on continued global growth.

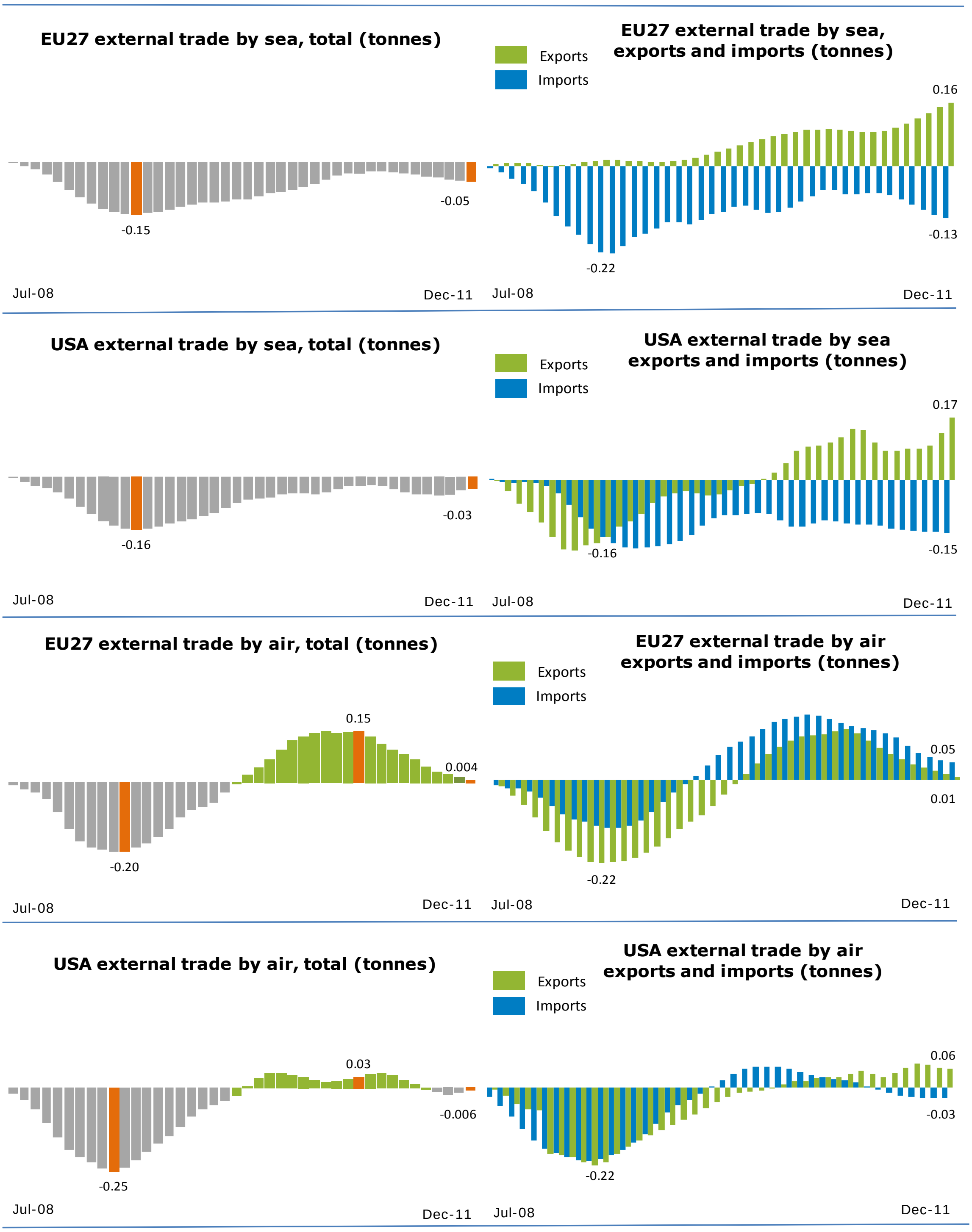
5. Global Trade Alert http://www.globaltradealert.org/

6. IMF *Protectionist Responses to the Crisis: Damage Observed in Product-Level Trade", "Trade Winds – Has the Spectre of Protectionism Blown Away?*, OECD *Trade and Economic Effects of Responses to the Economic Crisis.*

7. Padoan C.P., *What is the economic outlook for OECD countries? An interim assessment*, OECD, Paris, March 29 2012.

8. TI Global Logistics Monitor, April 5 2012.

Figure 3. **External trade, EU27 and USA, percentage change from pre-crisis peak of Jun-08 (Tonnes, monthly trend, seasonally adjusted)**



Source: ITF Global Trade and Transport Database.

CHAPTER 2. LONG RUN DEVELOPMENTS OF TRANSPORT DEMAND – HORIZON 2050

2.1. Prospects for travel volumes

2.1.1 Purpose and context of the projections

Transport systems show considerable inertia in the way they respond to changing circumstances. This is not to say that responses to macroeconomic shocks are small. As outlined in Chapter 1 the contrary is true. Instead the inertia is in how the organisation of the mobility system, a conglomerate of individuals' and firms' decisions and public rules, adapts to changing framework conditions. This process is slow to start and to complete. Consequently, to the extent that future patterns of demand and resource use are likely to pose problems, policy responses need to be designed and prepared well in advance. Doing so requires an idea of what the future of transport could look like. In order to clarify possible transport futures, it helps to construct projections based on assumptions regarding the evolution of external factors that shape transport demand and resource use, and on evidence and hypotheses as to exactly how these factors translate in transport volumes. The projections presented in our Outlook are not an exercise to which a formal degree of confidence can be attached, but rather coherent storylines about the potential development of the sector. They help gauge the size of the future benefits and costs of transport and help clarify what the relative contribution of different factors to the evolution of demand could be.

The projections presented in this Outlook are based on highly aggregated models that aim to capture the relation between economic development, approximated by GDP, and key socio-demographic variables (population size, population density, degree of urbanization), and transport volumes. Given the long run focus, with a horizon of 2050, such a broad-brush approach is warranted. Transport volumes are affected by many other factors which – with the exception of energy prices, see Section 2.2.2 – we abstract from in the projections. The base case assumptions on external factors are summarized in Table 2.

The Transport Outlook uses a version of the IEA's MoMo model (see box 1) developed by the International Transport Forum in close cooperation with the IEA's Energy Technology Policy Division[9]. The two organisations collaborate to improve the model continuously. The transport demand scenarios for light-duty vehicles and road freight discussed in this Chapter were constructed at the ITF. The detailed mobility, energy and emission outcomes were calculated using the MoMo model and we are grateful to the IEA for making the software available to us.

As table 2 shows, population growth is fairly low in the OECD and high outside of it. The 2050 OECD population is expected to be 14% higher than in 2010, and the non-OECD population should increase by 39%. All else equal, population growth translates into more demand for mobility. By 2050, global mobility systems will need to meet the needs of 9 billion people, compared to 6.5 billion people today. Nearly 8 billion of these will live in non-OECD countries. This in itself puts increased strain on resources and the need to extend infrastructure considerably is almost obvious. The table also shows that population densities rise in accordance with population growth, i.e. by 37% in non-OECD regions. Note that population density outside the OECD is twice as high as in the OECD in 2010, and will be

9. IEA 2012, *Energy Technology Perspectives 2012*. IEA/OECD, Paris. IEA 2009, *Transport, Energy and CO_2 : Moving Toward Sustainability.* IEA/ OECD, Paris.

2.7 times as high in 2050 according to the projections. Higher density tends to moderate the impact of income on car ownership levels[10], an effect we account for in our projections. Urbanization is another factor that can dampen the income effect on car ownership rates and overall mobility demand, which we account for. The table shows that urbanization rises through 2050, in the OECD (by about 10%) and much more strongly outside of it (about 42%). Despite higher average population density, the share of people living in urbanised areas is and remains lower outside of the OECD on average. In 2010, 78% of OECD inhabitants were urbanites, against 45% of non-OECD inhabitants. In 2050, the respective shares are 86% and 65%.

Box 1. **IEA Mobility Model (MoMo)**

The IEA has developed its Mobility Model over the past 10 years. It is a global transport model that allows projections and policy analysis to 2050, with considerable regional and technology detail. It includes all transport modes and most vehicle and technology types. MoMo is used to produce the periodic IEA Energy Technology Perspectives report.[11] MoMo covers 29 countries and regions. It contains assumptions on technology availability and cost at different points in the future, how costs could drop if technologies are deployed at a commercial scale, and other features. It allows fairly detailed bottom-up "what-if" modelling. Energy use is estimated using a bottom-up approach. MoMo is used to produce projections of vehicle sales, stocks and travel, energy use, GHG emissions (on a vehicle and well-to-wheel basis). It allows a comparison of marginal costs of technologies and aggregates to total cost across all modes and regions for a given scenario. More information on MoMo is provided in IEA (2009).[12]

For GDP projections, we distinguish between two scenarios. Both assume the continuation of global growth patterns as they have emerged over the previous decades – increasing economic integration and interdependence and further high-paced progress in emerging economies - but the scenarios differ in how they account for the long term impact of the 2008 shock. In the first, GDP world projections up to 2016 are those of the World Economic Outlook 2011 of the International Monetary Fund[13]. According to these projections, over the period 2011-2016 both OECD and non-OECD countries will recover from the 2008-2009 crisis and will return to pre-crisis expectations regarding levels of output. Therefore, in this scenario, the economic shock of 2008 and its aftermath are not expected to alter long run output levels. For the period 2016-2050, long-term annual growth rates are those used by the IEA in the World Energy Outlook 2011. IEA's sources for these growth rates are IMF, OECD, and World Bank databases.

The second scenario illustrates what might happen should such a return to pre-crisis output levels not materialize. In other words, it assumes that there is a permanent loss of output, which is carried through into the future because similar future growth rates are now applied to lower output levels. In this scenario, long-term growth rates projected by the IEA are applied to the short-term as well (2011-2016). The result is roughly a 5 year delay in the attainment of the projected GDP levels of the first scenario.

10. Dargay J., D. Gately and M. Sommer, 2007, *Vehicle ownership and income growth, worldwide: 1960 – 2030,* The Energy Journal.

11. IEA 2012, *Energy Technology Perspectives 2012*. IEA/OECD, Paris.

12. IEA 2009, *Transport, Energy and CO2 : Moving Toward Sustainability.* IEA/OECD, Paris.

13. *World Economic Outlook Database*, September, 2011: http://www.imf.org

Table 2. **Assumptions for external parameters used in the transport volume projections, OECD and non-OECD** (indexes 2010=100 and OECD-2010=100)

index - 2010 base		2010	2030	2050
OECD				
Population		100	109.7	113.7
Population density		100	103.9	104.5
Urbanisation		100	105.7	109.9
GDP	high	100	159.1	231.2
	low	100	144.2	209.9
GDP/cap.	high	100	149.0	208.8
	low	100	131.5	184.6
non-OECD				
Population		100	122.9	139.3
Population density		100	122.2	137.3
Urbanisation		100	120.5	141.9
GDP	high	100	242.4	516.4
	low	100	206.6	442.5
GDP/cap.	high	100	197.0	370.3
	low	100	167.9	317.3
index - OECD 2010 base		**2010**	**2030**	**2050**
OECD				
Population		100	109.7	113.7
Population density		100	103.9	104.5
Urbanisation		100	105.7	109.9
GDP	high	100	159.1	231.2
	low	100	144.2	209.9
GDP/cap.	high	100	149.0	208.8
	low	100	131.5	184.6
non-OECD				
Population		453.5	557.5	631.6
Population density		208.3	254.5	286.0
Urbanisation		58.6	70.6	83.1
GDP	high	79.5	192.8	410.6
	low	78.6	162.3	347.7
GDP/cap.	high	17.6	34.7	65.2
	low	16.9	28.4	53.8

Source: UN Population Prospects 2010 Revision, UN Urbanization Prospects 2009 Revision, IMF

The result in either scenario is that GDPs increase strongly over the projection horizon, being more than twice as high in the OECD in 2050 than in 2010, and four-and-a-half to five times as high outside of the OECD over the same period. Faster growth outside of the OECD means that (average) incomes in both regions are on a converging path. This is best seen in per capita GDP. Whereas in 2010 per capita GDP in the OECD is more than five times as high as outside of the OECD, by 2050 average non-OECD per capita output is half of the OECD level in the pessimistic case and two-thirds of it in the optimistic case. The difference between the cases is explained by the cumulative effect of applying growth rates to lower base income levels. Heterogeneity among non-OECD countries of course is large. Some countries – notably China – are growing quickly on per capita basis, resulting in considerable but not complete convergence to OECD levels by 2050. According to the optimistic projections, China would have nearly the same per capita income level in 2050 as the OECD is expected to have on average in 2035.

The GDP and population projections indicate what can be expected in terms of the development of mobility. Higher growth of the population and of per capita income imply faster growth of mobility outside of the OECD as long as mobility patterns there will develop in ways that are somewhat similar to what is observed in the OECD (a hypothesis we deem plausible in the sense that there are no reasons to expect mobility patterns to be radically different, although mobility and energy management and prices have the potential to steer demand to some degree). Section 2.1.2 develops these ideas in some detail.

2.1.2 Broad growth expectations for mobility and transport

Figures 4a and 4b provide a summary of the projected impacts of the evolution in GDP, urbanization, population density, and total population (discussed in Section 2.1.1) on total passenger mobility. Scenarios are shown for the high and low GDP assumptions, for OECD and non-OECD. In addition, for the high GDP scenario a distinction is made between a high car ownership and a low car ownership scenario ("high car" and "low car"). The difference between these ownership cases is discussed in detail in Section 2.2.2. The bottom line is that high ownership refers to continued evolution of car ownership along patterns observed in the OECD in the past, both in and outside the OECD. In the low ownership case, policies and framework conditions are less conducive to car ownership and use, both inside and outside the OECD. The impact of discouraging car ownership is proportionally larger outside the OECD as it takes place at an earlier stage in the development of the mobility system. Passenger mobility is measured in passenger-km, and all modes are considered. Two observations stand out:

- Passenger mobility growth is very strong outside of the OECD, where it is expected to increase by a factor of about 2.5 to 3.5 (Figure 4b). Growth in the OECD is much more limited, but nevertheless there too mobility is expected to be about 30% higher in 2050 than in 2010, with a range of 10 to 50% (Figure 4a). Population growth and per capita income growth are the driving factors, far outpacing the mitigating potential of increasing density and urbanization.
- Lower GDP growth leads to lower mobility growth, and this effect is particularly pronounced in places where the impact of GDP growth on mobility growth is high, i.e. outside the OECD. In the OECD higher incomes translate into more mobility, but to a much weaker extent given the already high levels of income and of mobility (see the discussion on saturation in Section 2.2). The effect of slower income growth outside of the OECD is mainly to horizontally shift the mobility growth curve, i.e. to delay growth but not to alter it, as the income growth path is not fundamentally altered.

If population and incomes grow even roughly in accordance with expectations, and if the relation between income and the demand for mobility is more or less as captured in the model, then mobility will grow strongly, particularly outside of the OECD. What about the modal composition of mobility? Table 3 provides some insight, following baseline projections using the MoMo Model (high GDP and low car ownership).

Passenger mobility in the OECD is dominated by light-duty vehicles (cars and light trucks), and this dominance declines only to the extent that air travel takes up a greater share of total passenger-km: light-duty vehicle travel rises by 19% from 2010 to 2050, while air travel increases by 79%, leading to a decline in the light-duty vehicle share in passenger-km of 5% and an increase for air of 6%.

In non-OECD countries growth is strong for all modes but is particularly high for light-duty vehicles and for two-wheelers, which grow by a factor of 5.7 and 3.8 respectively in the

low car ownership scenario. The result is a sizeable change in the modal composition of passenger mobility, with the share of light-duty vehicles rising from 25% in 2010 to 48% in 2050. two-wheeler use represents 12% of the total in 2010, 19% in 2030 and 15% in 2050. The pattern whereby two-wheeler use rises first and then declines reflects an assumption in which growing mobility in a number of large emerging economies first is produced through increased use of two-wheelers and later with more widespread acquisition of cars and light trucks. In the high car ownership scenario, cars and light trucks are acquired more quickly, so that two-wheeler shares remain lower throughout. We discuss this in more detail in Section 2.2.1. In either case, the growth of privately produced passenger mobility is expected to grow rapidly outside of the OECD, and by 2050 this growth mainly takes the form of light-duty vehicle acquisition and use. The rising share of car and light truck use should not obscure the expectation that passenger mobility in non-OECD countries is set to grow fast throughout. Air and rail use could grow by a factor of 2.5 to 3. Only bus use growth is more moderate, with a projected 30% increase from 2010 to 2050.

Figures 5a and 5b show projections for surface freight output, which is the sum of road and rail freight where the former consists of light commercial vehicles, medium and large trucks, and which is measured in tonne-km. Here too we consider a high and a low scenario. In the first, freight volumes grow roughly in proportion to GDP, in the second they grow more slowly (i.e. there is decoupling of GDP and freight growth). The decoupling scenario is in line with the IEA baseline scenario, but given past experience proportional growth is a scenario worth considering. There is evidence that on the whole in the advanced economies at present GDP growth remains transport intensive.

With high GDP and proportional growth, freight volumes in non-OECD regions would be about 6 times as large in 2050 as in 2010, see Figure 5b. In the OECD volumes would more than double, see Figure 5a. With decoupling, the growth expectation for the OECD is of the same order of magnitude as for passenger traffic (+50% from 2010 to 2050). For non-OECD, in the baseline scenario used by the IEA, surface freight grows more slowly than GDP, so that volumes would more than double by 2050. The decoupling freight projections are on the conservative side, and imply active policies to dampen freight growth and rapid dematerialisation of GDP inside and outside of the OECD.

