CHAPTER 2. TRANSPORT DEMAND IN THE LONG RUN

This chapter presents an overview of long-run scenarios, up to 2050, on the development of global passenger transport and freight volumes. The transport scenarios are translated into CO_2 emission scenarios by applying different transport technology paths. The chapter also introduces a Latin America urban transport case study that explores specific characteristics of mobility development in developing countries. The urban model analyses the impact of land use, infrastructure and fuel pricing policy on the development of urban mobility in Latin America, improving the evidence base for scenario analysis. Finally, the chapter presents regional implications of different development paths for passenger and freight transport and CO_2 emissions.

Overview of global scenarios to 2050

The International Transport Forum (ITF) *Transport Outlook* presents long run scenarios, up to 2050, on the development of global passenger mobility and freight volumes. Scenarios on passenger mobility are constructed using ITF modelling tools, which are fully revised compared to earlier editions of the *ITF Transport Outlook*. The tools are fully compatible with the International Energy Agency's Mobility Model (MoMo), version 2013, and partly draw from its database. Freight transport volume projections are based on IEA MoMo. A detailed description of different scenarios can be found in the Reader's Guide.

Population and Gross Domestic Product (GDP) scenarios are a key driver of the passenger and freight transport scenarios, particularly given the long run and aggregate modelling approach adopted. The 2013 *ITF Transport Outlook* uses new GDP scenarios, developed by ITF. These too are MoMo-compatible. We discuss the main features of these projections below.

GDP volumes in the *ITF Transport Outlook* are noted in constant 2007 US dollars expressed in purchasing power parity (PPP) terms. This allows for accurate comparison of actual production volumes between countries based on differences in real costs and controlling for inflation. More specifically, using PPP equalised currencies better illustrates the differences in the real value of developed and developing country economies since it corrects for the generally lower price of non-tradable goods in developing countries.

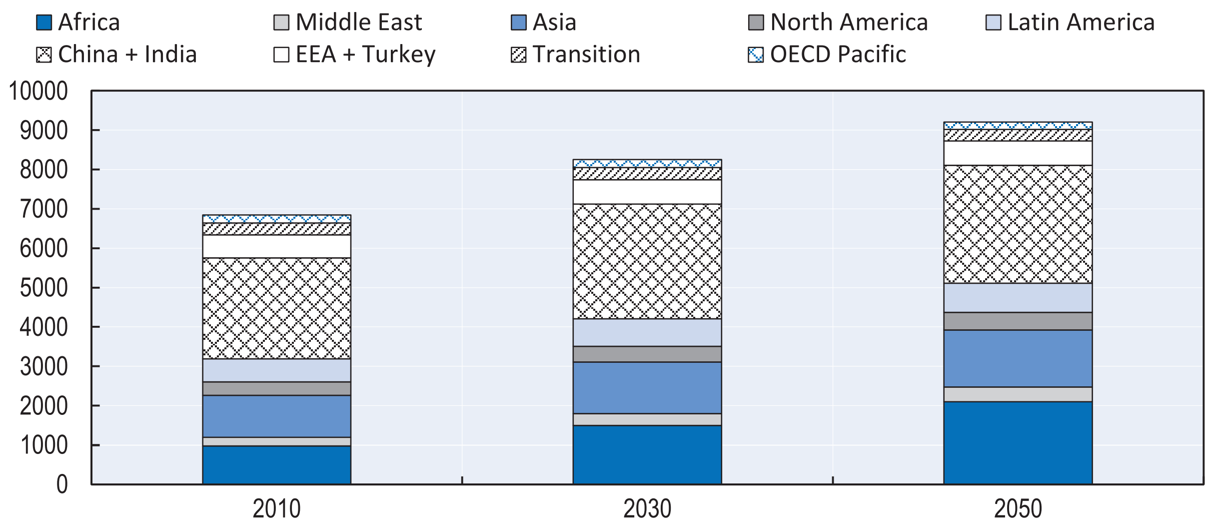
We present the world economy over the period 2010–2050 using two different regional aggregations. In order to illustrate the dimensions of the scenarios we arrange countries by development status and relative size in the global economy (OECD, emerging economies and the rest of the world) and into nine geographical groupings (Africa, Asia, China + India, EEA + Turkey, Latin America, Middle East, North America, OECD Pacific, and the Transition Economies).

The transport scenarios are translated into CO_2 emission scenarios by applying transport technology paths. The technology assumptions and emission calculations are taken from the International Energy Agency's MoMo model and the World Energy Outlook. The scenario used is the New Policies Scenario, which corresponds to a context in which broad policy commitments and plans that have been announced by countries are implemented. Under this scenario fuel economy standards are tightened and there is progressive, moderate uptake of advanced vehicle technologies (IEA, 2013 and Dulac, 2013). The result is a slow but sustained decrease in fuel intensity of travel and carbon intensity of fuel for all vehicles. Such a decrease is in general higher within the OECD region.

Global demographic scenario

Population projections are taken from the UN World Population Prospects, 2012 Revision, medium variant. Urban population projections come from the UN World Urbanization Prospects, 2011 Revision, medium variant. According to these, the world population is expected to grow to about 9 billion people in 2050, from 6.8 billion in 2010, see Figure 2.1. Population growth is strongest in Africa, the Middle East and Asia. It is weakest in the European Economic Area (EEA) and Turkey, the transition economies and the OECD Pacific.

Figure 2.1. **Population by region, 2010, 2030 and 2050**
Millions



Source: Based on UN World Population Prospects (2012 Revision). Data are ranked by declining growth rates from bottom to top.

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Growth rates are lower on average in OECD countries, resulting in ageing populations given the migration scenarios assumed by the United Nation's (UN) Moderate population scenario. Some non-OECD economies, including transition economies and China, also experience rapid ageing by 2050. Table 2.1 displays the share in total population of people aged 65 years or more, by region.

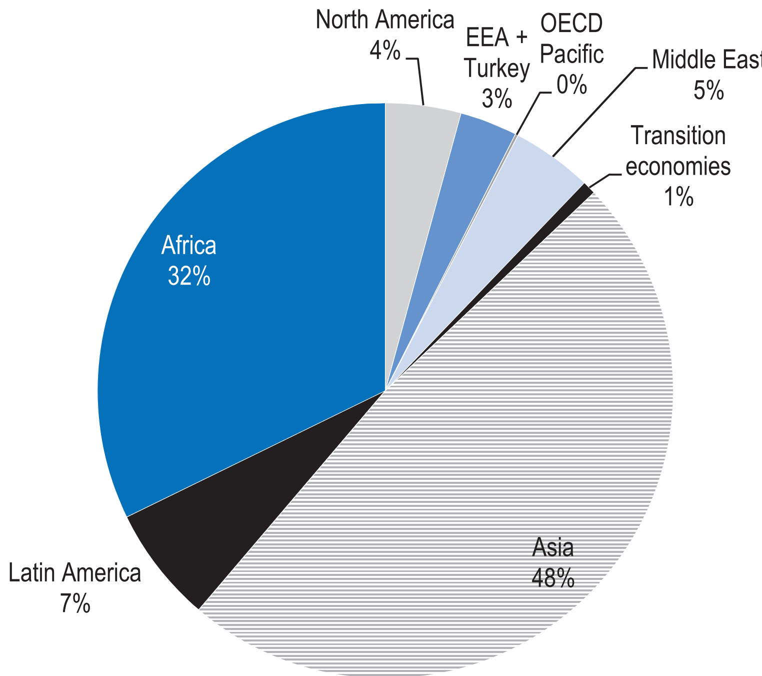
Table 2.1. **Share of total population aged 65 years and over, by region**
Lowest to highest share

	2010	2030	2050
Africa	3.5	4.5	6.5
Middle East	4.1	6.9	13.9
Asia	5.4	9.4	15.6
China + India	6.6	12.2	18.7
Latin America	6.8	12.1	19.1
Transition	11.4	16.4	20.4
North America	13.2	20.2	21.6
EEA+Turkey	16.0	21.9	26.9
OECD Pacific	18.7	26.8	32.5

Source: Based on UN World Population Prospects (2012 Revision).

Between 2010 and 2050, the share of urban population in total world population will grow from 50% to 70%. Under the UN scenario, most of this rural-urban shift will take place in the developing world: of the almost 2.7 billion *additional* urban dwellers, 92% will live in developing countries (Figure 2.2).

Figure 2.2. **Share of world urban population growth by region of the world (2010-2050)**



Source: Based on UN Urbanization Prospects (2011 Revision).

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Global GDP scenarios

The GDP scenarios are the result of assumptions about institutional developments within and between countries and the extent of technological diffusion. Technological diffusion is the major driver of long-term growth including in countries undergoing one-off readjustment, once a balance in capital stock has been attained. The length and extent of transition to a balanced global economy will impact global production and transport volumes as well as the geographic distribution of transport activity.

Global economic growth since the financial crisis has been slow, and uncertainty about medium term developments is high. The long run GDP scenarios chosen for the *ITF Transport Outlook* are at the lower end of the spectrum of available growth projections. They reflect the consequences of a deep shift in the world economy which is yet to be completed.

On the basis of standard growth theory a slowdown of world growth is to be expected but a more drastic deceleration of growth could unfold if the transition is not managed successfully. While this is not necessarily the most likely scenario given past strong growth in economies such as China and India, in times of uncertainty such an outcome is worth considering. An unsuccessful transition from investment led (and debt-financed) growth in the developing world to more consumer driven growth could suppress growth prospects also in other regions of the world.

Growth rates correlate strongly with initial per capita income levels and low income countries generally grow faster as they catch up with more developed countries. Initially, capital stocks of countries are low. As these rise more productive capacity is released as the economy moves to an industrial and service sector base. During rebalancing more capital is accrued to workers with more productive labour and higher wages result. At this stage decreasing returns to capital set in, which generally increases the reliance of further economic growth on the productivity of labour. Demographics can impose limits to growth as populations age and population growth slows or even declines. Often high growth regions enjoy a demographic dividend, in which a young population enjoys labour productivity improvements which quickly translate into wider economic growth.

A commonly accepted way to improving economic productivity is better regulation of both domestic and international product and service markets, promoting competition and rapid diffusion of technologies. The long-term growth path of countries thus depends on the extent to which these drivers are supported (Johansson et al. 2013). The transition that characterises a large part of the global economy is not only one of rebalancing but coincides with increasing unbundling of production geographically (with increases in the distance component per unit of value-added).

Growth prior to the economic crisis coincided with an unprecedented boom in international trade and transport. Whereas (investment fuelled) economic growth was a cause of higher trade, it has also been supported by the lowering of effective transport and communication costs and closer co-operation between national economies. In the future a further unbundling of global production chains is likely to involve more industrial sectors and more country pairs. Transport systems will remain central to economic growth processes. If growth becomes less dominated by investment, the role of lower trade costs in terms of communication, travel and freight transport will come increasingly to the fore.

The modelling exercise which underlies the *ITF Transport Outlook* scenarios views economic growth and population dynamics as exogenous. Assumptions about transport are however implicitly included in the GDP scenarios. Both GDP scenarios and baseline assumptions on population dynamics and urbanisation imply continuous and rapid increases in the demand for transport. This also means that if projections of yet higher output are to materialise infrastructure will be strained.

> "…the entire trend in transport infrastructure will have to be revised upwards, rather than being based on extrapolation of the past."
>
> Amartya Sen in his 2013 International Transport Forum Summit keynote (Sen, 2013)

Two GDP scenarios are used: *a baseline scenario* and a *low growth scenario*. In the baseline, interpreted as the more likely scenario, world GDP grows by 3.2% per year on average between 2010 and 2050 (in PPP terms, 2007 US dollars). In the low growth scenario, average annual growth is 2.4%. World GDP grows by a factor of 3.6 in the former, and 2.6 in the latter. Details on the GDP scenarios are provided later in this chapter, here we summarise key features.

World average per capita income grows from 10 thousand USD (in 2007 USD at PPP) to 20 thousand USD in the low scenario and 28 thousand USD in the high scenario by 2050. This means that a larger share of the world population will be enjoying middle income status.

In the baseline scenario, world GDP growth declines from around 3.5% per year in the near term (a level in line with those observed in the recent past) and declines gradually to reach around 2.7% as of 2040. The higher growth is the result of rising capital stocks and increasing labour productivity in emerging economies. As these economies mature and capital stocks balance, growth is mainly driven by diffusion of technology. Frontier countries, defined as a group of high-tech OECD economies, are the source for innovation and technology improvements which diffuse through the world economy through knowledge sharing and trade in machinery and other inputs.

The low growth scenario illustrates the downside risk associated with the transition in emerging economies from export- and investment- (and debt-) financed growth to one led by consumer demand. The result is slower growth in the emerging economies which reverberates throughout the world economy.

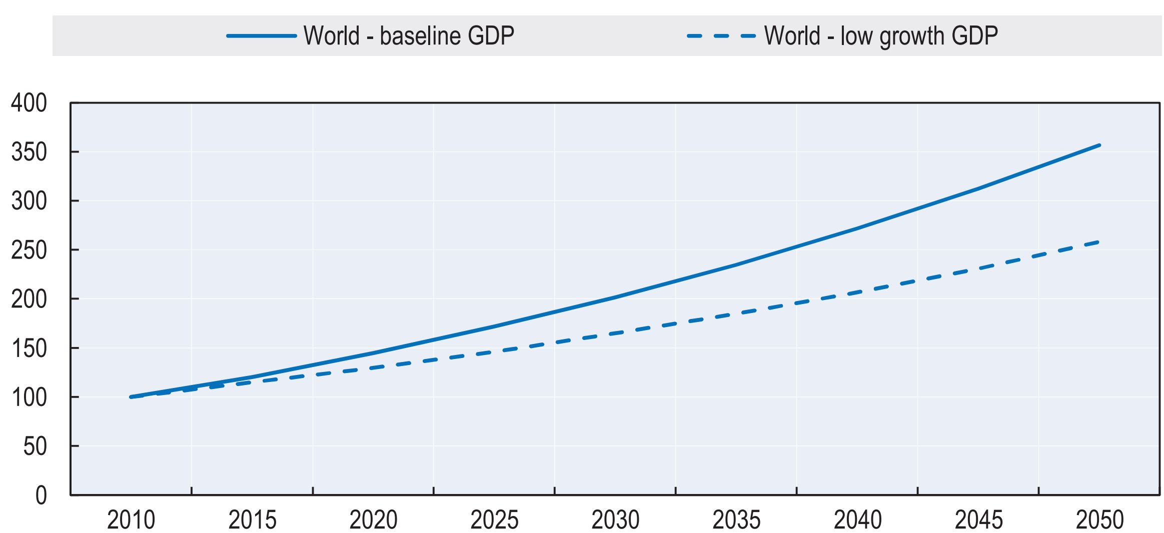
Figure 2.3 shows the evolution of world GDP in the baseline and low growth scenario. It illustrates the (sizeable) difference between world output growth between the scenarios. Figure 2.4 presents a breakdown for three regions: the OECD, the emerging economies, and the rest of the world. It illustrates that the lower growth is to occur mainly in the emerging economies. Figure 2.5 displays the evolution of the shares of world GDP generated in the same three regions.

The low growth scenario reflects what may happen when misgivings about growth potential and conversion of growth models as they have appeared recently in the public debate actually materialise and persist. We do not take it to be the most likely outcome, but rather treat it as a lower bound. Growth performance in the vicinity of the baseline is seen as more probable.

The baseline scenario of GDP growth in the 2013 *ITF Transport Outlook* is similar in terms of 2050 results to that of the 2012 edition (which already considered a permanent impact of the financial crisis rather than a bounce-back to pre-crisis growth paths), whereas the low scenario is considerably more pessimistic for non-OECD regions (see Figure 2.6). The low growth scenario in 2012 reflected a slower than expected return to pre-crisis growth patterns, whereas the 2013 low growth scenario captures prolonged slower growth due to difficulties with moving to a less export- and investment oriented growth approach in emerging economies.

In both growth scenarios, faster growth outside the OECD results in a rapid shift of economic mass and an increase in the share of world GDP produced outside of the OECD (see Figure 2.5). This increase is considerably slower in the low GDP scenario, however. In the baseline, OECD and emerging economies produce equal shares of world GDP by 2030; OECD and non-OECD economies as a whole produce equal output shares by 2020. With low growth, OECD and non-OECD outputs will level only by 2050. Note that the relative impact of the low growth scenario is larger for non-OECD economies. This slow growth has direct effects on the development of transport volumes.

Figure 2.3. **World GDP volumes**
2010=100



Source: Based on OECD (2012), Conference Board (2012) and IMF (2013).

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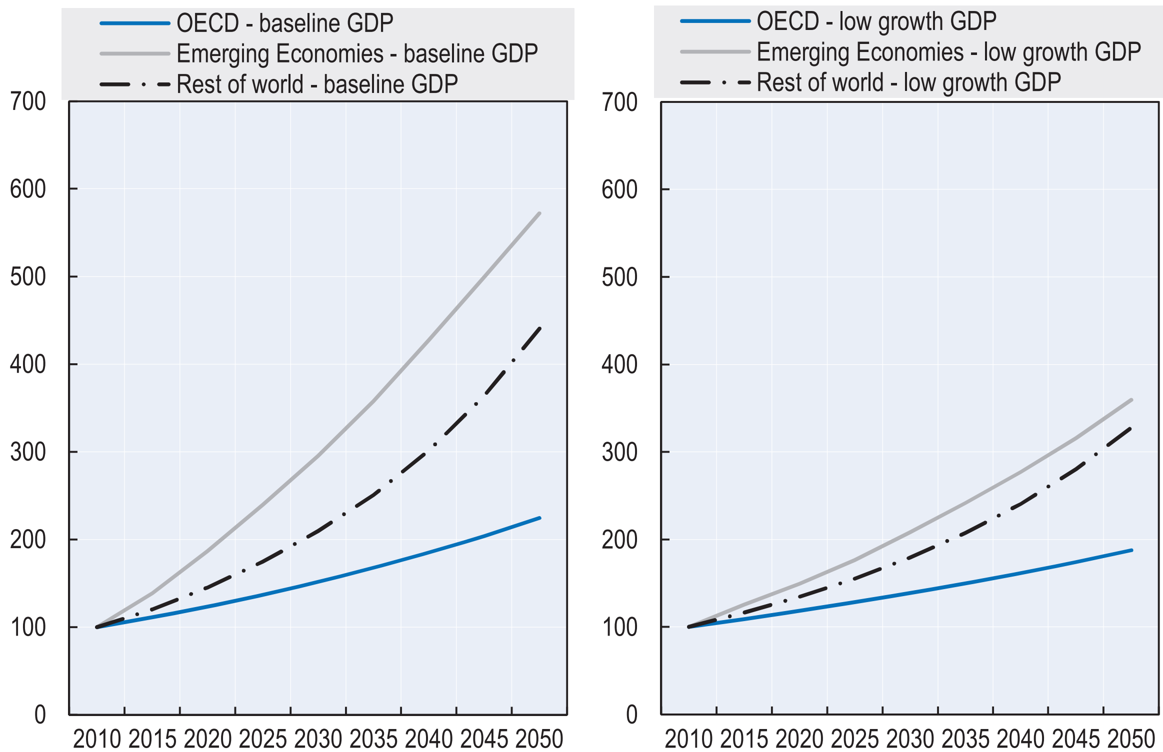
Figure 2.4. **GDP Volumes in OECD, the emerging economies and the rest of world**
2010=100



Source: Based on OECD (2012), Conference Board (2012) and IMF (2013).