Details of the modal split between rail and road vary by country, depending on policies and product mix. Even within the OECD there are large differences in these shares. How non-OECD and also OECD regions will develop in this regard in the future is uncertain. For the non-OECD countries it can be expected that GDP growth in the medium term will be especially freight intensive, given the stage of development they are currently in. The general trend may be towards a higher share in use of road vehicles since this provides for more flexibility in terms of delivery and uses relatively cheaper infrastructure than rail. For the transport of bulky goods rail is a more cost-effective choice due to economies of scale, but with the sophistication of the product mix expected to increase in the non-OECD region, more use of road transport can be expected. Even where large-scale rail infrastructure exists maintenance costs can be high and there is evidence of a stronger growth in road transport recently. In the baseline projections for the OECD, the shares of rail freight are held constant at about 56% of tonne-km. Outside the OECD the road freight remains at 38%. Rail use grows more strongly than light-duty vehicle use as well (+78%), but this translates into only a small increase in its modal share.

Figure 4a. **Index of total private mobility (passenger-km, all modes) OECD 2010–2050, high and low GDP scenarios, high and low car ownership**
(index 2010=100)

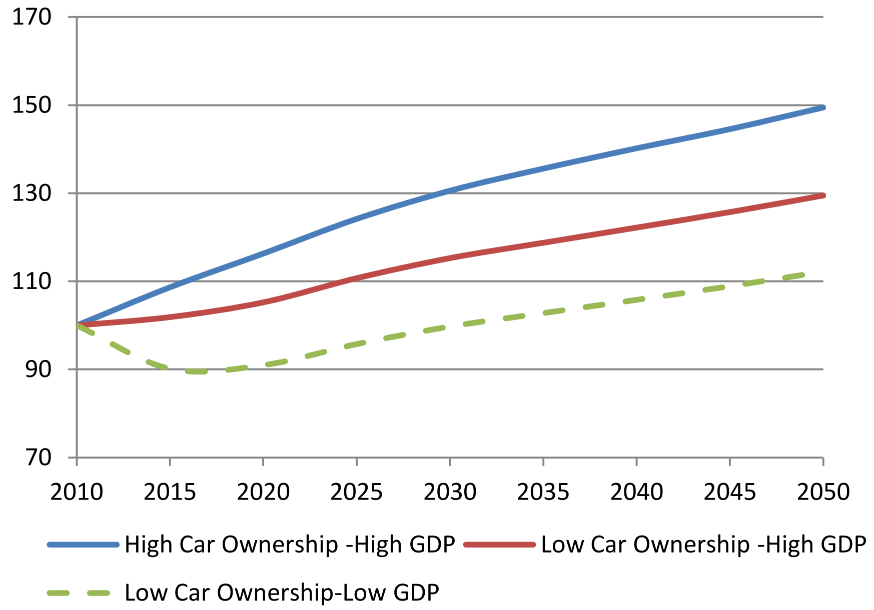
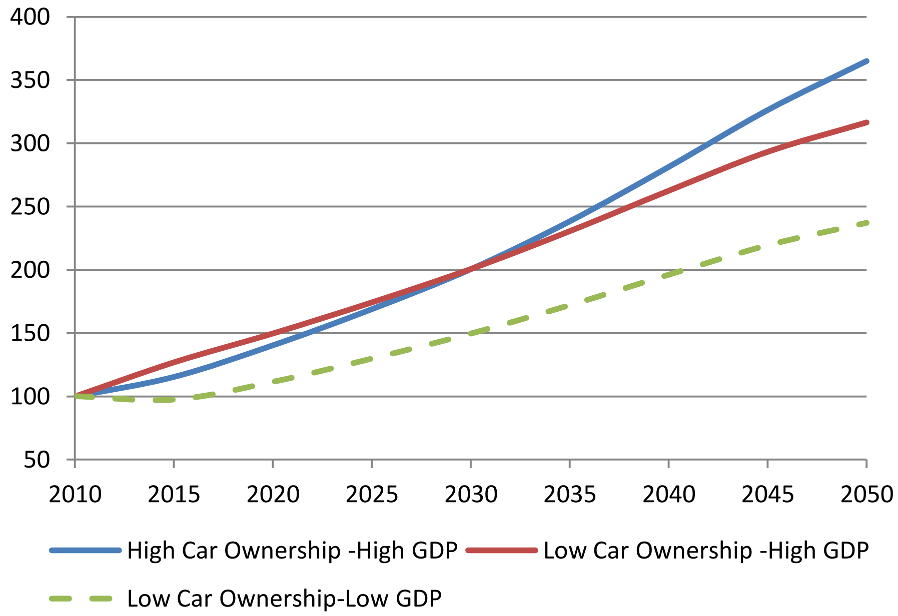


Figure 4b. **Index of total private mobility (passenger-km, all modes), non-OECD, 2010–2050, high and low GDP scenarios, high and low car ownership**
(index 2010=100)



Source: ITF calculations using the MoMo-model.

Figure 5a. **Index of total freight mobility (tonne-km, all modes), OECD 2010–2050, high and low GDP scenarios, baseline and decoupling**
(index 2010=100)

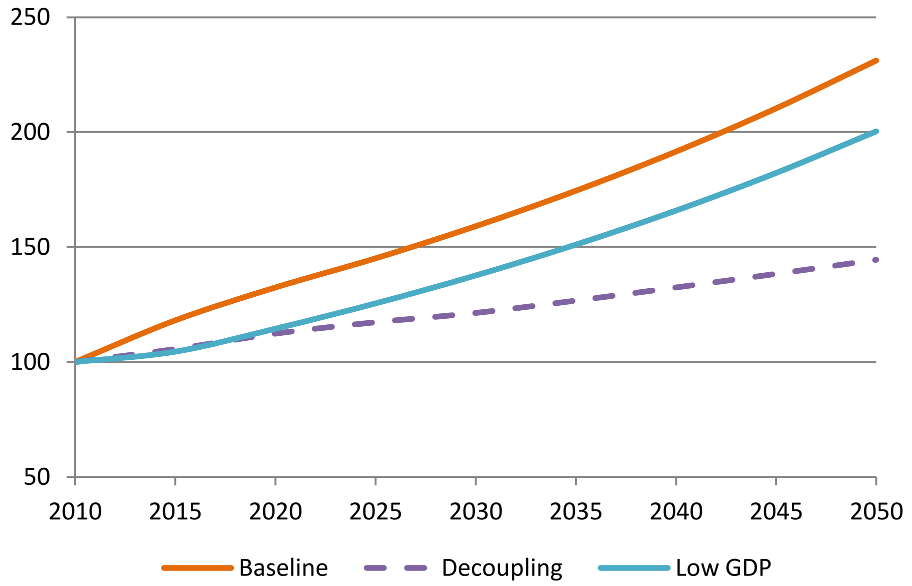
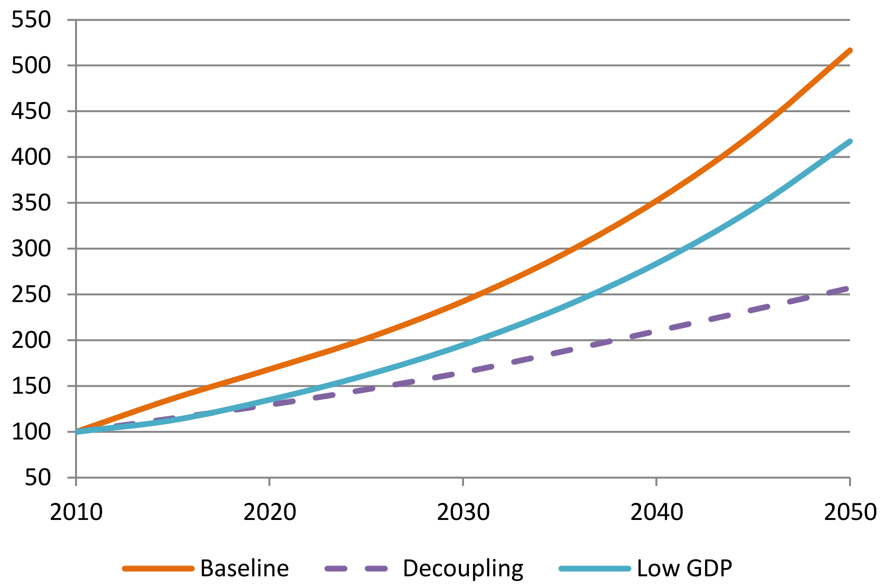


Figure 5b. **Index of total freight mobility (tonne-km, all modes) non-OECD 2010–2050, high and low GDP scenarios, baseline and decoupling**
(index 2010=100)



Source: ITF calculations using the MoMo-model.

Figure 6a. **Index of total passenger mobility emissions (Mt equivalents), OECD 2010–2050, high and low GDP scenarios, high and low car ownership**
(index 2010=100)

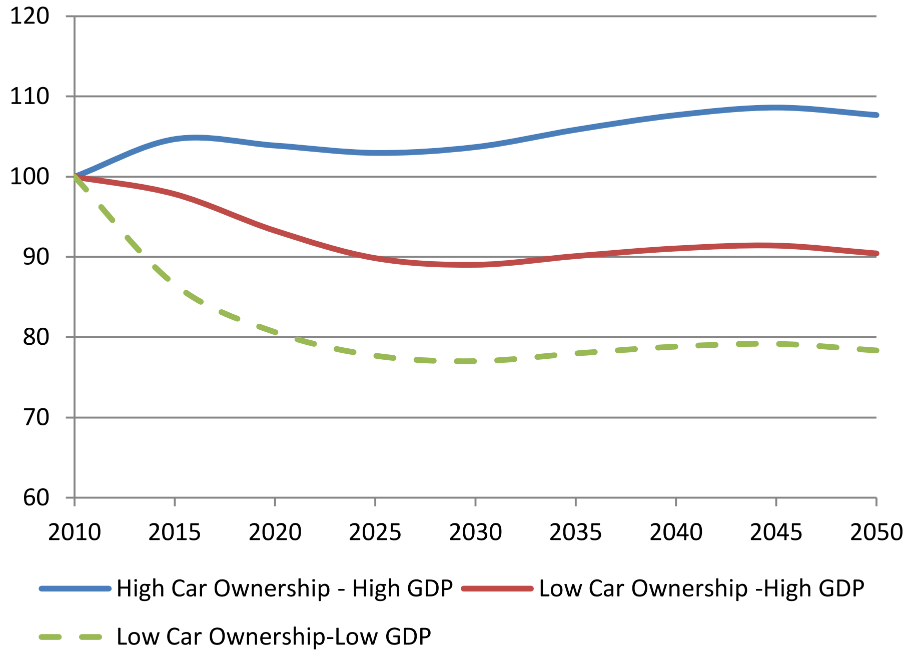
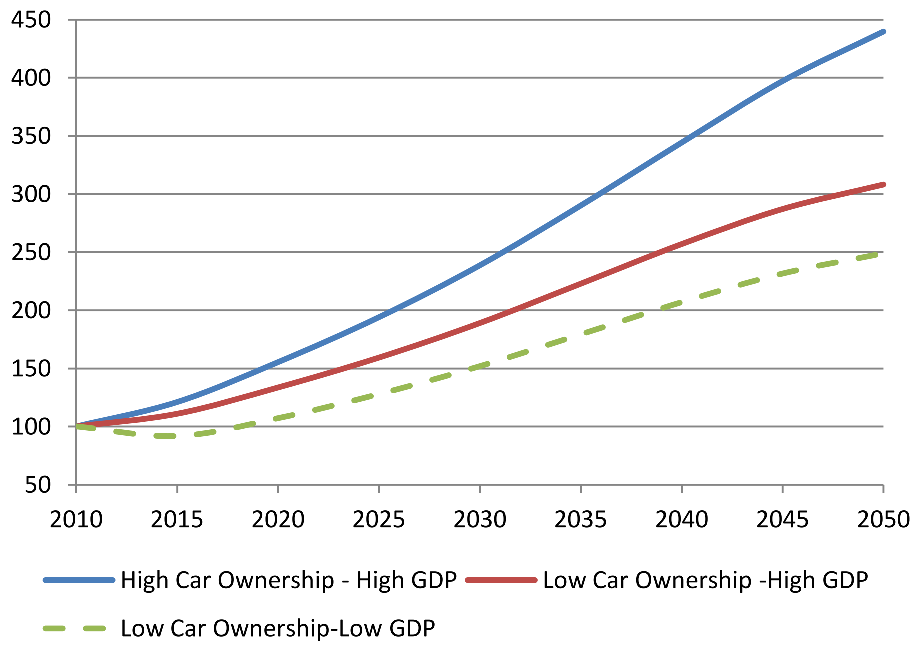


Figure 6b. **Index of total passenger mobility emissions (Mt equivalents), non-OECD, 2010–2050, high and low GDP scenarios, high and low car ownership**
(index 2010=100)



Source: ITF calculations using the MoMo-model.

Figure 7a. **Index of total freight mobility emissions (Mt equivalents), OECD 2010–2050, high and low GDP scenarios, baseline and decoupling**
(index 2010=100)

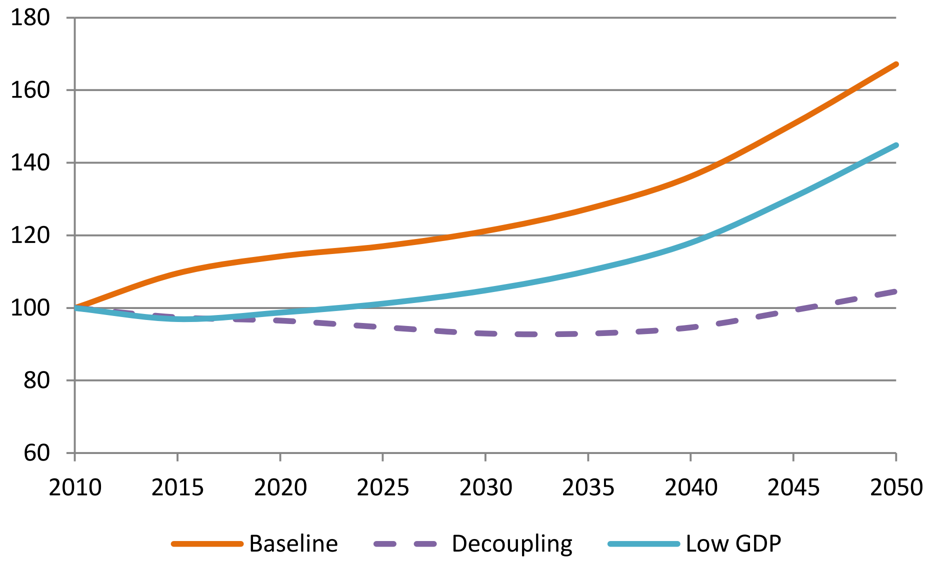
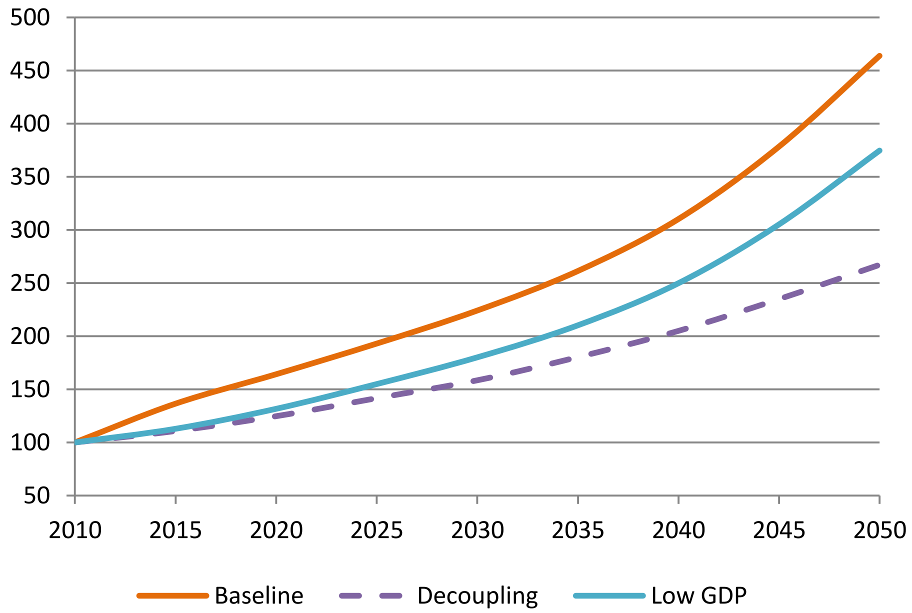


Figure 7b. **Index of total freight mobility emissions (Mt equivalents), non-OECD, 2010–2050, high and low GDP scenarios, baseline and decoupling**
(index 2010=100)



Source: ITF calculations using the MoMo-model.

Table 3. **Modal composition of motorised passenger mobility, OECD and non-OECD, 2010, 2030 and 2050, low car ownership, % of passenger-km**

	2010	2030	2050
OECD			
Light-duty vehicles	71%	69%	66%
Air	15%	18%	21%
Rail	4%	4%	5%
Bus	9%	8%	7%
two-wheelers	1%	1%	1%
Non-OECD			
Light-duty vehicles	25%	36%	48%
Air	7%	7%	8%
Rail	10%	8%	9%
Bus	46%	29%	21%
two-wheelers	12%	19%	15%

Source: ITF calculations using MoMo-model.

Table 4. **Modal composition of CO_2 emissions of motorised passenger mobility, OECD and non-OECD, 2010, 2030 and 2050, low car ownership, % of Mt of CO_2 equivalent**

	2010	2030	2050
OECD			
Light-duty vehicles	79%	71%	67%
Air	17%	24%	29%
Rail	0%	0%	0%
Bus	3%	4%	3%
two-wheelers	1%	1%	1%
Non-OECD			
Light-duty vehicles	51%	60%	70%
Air	20%	17%	17%
Rail	2%	1%	0%
Bus	20%	12%	5%
two-wheelers	7%	10%	8%

Source: ITF calculations using MoMo-model.

We now consider the likely impact of the scenarios for mobility development on tank-to-wheel emissions of CO_2 from the transport sector. All else equal, growing mobility leads to proportional changes in emissions. But of course not all else is equal. First, the modal composition of total mobility changes. For this our scenarios show strongly increasing reliance on light-duty vehicles in non-OECD economies, that is to say a shift to relatively CO_2-intensive modes. Second, the energy technologies embodied in vehicle stocks change over time. Here the general trend is towards reduced CO_2-intensity.

The assumptions on the evolution of the technological composition in the world stock are those of the IEA New Policy Scenario. They imply a gradual uptake of new technologies, resulting in moderate shares in the global vehicles stock by 2050. The share of conventional gasoline vehicles in the world light-duty vehicle stock decreases progressively from 85% in 2010 to only 51% in 2050. Conventional diesel increases its share until 2020 (16%) and then is reduced, constituting 11% of the fleet in 2050.

Gasoline hybrid vehicles and plug-in hybrids are the technologies that increase their shares the most, rising from near 0% to 30% of the world stock. All other technologies, such as natural gas, diesel hybrid, and electric vehicles remain a marginal part of the fleet. For the commercial vehicle stock the uptake of new technologies is less diversified. Gasoline and diesel are the primary fuels for light commercial vehicles, with a slightly increasing share of diesel through 2050, which to an extent replaces gasoline powered vehicles. In total shares of the traditional fossil fuel-based fuel types in both OECD and non-OECD countries are higher than 90% throughout. For medium and heavy trucks the dominant fuel type remains petroleum diesel, especially outside of the OECD. For heavy trucks the share of diesel internal combustion engines is close to 100%. There is minor uptake of LNG and diesel hybrid vehicles towards 2050, mostly for medium trucks and in the OECD. Technological uptake is somewhat delayed in the non-OECD compared to the OECD, not only in terms of fuel shares but also in terms of fuel efficiency improvements. In the aviation sector the IEA baseline assumes 30% efficiency improvements (see the discussion in Section 2.4), two-wheelers and rail become 5-10% more efficient by 2050.

The result of the combined evolution of mobility volumes, modal composition and technological change is that global CO_2 emissions rise less quickly than mobility. In the OECD, the CO_2-saving effect of technological change is sufficiently large that emissions from passenger transport stabilize or even decline despite the transport volume growth of around 30%, see Figure 6a. Outside the OECD, the fast growth of mobility and the switch to more CO_2-intensive modes imply a large increase in emissions that is only mildly tempered by technological change. In the low car ownership scenario, CO_2 emissions rise less quickly than mobility, but not by very much. If car ownership is high, emissions rise faster than overall mobility (Figure 6b). The CO_2 emissions patterns in freight will depend strongly on the modal composition of freight transport. Strong growth in both sectors leads emissions to quadruple by 2050 outside the OECD (Figure 7b), where emissions from road freight are up to 18 times higher than those from rail, at constant modal share assumptions. Similar growth in total surface freight activity with a decreasing share of rail may thus lead to much stronger growth in emissions outside the OECD. The effect of technological change and fuel efficiency on road freight is more limited outside the OECD. In the OECD, freight emissions rise by less than transport volumes, because of improving fuel economy (Figure 7a), but emissions are set to rise.

2.2. A closer look at private vehicle ownership and use

Section 2.1 presented an overview of the potential development of passenger and freight mobility, the modal split, technologies used and resulting CO_2-emissions. The projections are based on assumptions on the evolution of broad factors that drive mobility (population, GDP, urbanization, and density) and on the precise way these factors translate into mobility. These assumptions obviously are subject to very high uncertainty. For GDP, we have assumed that it develops along paths established over the past decades, and although different scenarios embodying trend-breaks can be imagined, we retain that assumption in what follows. The paths for other exogenous variables are kept constant as well. This section looks at several aspects of the broad projections in more detail.

Section 2.2.1 focuses on possible developments in personal vehicle ownership and use, where personal vehicles include light-duty vehicles (cars and light trucks) and two-wheelers. Specifically, we investigate a scenario where some emerging economies adopt "OECD-style" development of personal vehicle ownership and use, and a scenario in which they follow a pattern observed in some ASEAN countries at present.

The first scenario is heavily oriented towards light-duty vehicle ownership and use, even at lower income levels, whereas the second one sees more constraints on private car ownership which in some regions results in more two-wheeler oriented ownership at lower income levels. The second scenario is the one used in the projections of Section 2.1.

Section 2.2.2 focuses on light-duty vehicle use by exploring how use may be affected by different assumptions on the evolution of the price of driving a kilometre, which themselves depend on alternative assumptions on the price of crude oil and on the way car use is taxed in emerging economies in particular. In Section 2.2.3, we revisit and update our discussion of the debate on saturation of car and light-truck use in high income economies (ITF Transport Outlook 2011). Private travel is currently declining in some economies, and it is important to monitor this trend and understand what drives it.

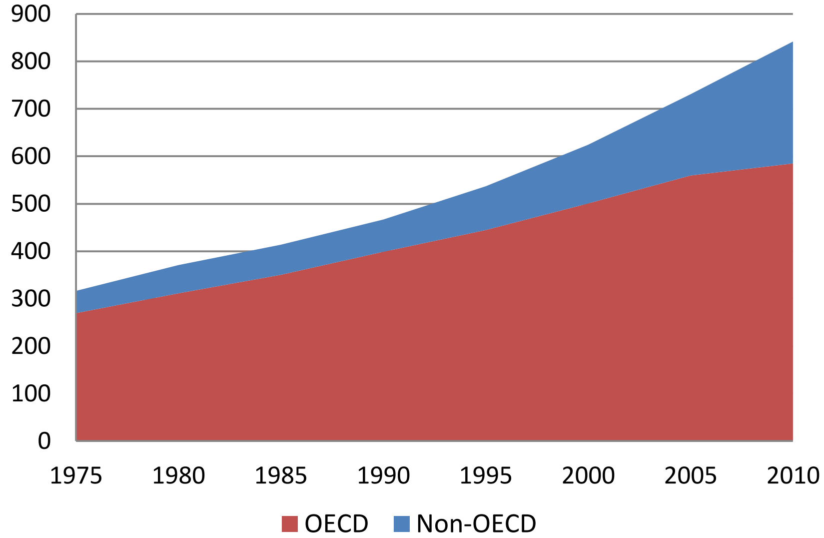
Projections obviously are subject to uncertainty: confidence in the projected paths of the exogenous variables is not particularly high and applying a highly stylized model for transport projections well outside of the time frame and the set of countries for which it was estimated, is a tenuous exercise. We do not aim to quantify uncertainty explicitly, given our view of the scenarios as storylines rather than predictions. The use of scenarios is designed to get an understanding of the potential order of magnitude of change, and to compare the impact that changes in assumptions may have on the rate of change.

2.2.1 Cars and two-wheelers

Past development of the global car stock

In 2010, the world passenger light-duty vehicle (LDV) stock reached 841 million units, more than double the level of 1975 (Figure 8). The share of non-OECD countries in the total rose slowly over this period: in 1975, 85% of passenger light-duty vehicles in the world where in OECD countries; in 2010 this share had declined to 70%. The vehicle stock in the OECD grew at a nearly constant rate up to 2005, and then growth slowed down. Outside the OECD growth rates slowly increased between 1975 and 2010. As will be seen in the projections, this pattern is expected to intensify, with slow or no growth in the OECD and increasing growth rates outside of it.

Figure 8. **Development of the global light-duty vehicle stock, OECD and non-OECD, 1975–2010** (millions)



Source: MoMo-model database.

The following features of vehicle ownership patterns in the past 40 years are worth noting:

- "S-shaped relations" between income and light-duty vehicle ownership rates

Ownership rates generally increase with income, but the strength of the income effect varies with the income level. Vehicle acquisition rates are low when incomes are low, they increase as incomes rise to intermediate levels, and the rate of increase of acquisition rates slows down again when incomes are high. Between 1975 and 2010, most OECD countries´ income grew from middle to high levels of income, while many non-OECD countries´ economies were still at low levels of income. Therefore, during this period, vehicle markets in most OECD countries developed significantly more than those in non-OECD countries. But if past experience is any guidance, it is highly likely that we are entering an era where non-OECD regions embark upon high growth paths of vehicle ownership.

- Higher acquisition rates at lower incomes outside the OECD?

In general, up to the income level that they have reached, non-OECD countries have shown higher levels of vehicle ownership than OECD countries at similar income levels: vehicle ownership growth seems to accelerate more quickly outside the OECD as income in these countries rises. There are several possible explanations for this. First, their transport infrastructure is significantly more developed than it was in OECD countries when their motorization started. Secondly, motorized vehicles are, in general, more affordable now than when more advanced economies were going through middle-income level growth. A third important factor is the general difficulty for governments in developing countries to implement taxes and fees for private vehicle ownership and use[14], which lowers the relative cost of using a vehicle.

Finally, low quality transport alternatives, also contribute to lower relative costs of using private vehicles. This last factor is especially hard to overcome in most cities in developing countries due to elevated rates of migration to the cities. The high numbers of poor migrants that establish settlements around city fringes creates pressure on the quality of public transport services while the systems struggle to serve the new populations whilst usually required to maintain prices below costs. Consequently better-off migrants acquire private vehicles even when their incomes are not that high.[15] Also, relatively high income inequality (implying that there are sufficiently well-off households that purchase vehicles despite fairly low average incomes) may help explain the observed pattern.

- A decline of income effects in advanced economies

Near the end of the 1975-2010 period, most advanced economies experienced a slowdown in the relationship between income growth and vehicle ownership expansion. This does not mean that "saturation" levels of ownership (meaning that further income growth would not translate into higher ownership rates) have been reached, but it is highly plausible that further income growth will have ever more limited impacts on the expansion of the stock.

14. As mentioned in 2.2.1 private vehicle restrictions in some cities in China, such as Shanghai and Beijing, are an exception to this general trend.

15. Sperling, Daniel and Deborah Salon, 2001, *Transportation in Developing Countries, An Overview of Greenhouse Gas Reduction Strategies.* University of California, Davis. *Prepared for the Pew Center on Global Climate Change.*

The light-duty vehicle ownership levels at which the decline of income effects sets in, varies considerably among countries. For example, in the USA the slowdown set in when it reached an ownership rate of about 600 vehicles per 1000 inhabitants, while Japan showed a weaker response at levels of 400 vehicles per 1000. This implies that there are variations among countries in the vehicle ownership level at which benefits from investing additional income in acquiring private vehicles begins to decrease. The reasons for these differences are several, and are a combination of "nature" and "nurture". For example, differences in geographical features between the USA and Japan explain part of the difference in car ownership rates. Other factors relate to policy and to attitudes. Road network provision in the USA and in many OECD countries has accommodated, or encouraged, private vehicle acquisition and use. Pricing structures generally have worked in the same direction, e.g. through low charges for storage (parking) and use. Differences in pricing structures between the USA and Europe have effects in terms of ownership rates, but also in terms of choices of vehicle type and usage decisions.

Densification and urbanization have potentially large effects on car ownership and usage patterns, in the sense that they present an opportunity for satisfying mobility aspirations at lower ownership and usage levels because mass transit and two- or three-wheelers become more competitive, and in the sense that rising congestion in itself discourages car use and to some extent ownership. But more urbanization does not automatically lead to a different mobility mix. The type of densification and urbanization observed in many cities in the USA has limited only very slightly the benefits and costs of additional vehicle ownership. This is one factor explaining high ownership rates in the USA. Japan has followed a densification and urbanization process that is less conducive to private vehicle travel, so that the benefits of investing additional income in private vehicle ownership began to translate into lower benefits at lower levels of private vehicle ownership. Given the expectation of fast urbanization and fast income growth in a number of major non-OECD economies, the way in which the relation between urbanization and mobility plays out in these economies will have a noticeable impact on the development of global ownership and use of light–duty vehicles.

Given the long lifecycles of transport infrastructure and the built environment in general, land-use and transport choices that are being made now will have a lock-in effect for mobility patterns that extends up to our planning horizon of 2050.

Private vehicle ownership and use projections

This section discusses projections of the global stock of light-duty vehicles (cars and light trucks) and two-wheelers. We consider two scenarios, labelled the high car ownership scenario and the low car ownership scenario. The light-duty vehicle stock projections in the 2012 Transport Outlook are based on a revised methodology. Compared to earlier editions, the projections are based on a broader set of data (more countries, longer time series) and they are more directly based on the analytical work by Dargay, Gately and Sommer (2007, see footnote 9), which itself is an update and extension of the model that earlier projections were based on. Among other things, the revisions allow us to take account of effects of urbanization and increasing population density more rigorously than before. The light-duty vehicle stock projections in the high car ownership scenario are the result of applying this revised method directly to historical starting points contained in the MoMo-model, given the projections of exogenous variables discussed before. The low car ownership scenario is generated by assuming that total personal vehicle ownership develops along the same lines as in the high car ownership scenario, but that it is more geared towards two-wheeler ownership especially in the period 2010 – 2030. We now discuss the two scenarios in more detail.

The high car ownership scenario can be seen as one where emerging economies mimic private vehicle ownership patterns as observed in the OECD. The take-off in light duty vehicle ownership even takes place at lower income levels than it did in the OECD, perhaps because of strong preferences or because framework conditions (prices, availability of other modes) steer in that direction. The underlying assumptions for the high car ownership scenario are that car ownership aspirations in emerging economies are the same as in advanced economies, and that policies (including infrastructure supply and pricing) and resource availability make it possible for these aspirations to be realised in a fairly unconstrained manner. In urban areas this calls for strong infrastructure investments to alleviate congestion, and a relatively neutral stance towards modal choice (e.g. no strong prioritization of public transport development and improvement). As a result, rapid urbanization has a limited effect in constraining passenger light duty vehicle growth during the 2010-2050 period. In high income economies, the high passenger light duty vehicle ownership case exhibits a declining responsiveness of ownership to income that results in very low growth in vehicle stock, mostly driven by population growth.

In the high car ownership case, saturation ownership rates differ among regions but the gap between them declines over time. Both developed and developing countries' demand head to high levels of vehicle ownership. In emerging economies such as Brazil, Russia, China, and India, the intensity of the income-ownership relation will not decline until reaching vehicle ownership rates between 600-700 vehicles per 1000 population. From 2010-2050, China and India go from very low (41 and 11 respectively) levels of vehicle ownership to levels between 400 and 500 vehicles per 1000 population. Motorcycles are used mostly as a complement to cars and never reach the high ownership rates that would be associated with them becoming the principal mode of private transport. Current motorcycle ownership growth trends will discontinue and income growth translates mostly into car ownership.

In the high car ownership scenario, the world passenger vehicle stock reaches 3.3 billion units by 2050, which is four times the 2010 global stock. This growth in vehicle stock is almost entirely driven by the emerging economies. India and China are responsible for 56% growth, given their large shares in world population and given the fast income growth in China, and become *the* major car markets. Their share of global vehicle stock in the non-OECD regions rises from 30% to 70% over the period 2010 - 2050.

The low car ownership scenario assumes stronger constraints on ownership and use which cause a declining responsiveness to income growth much earlier than in the high ownership scenario. There is higher divergence in ownership across countries and time, based largely on differences in the extent to which private car ownership and use is accommodated through the urbanization process. There is not only a downward push on vehicle ownership at high levels of urbanization as assumed in the high car ownership scenario, but at all levels of urbanization the congestion effects are more pronounced. Overall, this results in lower vehicle ownership rates through 2050 in all regions. Evolving towards less car-oriented mobility will require making available high quality transport alternatives, including public transport, in addition to constraining car use. The low car ownership assumes implicitly that public transport supply will develop in a way that reduces car-dependence while retaining similar capacity to satisfy mobility needs. There is increasing evidence that thinking in terms of seamless and integrated mobility will help realize that objective. Preston (2012)[16] sees reduced car-dependency as a principal benefit of better integration in public transport and in the mobility system as a whole. He cites evidence of

16. Preston, J., 2012, *Integration for seamless transport*, Paper for the International Transport Forum's Summit on Seamless Transport: Making Connections, 2-4 May 2012.

high social rates of return to projects that promote integration, particularly among transport modes.

This indicates both that these projects are worth implementing and that the current degree of integration is too low. In the short run, integration often means relying more on bus transport. In the medium run, integrated pricing for all modes is a key objective. In the long run, governance can be integrated more but sufficient flexibility to adapt to changing circumstances is needed. It is noted that attempts to introduce competition have sometimes hampered system integration. Strategic planning is a public task and assuring the emergence of network benefits requires cooperation between the public and private sector. Operational cost savings may be best pursued through competitive tendering with the public authority making the award of concessions conditional on business plans that provide for integration and delivering more seamless transport. The importance of integration to reduce overreliance on cars has also been noted in the ITF/KOTI seminar held in March 2012 (see Chapter 3 for more discussion). A special issue of PIARC's Routes/Roads journal shows the success of such a strategy in a number of cities and regions, and highlights the need to adapt the general strategy to local circumstances (Van Dender, 2012[17]).