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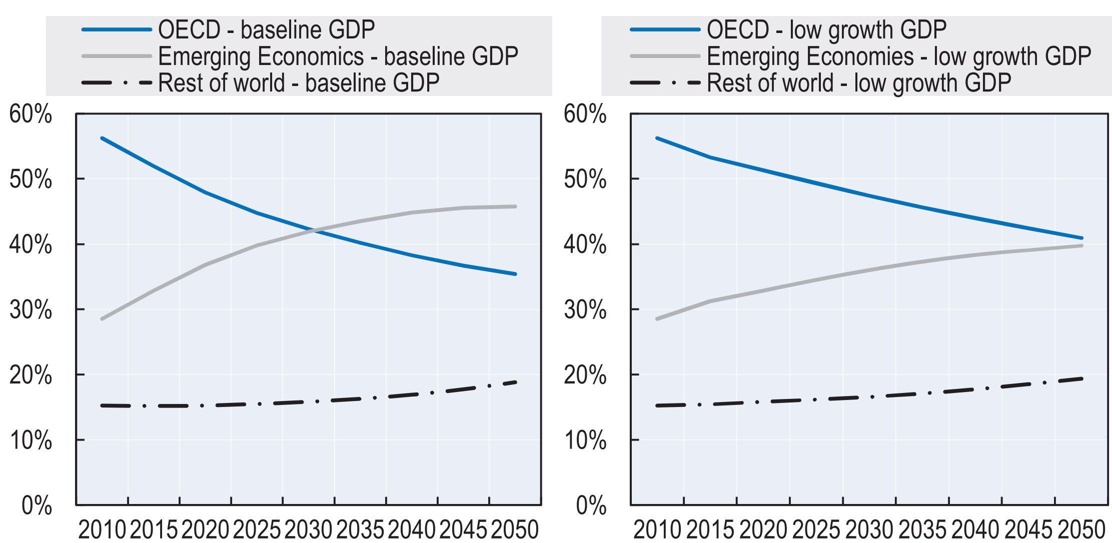
Figure 2.5. **Share of world GDP volumes generated in OECD, the emerging economies and rest of world**

Percentage



Source: Based on OECD (2012), Conference Board (2012) and IMF (2013).

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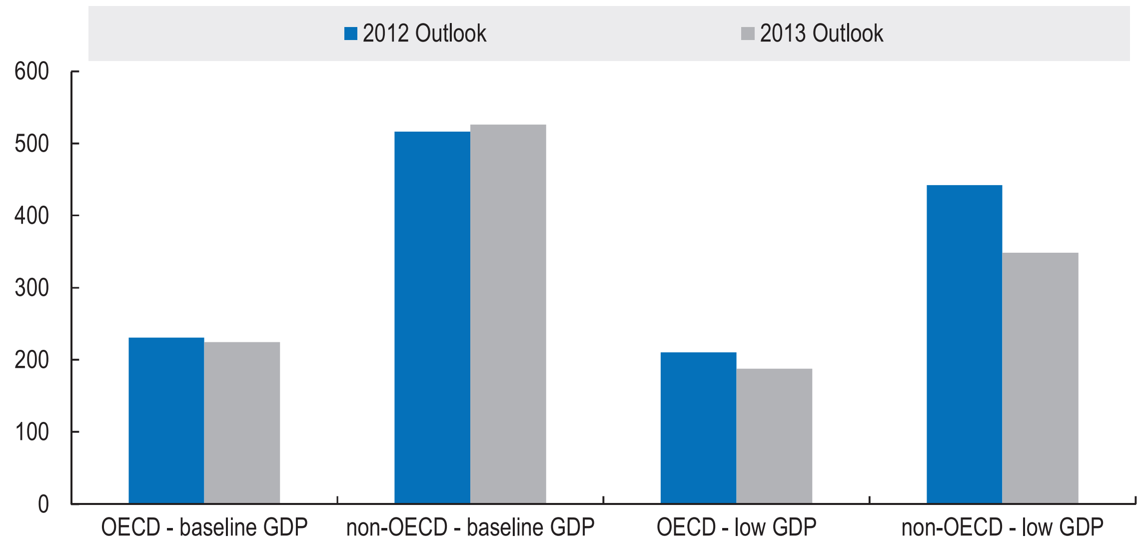
Figure 2.6. **World GDP in 2050, baseline and low GDP growth scenarios**
2010=100



Source: Based on OECD Economic Outlook (2012), IEA MoMo, Conference Board (2012), IMF (2012) and IMF (2013).

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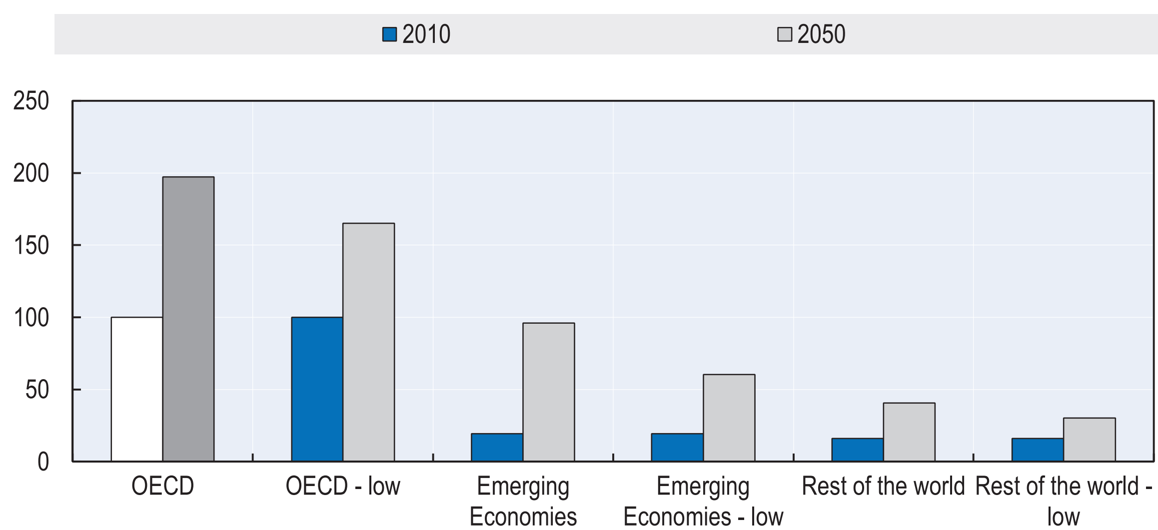
Figure 2.7. **Per capita GDP in OECD, the emerging economies and the rest of the world, baseline and low growth**
OECD 2010=100



Source: Based on OECD (2012), Conference Board (2012) and IMF (2013).

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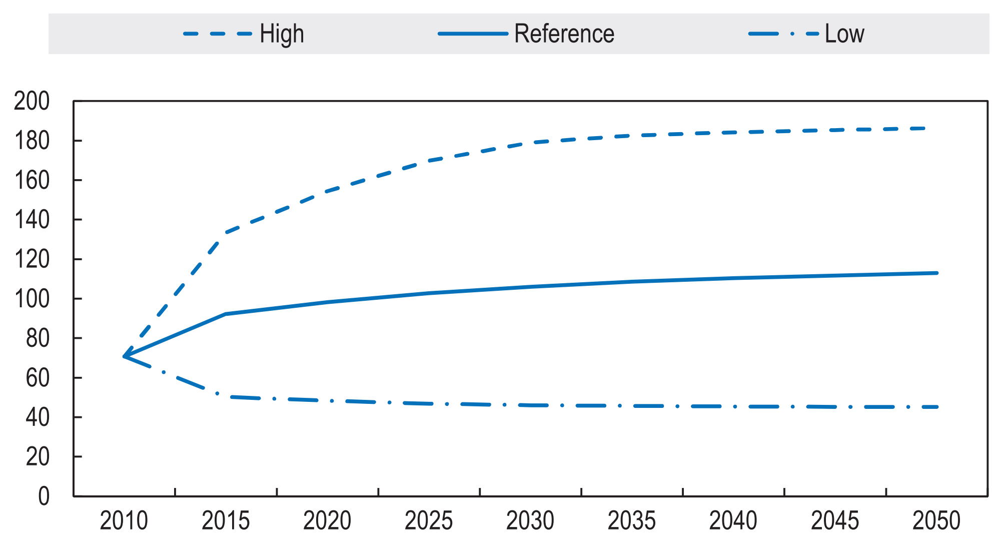
The combined population and GDP scenarios imply global convergence of GDP per capita (see Figure 2.7). Convergence is slower in the low growth scenario, but the dispersion between countries of per capita GDP declines in both scenarios. Per capita GDP in the emerging economies approaches levels currently observed in the OECD by 2050, meaning that transport demand and modal composition may approach current OECD levels, at least if policies allow similar demand-driven development of mobility.

With low GDP growth, per capita GDP remains well below current OECD levels in the emerging economies and *a fortiori* in other non-OECD economies.

Box 2.1. **Oil price scenarios**

We constructed 3 oil price scenarios based on work by the International Energy Agency (IEA) and United States Energy Information Administration (EIA). In particular, our reference price scenario corresponds to the New Policy Scenario of the IEA World Energy Outlook 2012 (IEA, 2013) and is also the reference case scenario used in the Mobility Model of the IEA. The high and low scenarios are based on the continuation to 2050 of trends presented in the 2011 International Energy Outlook of the EIA. As such, they represent strong deviations from the reference case. In the reference case the oil price reaches 113 real USD per barrel by 2050, which is approximately 60% above price levels in 2010, and lies at around 100 real USD in 2020. In the high scenario the oil price reaches 186 real USD per barrel in 2050 (160 real USD in 2020) and in the low scenario it drops to approximately 42 real USD per barrel by 2020 and stays at that level through 2050. It should be noted that oil prices have been characterised by instability over the last 40 years and that this is likely to continue to be a feature of prices to 2050. The lower scenario relates to long-run elasticities of supply and demand and the potential for new and unconventional sources of oil, oil substitution and energy efficiency to influence prices. The upper scenario relates to short-run elasticities of supply and demand in the presence of market power and political constraints on supply (ITF 2008).

Figure 2.8. **World oil price: high, reference and low scenarios**
Real 2005 USD



Source: Based on International Energy Agency and United States Energy Information Administration data.

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Connections between population, urbanisation, GDP and transport

Population growth generates rising mobility needs. Population and urbanisation trends indicate that rising mobility demand will be concentrated in urban agglomerations and in particular in those of the developing world.

Growth in per-capita income levels also generates transport demand and has in particular a positive effect on the ownership of private vehicles. This in turn tends to increase reliance on private vehicles to meet growing mobility demand. The elasticity of private ownership with respect to per capita GDP follows an S-shaped curve (see Figure 2.17), with ownership rising slowly with income at first, accelerating as income rises through medium levels and slowing again as incomes reach high levels.

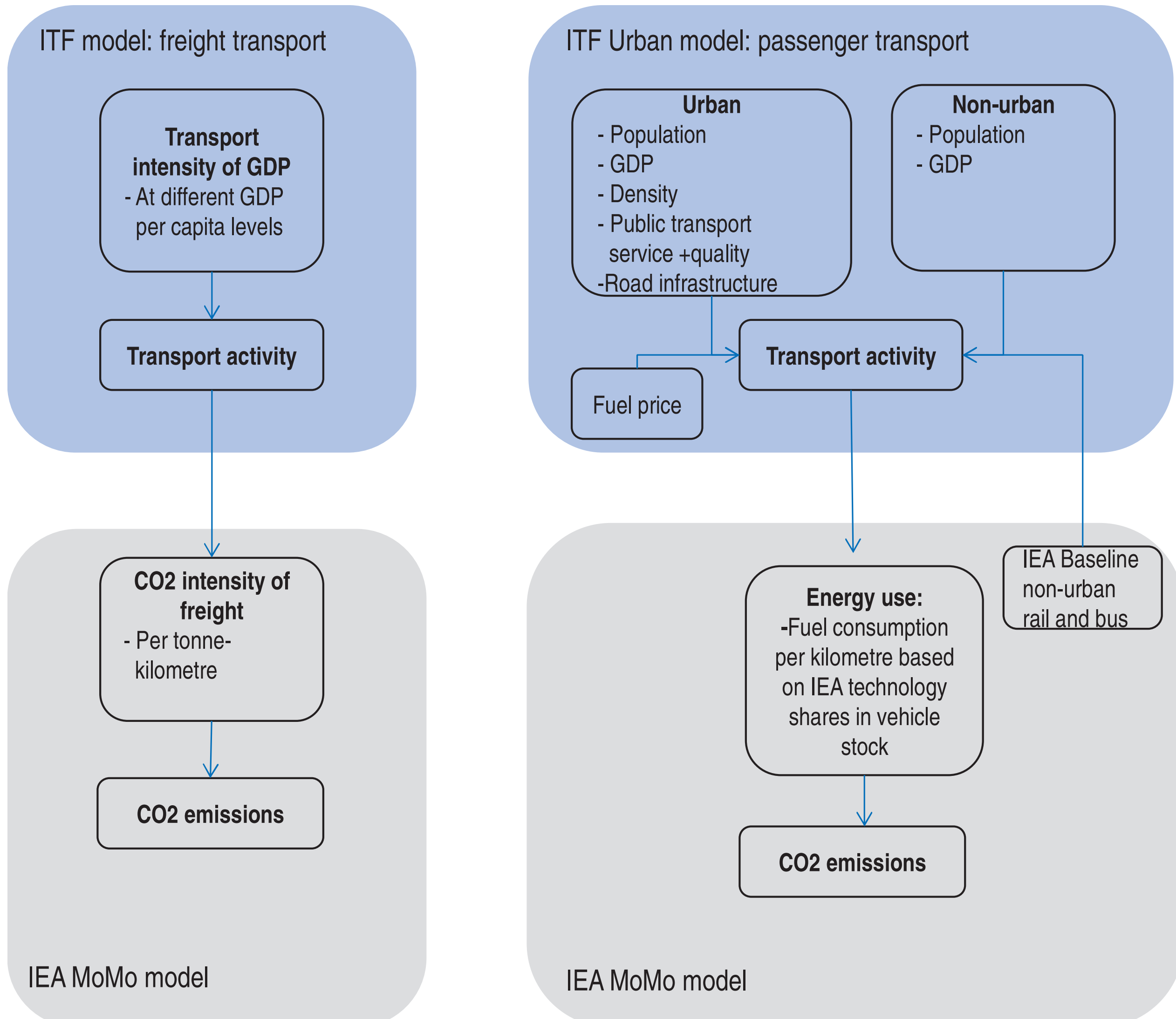
High concentration of population allows urban agglomerations to offer transport alternatives to private vehicles. Providing public transport services tends to slow down the increase in car ownership and use as incomes grow. Cities hence have the potential to embark on less private ownership-oriented pathway and rely more on other modes to meet growing mobility demands.

Global passenger trends will be increasingly defined by the modal distribution in urban areas, particularly in developing countries. As discussed in detail below, urban form and infrastructure expansion will play an important role in determining the relative share of competing modes in meeting rising passenger transport demand in urban centres. Fuel prices will also influence the volumes and modal shares of passenger transport. These have an effect in both urban and rural areas, although their effect is intensified at the urban level due to the higher number of transport alternatives.

Freight traditionally correlates strongly with GDP especially during early stages of economic development, and we assume a weaker relation as GDP rises. The surface freight transport scenarios show changes in total regional surface freight volumes (measured in tonne-kilometres) following either a unitary relationship to high and low GDP scenarios or a slowing relationship between surface freight and baseline GDP growth. The latter is more likely during a dematerialisation of the economy as incomes increase.

The connection between trade volumes and GDP in our scenarios is largely implicit. Higher GDP is associated with more trade. In the 15 years before the crisis of 2008, trade grew very quickly, with growth strongly concentrated in a small number of trade routes between North America, Western Europe and Asia, and with particularly strong growth in exports of electronics from China and in raw materials trade. Future trade growth is likely to be less concentrated on these routes and less skewed towards these commodity types. Unbundling of production along value chains may also drive trade growth and contribute to output growth, if supply chain resilience is maintained and trade costs kept low and predictably stable.

Figure 2.9. **Schematic description of the model**



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Global transport and CO_2-emission scenarios to 2050

Passenger transport volumes and CO_2-emissions

Figure 2.10 summarises growth in vehicle-kilometres for passenger traffic between 2010 and 2050 for the OECD, non-OECD economies and the world as a whole, using both the baseline and low growth scenarios for GDP. Figure 2.11 shows the corresponding levels of CO_2-emissions on the basis of the IEA's business-as-usual (New Policies) scenario for the development of vehicle technology.

The figure shows the range of outcomes from the alternative transport scenarios modelled. The lowest passenger travel (vehicle-kilometres) growth scenario assumes high fuel prices and urban transport development that is transit-oriented with slow expansion of road infrastructure. The highest growth occurs when fuel prices are low and urban transport development is private-vehicle oriented, with strong expansion of road infrastructure. The central scenario assumes reference fuel prices while public transport supply and road infrastructure grow in pace with population growth, resulting in stable levels of infrastructure per capita. Detail on the different scenarios is found in the discussion of urban transport scenarios below.

Figure 2.10. **Vehicle-kilometres for passenger transport, 2050**
2010=100

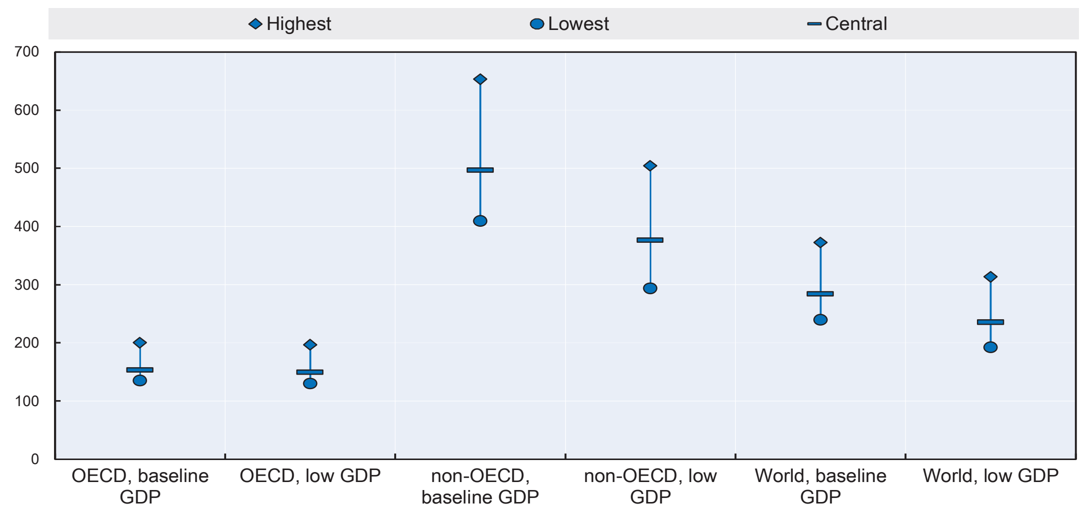

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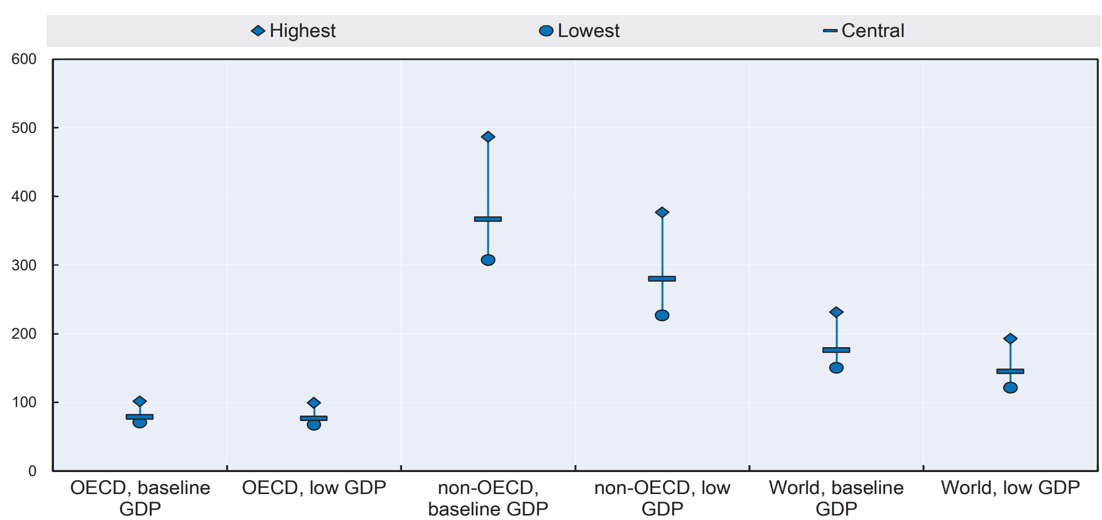
Figure 2.11. **CO_2-emissions from passenger transport, 2050**
2010=100



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Depending on the evolution of GDP, fuel prices and urban transport development, global vehicle-kilometres for passenger transport are set to grow by a factor of 1.9 to 3.7 from 2010 through 2050. In the central scenario the growth factor is 2.4 for low GDP and 2.9 for baseline GDP.

Growth is much larger outside the OECD region than within it. This is because both GDP grows faster and because transport demand increases more strongly with GDP outside of the OECD.

Baseline and low GDP scenarios produce similar outcomes for the OECD, with around 55% growth of vehicle-kilometre volumes between 2010 and 2050. This similarity occurs because the difference between the GDP projections is small for the OECD and the elasticity of vehicle-kilometres with respect to GDP is low.

Outside of the OECD, larger differences between the low and baseline projections of GDP and a higher elasticity of vehicle-kilometres with respect to GDP lead to much bigger differences in the passenger transport volume projections: for baseline GDP the central scenario results in five-fold growth of vehicle-kilometres, whereas for low GDP the growth factor is 3.8. Combining baseline GDP growth with low fuel prices, low public transport expansion, and car-accommodating urban transport policies would lead to vehicle-kilometre volumes increasing 6.5 times. The same economic growth under a context of high oil prices, transit-oriented policies and low road infrastructure expansion would result in a growth of vehicle-kilometres of 4.1 times over 2010 levels.

Applying the IEA-MoMo New Policy Scenario for the evolution of vehicle technology to these transport volumes leads to increases of CO_2 emissions for passenger transport from 20% in the lowest scenario with low GDP growth to 130% in the highest scenario with baseline GDP growth. The central scenario results in 50% emissions growth for the low GDP and 80% for the baseline GDP. The global results reflect declining emissions in the OECD (by about 20% in the central scenario), and rising emissions outside of it, by 190% under low GDP growth and 280% under baseline GDP growth in the central scenario.

Comparing CO_2 and vehicle-kilometre growth, it is clear that emissions grow more slowly than transport volumes. In the OECD, vehicle-kilometres grow and emissions decline. Outside the OECD, emissions grow only three-quarters as much as vehicle-kilometres. The declining CO_2-intensity of vehicle-kilometre volumes is to a very large extent the consequence of technological change. Changes in modal split, measured in vehicle-kilometres, and changing weights of regions within the broad OECD and non-OECD categories are of minor importance. This holds for all scenarios.

Surface freight transport volumes and CO_2-emissions

Figures 2.12 and 2.13 show the growth of total surface freight volumes (including light commercial vehicles) and the emissions thereof for the OECD and non-OECD economies, and the world, between 2010 and 2050. The scenarios presented correspond to a high, central or low correlation with GDP and the baseline and low GDP growth scenarios discussed in more detail in Appendix 1. The CO_2 emissions per unit of transport volume are based on IEA New Policy Scenario developments in vehicle technology.

In the high freight scenario surface freight develops in line with GDP – assuming a unitary relationship. In the low scenario, there is decoupling from GDP growth which can occur with a dematerialisation of GDP. The central scenario differs for the OECD and non-OECD economies and rests on the assumption that the transport intensity of GDP decreases with rising per capita income levels. More details of the scenarios are given below in Section discussing regional implications of different development paths at the end of this chapter. Lower vehicle technology improvements also lead to stronger growth in emissions from freight transport in all regions.

Surface freight growth ranges from 42% to 124% of 2010 levels in the OECD and between 100% and 430% in the non-OECD economies. CO_2emissions decrease by up to 4% in the OECD under a scenario of slow economic development and decoupling scenario, but increase up to 50% assuming stronger growth and a one to one relationship between GDP and freight transport. In the Non-OECD economies, emissions rise much more strongly, between 100% and 460%.

The modal share of rail transport in surface transport (road and rail) is assumed to increase slightly from 42% to 46% in the OECD but decrease from 58% to 46% in the non-OECD economies. Currently some non-OECD economies exhibit very high rail market shares. For non-bulk commodities the share is likely to decrease due to strongly increasing demand for more flexible road transport. In many places the commodity mix carried will primarily allow producers to pay the relatively higher per unit shipping costs by truck and increase the demand for reliability and timely delivery.

Baseline GDP growth and a strong stake of transport in growth can lead to global surface freight volumes increasing by up to 4 times between 2010 and 2050 and corresponding CO_2 emissions to increase 3.3 times. Under a low growth scenario, combined with the possibility of a declining intensity of freight transport in economic growth, global surface freight could be only 1.7 times higher in 2050 than 2010 with corresponding growth in emissions a factor of 1.4 times.

Figure 2.12. **Tonne-kilometres for surface freight transport, 2050**
2010=100

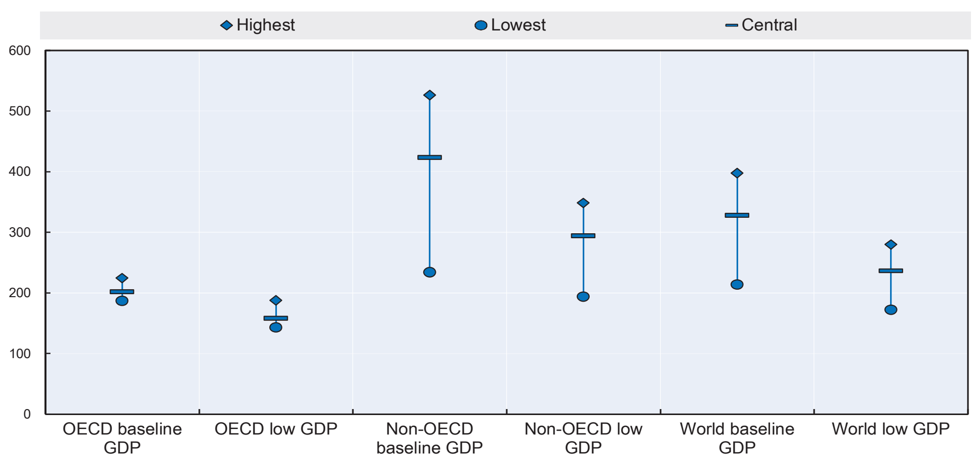

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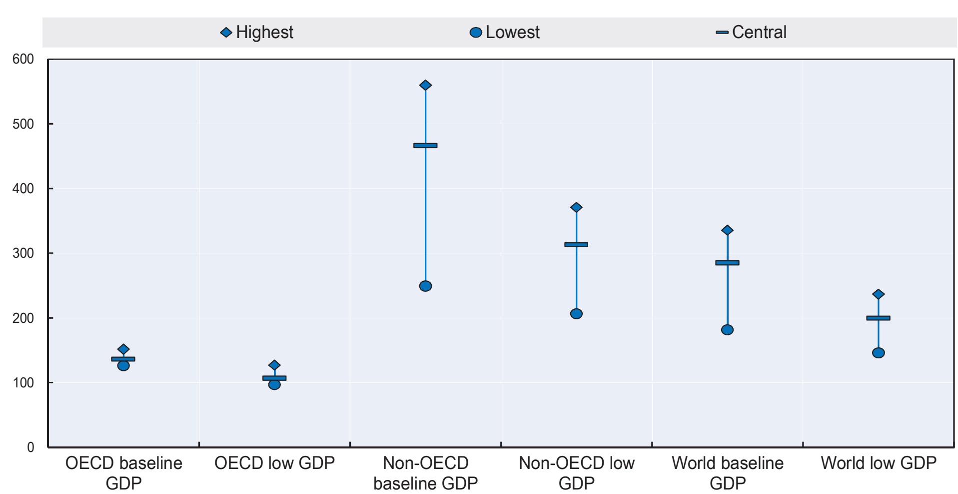
Figure 2.13. **CO_2-emissions from surface freight transport, 2050**
2010=100



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Total CO_2-emissions from passenger and freight transport

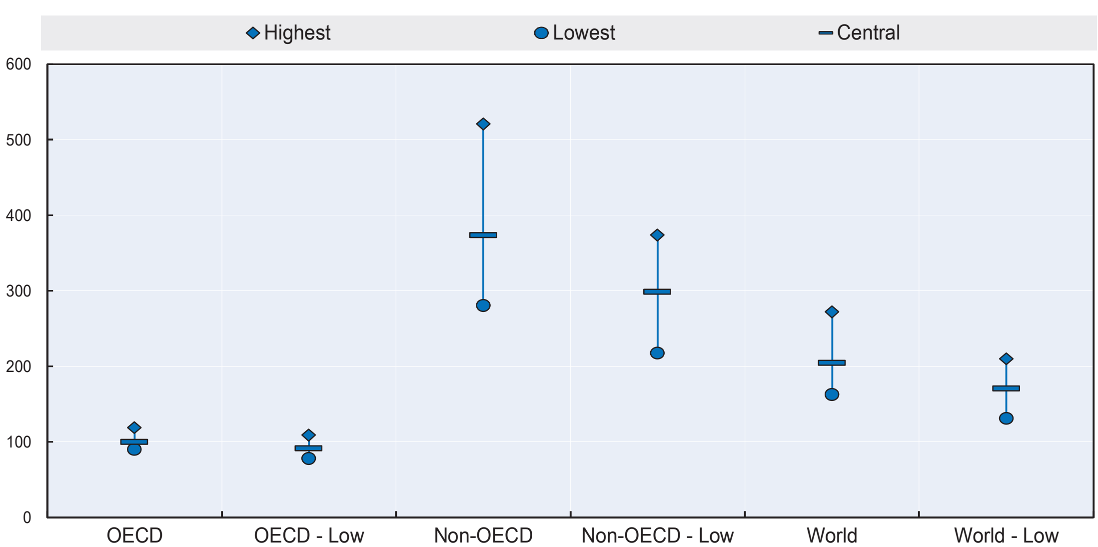
Overall transport volumes and CO_2 emissions from both passenger and freight transport will increase strongly between 2010 and 2050. This growth is much more pronounced in the non-OECD economies since this is where most economic growth will occur and transport correlates strongly with economic growth. Factors that impede or facilitate economic growth and the relationship with transport are captured by our choice of GDP scenarios and high, low and central transport scenarios.

CO_2 emissions will grow more slowly than transport volumes in part due to policies to improve fuel economy. These are generally more powerful than modal shift policies. In developing countries the impact of fuel economy improvement will be less marked. Improving fuel economy has the added benefit of containing the cost of mobility in times of high oil prices.

Globally, and for all scenarios considered, CO_2 emissions from freight and passenger transport are to rise between 30% and 170%. In the Non-OECD economies this range is considerably higher and lies between 120% and 420%. In the OECD we can expect a decrease of 20% in the lowest case and an increase of 20% in the highest case over the period 2010 – 2050.

The scenarios highlight the rising share of surface freight transport emissions in total surface transport emissions, particularly in the OECD. In 2010 emissions from surface freight are 35% of the total emissions in the OECD (Figure 2.14) and 46% in the non-OECD economies. By 2050 these figures change to between 40% and 49% in the OECD and 41% to 50% in the non-OECD economies, depending on the scenario. Exploiting cheap abatement options in the surface freight sector therefore can be expected to have large payoffs.

Figure 2.14. **CO_2 emissions from surface freight transport and passenger transport, 2050**
2010=100



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Urban transport scenarios for a middle-income region: Case study of Latin America

Increasing urbanisation with the proportion of the world population living in cities rising from 50% to 70% between 2010 and 2050, is a phenomenon mainly driven by the developing world.

A rising share of urban dwellers and faster growth in urban areas leads to strong concentration of GDP in cities. 74% of global growth between 2010 and 2025 is expected to occur in urban agglomerations in developing countries (McKinsey Global Institute, 2012).

As a consequence, global mobility trends will be increasingly defined by urban mobility outcomes, particularly in developing countries. Urban mobility policy will therefore be increasingly influential on the achievement of national and global sustainability goals.

Due to higher density of demand the scope for relying on public transport to meet mobility needs is broader in cities than elsewhere. Higher congestion levels also reduce the benefits of using private transport compared to situations where its use is less constrained by capacity limits. Urbanisation hence can result in a lower share of cars in meeting transport demand even if urban incomes are higher. However, realising this potential requires supporting policy, and this is reflected in the scenarios.

Incomes in cities in the developing world will remain below those in developed economies – reducing poverty will remain a challenge – but increasing demand will put pressure on infrastructure provision. The impact of infrastructure provision on transport volumes has to be factored into the outlook.

Urban centres in the developed world show differences in the relative importance of transport modes to meet their mobility demand. This is because of differences in geography and historical context but also because of diverging policies. Analysis of past experience informs scenarios on possible futures for mobility in cities experiencing rapid economic expansion.

Important differences between transport trends in developed and developing cities have already begun to make themselves evident. The Latin American urban transport case study explores specific characteristics of mobility development in developing countries with the objective of improving the evidence base for scenario analysis. It analyses the impact of land use, infrastructure and fuel pricing policy on the development of urban mobility.

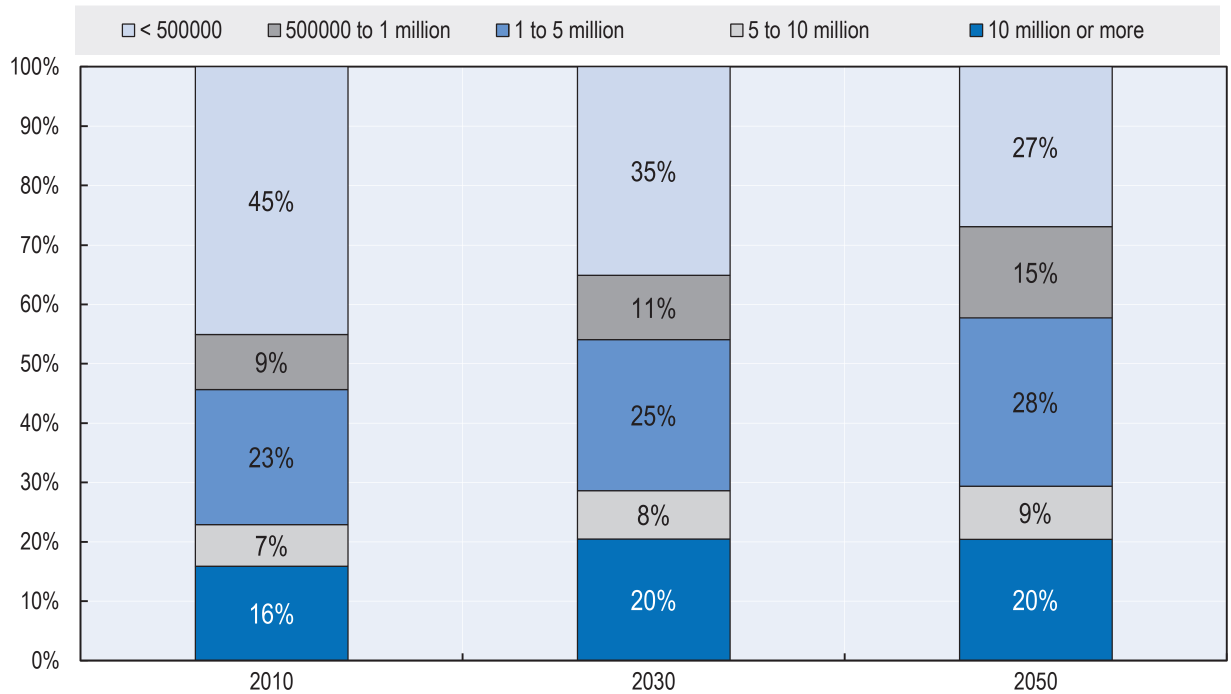
Underlying scenarios for Latin America

Demographic and GDP scenarios

Latin America is a highly urbanised region. Its concentration of population in urban centres (80%) is comparable with that in the United States and higher than in Europe. The rural-urban shift that took place over recent decades was particularly rapid. The urban population increased from 40% to 70% over the 1950-1990 period (United Nations, 2012b). The process was characterised by strong concentration of population and economic activity in capital cities. These and some additional urban centres have become central economic entities, with more than 5 million inhabitants, and often going over 20 million population. As in many other regions, urban centres have grown beyond administrative boundaries, and this has resulted in major challenges in terms of planning, service delivery, and infrastructure expansion.