The high car ownership scenario focuses heavily on private mobility taking the form of car use since it assumes that emerging economies will follow OECD private mobility trends. The low car ownership scenario, which considers more constraining conditions for car ownership assumes that such constraints will also generate a private mobility demand which is not necessarily limited to passenger cars and light trucks and can be satisfied by different types of private vehicles. In other words, households respond to constraints (infrastructure, congestion, prices, policies) by acquiring and using various kinds of two-wheelers instead of cars, in addition to curbing mobility. The scenario aligns with current developments in some Asian economies, where private vehicle ownership is dominated by powered two-wheelers.

In the low car ownership scenario, projections for two-wheeler ownership are made for China, India, ASEAN countries, other developing Asia, and Latin America. Modelling of future two-wheeler trends in these zones was done based on the model constructed by Tuan (2011)[18] taking into account data for selected countries in Asia. According to this model, rather than the S-shaped relation between income and ownership followed by cars, two-wheeler ownership presents a bell shape with respect to income. Two-wheeler vehicle ownership has its highest responsiveness to income growth at low income levels of about $1000-3,000 per capita income (2007 prices), ownership reaches its most elevated level between $10,000-20,000 per capita income and then begins to decline as income continues to grow. Cars and two-wheelers of course are not perfect substitutes given strong differences in terms of size, safety features, load factors, range and comfort. But for certain tasks two wheelers can be sufficient, and there is evidence that levels of car ownership affect saturation demand for two-wheelers, and vice versa. A household that owns several motorcycles may, with growing income, invest in a car and sell motorcycles. As incomes grow further a second car may follow, this being more likely the higher the income. At higher income levels, car stock growth accelerates more strongly and eventually overtakes the stock of two-wheelers. In this scenario, households tend to have one car and multiple two-wheelers for a long time and only when their income is very high trade two-wheelers for more passenger light duty vehicles. As a result, two-wheelers reach very high levels and constitute an important share of private mobility even at relative high income levels.

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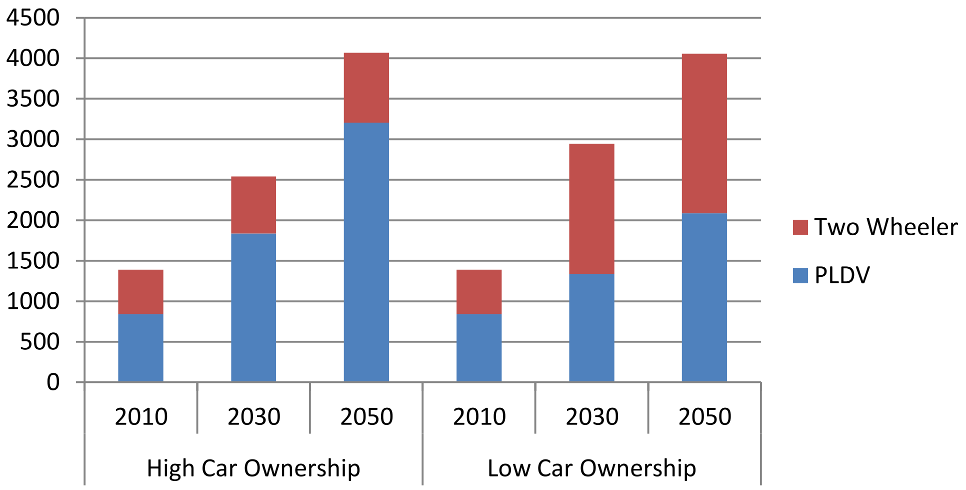
17. Van Dender K., 2012, *Introductory article to Routes/Roads*, PIARC, April 2012.

18. Tuan, Vu Anh, 2011, *Dynamic Interactions between Private Passenger Car and Motorcycle Ownership in Asia: A Cross-country Analysis*, Journal of the Eastern Asia Society for Transportation Studies, Vol. 9.

Chinese Taipei provides an extreme example, where motorcycles appear to have substituted for cars as the mode of choice for private travel for a broad income bracket and where two-wheeler ownership continues to grow at relatively high income levels. Beginnings of similar trends can be seen in Vietnam where, before reaching per capita income levels of $3000 (2007 prices), motorcycles have already reached ownership rates of 300 units per 1000 inhabitants. Car ownership in the same time period has increased by much less but has also taken-off at an earlier stage than in countries with currently high rates of car ownership. Similar patterns are observed in Indonesia and other ASEAN countries, to varying extents. China's motorcycle ownership rate increased 10-fold between 1996 and 2010, and although still low, car ownership has increased 10-fold since 2001. India has shown more intensive motorcycle ownership growth compared to China, but both could in the medium term conceivably either follow more closely a two-wheeler intensive path or one that follows more closely the OECD. This has major implications for the global vehicle stock. Results for the low car ownership are based on strong two-wheeler stock growth in China, India and ASEAN and to some extent in other developing Asian economies. In this scenario there are now two billion two-wheelers in non-OECD countries by 2050, 1.1 billion more than under the high car ownership scenario.

Figure 9 shows the results of the stock projections for non-OECD economies underthe low and high ownership scenarios. As can be seen the growth in the total stock is similar in both. The non-OECD stock in 2050 is about ten times as large as in 2010. The composition of the stock differs strongly. The high car ownership scenario comes out at 80% cars and light trucks in 2050, while in the low car ownership scenario two-wheelers and light-duty vehicles each represent about half of the total stock.

Figure 9. **Global Private Vehicle Stock, light-duty vehicles and two-wheelers, 2010–2050, high car ownership and low car ownership** (millions)



Source: ITF calculations using MoMo

The two scenarios differ strongly in terms of composition of the vehicle stock and this has large effects on mobility and energy use. Figure 10 shows the evolution of vehicle-km in both scenarios. In the high car ownership scenario, light-duty vehicle total travel in the non-OECD region would be ten times higher in 2050 than it was in 2010, while two-wheeler travel will only rise by about 60% in the entire period.

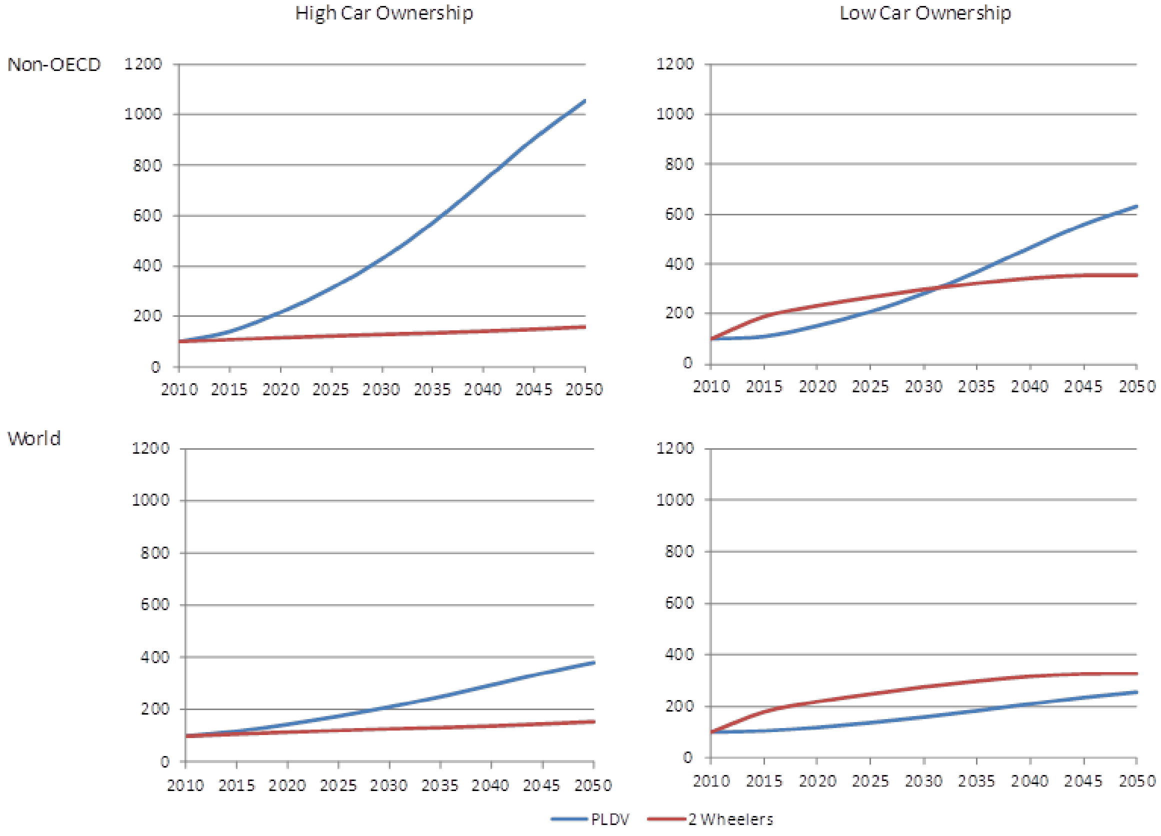
In the low car ownership scenario light-duty vehicle travel in non-OECD countries would be six times higher in 2050 than in 2010. Some of the light-duty vehicle travel difference between the two scenarios would be compensated by higher growth in two-wheeler travel, which would more than double by 2020 and by 2050 be more than 3.5 times the 2010 level in the low car ownership case. With high car ownership, mobility growth would be driven by light-duty vehicle travel growth and two-wheeler growth would be marginal. This difference between the two scenarios highlights the fact that the type of mobility development that will take place in non-OECD countries in the coming years, and in particular in the Asian region, will have a major effect on global mobility volumes and resource use. In this respect, it is worth noting that, while the total stock may be similar in both scenarios, the level of vehicle-km is considerably lower in the low car ownership scenario (about 26% less for the 2010-2050 period). The reason is that two-wheelers are used much less than light-duty vehicles, which in turn emphasizes that the total mobility outcomes in both scenarios differ strongly. This difference in mobility outcomes is one reason why cars are more preferred by households, so that the realisation of the low car ownership scenario – should that be a policy preference - will require more constraints on household choices. A slightly different way of reading this is that efforts to reduce growth in car and light-duty vehicle stocks can spur growth in two-wheeler stocks, and this can to some extent undo efforts to control congestion and emissions, in as far as this growth is an unintended side effect.

The different mobility outcomes translate into different impacts on the growth of emissions. In the high car ownership scenario, global emissions of CO_2 from private passenger vehicles are 2.4 times as high in 2050 as in 2010. In the low car ownership scenario the growth factor over the same period is limited to 1.6. The difference is driven by the non-OECD countries which in the high ownership case would have six times the CO_2-emissions from private mobility in 2050 compared to 2010, while in the low ownership scenario the increase would be by a factor of four.

As indicated, a restrictive scenario for car and light-truck ownership in non-OECD countries would lead to a fall in private mobility that is partly mitigated by a shift to other types of private modes, such as two-wheelers. Recent experience from Shanghai and Beijing illustrates the impact of policies towards car ownership and use in a shifting private mobility towards powered two-wheelers and also e-bikes (electric-assisted pedal bikes).

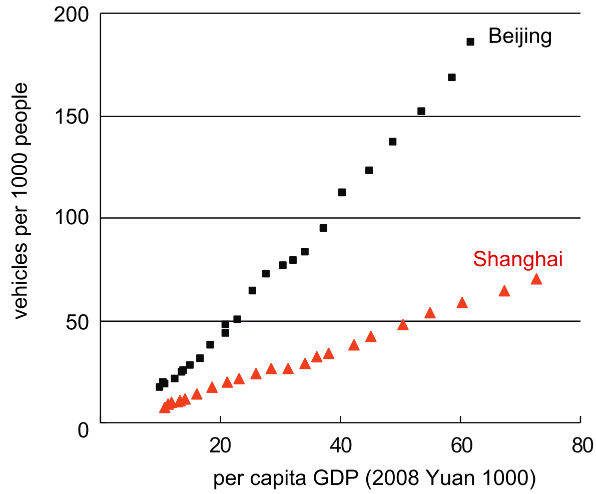
In an effort to manage congestion, Shanghai put in place in 1994 a licence-plate auction system. This policy limits the number of new car registrations that can be registered annually in by residents of the Shanghai administrative area and has resulted in motorisation trajectories below those of cities with similar levels of economic development, such as Beijing (see Figure 11). Beijing adopted a licence plate lottery system in 2011 to control congestion. This capped new registrations for 2011 at 240 000 – two thirds below the 2010 level. As Beijing's market represents 6% of the total Chinese car market, the effect on the country's stock development will be significant. Guiyang has implemented a similar lottery system and other cities are exploring doing so as well.

Figure 10. **Index of private mobility (vehicle-km), non-OECD and world with light-duty vehicles and two-wheelers, high car ownership and low car ownership 2010–2050** (index 2010=100)



Source: ITF calculations using MoMo.

Figure 11. **Motorisation rates in Shanghai and Beijing in relation to GDP per capita**



Source: Hao H., H. Wang and M. Ouyang, 2010, *Comparison of policies on vehicle ownership and use between Beijing and Shanghai and their impacts on fuel consumption by passenger vehicles*, Energy Policy, 39, 1016-1021.

In addition to policies that control car ownership, Chinese cities have also implemented bans on two-wheelers, mostly for gasoline-powered two-wheelers but bicycle use was discourage for a time in Beijing too (to free the roads for cars – a policy now reversed). By 2009, 29 cities of over 2 million inhabitants had either a partial or complete ban on gasoline-powered motorcycles. Two cities had some kind of ban for e-bikes (Asian Development Bank, 2009). The Chinese e-bike fleet is estimated at over 120 million units with sales growing rapidly (over 27 million in 2010) representing the largest uptake of motorised non-fossil fuel vehicles in recent history.[19]

The extent to which private mobility shifts to different technologies of two-wheeler vehicles will make an important difference in total CO_2 emissions of private mobility. Growth in e-bikes will likely dampen transport CO_2 emissions from what they otherwise would have been, especially if households buy them instead of a car. However, because of highly carbon-intensive power generation in Northern China, e-bikes that are bought instead of modern fossil fuel-powered two-wheelers may increase CO_2 emissions from what they otherwise might have been (though the absolute increase in emissions would be relatively small).

As well as restricting car ownership, auction policies in markets with strong latent demand for cars will tend to orient new car sales towards larger, more powerful and heavier cars under current buying patterns. Auction prices for new licence plates in Shanghai are elevated and have grown steadily since 1994 reaching a high of USD 9 400 on average in March, 2012.[20]

These prices limit licence acquisition to relatively well-off households and businesses that purchase relatively expensive larger cars, unless the license is so costly that car choice is affected. In so far as these cars emit more CO_2 per kilometre than average Chinese cars, relative emissions will rise but this increase is likely to be insignificant when compared to the emission-dampening effect of limiting car sales.

2.2.2 Light-duty and commercial vehicle use when prices change

The discussion of light-duty vehicle use (as opposed to ownership) up to now has focussed on the impact of changes in non-price variables. This section considers the potential impact of changes in the cost of driving, specifically changes in crude oil prices and changes in the way vehicle use is taxed in non-OECD countries. As before, the scenarios are to be interpreted as "what-if" exercises, i.e. they aim to gauge the effect of given price change without attaching any notion of prediction or probability to that price change itself. All scenarios consider the low car ownership case discussed before.

Oil price scenarios

The price of crude oil has an effect on how much people drive because, all else equal, it increases fuel prices, and driving declines when it becomes more expensive. We consider three oil price scenarios, labelled low, middle and high. All scenarios discussed up to now were modelled under the middle oil price scenario. The middle scenario presented below is nearly the same as the IEA-ETP's base case scenario for light-duty vehicles. It posits a moderate increase of a barrel oil compared to 2010 levels, resulting in prices slightly above $100/barrel (2005 USD) as of 2015 ($113 by 2050). The high oil price scenario assumes a

19. Ji et al, 2012, NYTimes, 2010, http://www.nytimes.com/2010/02/01/business/global/01ebike.html?pagewanted=1&_r=2; Pike Research, 2012, http://www.pikeresearch.com/research/electric-bicycles.

20. Xinhua, 2012: http://news.xinhuanet.com/english/china/2012-03/18/c_131474337.htm

very fast increase in prices between 2010 and 2020, so that a barrel costs $160 in 2020 and this increases to $196 in 2050. In the low scenario prices go down very fast between 2010-2020, reaching $40 by 2020. They continue to go down to reach $30 by 2050. Figure 12 shows that historical prices have decreased to levels comparable to those assumed in the low oil price scenario presented. The high oil scenario was modelled as a symmetrical increase in prices relative to the medium oil scenario baseline used. Neither the high or low scenario is intended to posit a plausible crude oil price path but the high scenario reflects expectations widely held during the bubble economy that preceded the 2008 financial crisis and the low scenario reflects historical price trends since the first oil crises in 1973.

Figure 13 summarises the effect on average annual light-duty vehicle travel, assuming an elasticity of vehicle use with respect to the cost of driving per kilometre of -0.25 (i.e. a 10% price increase per kilometre leads to a 2.5% reduction in use, all else equal). It should be noted that the effect of changing crude oil prices on the cost of driving depends on the fuel economy and the technological composition of the vehicle stock. We rely on the IEA's base case assumptions for translating the crude oil price increase into a final change into the price of use, and do not account for effects that oil prices changes might (and probably would) have on the fuel economy and technology choices. Any compensating tax changes and possible effects of changing oil prices on growth rates are also omitted.