From 2010 to 2050 rural-urban migration is expected to decrease but the urbanisation rate will continue to rise, to reach 90% by 2050. Many small cities will consolidate into medium ones, and some of the medium cities of today will become large and even megacities of above 10 million population (see Figure 2.15).

Figure 2.15. **Evolution of urban population in Latin America by size of urban agglomeration**



Source: Based on the UN World Urbanization Prospects, 2011 Revision.

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Urban areas are the engines of economic performance in Latin America. Urban centres with populations of 500 000 or more make up 60% of total regional GDP; urban agglomerations with more than 200 000 inhabitants account for two-thirds of it. The four megacities with populations of 10 000 000 or more alone account for 14% of regional population and 23% of the region's GDP. In general, personal incomes in cities in the region increased three-fold between 1970-2010 (United Nations, 2012b).

Despite this overall improvement, cities have gone through stages of slow and even negative growth, suggesting severe challenges to generating sustained growth. Accelerated environmental deterioration and the high shares of the population with limited access to services and opportunities in Latin American cities highlight a lack of capacity for translating economic growth into environmental and social sustainability.

The way in which the many growing cities of the region develop in the coming decades will be of particular importance to the future of the region. It will determine the extent to which its countries will benefit from the high proportion of working-age population and prepare forageing of the population.[1]

Urban planning policies can make a significant difference in how well cities meet rising mobility demands driven by the expansion and rising incomes. In order to contribute to long-term growth, mobility policy will need to assure that such demands are met while minimising the environmental burden and in a way that fosters social inclusion.

The transport projections for the case study are based on an urban transport model for Latin America, developed by the International Transport Forum. The model simulates transport volumes, modal shares, and transport-related CO_2 emissions for the 2010-2050 period. The unit of analysis is the average urban agglomeration in each of the United Nations categories for urban agglomerations[2], and each country. The main model features and assumptions are discussed next.

Box 2.2. **Urban transport model for Latin America**

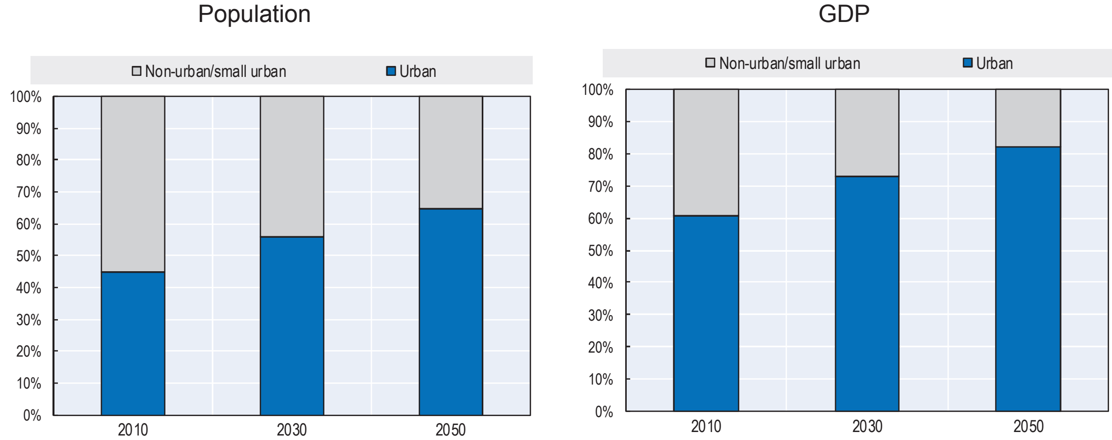
The model simulates the urban context of the average agglomeration in each category and country, in terms of economic growth, land use, fuel prices and infrastructure, under different scenarios. The UN projects the number of agglomerations in each category up to 2050.[3] Mobility levels and the share of each mode in delivering them are derived according to the simulated urban context. The model uses various assumptions on load factors, fuel economy and CO_2 emission factors from the MoMo mobility model of the *International Energy Agency.* Economic analysis and modeling by type of agglomeration is based on data from MGI cityscope provided by the *McKinsey Global Institute*. Relations between urban variables and mobility were estimated using data from the Urban Mobility Observatory created by the *Development Bank for Latin America-CAF*. This database contains information for fifteen Latin American cities for 2007: Buenos Aires, Bogotá, Caracas, Mexico City, Guadalajara, León, Lima, Sao Paolo, Rio de Janeiro, Curitiba, Porto Alegre, Belo Horizonte, Montevideo, Santiago, San José.

Between 2010 and 2050, the urban population in agglomerations with 500 thousand population or more is expected to grow by 80%. For economic growth, two alternative scenarios are used, corresponding to the *Baseline* and *Low growth* scenarios described above. This results in annual growth rates for GDP and GDP/capita in the region of 3.4% and 2.8% in the baseline, and 2.5% and 2% in the low growth scenario.

To account for differences in urban and non-urban growth rates, the model calculates the evolution of GDP and GDP/capita by category of urban agglomeration while retaining consistency with the economic growth scenario on the country level. This is done using the estimated relation between the concentration of population and the concentration of GDP in urban agglomerations. The relation is S-shaped[4] to allow for the general observation that when urban agglomerations are relatively small the elasticity between wealth and population concentration is lower, then rises as agglomerations grow, and when agglomerations get very big the marginal benefit of increasing the concentration of population begins to decrease.

Data to estimate the relation for the different countries was taken from the McKinsey City Scope Database, which contains 2010 population and GDP observations for 51 agglomerations in the region and a 2025 forecast for these same cities. Using these data for projections up to 2050 implies the assumption that countries maintain the same relation between population concentration and growth for 2025 through 2050 as between 2010 and 2025. Results show that by 2050 urban centres with more than 500 thousand inhabitants in the Latin American region will concentrate 65% of total population and 82% of GDP in Latin America, see Figure 2.16.

Figure 2.16. **Percentage of Latin American population and GDP in urban agglomerations of 500 000 inhabitants and above**



Source: Based on McKinsey Global Institute Cityscope 2.0 database

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In the baseline economic growth scenario, urban GDP in 2050 grows by a factor of 5 while non-urban GDP is 70% higher than in 2010. In the low growth scenario, urban GDP grows by a factor of 3.5 and non-urban GDP increases by 16%. In terms of personal incomes, the baseline economic growth scenario results urban personal incomes growing by a factor of 2.8 and non-urban per capita GDP by a factor of 2.1. Under low growth urban and non-urban incomes would rise by a factor of 1.9 and 1.4 respectively.

Land use scenarios

The land use scenarios capture different evolutions of urban density. They are constructed as follows. First, country pathways of urban agglomeration population growth and urban surface expansion were calculated for the countries of the region[5]. Next, using projections of average population size by country and category and the calculated relation between population growth and surface expansion, the model calculates urban surface per country and urban category type. Finally, the model calculates the density of the average urban agglomeration for every country and category by dividing the population over the calculated surface. From the available countries, Argentina was found to have the highest surface expansion in its urban agglomerations relative to population growth; Colombia was found to have the lowest ratio. Based on these findings, three land use scenarios where created in the context of this analysis:

- *Baseline:* from 2010 through 2050 period, urban agglomerations in all countries grow in surface, relative to population expansion, following their own past population growth-surface expansion path. By the end of the period this results in an urban density of the average[6] urban agglomeration that is 13% higher than in 2010.

- *High sprawl:* from 2010 through 2050, urban agglomerations grow in surface, relative to population expansion, following the Argentinean population growth-surface expansion path. In this scenario by 2050 the average urban agglomeration in the region has an urban density that is 30% below that of 2010.

- *Low sprawl:* from 2010 through 2050, urban agglomerations grow in surface, relative to population expansion, following the Colombian population growth-surface expansion path. By 2050 this results in an increase by 30% of the urban density of the average Latin American urban agglomeration.

In the model, urban density is linked to mobility through two mechanisms. The first is through public transport and road infrastructure provision. These relations are estimated based on the Urban Mobility Observatory data and explained below. Second, urban density correlates positively with public transport ridership. This relationship is examined in the analysis of the Land Transport Authority (LTA) Academy, which finds an increasing elasticity of ridership to density as urban density rises (Ely, 2012). These elasticities are used in our model.

Public transport service scenarios

We simulate public transport provision for each urban agglomeration category and country. There is a positive relation between urban density and public transport supply, measured as vehicle-km per capita (based on CAF, 2010). Thus, each of the land-use scenarios described above is associated with a different level of public transport provision. **Three public transport quantity scenarios** are used in this analysis.

Baseline: Public transport expands according to the baseline evolution of urban density of each country. By 2050, total vehicle-kilometres of public transport service in the region are 1.9 those in 2010, and in per capita terms remain stable.

High public transport: In this scenario, the increase of public transport service provision depends not only on the relation with urban density but is intensified by a policy shift towards public transit expansion. In this case, expansion of service is set to be 50% higher than urban population growth in each country.[7] Total vehicle kilometres offered in public transport modes grow by a factor of 2.8.

Low public transport: Supply of public transport service develops in this case according to the *High sprawl* evolution of density in cities. As a result total vehicle-kilometres increase by only 20% during the 2010-2050 period. This corresponds to a 30% decrease in per capita service.

Data from the Urban Mobility Observatory reveal a positive relation between income and the proportion of public transport services delivered in rapid transit modes (rail or BRT trunk corridors[8]). This relation was used as an upper bound on how income growth translates into better quality public transport service in the region. The lower bound is the share of rapid kilometres in the preceding period. The model assigns increasing weights to the high bound share over time, reaching the share of rapid kilometres established in the chosen scenario by 2050.

Two public transport quality scenarios are explored. Since public transport quality is dependent on economic growth in our model, each scenario results in a different share of rapid kilometres. In the *baseline transport scenario*, kilometres of rapid public transport supply are 10% of the total offer in 2050 under baseline economic assumptions. Under lower growth, the share reaches 7.6% in 2050. In the *high quality* scenario, by 2050 rapid kilometers account for 15% of public transport service under *baseline* GDP growth. Under low GDP growth scenario, rapid kilometres account for 10.8% of public transport services.

Road infrastructure scenarios

Road infrastructure per capita is simulated by urban agglomeration category and country based on the negative relation between urban density and this variable (based on CAF, 2010). As in the case of public transport service, the relation between density and road expansion means that the different land-use scenarios lead to different outcomes for road infrastructure. The three scenarios used in this analysis are:

Baseline: Road infrastructure per capita expands at the rate that corresponds to the urban density evolution under *baseline* sprawl. Total kilometres of urban roads grow by a factor of 1.7. Road infrastructure per capita remains almost constant during the period.

High roads: Kilometres of urban roads per capita develop according to the scenario where road expansion is intensified. Road expansion is calculated to grow 50% more than urban population growth in every country. By the end of the period, this results in total vehicle-kms of road infrastructure in the region that are 2.6 times those of 2010. The growth factor in per capita terms is 1.46 compared to 2010.

Low roads: In this scenario, urban road infrastructure per capita grows following the *Low sprawl* evolution of urban density. Total urban road kilometres increase by a factor of 1.5, while per capita infrastructure decreases by 20% by 2050.

Table 2.2 summarises values of the context variables discussed above for the different scenarios in index form. It also recalls assumptions on technology and oil prices.

Table 2.2. **Latin American urban context under different scenarios**

				2010	2030	2050
Population				100	147	181
GDP		Baseline		100	234	507
		Low growth		100	194	349
GDP/capita		Baseline		100	159	281
		Low growth		100	132	193
Land use	Urban Density of Average urban agglomeration	Baseline		100	106	113
		High sprawl		100	75	70
		Low sprawl		100	117	130
Public transport service	Total vehicle -kms of service	Baseline		100	149	190
		High public transport		100	167	281
		Low public transport		100	106	121
	Per capita kms of service	Baseline		100	103	104
		High public transport		100	114	155
		Low public transport		100	73	67
	Share of rapid kms (quality)	Baseline	Baseline growth	4.4%	5.0%	10.0%
			Low growth	4.4%	4.6%	7.6%
		High quality expansion	Baseline growth	4.4%	6.4%	15.0%
			Low growth	4.4%	5.6%	10.8%
Road infrastructure	Total kms of road	Baseline		100	144	171
		High roads		100	162	263
		Low roads		100	130	149
	Per capita kms of road	Baseline		100	98	95
		High roads		100	110	146
		Low roads		100	89	83
Oil prices		Baseline		100	150	160
		High oil prices		100	253	264
		Low oil prices		100	65	64

Connection between underlying scenarios and transport

Ownership levels for light-duty vehicles and motorcycle ownership are calculated by urban agglomeration and country using quasi-logistic S-curves (figure 2.17). These were estimated on Urban

Mobility Observatory data and historical data on country ownership levels for the 15 cities included in the database. Explanatory variables are personal income, quantity[9] and quality of public transport, fuel prices, and road intensity.[10]

The form of the model implies that fuel prices will have an effect on the threshold of income at which growth in vehicle ownership speeds up. For both motorcycles and Passenger Light Duty Vehicles (PLDV), the negative sign of the corresponding coefficient means that the higher the fuel price, the higher the income threshold at which ownership growth accelerates. Even for urban agglomerations that present ownership levels that are above take-off, modifying fuel prices throughout the period shifts downwards the 2010-2050 path of ownership.

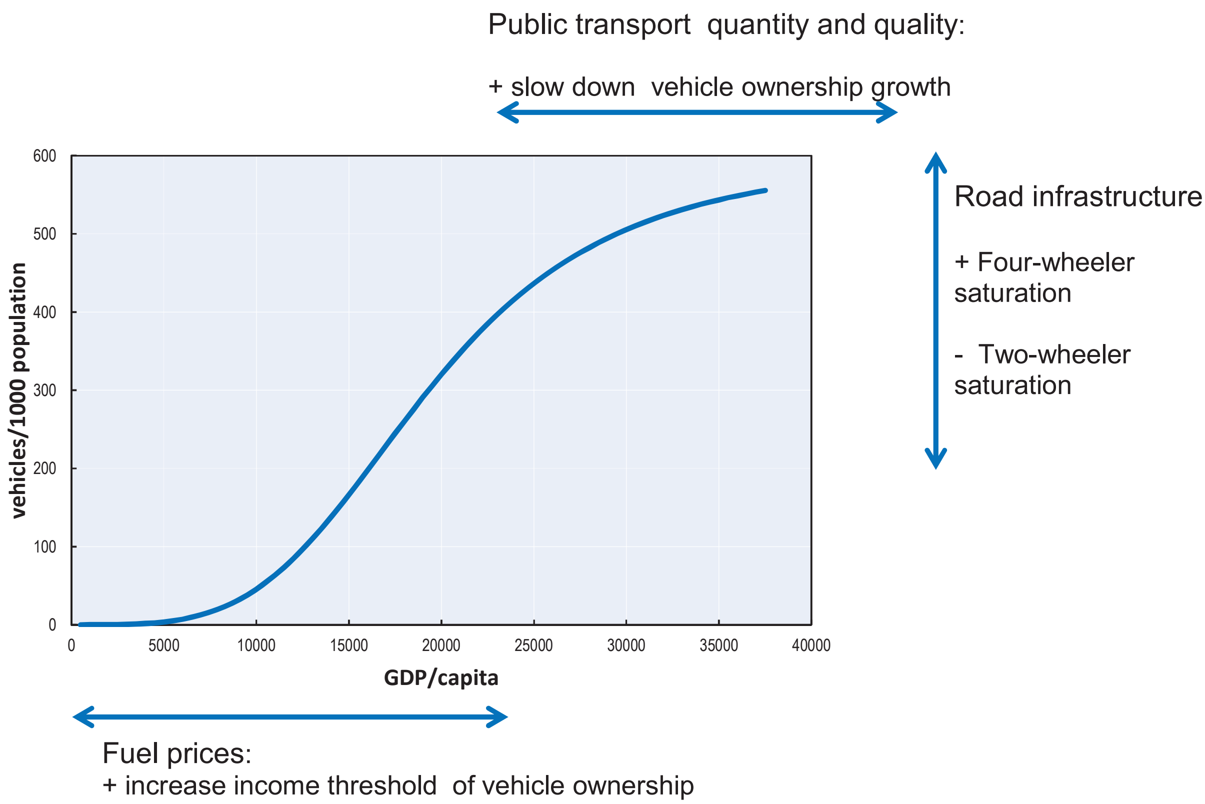
For both types of private vehicles, higher levels and quality of public transport tend to slow-down the growth of ownership.

Road provision has opposite effects on car and motorcycle ownership and data suggests that higher road provision will tend to increase the saturation levels for cars and decrease those of motorcycles. Figure 2.17 summarises impacts of different scnearios on urban vehicle ownership.

Vehicle-kilometres driven by private modes are calculated using a -0.25 elasticity of usage with respect to fuel prices, with initial levels of use matched to the IEA MoMo model for each country. Passenger-kilometres, fuel consumption and CO_2 emissions are based on IEA MoMo assumptions.

Public transport ridership depends on urban density and its correlation with the share of public transport in overall passenger mobility and on income and fuel price elasticities. As we are not aware of any study that has calculated these elasticities for Latin America, international parameters from urban studies are applied. The fuel price elasticities used are 0.15 for buses and 0.27 for rail and Bus Rapid Transit (BRT). The income elasticity is only used for buses and is set at -0.62 (Litman, 2004). Reduction in private passenger-kilometres due to improved public transport service quality is allocated to public transport modes.

Figure 2.17. **Impact of different scenarios on urban vehicle ownership**



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Urban mobility and CO_2-emission scenarios for Latin America

Isolating the effects of different urban scenarios

This section discusses scenarios where only one parameter changes. The next section examines four scenarios combining urban policies and exogenous variables to reflect a diverse range of strategies for urban mobility in Latin America. Anticipating the results, it is worth noting that strong changes in mobility outcomes only result when several transport and planning policies are combined. The baseline, business as usual, scenario serves as the benchmark and is discussed first

In the *baseline* scenario all variables develop according to their business as usual trend (see Table 2.2). Under these assumptions and with baseline GDP growth, mobility in urban Latin America grows rapidly and by 2050 is 3.7 times as large as in 2010 (Figure 2.19). The share of public transport in urban mobility falls by more than half by 2050. Four-wheeler and two-wheeler shares rise by 16% and 8% respectively (Figure 2.18). Passenger transport related CO_2 emissions are, by 2050, 3.2 times the 2010 levels. On average, CO_2 emissions rise by a rate of 0.88% for every 1% rise in mobility (Figure 2.19).