Figure 12. **Historical crude oil prices (US imports) in nominal and real (January 2012) prices**

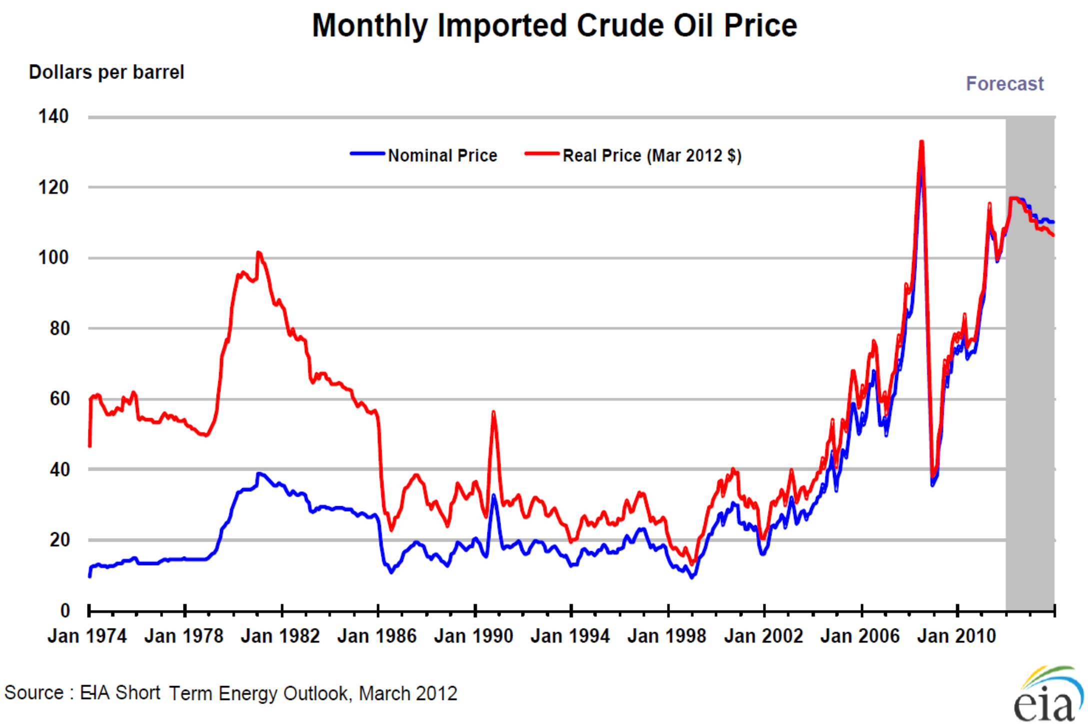
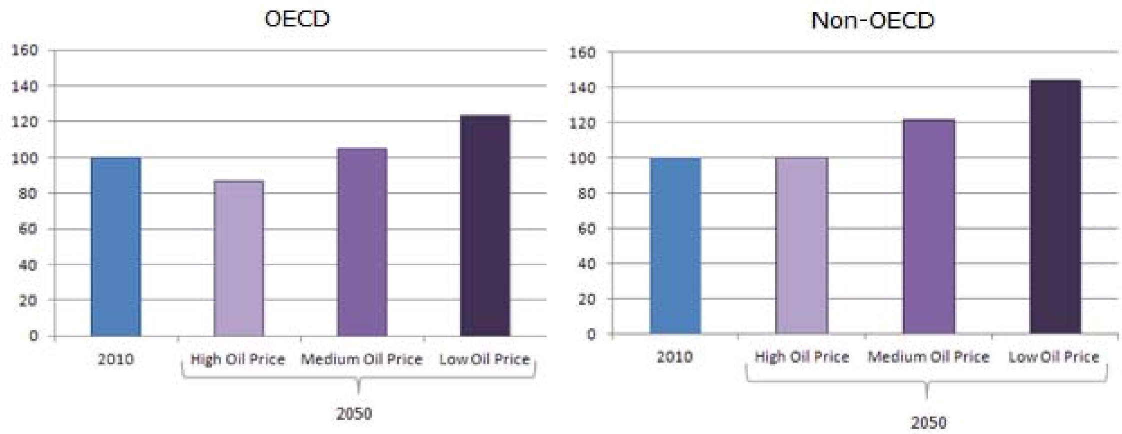


Figure 13. **Index of average annual light-duty vehicle travel under high, middle, and low crude oil prices** (index 2010=100)



Source: ITF calculations using the MoMo model.

The high oil price (around $160 to $196 per barrel) scenario would limit the extent to which average annual vehicle use could grow during the 2010-2050 period, and in our scenario results in a slight decrease in average vehicle travel in the OECD, while in non-OECD countries travel per vehicle would stay at 2010 levels, despite simultaneous income growth (see Figure 13).

In the middle oil price scenarios, average vehicle use would rise in both regions but only very moderately in the OECD (about 5%) and much more in the in the non-OECD regions (22%). A low oil price would allow significant growth in average vehicle travel, about 24% in the OECD and nearly 44% in the non-OECD countries.

Figures 14 and 15 show how the change in average use translates into changes in aggregate travel volumes, for the OECD and the non-OECD respectively. In the OECD, high oil prices would reduce travel with light-duty vehicles. The negative effect of the oil price increase would be compensated by income growth (stock growth) only after 2020, and growth thereafter in total light duty vehicle travel would be small. The results of the middle price scenario are those of Section 2.1. (low car ownership). With low oil prices, light-duty travel would increase considerably faster, reaching a level almost 60% above total travel in 2010 by 2050. Outside the OECD (Figure 15), incomes grow quickly and translate into high growth in vehicle use both in the medium and low oil price scenarios. Low oil prices would give a considerable boost to light-duty vehicle use, so that total use by 2050 is close to 7.5 times as large as 2010 total light-duty vehicle travel. This is significantly higher than the results in the medium oil price scenario which shows travel levels that are about six and a half times those of 2010. In the high oil price scenario, although average per vehicle travel is more or less constant throughout the period, income growth (vehicle stock growth) would be enough to compensate this effect throughout the period. Therefore, even in this scenario, total light duty vehicle travel would be about five times larger than in 2010. Prolonged changes in the price of oil – and more generally in the retail price of light-duty vehicle use – have appreciable effects on the long run development of light-duty vehicle use.

The changes in total vehicle travel translate into effects on CO_2-emissions. Given the baseline assumption on the evolution of the technological composition of the vehicle stock, CO_2-emissions in the OECD are set to decline moderately under all three oil price scenarios.

The decline of course would be larger when oil prices are high, by about 29% compared to the low price case. When oil prices drop immediately (as is assumed in the scenario), CO_2-emissions would rise in the coming decade, before technology and fuel economy cause them to decline. Outside of the OECD, emissions will rise rapidly in response to the fast growth in vehicle stock under all price assumptions. Nevertheless, total CO_2-emissions during the 2010-2050 period would be about 37% higher for this region in the low price scenario than in the high price case.

Figure 14. **Light –duty vehicle-km projections under low, medium and high oil prices, OECD, 2010–2050 (low car ownership)** (index 2010=100)

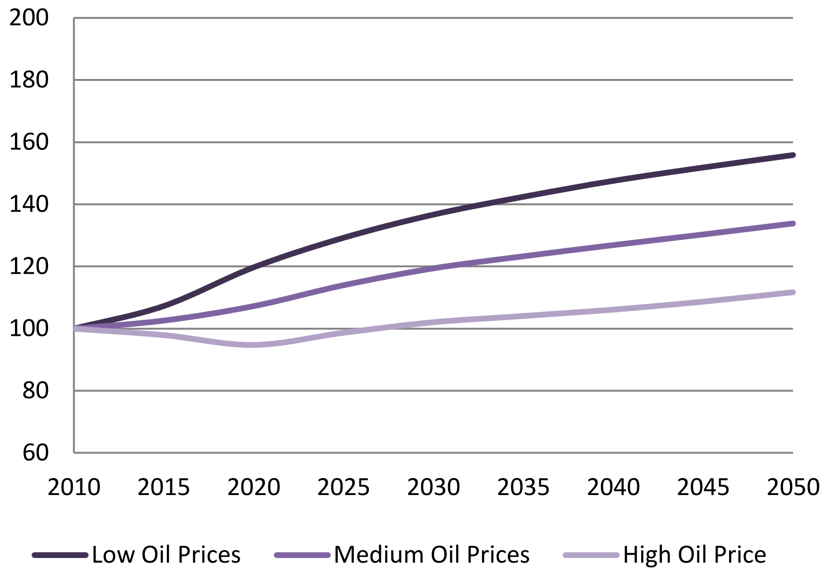
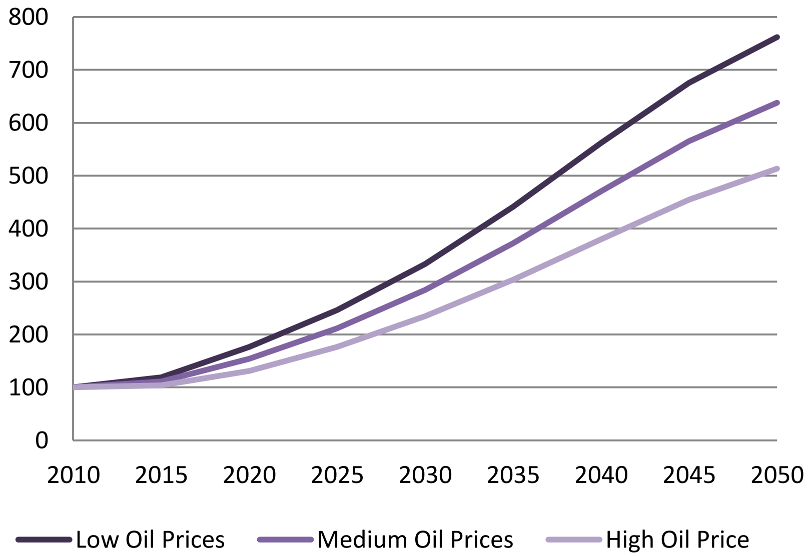


Figure 15. **Light–duty vehicle-km projections under low, medium and high oil prices, non-OECD, 2010–2050 (low car ownership)** (index 2010=100)



Source: ITF calculations using the MoMo model.

In the road freight sector the responses to different oil price scenarios are similar to those for passenger road transport. Here, the baseline medium oil price scenario assumes freight transport growth in line with GDP growth. Lower oil prices boost freight travel in terms of vehicle kilometres which are then set to grow more than six-fold by 2050 outside of the non-OECD, rather than increase about 5-fold (Figure 17). Conversely, in the high oil price scenario, vehicle kilometers would grow by a factor of about 4.

In the OECD the effect is similar with a larger downward pull of high oil prices, see Figure 16. Given positive GDP growth and proportional growth in surface freight, mobility growth will still occur.

High oil prices, if sustained for a longer period of time, can make other modes of surface transport more attractive. Given the high oil intensity of road freight increases in the oil price will raise the kilometre cost of driving more for trucks than for other modes. Surface freight may in this case be shifted toward higher usage of rail, which is the closest competitor for domestic freight. In non-OECD regions, where a shift from rail to road is yet to take place, a high oil price scenario may slow down this process and mean a continued reliance on rail in the near term.

Figure 16. **Commercial vehicle, medium and heavy freight truck vehicle km , projections under low, medium and high oil prices, OECD, 2010—2050** (index 2010=100)

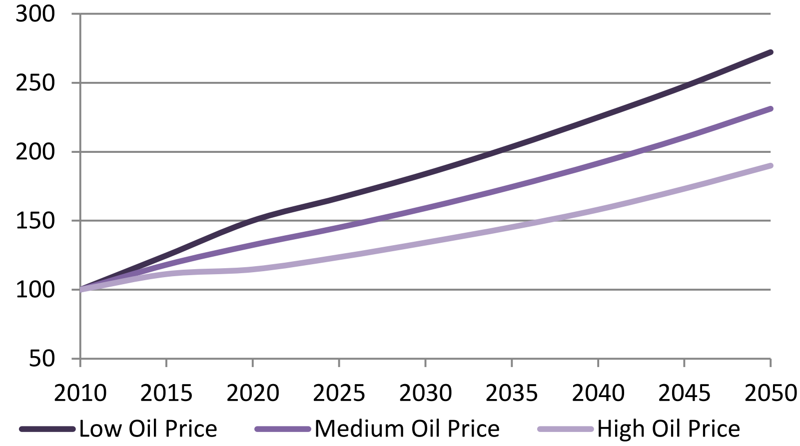
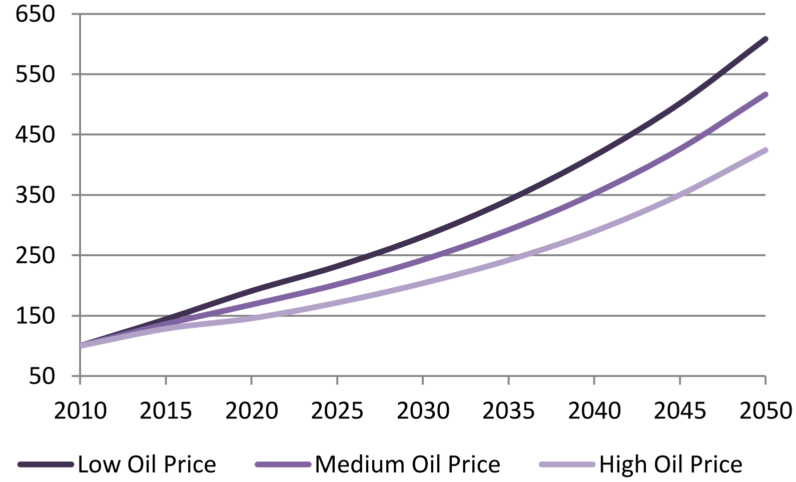


Figure 17. **Commercial vehicle, medium and heavy freight truck vehicle km, projections under low, medium and high oil prices, non-OECD, 2010—2050** (index 2010=100)



Source: ITF calculations using the MoMo Model.

Convergence in fuel taxes

The overall shift of road mobility to the non-OECD countries expected in the coming decades is large, as shown above. It is worth noting that these trends assume a policy scenario which accommodates road travel through low taxes and in some regions subsidization of gasoline, diesel and other fuels. Currently all OECD countries impose fuel taxes, which are as high as 200% of the untaxed petroleum gasoline fuel price in OECD Europe. Fuel taxes can be a stable and large source of government revenue and are well-suited to internalize some types of external costs, and it is conceivable that some non-OECD countries will introduce fuel taxes in the future (this appears less likely in some oil-producing regions such as the Middle East, but more likely in large developing countries such as India and China).

To consider the effect on travel volumes of the introduction of such taxes figure 18 and 19 show a scenario in which taxes outside the OECD converge to average OECD Europe tax rates by 2025. This exercise should be seen as an upper bound, given the high tax levels in Europe relative to any other region. For many emerging economies this implies that the cost per kilometre of driving increases strongly over the next decade if we hold baseline fuel economy, fuel shares and oil price assumptions constant. The most heavily taxed fuel type is petroleum gasoline, which is set to remain the most common fuel for light-duty vehicle travel through 2050 in the baseline technology scenario, especially in non-OECD countries. On average, tax convergence in the non-OECD regions assumes that taxes as a percent of the untaxed fuel price will rise from less than 50% to over 200%. For petroleum diesel, the most commonly used fuel for road freight, taxes on average increase to 113% of the untaxed fuel price from a baseline average of -0.20% tax across the region. The immediate effect is a reduction in vehicle-kilometres driven of about 20% in 2025 and 17% in 2050 for light-duty vehicles and 15% for total road freight vehicle-kilometres by 2050, compared to the reference scenario. Similarly emissions from light-duty vehicles are 20% and 22% lower in 2025 and 2050 respectively. Emissions from road freight are reduced by 15%.

The effect of fuel taxes on driving and CO_2 emissions is complex. One response is technological innovation by manufacturers resulting in higher fuel economy for new vehicles. Higher costs to consumers for more advanced technologies are made up for by lower costs of driving and can so lead to more sales of more fuel-efficient vehicles. This effect is more pronounced when tax rate policies are seen as predictable.[21] In the projections shown in figures 18 and 19 vehicle fuel technology improvements are those assumed in the baseline. If such tax increases were introduced in a transparently predictable manner one could expect more improvements in the fuel economy, especially post 2025, than is assumed here. Fuel economy improvements in part compensate for the higher costs of driving caused by the imposition of taxes and can mitigate the impact on reducing mobility (the rebound effect). The likely long-term effects of tax increases on CO_2 emissions depend on the size of this rebound effect. A more detailed discussion on fiscal impacts of fuel economy changes and fuel taxation can be found in Crist and Van Dender, 2011.[22]

21. *Taxation, Innovation and the Environment*, OECD Environment Directorate (2010).