The *baseline* with l*ow* economic growth leads to a rise in mobility by a factor 3.2 between 2010 and 2050. The slower rise in personal incomes delays the rise of private vehicle ownership and therefore the shift away from public modes. Nonetheless, four-wheeler and two-wheeler shares grow by 12% and 5% respectively, and the public transport share in mobility still drops significantly to 28%. C02 emissions in 2050 are 2.6 times as high as in 2010 levels. The lower share of private vehicles translates into a rise in emissions at an average rate of 0.83% per every 1% rise in mobility.

Different patterns of *urban sprawl*, here modelled through different population density scenarios, do not affect total mobility levels by much, but outcomes do differ in terms of modal split and CO_2 emission growth. More sprawl intensifies road provision and discourages public transport service. Higher levels of sprawl accelerate ownership of private modes by making public modes less available and competitive. They also generate lower ridership of existing public transit service. By intensifying road infrastructure, sprawl speeds up car ownership as costs of congestion are delayed. With high urban sprawl public modes represent 13% of total urban passenger-kilometres in 2050, against 25% with low urban sprawl. In terms of CO_2 emissions, the result is growth by a factor 3.6 with high sprawl and 3.1 with low sprawl – for similar total mobility levels. Sprawl increases CO_2 emissions 13% relative to baseline outcomes. High density land use development reduces CO_2 emissions 3% (figure 2.20).

Low *oil prices* (which here translates into low fuel and usage costs) increase ownership and, more strongly, use of private modes. Conversely, high fuel prices or vehicle usage costs are a relatively powerful tool for reducing use of private vehicles. However, isolated pricing policies tend to reduce negative impacts of transport at the expense of reducing mobility, because more expensive private transport without expanded availability of public transport confronts growing proportions of the population with restricted mobility options. With high and low fuel prices CO_2 emissions grow to 3.8 and 2.9 times their 2010 levels respectively. This is equivalent to a 9% decrease and a 19% decrease over the baseline respectively. Mobility would grow by factors of 4.2 and 3.4 respectively by 2050, and the share of public transport would be 17% and 24% respectively.

The level and quality of public transport and of road infrastructure affects the share of public transport as well as the relative use of four-wheelers and two-wheelers. The following combinations illustrate the effects:

- *High public transport* and *High road* provision*:* expansion of public transport service is 50% higher than urban population growth; by 2050 the proportion of service offered in rapid modes is 15% of total public transport service; road provision also is 50% above urban population growth.
- *High public transport* and *Low road* provision*:* same as previous for public transport; road expansion lags behind population growth as it would in case of low sprawl development (but sprawl itself is modelled following baseline trends).
- *Low public transport* and *High road* provision: expansion of public transport service lags behind population growth in a similar magnitude as in the high sprawl scenario; by 2050 the proportion of service offered in rapid modes is maintained at 10% of total public transport service; road provision expands at 50% above urban population growth.
- *Low public transport* and *Low road* provision: same as previous for public transport; road expansion lags behind population growth as it would in case of low sprawl development.

The first of these four scenarios leads to the strongest urban mobility growth, by a factor of 4 between 2010 and 2050. Public transport mobility grows significantly, and private mobility is strongly dominated by four-wheel vehicles. The lower bound in terms of mobility is found in the fourth scenario, where mobility grows by a factor 3.6 from 2010 through 2050. This is below business as usual growth and is mainly due to low growth in public transport mobility and the higher share of two-wheelers in private mobility.

High public transport with *Low road* infrastructure and *Low public transport* with *High road* infrastructure scenarios produce mobility levels just above *Baseline* levels (3.8 times the 2010 level). The scenario with *Low public transport* and *High road* provision generate slightly higher mobility throughout but the gap between the two scenarios closes towards the end of the period (Figure 2.19).

Scenarios where more and better public transport is provided result in a higher share of public transport use and in this way reduce transport-related CO_2 emissions compared to *Baseline* levels. Public transport mobility shares by 2050 are 38% and 41% in the high public transport with high and low road provision cases respectively. CO_2 emissions in 2050 in the two cases are 3 and 2.7 times the 2010 levels (7% and 17% less than baseline CO_2 emissions). In contrast, the low public transport expansion case results in a share of public transport by 2050 of 14% and 15% in its high and low road expansion variants. CO_2 emissions are 3.7 and 3.3 times as high as in 2010 respectively, both above *Baseline* levels (16% and 3% respectively).

Figure 2.18. **Transport modal shares when varying elements of the urban context**

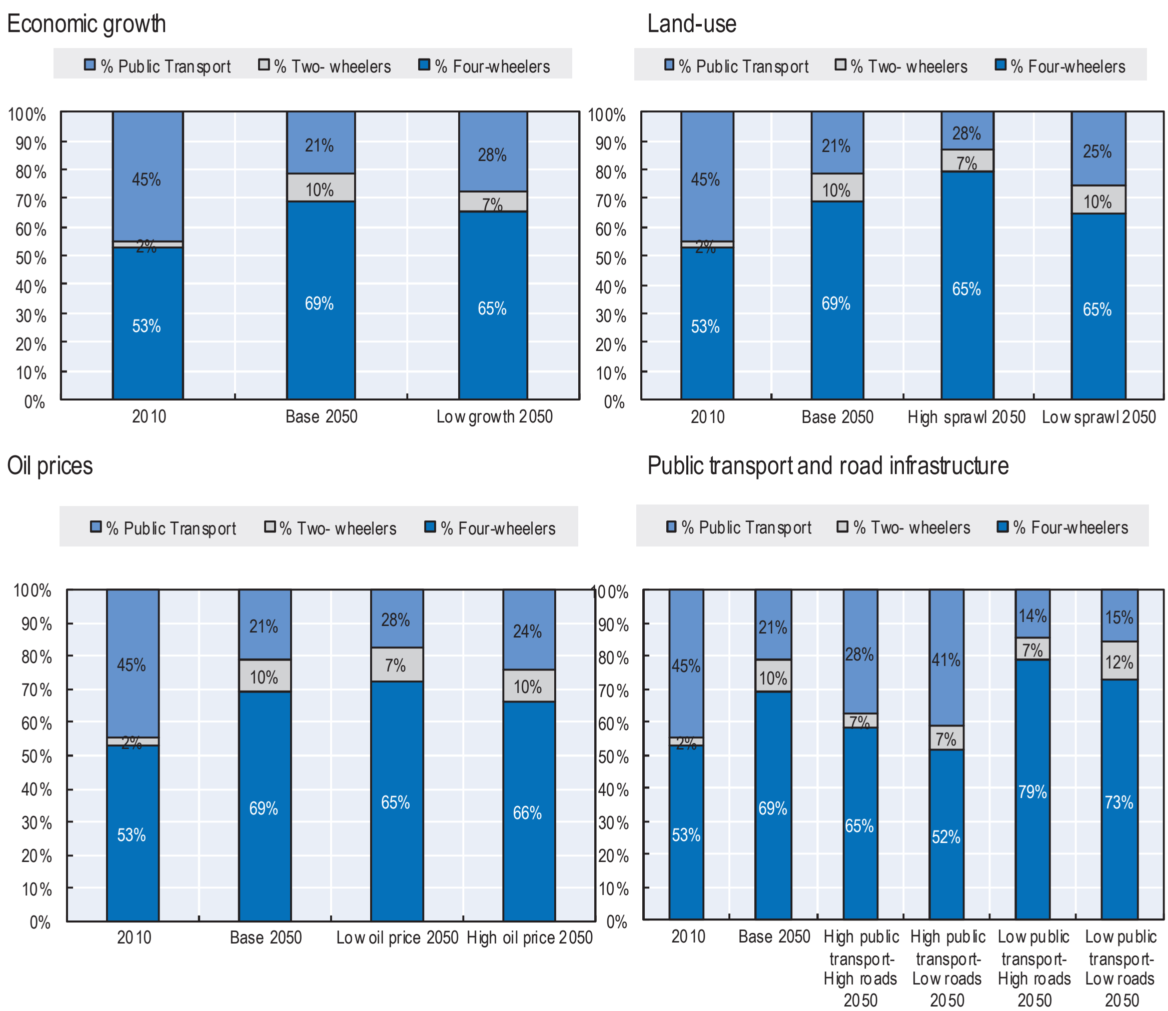

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Figure 2.19. **Urban mobility and CO_2 emissions when varying elements of the urban context**

2010=100

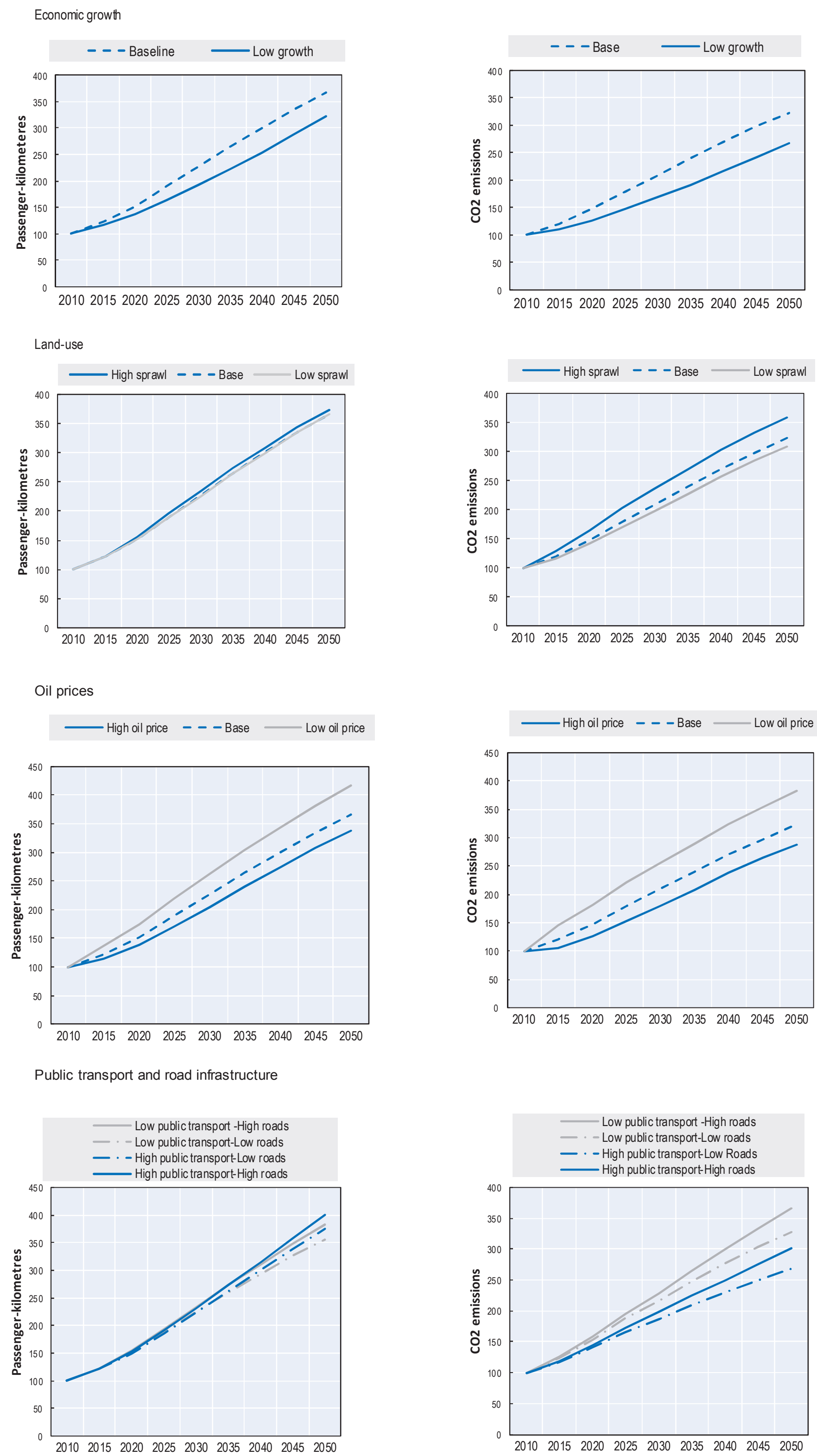

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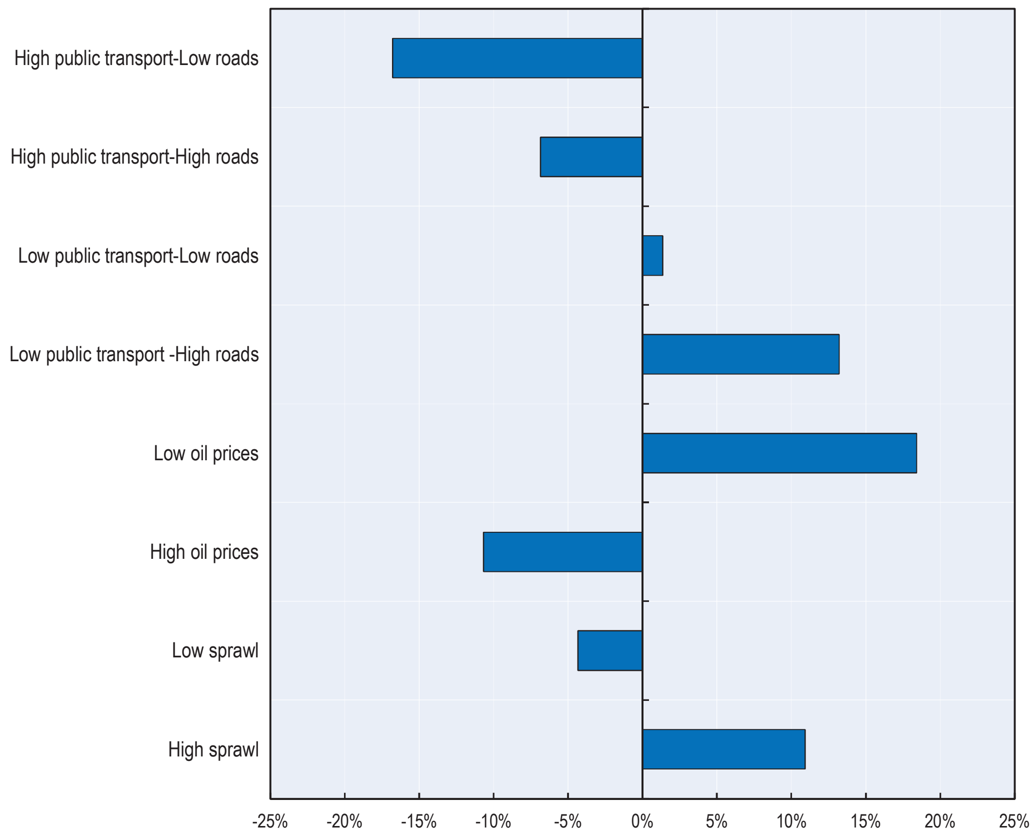
Figure 2.20. **Changes in CO_2 emissions relative to the baseline**



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Summary of different urban policy pathways

This section considers combinations of changes in context variables. It is these combinations that are relevant to the development of urban and total mobility in Latin America. With the aim of exploring the scope of the possible differences two main settings have been considered. Under *Private transport-oriented* urbanisation**,** urban agglomerations grow following the *High sprawl* scenario. Public transport service evolves according to the resulting sprawl and therefore follows the *Low public transport* path. Quality of the public transport offer increases at its *Baseline* rate. Finally, fuel prices develop under the *Low oil price* case. Under *Public transport-oriented* urbanisation, urban agglomerations grow following the *Low sprawl* scenario. Public transport expands at a faster rate than population, and its quality increases significantly. These trends correspond to the *High public transport* and *High quality* configurations. Fuel prices follow the *High oil price* path. Combining these basic urbanisation paths with the *High* and *Low road* infrastructure scenarios creates four variants.

Private transport-oriented mobility urbanisation with *High road* infrastructure expansion,

Private transport-oriented mobility urbanisation with *Low road* infrastructure expanion,

Public transport-oriented mobility urbanisation with *High road* infrastructure expansion,

Public transport-oriented mobility urbanisation with *Low road* infrastructure expansion.

In *Private transport-oriented* scenarios urbanisation fosters private mobility and results in higher levels of mobility (Figure 2.22). Mobility levels are 4.3 and 4 times the 2010 level respectively. A significant proportion of the mobility difference with public transport oriented urbanisation is generated by diverging fuel prices, as can be inferred from considering *Private transport-oriented* mobility urbanisation with *High road* infrastructure expansion, under *baseline* oil prices. This generates mobility that is 3.8 times as high as in 2010 instead of 4.3 times as high.

While *Public transport-oriented* urbanisation scenarios result in lower mobility throughout the period, the gap with mobility levels under *Private transport-oriented* urbanisation scenarios tends to close as time progresses. This is because by the end of the period the expansion of public transport service and the progressive penetration of high quality modes begin to offset restrictions in private mobility caused by the high costs of fuel assumed in these scenarios. Lower sprawl also promotes the reduction of the gap by fostering higher ridership of public transport.

Modal splits differ strongly between the two types of urbanisation scenarios (Figure 2.21). In *Private transport-oriented* urbanisation, public modes would have an 11% and 12% share in 2050 while 4 and 2-wheeler vehicles shares rise strongly. With *Low road* infrastructure motorcycles reach the same proportion of total passenger-kilometres as public transport in 2050. With *High road* infrastructure, the rise of 2-wheeler use is smaller but their share still increases, to 7% in 2050. Contrastingly, *Public transport-oriented* urbanisations scenarios allow to maintain current private/public mobility shares while urban mobility grows. In both scenarios, motorcycles still increase their share but at a lower rate. In the *Low road* expansion case their increased participation accompanies a decrease in the share of 4-wheeler vehicles.