22. Crist P. and K. Van Dender, *What Does Improved Fuel Economy Cost Consumers and What Does it Cost Taxpayers? Some illustrations,* International Transport Forum Discussion Paper 16, 2011, http://internationaltransportforum.org/jtrc/DiscussionPapers/DP201116.pdf

Figure 18. **Impact of fuel tax policies on road passenger transport, low car ownership scenario, vehicle-km** (index 2010=100)

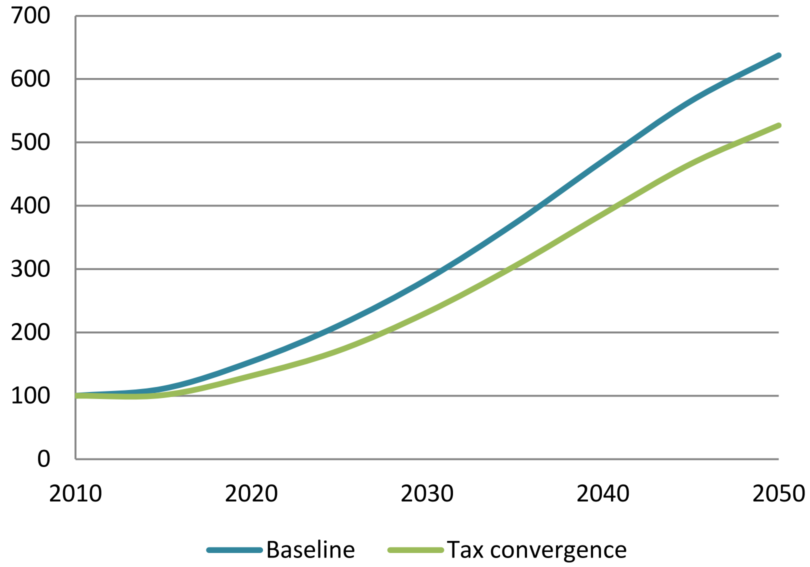
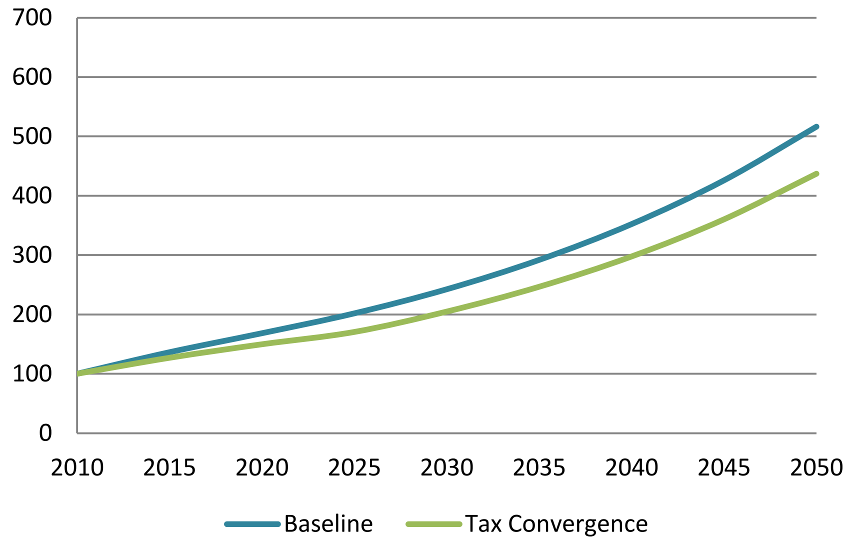


Figure 19. **Impact of fuel tax policies on road freight transport, scenario, vkm** (index 2010=100)



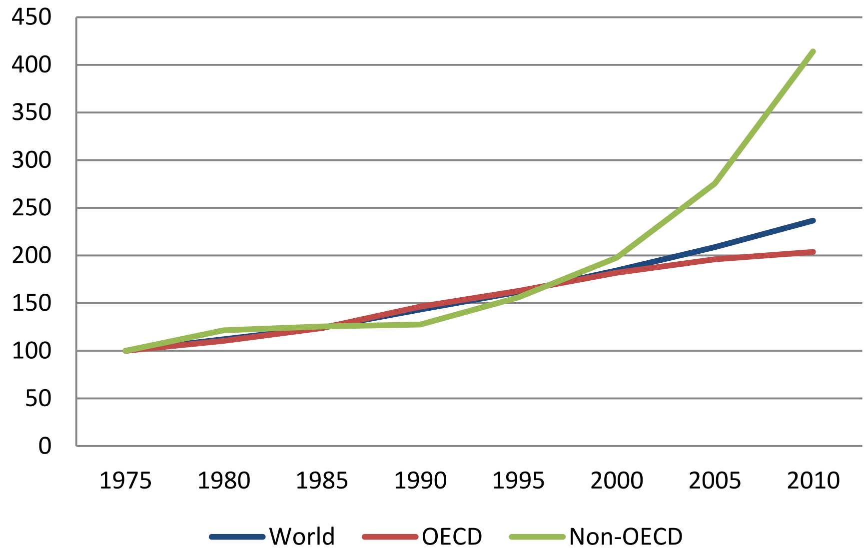
Source: ITF calculations using MoMo.

2.2.3 Light-duty vehicle use in high-income economies: signs of saturation?

As Figure 20 shows, passenger light-duty vehicle use grew at a steady rate of 2% per year in the OECD between 1975 and 2005. In 2005 – 2010 the growth rate declined to 1%. Outside the OECD growth was on average as fast as in the OECD up to the end of the 20th century. After that, usage started growing very quickly, starting a process that will lead to massive growth of light-duty vehicle ownership and use if it continues unfettered – see the

projections in section 1.2. The overall result is that global annual light-duty vehicle use is nearly 2.5 times as high in 2010 as in 1975.

Figure 20. **Annual private light-duty vehicle travel** (index 1975=100)



Source: MoMo-model database.

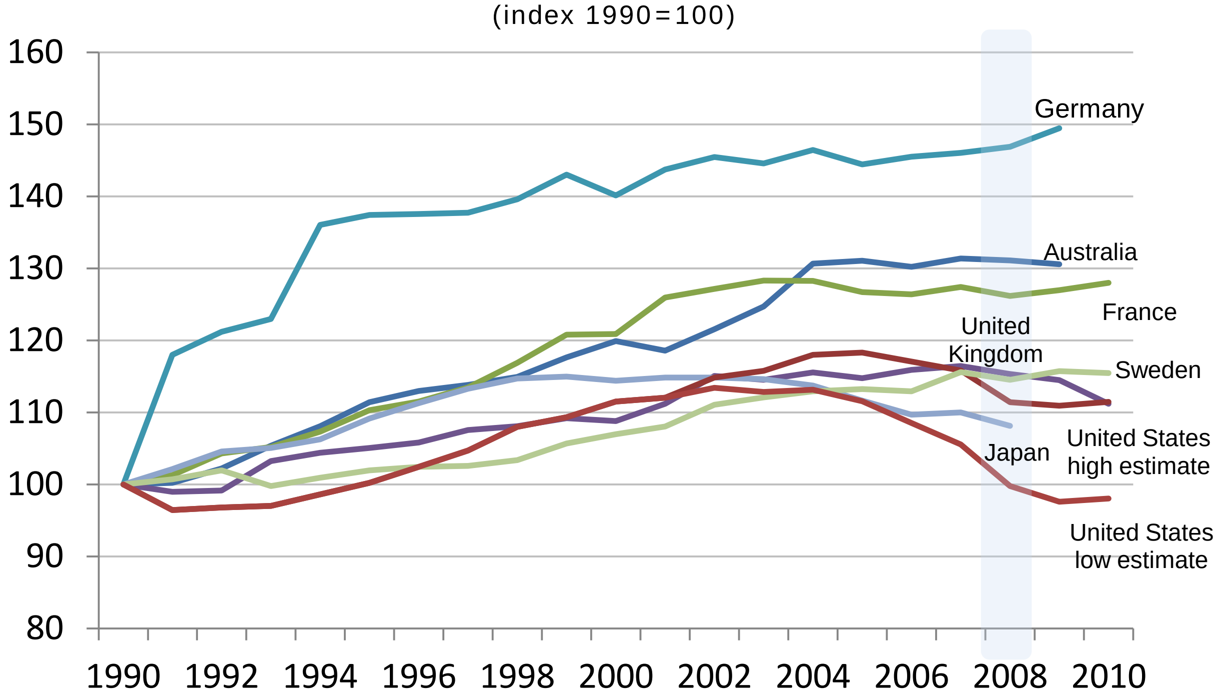
Light-duty vehicle use in advanced economies has followed a similar pattern to that discussed above for rates of vehicle ownership in relation to incomes. Figure 21 shows how car and light truck activity (passenger-kilometres) has evolved from 1990 through 2009 in a number of advanced economies. Growth rates decline over time and reduce to zero or even negative values in some cases and years. The levelling-off recorded in the data precedes the crisis and the most recent oil price spikes, so these factors cannot explain the phenomenon in its entirety. Since aggregate incomes mostly increase over time, the time series suggests a weakening response of car and light truck travel demand to increasing incomes. Millard-Ball and Schipper[23] find that in most countries this levelling off occurs at a per capita GDP between $25 000 and $30 000 (prices of 2000 at PPP); for the USA the turning point is at $37 000.

The observed patterns can be the result of a range of explanatory factors including saturation[24], higher fuel prices, declining rates of transport infrastructure expansion, ageing, urbanization, macroeconomic shocks, income inequality, the advent of the online economy, etc.

23. Millard-Ball A. and L. Schipper, Are we reaching peak travel? *Trends in passenger transport in eight industrialized countries,* Transport Reviews, 1-22, 2010.

24. Defined here as a situation in which additional car travel does not generate additional benefits for users and therefore travel will no longer increase even if higher time and money budgets allow it.

Figure 21. **Passenger-kilometres by private car and light trucks, 1970–2009**
(index 1990=100)



Source: International Transport Forum statistics.

Figure 22 uses travel survey information for the US to shed further light on the interaction between household income and vehicle use. It plots vehicle use against household income, for vehicle surveys from 1995, 2001 and 2009. The vehicle use pattern is similar in the three survey years, and shows a gradual decline and levelling off of vehicle use with income. On the one hand, this can be taken to suggest that the aggregate pattern observed in the previous figures is not time specific, so not driven by other factors changing at that time, but that the pattern truly reflects levelling off because of increased average and aggregate income levels. On the other hand, it suggests that as income levels grow at the lower end of the income distribution, this will still translate into increased travel for these households and therefore in the aggregate, as these households clearly have not yet reached the saturation point.

These two competing interpretations are potentially consistent: if average income growth is distributed very unevenly, with high growth at the high end and limited, zero or negative growth at the low end (a pattern for which there is some evidence[25], and one which is suggested by the increasing share of rich households' in total travel), then average income growth does not lead to more travel as the growth accrues only or mainly to those income classes that have already reached the saturation point. Future growth in car use is then contingent on how the proceeds of overall economic growth are distributed. This highlights that aggregate trends may have little direct bearing on specific effects and therefore do not necessarily give adequate guidance for future transport policies, including in relation to infrastructure investment and management.

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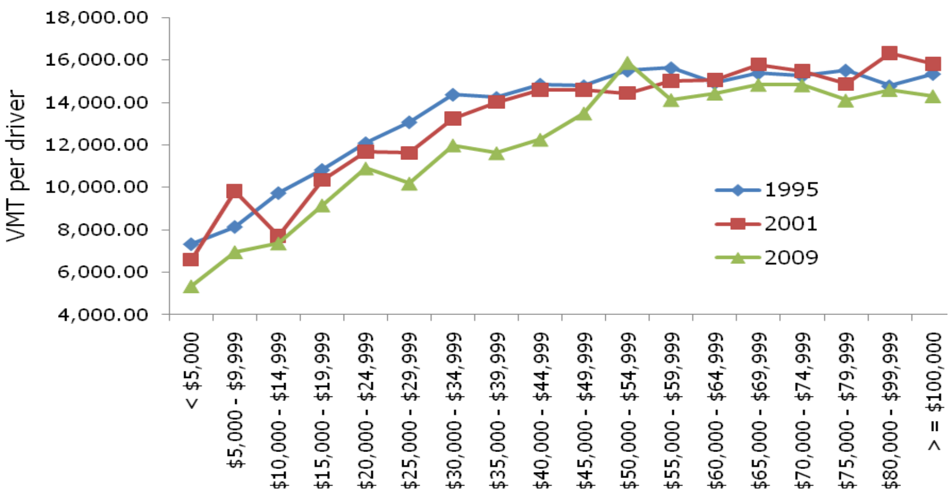
25. See, for example: Growing income inequality in OECD countries: *what drives it and how can policy tackle it?*, OECD Forum on tackling inequality, Paris, May 2, 2011; Transport for Society, ITF Secretariat Background Paper for the 2011 Summit; Collet R., E. Boucq, J-L. Madre, L. Hivert, Long term automobile ownership and mileage trends by income class in France, 1975-2008, paper presented at the 12th WCTR, Lisbon, 2010.

Income is just one of many determinants of the amount of driving. Age is another and the changing age structure of the population expected for the next decades (an increase in the share of the elderly in many countries), can be expected to translate into changes in the aggregate amount of driving. Specifically, driving falls as of age 50, declining rapidly and continuously thereafter. All else being equal, an older population of the same size means less driving, a tendency reinforced by an expected decline in the total population in some countries. But not all is equal: the reduction in driving with age is observed in all three survey years, but the reduction is smaller in more recent surveys. In other words, the age effect becomes smaller as more recent cohorts are considered. This trend will weaken the downward pressure of ageing on the demand for driving, without eliminating it. On the other hand, drivers up to the age of 30 travelled markedly less in 2009 than in the other survey years. It is as yet unclear whether this is because of changing circumstances or changing preferences, but in the latter case the impact on total future driving may be important.

Figure 22. **Average annual vehicle miles per driver by total household income**



Source: International Transport Forum calculations on US National Household Travel Survey, available at http://nhts.ornl.gov

2.3. Air traffic growth, technology and CO_2-emissions

Growth in passenger air travel has outpaced GDP growth in recent decades. Total scheduled air travel, measured in passenger-km, grew by 4.8% per year on average between 1999 and 2008. Air freight tonne kilometres increased by 4.1% per year on average in the same period. As indicated in our projections, fast growth is likely to continue over the next decades. As for other modes, growth will be particularly high in non-OECD economies. Income and population growth are key drivers, and deregulation in Asian regions will be a further growth factor. Many countries may experience higher levels of per-capita air travel at lower levels of per-capita income than has historically been the case in OECD countries. Airbus projects that 55% of the growth from 2011 to 2030 will concern emerging economies – Boeing makes similar projections (Figure 23). By 2030 the combined domestic markets in China and India are projected to surpass the current US domestic market which, in 2010, was the largest in the world. That global air travel growth will continue is not in question, in spite of expectations of higher fuel prices. But the rate at which it will grow, the form that growth takes in terms of global fleet composition and the energy and CO_2 implications of this growth are less clear.

Increasing demand translates into higher CO_2 emissions, despite current and predicted future aircraft fuel efficiency improvements. The main uncertainties regarding future levels of aviation CO_2 emissions relate to the evolution of oil prices and the impact this has on fleet turnover rates (which determine the uptake of efficiency-improving technologies), the adoption of different activity patterns (point-to-point versus hub and spoke) and regulatory developments (e.g. deregulation of Chinese domestic markets, impact of the EU emissions trading system, etc).

The global aircraft fleet has improved its fuel efficiency by 1.5% per year on average between 1960 and 2008 (weighting for aircraft shares in total travel volume). However, the rate of improvement has decreased over time after several important technological developments led to higher than average fleet-wide efficiency improvements in the 1970s and 1980s. About two thirds of the aggregate fuel efficiency gains were due to improvements in engine performance with the remainder resulting from improved airframe design. More recently, the impact of the combined oil price spike of 2008 and the ensuing recession and slow and uncertain recovery has led to the removal of many older and less-fuel efficient aircraft from the fleet. This is likely to have given a slight boost to the rate of fleet-wide efficiency improvements. To give a rough, overall impression of how fuel economy compares between modes, CO_2 emissions rates for the most recent aircraft types (Airbus A-380, Boeing 787) are similar to those of new cars sold in Europe if measured in emissions per seat kilometre.[26]

Looking forward, there are opportunities for improvement of the technological efficiency of aircraft currently in use but most of these have already been exploited following recent fuel price spikes. These options include aerodynamic wingtip treatments and weight-shaving strategies. Greater efficiency improvements are potentially available from upgrading engines. This is routine practice for certain engine components but whole engine replacement is rarely an economic proposition as it entails costly structural changes to the aircraft and prolonged down-time in addition to the capital cost of the engine itself.

Most of the technical efficiency improvements that are likely in the mid-term will come from new aircraft models incorporating new engine technology, wing configuration and weight saving from the use of composites. IATA estimates that the optimised deployment of these technologies could reduce fuel burn per passenger kilometre by approximately 25-35% for new aircraft designs around 2020-2025. Beyond that, efficiency improvements are expected to stem from two major changes in technology: open rotor engines for short- to medium-haul aircraft and blended wing bodies. The first application of open rotor engines is not expected before 2025 and blended wing aircraft (where the fuselage and wings merge into each other) are only expected to be a commercial prospect after 2030-2040.

Overall specific fuel efficiency for aircraft could improve by up to 50% per passenger kilometre by 2050 over the current baseline.

Given fast growth of the fleet and the slow rate of retirement, average fuel economy is most affected by the performance of new aircraft. And since the low-cost segment of the aviation market is likely to grow particularly fast, the choices made by low-cost carriers will have large effects. Low-cost carriers tend to operate homogenous fleets with high-frequency services.

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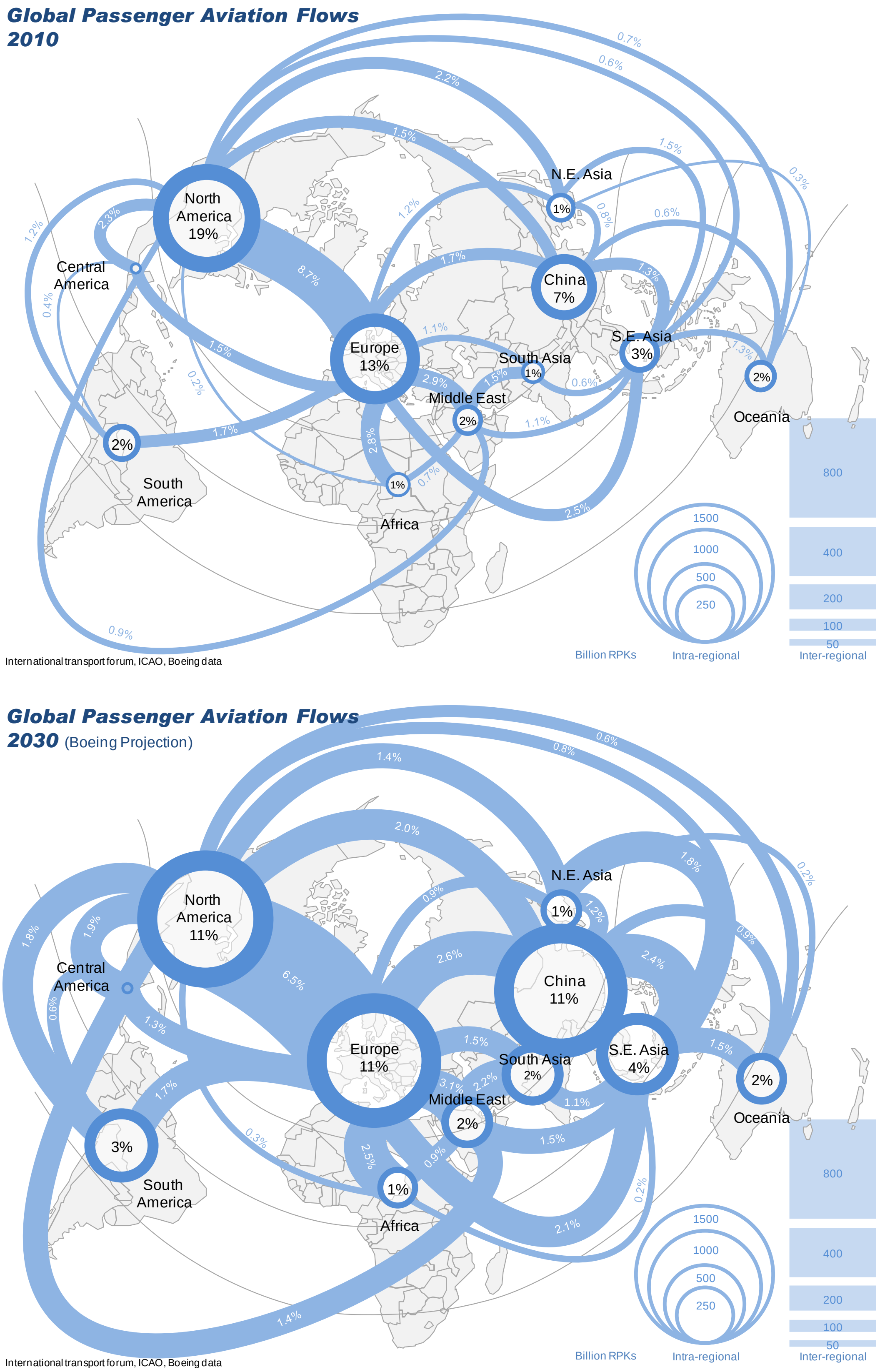
26. An A380 emits 75g to 109g CO_2 per seat kilometre and the Boeing 787-9 approximately 60g per seat kilometre. With occupancy rates of 1.5 and 1.8 people respectively for Western and Eastern Europe (according to the European Environment Agency), corresponding CO_2 emissions are approximately 93 to 78 grams of CO_2 per seat kilometre for the average new car sold in 2010 (average new car emissions were 140 g CO_2/km).

They have so far favoured short to midrange narrow body aircraft because these fit their business model well. Due to the combined effect of newer aircraft and higher load factors, low cost carriers today generally display lower fuel burn per seat kilometre than other carriers. The major manufacturers are planning significant upgrades to short and midrange narrow body aircraft, for production through 2025. These upgrades should reduce fuel burn by 10-15%.

The upshot is that the 2050 fuel efficiency scenario for aviation is largely determined by existing technologies (e.g. those deployed on A-380s, A-350s and B-787s). The foreseen fuel efficiency improvement potential may represent the upper end of what is feasible. Achieving it will require more than historic rates of fuel efficiency gain – possibly more than twice historic rates. Changes in air traffic management could contribute additional savings of up to 12% via more direct routing and improved landing practices. This will require coordinated action amongst a number of actors which, though progressing, has been slow to deliver anticipated results. Further reductions in CO_2 emissions are hoped to stem from greater use of biofuel blends in aviation though, as in the road sector, hopes have been high but there remain real doubts about feasibility, costs and lifecycle environmental impacts.

Fuel efficiency improvements do not translate proportionally into fuel savings. Keeping all other factors (e.g. prices) equal, improved fuel efficiency reduces operating costs and this can lead to lower fares, especially where competition is intense. This is known as the rebound effect, through which cost reductions lead to more demand and higher user benefits.

Figure 23. **Regional Passenger Flows in 2010 and 2030 (Boeing)**



CHAPTER 3. CHALLENGES AND POLICY PRIORITIES FOR THE TRANSPORT SECTOR

3.1. Priorities and ambitions – Green Growth and transport

Chapter 1 reviewed the deep macroeconomic crisis the global economy and particularly advanced economies are going through, with reductions in output followed by anaemic growth, as well as high unemployment and rising inequality. In early 2012, there is widespread sentiment that the global slowdown has not run its course quite yet. The present period is a break with development patterns of the previous 10 – 20 years, which were characterised by accumulation of debt accommodated by macroeconomic policy and accompanied by global imbalances. Renewed growth will require reducing debt, rebalancing in trade and financial relations, and restoring the confidence and vitality needed for escaping from the underutilisation of resources and taking up existing opportunities for growth. This will require government action, the more so given the need to move to green growth paths. In the near term, anaemic growth is likely to continue in Europe and to a lesser extent the USA, and this will negatively affect the performance of emerging economies. In the mid to long run, however, there is no particular reason why growth should not pick up again.

For the long run transport demand projections discussed in Chapter 2, the extent and the timing of the upward pressure on transport volumes is more uncertain than before 2008. In some cases near term growth prospects are bleak. But that the long run pressure on global transport volumes is strongly upward is virtually beyond doubt, and the strongest growth will take place outside of the OECD.

The transport demand projections in Chapter 2 are based on a highly stylized model in which GDP levels are translated into transport demand. This interaction is best seen as a correlation, as in fact the relationship runs both ways: transport drives growth and economic development, and growth drives transport demand. With weak growth prospects and an acute awareness of the need for growth, especially in advanced economies, the interest in transport as a driver of growth and economic development has come to the fore. This translates into a degree of re-balancing of key objectives for the transport sector, and by implication also for transport policy. Focussing on transport as a driver for growth and increased welfare means focussing on the positive contributions of the sector. Of course, what matters are the net positive contributions, so that costs and negative side effects are not suddenly of lesser importance, just less prominent in debate.

To varying degrees, the projections of Chapter 2 are indications of "where demand would like to go", i.e. they represent development of mobility patterns as mostly driven by preferences and (rising) incomes in an environment of stable and low prices and largely accommodated by public policy infrastructure provision and use. It is not straightforward that such development is desirable or even feasible. Mobility development guided by individual or household preferences can have aggregate outcomes that are detrimental to aggregate well-being, even if they are feasible in a narrower resource-based view. This view is held for example by the European Union which, in its 2011 White Paper on transport, views current mobility patterns as unsustainable, with greenhouse gas emissions and rising congestion as the main sources of unsustainability. A somewhat similar view, but this time on a global level, is found in the 2012 IEA – Energy Technology Perspectives report.[27]

27. IEA 2012, *Energy Technology Perspectives 2012*. IEA/OECD, Paris.

The transport development trends in the business as usual scenario of that report are substantially the same as those of the "low car ownership" case discussed in Chapter 2. The accompanying discussion suggests that even if such development were feasible given resource availability, it is not a desirable path from a societal point of view despite it being the outcome of individually rational decisions. This is not only because of external effects including greenhouse gas emissions but also because the result is a transport system that is much more costly than one that would constrain private choices more but would result in a cheaper system with – arguably – nearly the same benefits. The main idea is not to curb mobility, but to rely less on light-duty vehicles to produce it, as well as switching massively to low-carbon technologies.

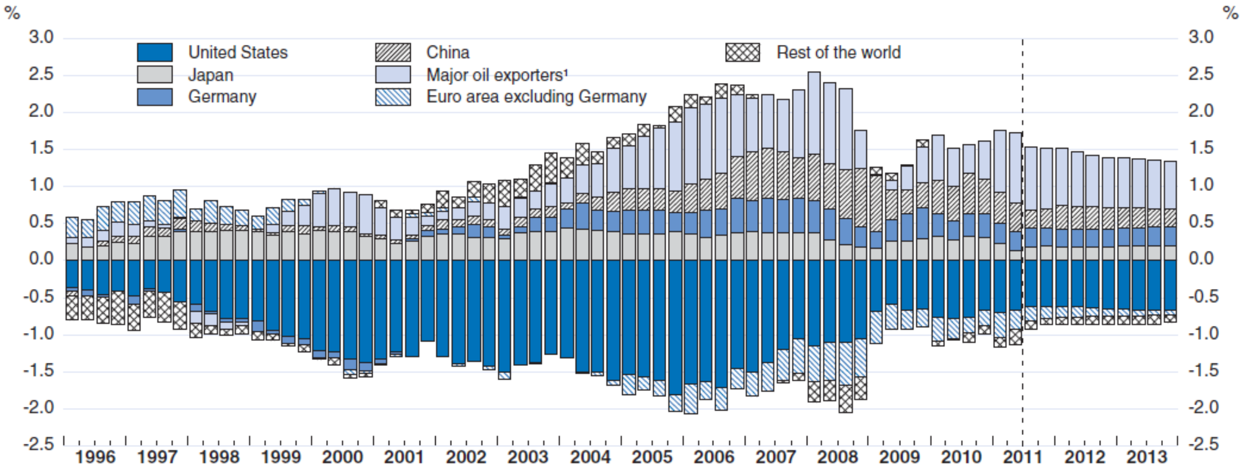
Maintaining mobility levels (more or less) but producing them in a considerably less car-reliant manner and with predominantly low carbon technologies is a massive challenge. It means entering uncharted territory in the sense of the structure of the production of mobility and in the sense of switching to a different energy basis for the system at large. The transition path to the new system is not traced easily, and will certainly run across major barriers. One such barrier is inertia: changes percolate through the system slowly and take a long time to deploy their full effects. This means that policies that intend to have major effects in one or two decades need to be implemented now. Another barrier, somewhat similar, is that the mobility aspirations of individuals and households are not broadly aligned with the requirements of the vision. Broadly, car ownership and use remains a household priority when it becomes affordable, despite signs to the contrary in some consumer segments in some countries.

Pricing policies have real but somewhat limited potential. Transport demand declines when prices rise, but the response is relatively small and is likely to become smaller as incomes grow. This adds to the appeal of taxes on light-duty vehicles for raising public revenue but reduces the effectiveness of charges for steering behaviour. The point is not that taxes have no effect on mobility choices (they do) but that obtaining large change through this channel will require drastic policies. There most definitely is scope for steering mobility choices through prices and taxes, especially to increase energy efficiency and to reduce congestion. These changes are in many cases desirable but it is not likely that they will lead to structural change in broad mobility patterns or to considerably slower growth in mobility volumes. Even the traditional policy model of public support for mass transit and rail systems has had only limited success in curbing the demand for car-based mobility. Pushing this approach further will require accompanying policies (land-use planning controls) and – if continued under traditional funding models – will constitute a shift of mobility away from what often are highly taxed modes to highly subsidized modes, with appreciable impacts on public finances.

It is clear that major changes in mobility patterns will require a strong, immediate, and enduring policy commitment. Even with such commitment at national levels, it is difficult to coordinate with the very large number of decision-makers involved with the supply of mobility and with its users. Modifying energy consumption patterns in transport is also far from easy but high oil prices create balance of payments imbalances that provide an additional rationale for policy intervention (see Figure 24). This arguably makes policies to improve fuel economy and shift to eclectic mobility and other fuels for transport with potentially lower carbon-intensity the core of green growth policies for transport. There is evidence that households are more inclined to improve energy efficiency than to reduce mobility when driving becomes more expensive, and this further strengthens the case for this approach.

Modifying the mobility options offered in cities and regions and ensuring the take-up of the "right" options by users does not appear very amenable to a top-down approach. The way forward may be to keep increasing the awareness of the social benefits and costs of different mobility choices, so that suppliers in cities and regions can make informed choices when designing systems and usage conditions, in a context where external costs of transport are appropriately charged for. The result will be a variety of models, which users can choose between through their choice of location and through modal choices conditional on their location. This approach presumes that a key shortcoming of mobility supply models in several parts of the world is the lack of diversity, with a heavy emphasis on car-based and CO_2-intensive mobility models. Better balanced mobility in that sense will reduce reliance on car use and provide opportunities to reducing the greenhouse gas footprint of mobility overall. Greenhouse gas emissions are not the only type of emission to be taken into account – local pollution has real and immediate health effects and causes environmental degradation. Congestion problems are another key concern. Balanced mobility systems take account of all these problems, and strike the best feasible balance between the various costs and benefits associated with mobility. Attaining such a balance is not straightforward. There are situations where furthering one objective (e.g. reducing congestion) can help other goals (e.g. lower emissions of pollutants and greenhouse gases), but expectations should not be set too high (e.g. when congestion pricing does more to redistribute traffic over space and time than to reduce overall car use). Furthermore, there can be conflicts between objectives. One example is that at least until the introduction of Euro6 emissions controls on cars, reducing CO_2-emissions through dieselization of car fleets increased emissions of air pollution from NO2 and particulate matter.

Figure 24. **Current Account Balance in Percentage of Global GDP**



Source: OECD Economic Outlook 2011 Volume 2.

3.2. Infrastructure needs and funding mechanisms

3.2.1 Rising mobility requires more infrastructure

A quick glance at the transport volume projections of Chapter 2 is enough to conclude that current infrastructure levels will not be sufficient to handle such flows. Detailed analysis, see for example OECD (2012)[28] and McKinsey (2010)[29], confirms that conclusion.

28. OECD, 2012, *Strategic Transport Infrastructure Needs to 2030*, OECD Publishing, Paris.

In emerging economies economic development necessitates considerable extension of transport networks. In advanced economies missing links need to be built, bottlenecks removed, and existing infrastructure often is in need of upgrading.

OECD (2012) calculates that around 2.5% of world GDP needs to be devoted to infrastructure investment (this is broader than just transport infrastructure), with particularly elevated needs in the emerging economies. With increasing concentration of economic activity in agglomerations, the opportunity to concentrate transport flows in corridors rises, and this allows cost savings per unit of transport flow. This highlights the need to supply capacity in gateways (including ports and airports) and in corridors. At the same time general purpose transport networks must be able to handle increased volumes shipped through these gateways and corridors, and therefore need expansion. Higher capacity ports are of little use when hinterland road and rail networks are increasingly congested (ITF, 2008).[30] Decisions on transport infrastructure hence need to be taken within a network view of the sector in order to ensure value for money.

The discussion of possible saturation of car travel demand is potentially relevant to the infrastructure question. If it turns out that car travel in high income economies is not likely to continue to grow quickly and may stabilise or even decline, this is an indication that further investment in the overall capacity of the network may have only limited social returns. It is of course possible that capacity limitations on the network itself cause a slowdown in growth, but that is just a further indication that investments need to focus on alleviating bottlenecks. The evolution of car traffic is uncertain and road networks are not used by cars alone, and freight traffic may continue to rise. Any reduced need for overall extension of networks has little direct bearing on the need for maintenance of what exists. There are indications that budgetary problems lead disproportionally to reduced expenditure on maintenance, and that this not only reduces service quality but also drives up total costs in the long run.[31] Life-cycle costing would help alleviate such problems. Institutional improvements to reduce the dependence of road funding allocations on short term political considerations would bring more stability.[32] Lastly, debates on infrastructure funding should not lead to overlooking the importance of exploitation costs, the funding of which too is under pressure as budgets shrink. Reducing costs sometimes is possible, but ultimately reduces service levels or quality. Higher fares for publicly provided services should not be ruled out, but this course of action is not well-received by users and is seen by some to counter environmental and equity objectives. However, the effectiveness of subsidies to public transport to induce modal switch and to promote equity is not necessarily as high as is sometimes taken for granted.[33]

3.2.2 Scarcer public funds in the near and mid-term

Before 2008, economic growth in most advanced economies was accompanied by increasing overall (public and private) debt. There is near universal agreement that overall debt levels need to be put on a path of decline soon, but views on how it should be done and

29. McKinsey Global Institute, 2010, Farewell to cheap capital? The implications of long-term shifts in global investment and saving, McKinsey&Company.