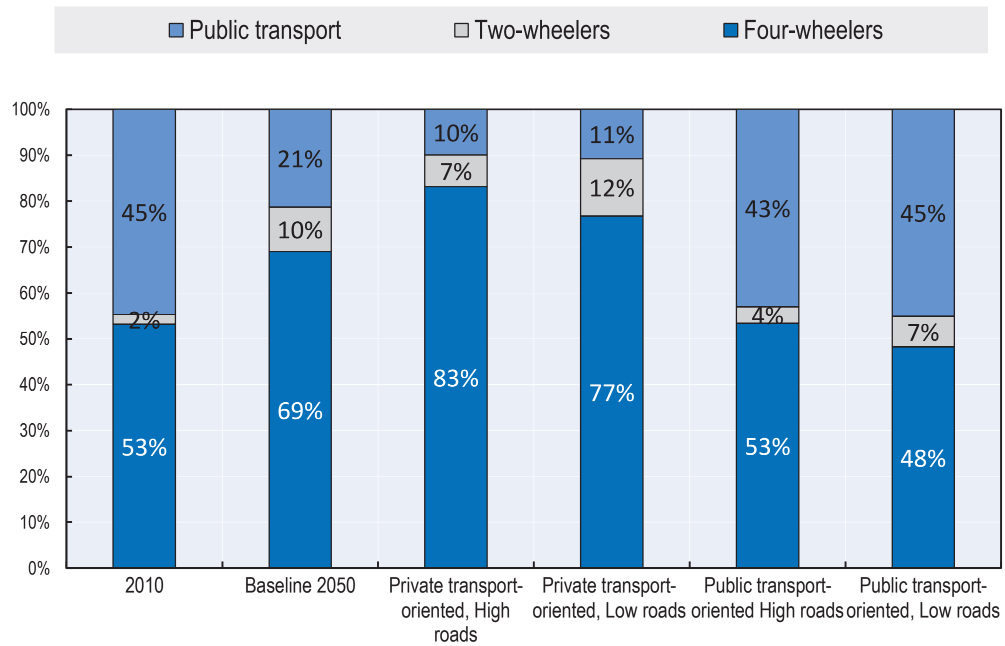
Not surprisingly, *Private transport-oriented* urbanisation scenarios result in higher than *baseline* growth of CO_2 emissions, 4.3 (34%) and 3.8 times (19%) 2010 levels respectively. The scenarios result in higher mobility than the Baseline case and they increase the carbon intensity of the additional mobility. In both scenarios, growth in CO_2 emissions is just as fast as mobility growth whereas in the *Baseline* case CO_2 emissions grow at 0.88% for every 1% increase in mobility. *Public transport-oriented* settings generate lower than *Baseline* growth in CO_2 emissions, 2.6 and 2.4 times that in 2010 (19% and 25% below baseline respectively). In both scenarios, mobility now is less carbon-intensive than in the *Baseline* scenario: CO_2 emissions grow by 0.7% for every 1% growth in mobility.

The IEA's 450 technology scenario[11] assumes significant fuel efficiency improvements for gasoline vehicles. It also includes higher penetration of alternative technologies (electric vehicles, plug in hybrids, etc.) which by 2050 make up about 40% of the world light-duty vehicle fleet. For two-wheelers, the electric share is even higher. Buses also become more fuel efficient. This scenario is more likely in the case where oil prices are high, making alternative technology adoption more cost-effective.

Other things equal, a shift to cleaner, more fuel efficient vehicle technologies would result in slightly greater use of private vehicles, as technology driven increases in car purchase prices are outweighed in the model by lower costs of using vehicles (per kilometre) than under the Baseline. Under the IEA's 450 technology scenario for vehicle fleet improvement, lower CO_2 emission pathways can be achieved at higher urban mobility levels under the public transport-oriented scenario. CO_2 emissions grow on average by only 0.4% for every 1% increase in mobility.

Figure 2.23 summarises effects of different urban pathways on CO_2 emissions relative to the baseline.

Figure 2.21. **Urban modal shares under alternative urban settings**



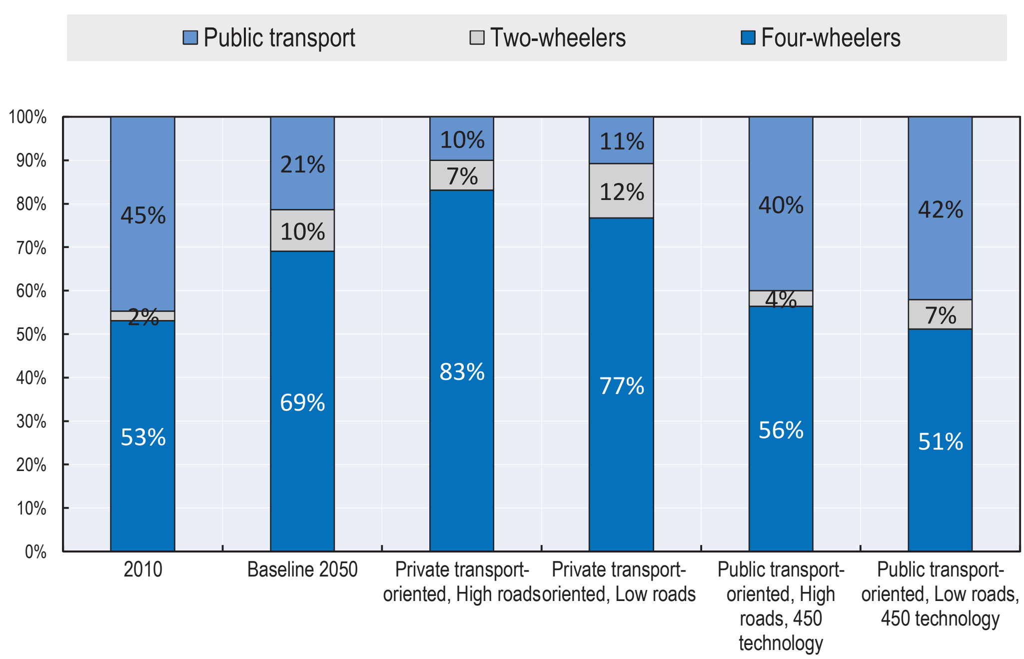


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Figure 2.22. **Urban mobility and CO_2 emissions**
Alternative urban pathways, 2010=100

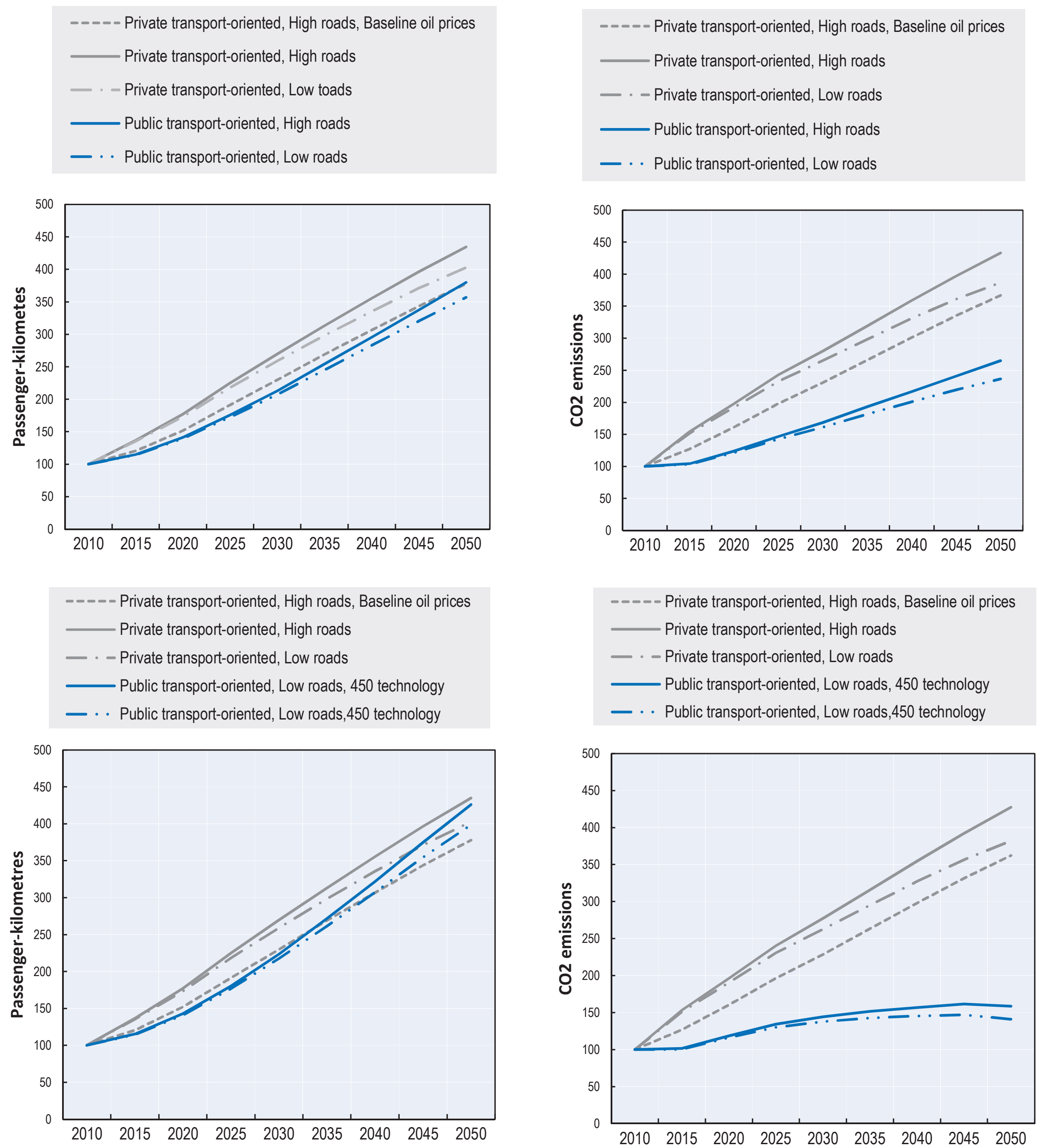

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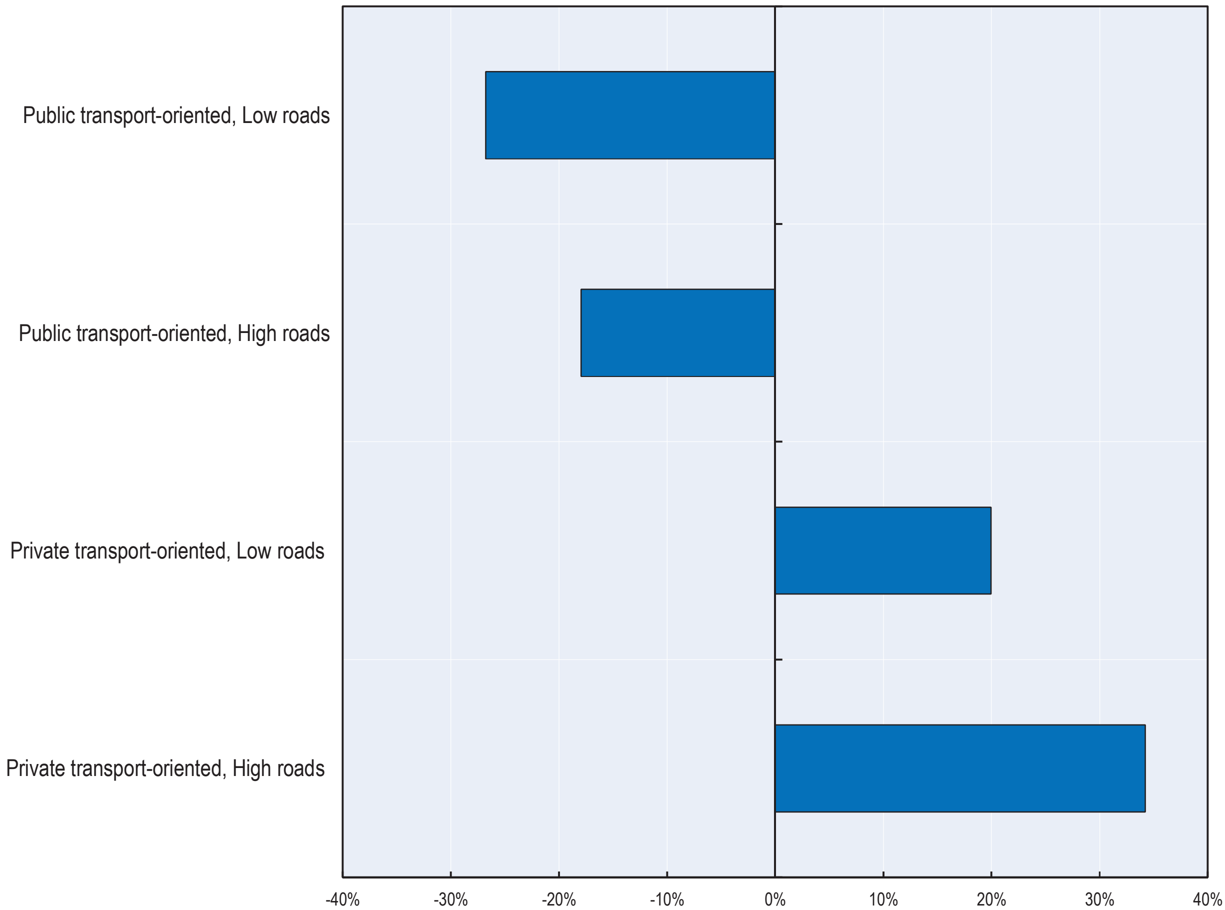
Figure 2.23. **Impact of different urban pathways on CO_2 emissions relative to the baseline**



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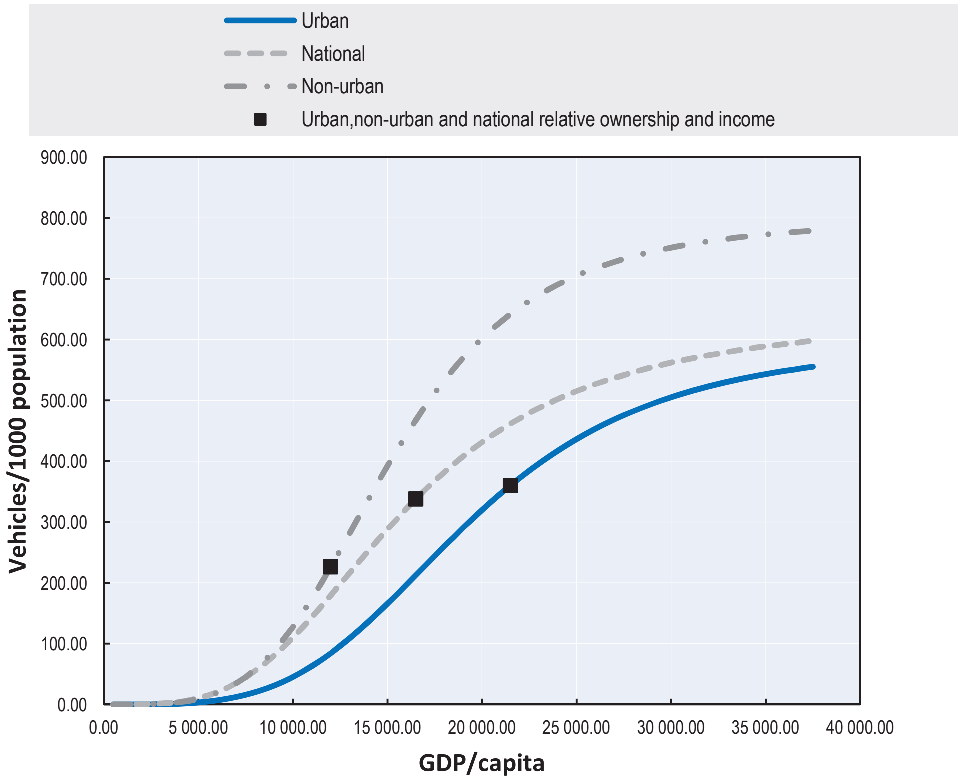
The results of the different urban policy scenarios have large effects on the overall transport outcomes for Latin America. In the model, national ownership rates are the average of urban and non-urban levels weighted by population shares in each sector (see Figure 2.24). Due to the concentration of income in urban areas and elevated levels of urbanisation the urban income-ownership pathways will account for much of the difference in national and regional fleet composition and travel patterns and related externalities.

Figure 2.24. **Relationship between urban, non-urban and national vehicle ownership**



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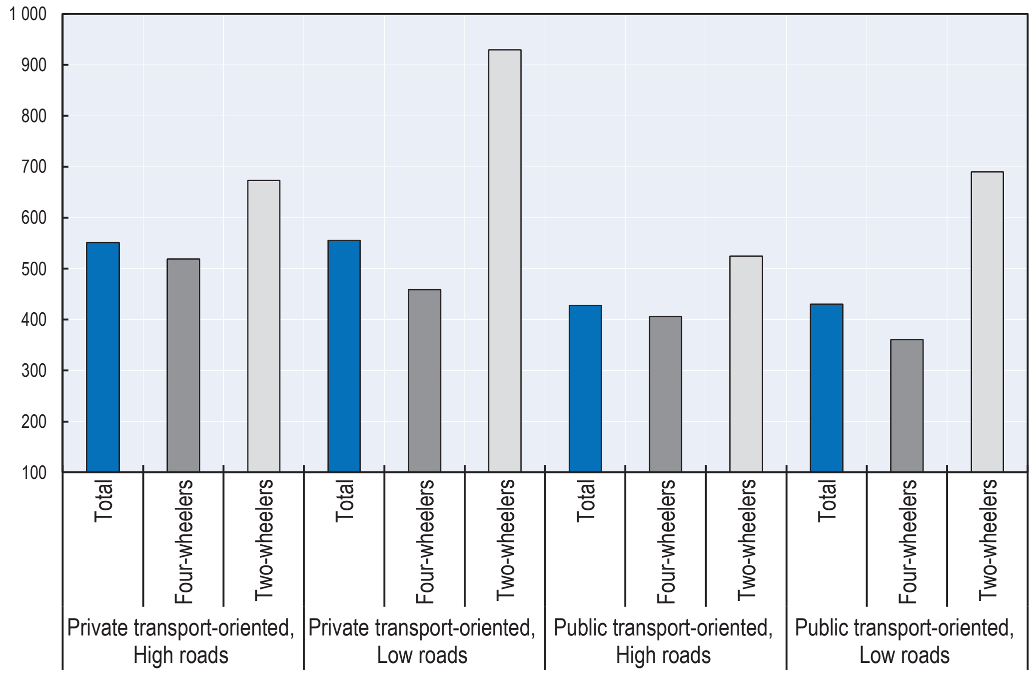
Under the urban policy scenarios the total private vehicle fleet in Latin America would grow 5.5 times in scenarios where urban policies foster private mobility and 4.3 times in the case where they foster more public transport modes (Figure 2.25). Private mobility oriented urban contexts where road infrastructure expansion is slow will speed up already high growth of two-wheeler ownership while lowering to some extent the future growth of 4-wheeler vehicles. In urban contexts that foster public mode use, high fuel prices and better public transport supply, would result in a lower growth for both four and two-wheelers.[12]