30. ITF, 2008, *Port competition and hinterland connections*, OECD Publishing, Paris.

31. See e.g. PIARC, 2005, *Evaluation and funding of road maintenance in PIARC member countries*, PIARC, France.

32. See e.g. Cook A., 2011, *A fresh start for the strategic road network*, Department for Transport, UK.

33. Robert Cervero, *State Roles in Providing Affordable Mass Transport Services for Low Income Residents*, ITF Discussion Paper 2011-17.

concrete policy approaches differ. Different policy approaches are partly justified by differences in countries' specific circumstances. Table 5 shows high debt levels in all selected countries, but substantial differences in the composition of overall debt. Japan has high government debt. The UK stands out by its particularly high level of corporate and especially financial institution debt. Like Spain, the UK saw strong growth in debt ratios from 2000 to 2008. Among the countries shown in the table Germany has the lowest level of overall debt and it stands out by the limited rise in the debt to output ratio in the years before 2008, reflecting macroeconomic policy choices that took effect in 2003. These same policies and Germany's robust economic performance after 2008 (which is partly but probably not entirely a result of these same macroeconomic choices) have allowed it to keep debt to output ratios more or less constant. The USA has managed to reduce its overall degree of indebtedness, as rising public debt has been more than compensated by rapid private sector de-leveraging. Other countries listed in the table have not yet started deleveraging, with rapid increases of debt to output ratios. Given the significant weight in the world economy of the economies faced with a need to deleverage, it will not be possible for all countries to embark upon an export-driven savings and growth path. This appears to strengthen views that "classical recipes" (reducing private agents' debt first while allowing public debt to grow, and reducing public debt only when growth picks up) will not work, at least not everywhere, and that governments need to make every effort to reduce public debt first. Irrespective of the strength of the argument, the probable consequence of the ensuing policy choices is that public funds will be scarce in advanced economies for the foreseeable future.

Reducing public debt means increasing tax revenues and/or reducing government spending. Reducing debt ratios can be done in the same way and by increasing growth. Lower spending can, but does not necessarily imply reduced investment in transport infrastructure. To the contrary, some governments highlight the contribution of transport infrastructure to their economies' growth potential and maintain investment plans while preferring to cut elsewhere. Another response is to seek increased private sector involvement in funding infrastructure, as discussed next.

Table 5. **2008 Debt to GDP ratios, and evolution since 2000, selected countries**

	Debt as a % of GDP						
	Households	Non-financial corporations	Financial institutions	Government	Total	% change 2000 - 2008	% change 2008 - Q2 2011
Japan	67	99	120	226	512	37	39
UK	98	109	219	81	507	177	20
Spain	82	134	76	71	363	145	26
France	48	111	97	90	346	89	35
USA	82	72	40	80	274	75	-16
Germany	60	49	87	83	279	7	1

Source: McKinsey Global Institute, 2012, Debt and deleveraging: Uneven progress on the path to growth, McKinsey and company

3.2.3 Relatively scarcer private funds in the near term?

A fairly common response to the expectation of increased scarcity of public funds is to propose to step up the involvement of the private sector in infrastructure funding, in transport and in other sectors. While it is plausible that more can be done to harness the potential of private funding, the type of projects that are funded and the way direct and

indirect beneficiaries and taxpayers pay for them may well be different in a private-public partnership context than under public funding.

One mechanism for remunerating private investment is to generate revenue by charging users of the facility a toll. Tolls can be helpful in managing usage levels of facilities. In particular they can be used to improve efficiency by avoiding wasteful congestion. It is not straightforward, however, that private operators would set efficient tolls (i.e. those that would reduce congestion by just enough), although even an inefficient outcome can sometimes be better than when there is no toll. Specifically, even if operators set high tolls to maximize revenue and as a result traffic falls below efficient levels, this can be better than not charging and coping with excessive congestion. However, when there is little or no congestion and marginal costs of facility use are low, tolls are of little value in managing use and are just a way of paying for the infrastructure. The advantage of the tolling approach over funding from general tax revenue then is less obvious. When a choice is made to use tolls to fund infrastructure, maintaining a close relation between receipts and outlays, so that tolls relate to a specific facility and not to a network or the transport system at large, can be useful. This avoids perceptions that tolls are just "another tax" – as might arise for example when a toll for road use by cars is used to fund expenditures on rail – and so improves acceptance. In such a framework revenues from increased charges to manage road congestion should ideally be invested in expanding road capacity to meet demand. However, expansion may not be an option, for example in city centres, and in these circumstances revenues may best be used in improving alternative options for mobility, or simply for general public expenditure.

One potential advantage of private involvement in infrastructure funding is that it may save costs by harnessing the private sector's strengths in producing value per unit of expenditure. Public-private partnerships involve the transfer of some of the risks associated with infrastructure projects (cost overruns, late delivery) from the public to the private sector, so that the private partner makes appropriate efforts to minimize these risks. The private partner obviously will seek compensation for risk-exposure for factors over which it doesn't have control – planning risk, demand risk – but good concession design can assign the risks appropriately and deliver a net benefit. [34]

Private involvement can make possible the introduction of tolls that would not have been politically possible under a public funding model. If this means a project with high returns goes ahead that would not have been possible under public funding, then private involvement can be a good solution. But turning to private involvement primarily to make possible user charges does not obviate the need to design PPPs carefully so that they obtain the cost-savings that should be their core focus. Flawed contracts can, and sometimes have, lead to disillusions and (at least temporary) abandonment of PPP options. It takes skilled partners on both sides to ensure that all parties obtain the advantages they seek. Private investors will need sufficiently strong public commitment to limit risk. The public sector, however, wishes to avoid engaging in agreements that limits its future course of action to strongly. Public-private partnerships are not a panacea and their applicability may well be more limited than current discourse sometimes suggests.

It is unlikely that private funds will be able to compensate fully for cuts in public funds, even if that were a good choice in principle. The first reason is that the global demand for investment in transport infrastructure (as well as other infrastructure) is likely to increase very substantially over the next decades.

34. Poor concession design, equally, can result in gaming strategies and cost over-runs.

As indicated in Section 2.1, the projected transport volumes of Chapter 2 cannot be produced with current infrastructure levels, especially in emerging economies, and in advanced economies many networks are in urgent need of maintenance, upgrading, and selective expansion, if they are not to limit growth potential. The portfolio of beneficial projects hence will expand strongly. The increase in investment demand is not limited to transport. Globally, we may be at the dawn of an era of much higher capital investment than has been witnessed in the past decades, with emerging economies the main drivers of increased demand. McKinsey (2010)[35] expects a new global investment boom, reporting a rise in global investment in physical assets (infrastructure, housing, plants, machinery,...) from 20.8% of global GDP in 2002 (a low point) to 23.7% in 2008 and an estimate of more than 25% in 2030. Given the development stages in emerging economies, the rise in global investment will be combined with a growing share of infrastructure (not least transport) investments.

The second reason is that the supply of private capital seems set for a decline as a consequence of demographic trends (including aging populations) and economic development with a reduced propensity to save in emerging economies, as growth becomes more domestically driven and households get richer. The simultaneous expansion of the demand for investment funds and contraction of supply leads to higher interest rates, so that the share of the portfolio of beneficial projects that can actually be funded declines. This declining share hits harder where marginal returns on projects are lower, which on average is where networks are more mature.

3.2.4 Whither transport funding?

Putting Sections 3.2.1 through 3.2.3 together, it is plausible that drastic public spending cuts, should they take place, will ultimately translate into reduced transport infrastructure spending unless this type of spending is somehow prioritized. Prioritization decisions should be made on the basis of broad policy goals (e.g. providing a platform for green growth) and how spending types and projects contribute to them. Good decisions hence are a matter of selecting projects and funding methods on the basis of socio-economic appraisal.

The best practice in socio-economic appraisal in transport has taken the form of social cost-benefit analysis, which on the benefit side is centred on the valuation of users' benefits from new or better infrastructure and which has over time been extended to account for the external effects – and sometimes the distributional effects – of the proposed project. Recently efforts have been made to quantify the contribution of transport projects contributions to productivity and economic growth, in addition to the standard focus on user benefits and welfare. Good appraisal has helped decision makers in the sector to allocate funds appropriately and has strengthened their bargaining power in debates on what share of public funds should go to transport. Further improvements in appraisal practice will continue to support decision-making and will allow a more direct alignment of appraisal with broad objectives for transport policy, e.g. in terms of green growth.

Comprehensive appraisal can also help identify appropriate funding channels.[36] Finally, the benefits and costs of transport projects are best considered in a door-to-door

35. McKinsey Global Institute, 2010, *Farewell to cheap capital? The implications of long-term shifts in global investment and saving,* McKinsey&Company.

36. Standard cost-benefit analysis focuses on direct user benefits, but this has no direct relation to funding preferences. It is a methodological choice on how to measure benefits, which is more or less appropriate depending on the characteristics of the project. If appraisal could clarify the incidence of benefits and costs, it could help with the design of "appropriate" mechanisms of funding.

framework. More than changing the nature of appraisal itself, this will broaden the set of projects under consideration (e.g. reducing the administrative burden at border crossings as well as expanding the capacity of freight corridors, or smoother security procedures at airports as well as new or faster public transport connections to the airport). Some of the additional projects can have high returns per unit of outlay, always desirable but particularly appealing when funds are scarce. Section 3.2.5.presents examples of "smart investment" in seamless public transport systems.

3.2.5 Seamlessness as smart investment

The ITFs 2012 Summit in Leipzig is held under the banner of Seamless Transport – Making the Connections. Seamlessness is a characteristic of advanced transport systems that minimise obstacles to inter-connection and barriers for users seeking information about and access to mobility services. Mobility of people and goods can be produced in a variety of ways, with combinations of individual and collective modes, motorized or not. Mobility options differ in terms of convenience, comfort, and speed. The more seamless the transport system, the easier it is for users to learn about travel options and to combine them into a high quality door-to-door trip choice.

Seamlessness is increased by allowing smoother switching between modes, for example through better intermodal terminals or more connected networks (involving higher frequency services, coordination of egress and access points across modes, etc.), and by integrated ticketing and charging systems.

Often, but not always, promoting seamlessness involves outlays similar to other means of improving the quality of service offered by the transport system. Judging whether the outlays are worth it should hence be made following the same principles of appraisal that apply to other spending decisions.

Highlighting seamlessness is not trivial, given its merit in terms of improving the network and system characteristics of transport and its focus on end-to-end journeys. Such a perspective can help identify new and effective design and investment opportunities. The mindset is that seams need to be removed where possible and that they should cause as little discomfort as possible where they cannot be avoided. A joint KOTI – ITF workshop[37] held in 2012 discussed rationales for investing in seamless public transport, and provided several examples of where "thinking seamless" helps make smart investment choices that go beyond just providing better service.

37. 2012 KOTI-ITF Seminar on Seamless Public Transport for All, Paris, March 6 2012

- Survey evidence for Korea identifies poor accessibility of public transport terminals and stations and the inconvenience of transfer systems between modes as the major impediment to use of the KTX high-speed rail system. The upshot is that returns from major investments in high-speed rail can receive a strong boost from efforts to physically integrate KTX, a long distance mode, with local transport modes.

- Public transport networks exhibit network economies, meaning that costs per unit of service decline as loads increase. For example, adding services to one link in a network can benefit travellers across the whole network by improving connections and reducing waiting and transfer times. This is an extension of the effect that when higher demand requires adding one more bus on a particular link, the frequency of service rises for all passengers using the route where the bus is added, and waiting times decline. Similarly, adding stops reduces walking time, and using bigger buses saves on operating costs per passenger. Network design that exploits network economies can help turn a "vicious cycle" in public transport (where declining demand translates into worsening service) into a "virtuous cycle" (where higher demand allows better, more seamless service). Awareness of network effects is one prerequisite for skill in the art of stitching high quality seams. Opportunities to reap network benefits are often missed, perhaps because of a lack of focus on cost-effectiveness in the network design stage.

- Integrated ticketing and integrated fare structures are a central feature of a seamless public transport system. The Dutch experience shows it is possible to obtain integrated ticketing on the national level. Success factors include a strong political will at the national level to obtain such a system, and the presence of a major actor (the Dutch railway operator, in this case) that stands to benefit from integration. Smart ticketing also reduces fraud, and strongly so from both the Dutch and the London experience. This illustrates that improving user service is not the only rationale, although it certainly is one (as indicated by increased passenger satisfaction after the introduction of the integrated ticket in the Netherlands).

- The Dutch experience also shows the importance of coordinating among all actors involved. Lack of such coordination contributed to problems in the early phase of the national chipcard, e.g. a lack of clarity on where customers could turn to register and process complaints. A Dutch report[38] suggests the creation of a chipcard authority to ensure coordination and a more user- (instead of operator-)oriented functioning of the system.

- Transport for London's approach to ticketing, with the introduction of the Oyster Card and the analysis for its future incarnations, clearly illustrates how smart ticketing systems can have considerable payoffs to providers as well as to users. Contactless smart-card ticketing has greatly increased gate throughput capacity, reducing strain on rail terminal capacity. In London this was the key factor in the business case for investing in smart cards as with high property prices it offered a lower cost alternative to the urgent need to expand station entrance areas. Contactless cards have also speeded up boarding on buses, increasing capacity and speed of service. Contactless bank cards will supersede the Oyster Card as switching to a bank account based system, from a card that has to be manually charged with

38. Meijdam H. et al. 2011, *Het spoor naar slagkracht – Advies Commissie Permanente Structuur end Dubbel opstaptarief in de treinrailketen*, Den Haag.

credit periodically by passengers, offers several advantages. It enables the processing of information to be moved from the card reader terminals to back-office computers with major cost savings. It offers the possibility of offering discounts and bonuses to travellers and refunds when there has been disruption to services. Bank account based systems offer the possibility of a universal payment system compatible with systems in any city and country (where the bank has agreed to take responsibility for any fraudulent use of cards before the system detects and rejects an invalid card).

- Socio economic assessment of the introduction of the Dutch smart card system suggests a benefit to cost ratio for the project similar to other priority transport sector investments. In the case of the Oyster card the benefit cost ratio is clearly much higher than the prohibitively alternative options for expanding capacity.

3.3. Balancing objectives in transport policy

Economic development and mobility are closely correlated. Mobility can drive economic development, i.e. it can create growth potential, by establishing connections that did not exist before or by improving the quality of existing connections. It can remove impediments to economic development by alleviating congestion and other service quality deficiencies in places where development potential already exists. Of course, mobility is not just there to stimulate economic development. It is also an essential ingredient of the populations' ability to enjoy the benefits of economic development. In other words, mobility potential is a key constituent of economic welfare and wellbeing.

The discussion in Chapter 2 and in earlier sections of this chapter has highlighted that the production of mobility is subject to increasingly tight constraints. The likely increase of the global demand for mobility is very large and translates into a very strong increase in the sector's resource requirements. Even if meeting this demand is feasible in the short run, it is not always desirable or sustainable in the long run. Environmental and climate change concerns are sometimes seen as overriding policy objectives, leading to views that if mobility is to maintained there is an urgent need to produce it differently, meaning with low or zero carbon technologies (changing transport's energy basis) and relying on collective modes much more than on individualized ones (changing mobility's transport basis).

Addressing climate change is a major and pressing challenge for the sector, and it needs to be addressed in a difficult context of rising demand for mobility, preferences for particular ways of producing that mobility, and increasingly tight public budgets. Taking account of the simultaneous existence of aspirations and constraints highlights obstacles, particularly on the path to "changing mobility's transport basis". For example, under the fiscal and subsidy structures prevailing in many advanced economies, a massive switch to collective modes will at the same time erode the public revenue basis currently provided from private transport (fuel tax, etc.) and increase public outlays for public modes. The impact on public budgets is substantial, a prospect that conceivably will meet with some resistance.

The envisaged switch from personalised to collective modes seems to reflect a view where one dominant mode (cars) is replaced by another (buses and trains), in a context where these two basic options compete. A different view recognises that users, transport modes, and transport needs are heterogeneous, and different mobility solutions fit different contexts. As long as infrastructure and pricing conditions reflect real social opportunity costs, the resulting diversity can be expected to result in a system that balances mobility costs and benefits well.

Presently, the appropriate infrastructure and prices are not in place, and progressing to their realisation is a key policy objective, which should take priority over quantity targets for modal shares. Better framework conditions will lead to higher public transport shares and less car use in some places, but in a way that reflects the variety of mobility needs and the social opportunity costs of different ways of addressing demand.

Will such a "diversity-based mobility policy" result in the strong reductions in CO_2-emissions that are sought from transport? It will contribute to that objective but will not allow attaining it by itself. The upshot is that reducing CO_2-emissions appears to be first and foremost a technological challenge. Prioritising technological change to alter transport's energy base may be the best bet to cutting carbon, in the sense of being most likely to succeed and in doing so at reasonable cost. Focussing on this goal strengthens clarity and accountability. Changing transport's energy basis is by no means straightforward and will come at considerable cost. Here too, there is a risk that efforts run counter to public finance concerns, but efforts to change transport energy technologies can be aligned with society's mobility aspirations.

International Transport Forum

Transport Outlook

Seamless Transport for Greener Growth

The mobility projections in this Transport Outlook indicate that global passenger transport volumes in 2050 could be up to 2.5 times as large as in 2010, and freight volumes could grow by a factor of four. Emissions of CO_2 grow more slowly because of increasing energy efficiency, but may nevertheless more than double.

The projected evolution of mobility depends on income and population growth, and on urbanization. The relation between framework conditions and mobility is uncertain and not immutable and the Transport Outlook examines a number of plausible policy scenarios including the potential effects of prices and mobility policies that are less car-oriented in urban settings. In this scenario, two-wheeler use in particular could contribute significantly to mobility growth in non-OECD regions. Low car ownership with increased two-wheeler use and somewhat lower overall mobility results in much lower emissions of CO_2.

More generally, the future growth of global mobility and of CO_2 emissions depends strongly on the development of urban mobility. Mobility policies can slow down CO_2 emission growth but cannot by themselves stop it; energy technology is the key to actually reducing the transport sector's global carbon footprint.

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