Figure 2.25. **Latin American private fleet growth, 2050**
Different urban pathways scenarios, 2010=100



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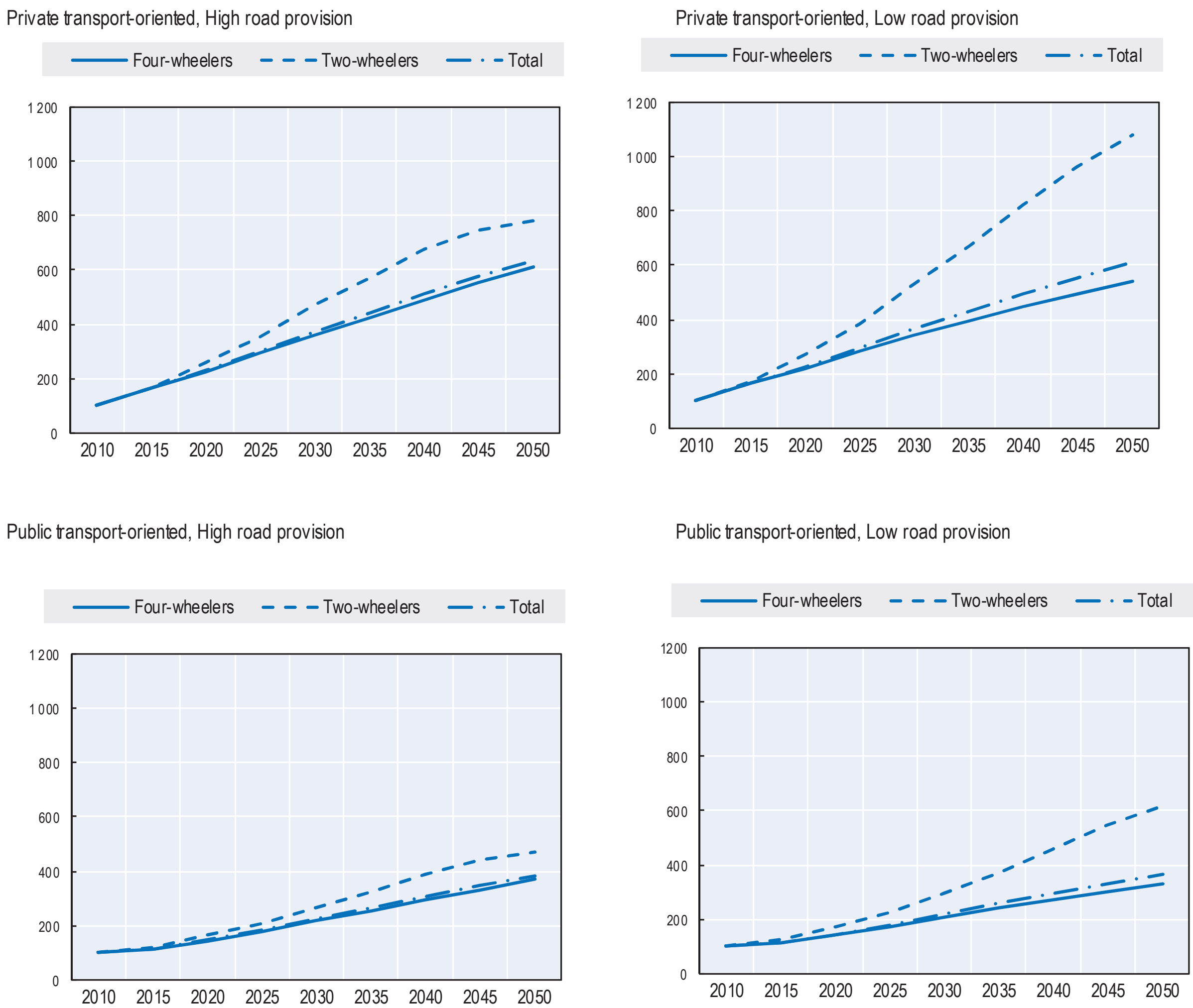
The evolution of private vehicle-kilometres under the different scenarios mirrors that of the fleet, but differences are magnified by the effect of variations in fuel prices on vehicle use (Figure 2.26). Both two-wheeler and four-wheeler travel will rise significantly faster under scenarios where urbanisation fosters private mobility. Scenarios where road infrastructure expansion in cities is fast will tend to see higher growth in kilometres travelled by four-wheelers. For two-wheelers, growth show signs of slow-down earlier in these scenarios.

Figure 2.26. **Total private vehicle-kilometres in Latin America under different urban settings**
2010=100



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Regional development paths and their implications for transport

Regional GDP scenarios

Table 2.3 shows the relative changes in GDP, population, GDP/capita and oil prices for the nine geographical regions relative to the base year 2010. For GDP and GDP/capita baseline and low growth scenarios are shown and for the oil price a reference and high and low scenario.

Table 2.3. **GDP, GDP per capita, population and oil price by region**
2010=100

Growth scenarios

GDP		2010	2030		2050	
			Baseline	Low growth	Baseline	Low growth
	Africa	100	211	184	467	351
	Asia	100	243	193	563	373
	China + India	100	345	227	669	404
	EEA + Turkey	100	143	134	204	177
	Latin America	100	195	168	375	273
	Middle East	100	197	172	379	298
	North America	100	162	149	246	209
	OECD Pacific	100	138	123	193	152
	Transition	100	161	153	250	215
	World	100	202	165	357	258
GDP per capita	Africa	100	139	121	219	165
	Asia	100	195	155	405	268
	China + India	100	303	200	575	347
	EEA + Turkey	100	136	127	194	168
	Latin America	100	165	142	300	219
	Middle East	100	142	124	221	174
	North America	100	139	128	190	161
	OECD Pacific	100	137	122	201	159
	Transition	100	160	152	257	222
	World	100	168	137	267	193

Population and oil prices

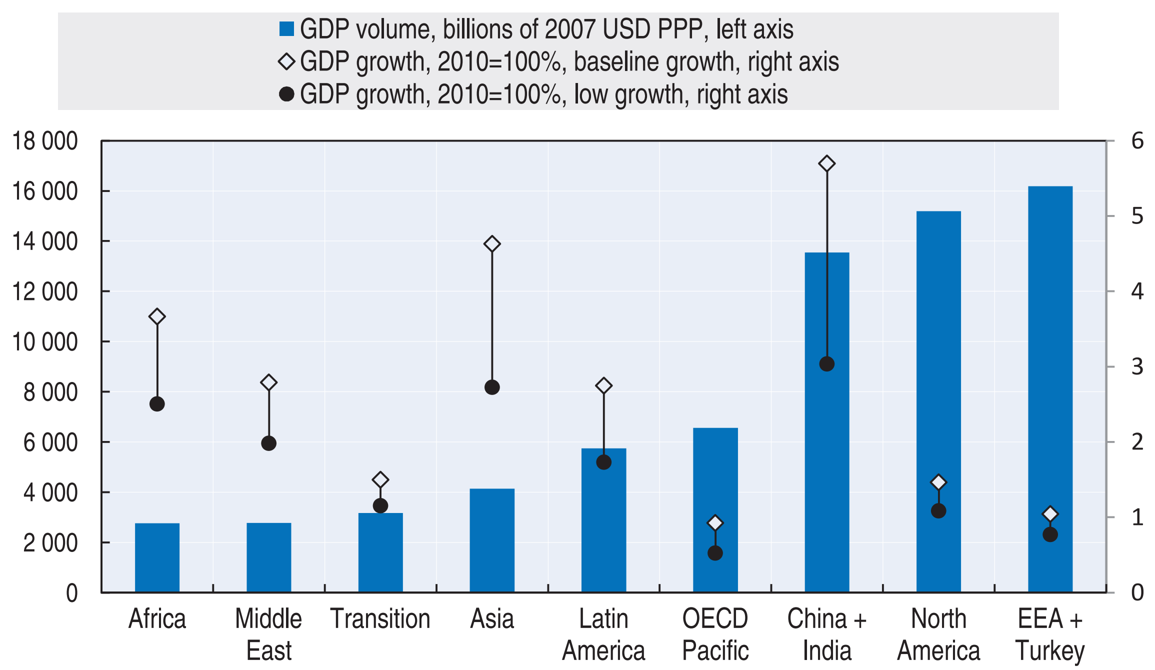
Population		2010	2030	2050
	Africa	100	152	213
	Asia	100	125	139
	China + India	100	114	116
	EEA + Turkey	100	105	105
	Latin America	100	118	125
	Middle East	100	139	171
	North America	100	117	130
	OECD Pacific	100	101	96
	Transition	100	100	97
	World	100	120	134
Oil prices	World, high	100	253	264
	World, baseline	100	150	160
	World, low	100	65	64

Source: Based on IEA (2013), United Nations (2012a), OECD (2012), Conference Board (2012) and IMF (2013).

Over the period 2010 to 2050 average annual growth of world GDP is 3.2% in the baseline scenario and 2.4% in the low growth scenario. This means global real GDP measured in PPP terms will increase by a factor of 2.6 to 3.6 by 2050, and is set to slow down from growth averaging 3.5% – 4% during the last decade, in both scenarios.

In the baseline growth scenario the world GDP growth rate is sustained in the near term (at 3.5% per year) and slows gradually during rebalancing, finally reaching 2.7% annual growth after 2040. In the low growth scenario the slowdown is much more abrupt (there is a "hard-landing") in the medium to near term with the average growth rates down from 3.5% - 4% and levelling off to between 2.3% and 2.5% per annum in the following periods. Despite our relatively low projections world output is set to double by 2030 or 2040, depending on the scenario. The loss of momentum during the aftermath of the financial crisis amounted to loss of economic output equivalent to about 5 years (ITF, 2012). Globally the economic centre of gravity will shift further east and further south, and demand patterns will change greatly as a much larger population base enters income ranges between 15 and 30 thousand USD at 2007 PPP.

Figure 2.27. **GDP volume, 2010 and growth to 2050, by region: baseline and low growth scenarios**



Source: Based on OECD (2012), Conference Board (2012) and IMF (2013).

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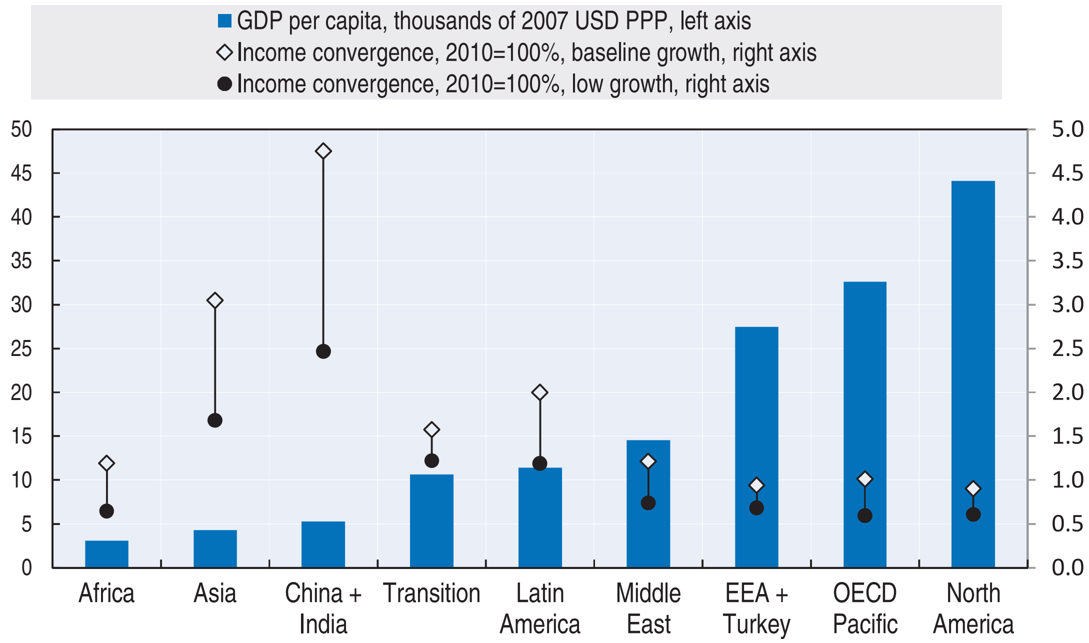
Figure 2.28. **GDP per capita, 2010 and income convergence between 2010 – 2050 by region: baseline and low growth scenarios**



Source: Based on OECD (2012), Conference Board (2012) and IMF (2013).

StatLink http://dx.doi.org/10.1787/888932944654

Income convergence is particularly strong in the lesser developed regions of non-OECD Asia including China and India, and Latin America. Asia and in particular China and India can be identified as the pivotal regions in the world economy. They are already producing output at levels similar to North America and EEA + Turkey but still show much larger growth potential. Per capita incomes are set to grow by 250% to 480% in China + India which means overall economic output could be up to 580% higher in the baseline scenario. In comparison, the economic output of North America and EEA + Turkey is only set to grow by 80% - 120% over 2010 levels.

The middle income regions of Latin America, the Middle East and the Transition economies show more moderate growth prospects but already enjoy higher levels of development.

In general natural resource rich economies will enjoy continued strong demand for their exports. In Latin America the development of a stronger industrial base will also contribute to growth. In the Transition economies this effect is more subdued. Per capita income growth over 2010 levels ranges from 110% –200% in Latin America and in the Transition economies between 120% – 150%. Economic output is to approximately double in the Eastern European and Central Asian transition economies but grows by 180% – 260% in Latin America, which in the medium term also benefits from positive demographic developments.

Efforts at increasing connectivity to major markets are underway in most regions. Transport infrastructure investment is increasing port catchment areas and extending the economic reach of the hinterland in both Europe and Asia. For example, the Iron Silk Road may allow countries to latch on to trade flows between Asia and Europe which benefit from reduced shipping times compared to maritime routes. This may help foster industrial and consumer bases in both regions. The Middle East, also at cross-roads of major trading regions and benefitting from natural resource endowments, will see economic output grow 200% – 280% over 2010 levels and per capita income by 65% – 120%.

Africa and Asia, excluding China + India, are the regions with the largest growth potential. Africa shows increasing realisation of this potential towards the end of the projected time period with average per capita income growth rates up to 2.3% during the period 2030 – 2050 up from 1.5% to 1.8% in earlier periods. Output volumes grow by 4.1% in later periods. Growth is already strong in some of the region's countries, but connectivity in general is still poor and some regions land-locked.

In South and South-East Asia production growth is strong with GDP volumes set to increase by 270% – 460% over 2010 levels. Per capita income levels increase by 170% – 300%. Growth is stronger from the onset, especially in some of the more dynamic ASEAN countries. This region depends on China due to geographic proximity and inclusion in regional value chains.

The OECD Pacific region is assumed to experience growth in line with current development levels, ranging from 60% – 101% growth per capita income and 50% – 90% growth in GDP. The largest economy in the region, Japan, faces increasing demographic pressures as population growth is to slow considerably. Australia can rely on export of raw materials, although previously strong exports to China slow in the low GDP growth scenario. Overall, the region is dependent on trade and on developments in the East and South-East Asian region as well as in North America.

Table 2.4. **Real GDP, average annual growth rates, baseline and low growth scenarios**

	2010-2020		2020-2030		2030-2050	
	Baseline	Low growth	Baseline	Low growth	Baseline	Low growth
Africa	3.8%	3.1%	3.8%	3.1%	4.1%	3.3%
Asia	4.7%	3.4%	4.4%	3.3%	4.3%	3.3%
China + India	7.6%	4.6%	5.1%	3.7%	3.4%	2.9%
EEA + Turkey	1.8%	1.5%	1.8%	1.4%	1.8%	1.4%
Latin America	3.4%	2.7%	3.4%	2.5%	3.3%	2.5%
Middle East	3.6%	3.0%	3.4%	2.5%	3.3%	2.8%
North America	2.5%	2.0%	2.4%	2.0%	2.1%	1.7%
OECD Pacific	1.5%	1.1%	1.7%	1.0%	1.7%	1.1%
Transition	2.5%	2.3%	2.3%	1.9%	2.2%	1.7%
World	3.8%	2.6%	3.4%	2.4%	2.9%	2.3%

Source: Based on OECD (2012), Conference Board (2012) and IMF (2013).

Table 2.5. **GDP/capita, average annual growth rates, baseline and low growth scenarios**

	2010-2020		2020-2030		2030-2050	
	Baseline	Low growth	Baseline	Low growth	Baseline	Low growth
Africa	1.5%	0.9%	1.8%	1.1%	2.3%	1.5%
Asia	3.4%	2.1%	3.4%	2.3%	3.7%	2.8%
China + India	6.8%	3.8%	4.6%	3.2%	3.2%	2.8%
EEA + Turkey	1.5%	1.2%	1.6%	1.2%	1.8%	1.4%
Latin America	2.4%	1.7%	2.6%	1.8%	3.0%	2.2%
Middle East	1.7%	1.1%	1.9%	1.1%	2.2%	1.7%
North America	1.7%	1.2%	1.7%	1.3%	1.6%	1.2%
OECD Pacific	1.4%	0.9%	1.8%	1.1%	1.9%	1.3%
Transition	2.4%	2.2%	2.4%	2.0%	2.4%	1.9%
World	2.7%	1.6%	2.5%	1.6%	2.4%	1.7%

Source: Based on OECD (2012) , Conference Board (2012) and IMF (2013).

Passenger transport projections

This section applies insights from the Latin America case study to global surface passenger transport projections. It builds on Dargay, Gately and Sommer`s framework for world car ownership projections. Their most recent work includes urbanisation as a variable that reduces the saturation levels of private vehicle ownership on the country level. Applying their framework under our GDP growth scenarios for the Latin American region results in levels of ownership obtained using the Latin American urban model discussed in the previous section, under our *Baseline* with *High Road* infrastructure expansion.

Box 2.3. **Dargay, Gately and Sommer's framework for world car ownership projections**

The framework develops a model for vehicle ownership simulations into the future. It is estimated on the basis of pooled time-series (1960-2002) and cross-section data for 45 countries that include 75% of the world's population. The main driver for vehicle ownership is GDP/capita. The framework explicitly models the vehicle saturation level as a function of observable country characteristics: urbanisation and population density.

Source: Dargay et al. (2007).

The four summary urban scenarios developed for Latin America above were applied to other regions of the world on the assumption that the Dargay, Gately and Sommer results reflect a business as usual scenario with high road infrastructure investment for all countries, as this is most similar to the data on which the model is estimated. Income-ownership pathways were shifted from the average using coefficients calculated in the Latin American case study for every element of the urban context,[13] weighted by the share of urban population in each of the countries. In this way, the methodology produces national scenarios that account for differences in levels of urbanisation. Ownership is also made dependent on the segment of the income-ownership pathway countries fall on. Countries at income levels where the income elasticity of ownership is low will, for example, have lower overall changes.

In the case of two-wheelers, there are no world ownership projections as far as we know. For countries and regions where specific research has been conducted, we used the findings to calculate business as usual income-ownership pathways.[14] This is the case for India, China, and the ASEAN and Other Developing Asia (ODA) regions (Tuan, 2011; Asian Development Bank, 2006; Argonne National Library, 2006). For other MoMo regions we took Baseline trends provided in the MoMo model to calculate the functions to be shifted. The procedure by which such functions where shifted to calculate income-ownership pathways under the different policy scenarios is similar to that used for four-wheel vehicles and accounts for regional differences in the same way.

Bus and rail world scenarios were built using the MoMo baseline for non-urban bus and rail simulations. In the case of urban bus vehicle kilometres, starting points were taken from MoMo. Urban rail vehicle kilometres for 2010 were estimated by ITF using data for urban rail track infrastructure from the International Association of Public Transport (UITP) and the vehicle-kms/infrastructure ratios calculated from the UITP's Millennium Database. Total public transport service in each scenario was assumed to expand at the same rate relative to urban population as in the Latin American case study in each of the scenarios. The percentage of rapid kilometres was assumed to grow at the same rate, relative to per capita income growth of each region than in the Latin American case study.

The different urban transport policy packages result in significant differences in the growth of the world's private vehicle fleet. The highest case results from a context where urban transport in the existing and new urban centres develops according to the *Private transport-oriented, High roads* policy package. The lowest case corresponds to a scenario where this development occurs under the conditions of the *Public transport-oriented, Low roads scenario*. Overall, urbanisation under these two pathways accounts for a difference of 500 million private vehicles by 2050 in the *Baseline* GDP case, and 600 million in the case of *Low* economic growth case (see Figure 2.29).

The effects of alternative urban transport policy on future private vehicle fleet growth vary by region. They depend on income and current location on the "S-curve" describing the development of motorisation as well as the present level of urbanisation and speed of future urbanisation. Another important factor is the level of market development for different types of private vehicle rates (four and two-wheelers). Description of past trends for two-wheelers is based on Montezuma (2012). Figures 2.30 and 2.31 show the 2010 four-wheeler and two-wheeler ownership by world region and expected 2010-2050 growth for these vehicles under the four different urban policy setting scenarios (with Baseline GDP growth).

Higher-income regions (North America, EEA+Turkey, OECD Pacific) have already gone through the accelerated motorisation phase in the past and today show a low and decreasing elasticity of private vehicle ownership with respect to income. Motorisation in these regions was predominantly in the form of four-wheelers, in particular in North America. In the EEA+ Turkey region, the spread of two-wheelers was more significant in countries such as Italy, Spain, Germany and France. However, decreasing prices of less expensive cars slowed down the demand and the production boom of the 1960's, reducing their role in the motorisation process of the region. During the 1980's these vehicles gained some market share but ownership rates remain very low compared to four-wheelers. In the OECD Pacific region, motorcycle ownership is highest in Japan, which during the 1970's became the main manufacturer of these vehicles. Ownership of two-wheelers grew rapidly during the 1960's and also during the 1980's reaching levels well beyond those of European countries. However, two-wheeler ownership slowed down soon after four-wheeler ownership began to accelerate and has even showed decreasing trends, suggesting that two-wheeler’s were significant only as a short-term stage of motorisation in this country. In Korea two-wheeler motorisation followed the same pattern but slowed down at lower levels of ownership than in Japan.

The low elasticity between income and private vehicle ownership plus the modest economic growth expected during the period, suggest low growth in the private vehicle fleet of high income regions in the years to come. Since urbanisation rates in these regions are high, diverging urban transport policy has appreciable effects, even when income elasticities are low. The highest differences are generated by higher road infrastructure expansion in urban centres which raise saturation levels for four-wheelers and therefore shift a significant part of the growth towards these vehicles. Overall higher private fleet growth is generated by these scenarios. Differences in public transport and fuel prices have a limited effect because of the small income elasticities in late motorisation stages. Nonetheless, these elements could explain to a great extent the inter-regional difference in the ownership levels at which elasticities began to decrease and therefore, different present private ownership levels between them.

Middle-income regions (Transition Economies, Middle East, Latin America) are still on an upward motorisation path, showing high elasticities of income to private vehicle ownership. The Middle East and Latin America show significantly higher elasticities than the Transition economies. Up to the present, motorisation in these regions has been mainly through the increase in four-wheelers while two-wheelers remain marginal vehicles used for specific purposes. Nonetheless, more recent trends suggest that two-wheelers will become important actors in the future stages of motorisation in the Middle East and Latin America. Various factors have played a role in this trend. Among them, the globalisation of production of two-wheelers which has allowed the introduction of low-price models into these markets. In the Latin American region, Brazil, Colombia and Argentina have now developed their own motorcycle production industry which has further reduced costs and increased supply. Besides low purchase costs, inexistent and lax regulation also account for low costs of ownership and use of these vehicles. Response of demand to decreasing prices of two-wheelers has been very high, even when incomes and motorisation in these regions are in middle stages. This is due to a great extent to deficient quality and insufficient supply of public transport in urban centres and to income inequalities that concentrate four-wheeler motorisation in a small part of the population (with multiple vehicles per household). In this way, two-wheel vehicles have become available as first stage motorisation vehicles for public transport captive users. Severe congestion problems have also increased competitiveness of such vehicles in the urban agglomerations of these regions.

Relatively high income elasticities of private vehicle ownership and personal income growth rates expected during the 2010-2050 period translate into elevated growth in the private vehicle fleet of middle income regions. Growth in the Transition region remains more four-wheeler oriented while the Middle East and Latin American regions show a significant shift to two-wheeler private mobility, and account for a large part of the overall growth of these vehicles. As in the case of higher income regions, greater than baseline urban road expansion generates a shift in the growth of the private vehicle fleet towards PLDVs. However, because ownership of private vehicles is still far from saturation levels, lower urban road expansion also generates significant differences, shifting private ownership growth towards two-wheelers. Scenarios where there are lower fuel prices and lower expansion of public transport result in higher private vehicle growth while those with high fuel prices and significant expansion in public transport slow-down the translation of increasing incomes into private vehicle fleet growth. Effects in public transport development and pricing scenarios have a larger impact in the development of two-wheelers in the Middle East and Latin America regions. Global effects of urban policy changes modelled are emphasised in the three regions since urbanisation rates are already high and continue to rise. This is more so in Latin America which is and will continue to be the most urbanised region among the three.

Lower-income regions (Africa, Asia, China and India) are at an early stage of overall motorisation but some of the countries present already high income elasticities of private motorisation. Many others are at income levels at which elasticity is still low. In the Asia region as well as in China and India two-wheeler motorisation began to grow at low per capita income levels, as in the case of Japan and Korea. Early introduction of two-wheelers into these markets was possible as many mass produce these vehicles (Malaysia, Indonesia, Thailand and later on China and India). In various countries, especially in the ASEAN region, motorcycle ownership has grown to very high levels (Chinese Taipei for example has passed 600 vehicles per 1000 population, see Montezuma, 2012). Recently, growth in four-wheelers has overtaken two-wheelers in the countries experiencing the highest economic growth in the region, which suggests a shift away from the two-wheeler dominated motorisation. Differences between four-wheeler and two-wheeler fleet growth will be especially pronounced in China and India as higher incomes accelerate the shift. In the case of Africa, vehicle ownership of both types of vehicles is still low. Two-wheeler development at early stages of the motorisation process has been less significant than in the Asian region. Nonetheless, there is significant presence of two-wheelers in the region which suggests that these will also play an important role in the overall motorisation process.

As a group, countries in these regions present the highest income elasticities to vehicle ownership and have the highest economic growth throughout the studied period. Because of this it is in these regions that the highest growth in private vehicle fleets occurs. In Asia, growth in four-wheelers is high and accounts for the largest part of the overall four-wheeler growth. Because of the high income elasticity, urban policy alternative scenarios have a greater effect in the increase of these vehicles. Higher urban road provision generates an even higher growth in four-wheelers and accelerates the slow-down in two-wheeler ownership. Higher development and better quality public transport, accompanied with higher fuel prices generates smaller growth in private vehicles and especially in four-wheelers. In Africa, both types of vehicles present relatively high growth and two-wheelers increase their share of the fleet. Better and higher public transport translate into lower overall private vehicle motorisation. The impact of alternative urban transport policies grows as countries become more urban. This will be especially the case after 2050, when urbanisation rates catch up with those corresponding to the middle and higher-income regions.

Figure 2.29. **World private vehicle fleet, 2050**
Different urban policy pathways and alternative economic growth scenarios, million units

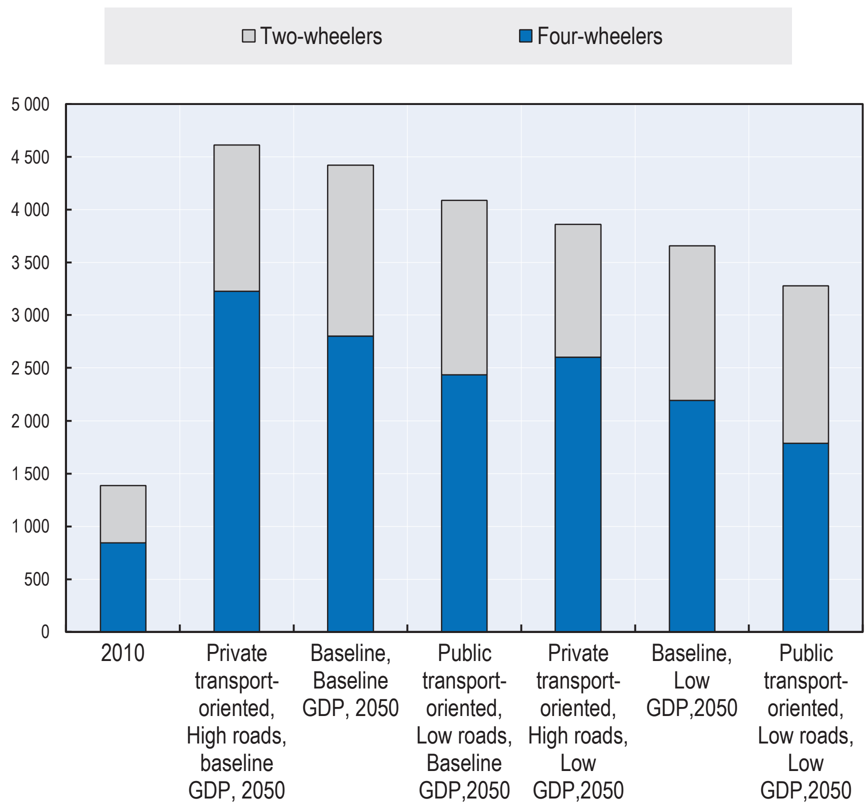


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Figure 2.30. **Four-wheeler ownership and growth by region**
Alternative policy pathways, baseline GDP

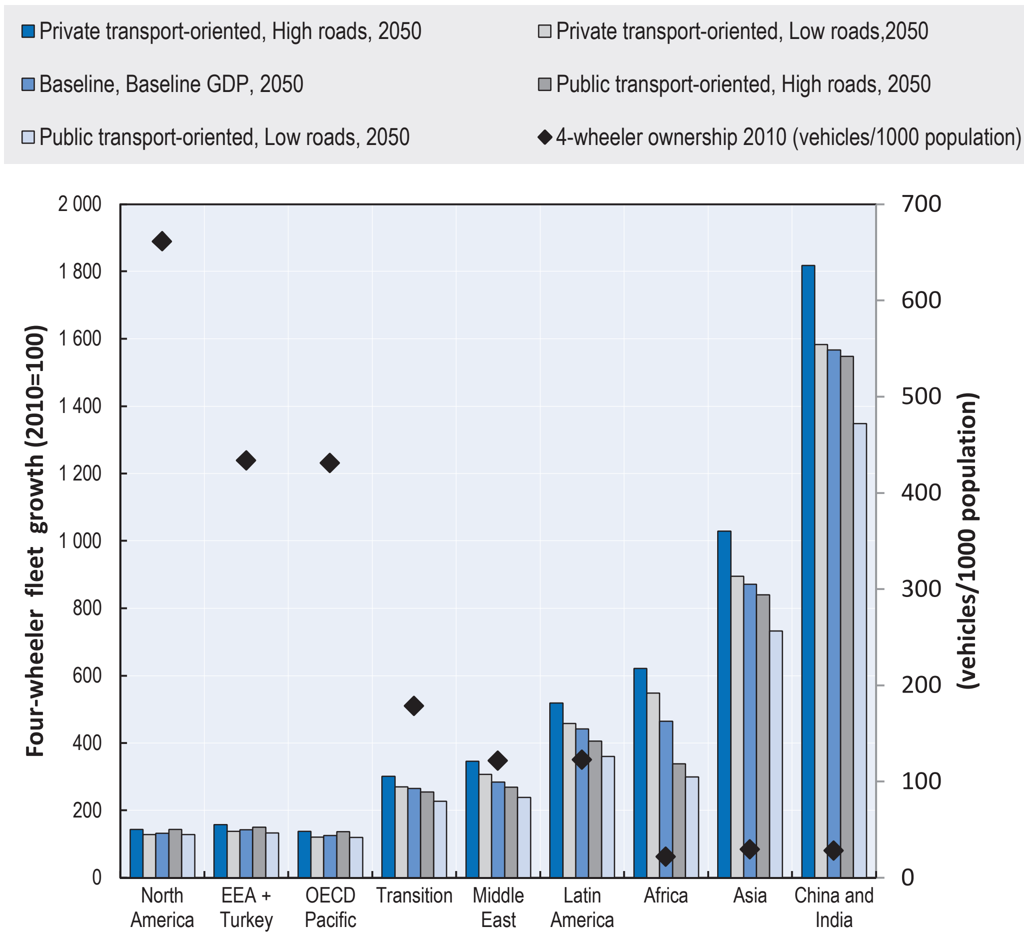

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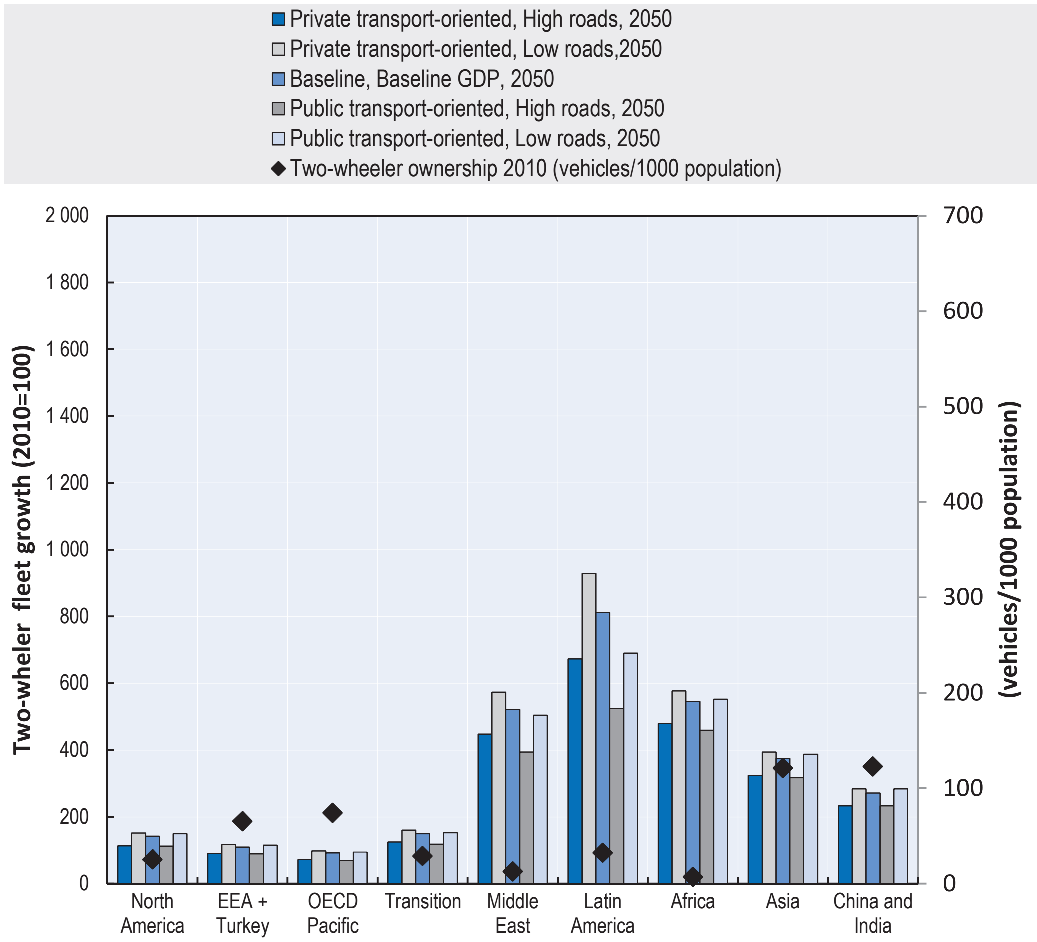
Figure 2.31. **Two-wheeler ownership and growth by region**
Alternative policy pathways, Baseline GDP



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Fleet differences between scenarios are magnified when translated into travel by the effect of different fuel prices. Figure 2.32 shows the total vehicle travel growth under the scenarios by region of the world, modelled under baseline growth assumptions. The figure illustrates *Lowest* and *Highest* scenarios presented in the beginning of this chapter (the *Private transport-oriented*, *High roads* and *Public transport-oriented, Low roads* scenarios respectively) together with the *Central baseline* scenario. The *Lowest* bound is also presented under low economic growth. In this way, the difference between the *Highest* and *Lowest with low GDP* scenario reflects the whole range of variance modelled, taking into account both economic and alternative urban policy scenarios. The effects of urban transport policy can be seen by comparing the *Highest*, *Central*, and *Lowest* scenario. The magnitude of economic growth uncertainty is shown by the difference between the *Lowest* and *Lowest with low GDP* scenario. Figure 2.33 shows the same information but in terms of CO_2 emission growth.

Overall, significantly higher rates of vehicle travel will happen outside the OECD, since it is in these regions where income elasticity of ownership will continue to be high, and where higher economic growth prospects are expected. It is therefore within these regions that diverging urban policies will have a largest effect on the private vehicle ownership pathways and on future growth of CO_2 emissions.

Figure 2.32. **Vehicle-kilometre growth for passenger transport by region, 2050**
Different urban pathways and alternative economic scenarios, 2010=100

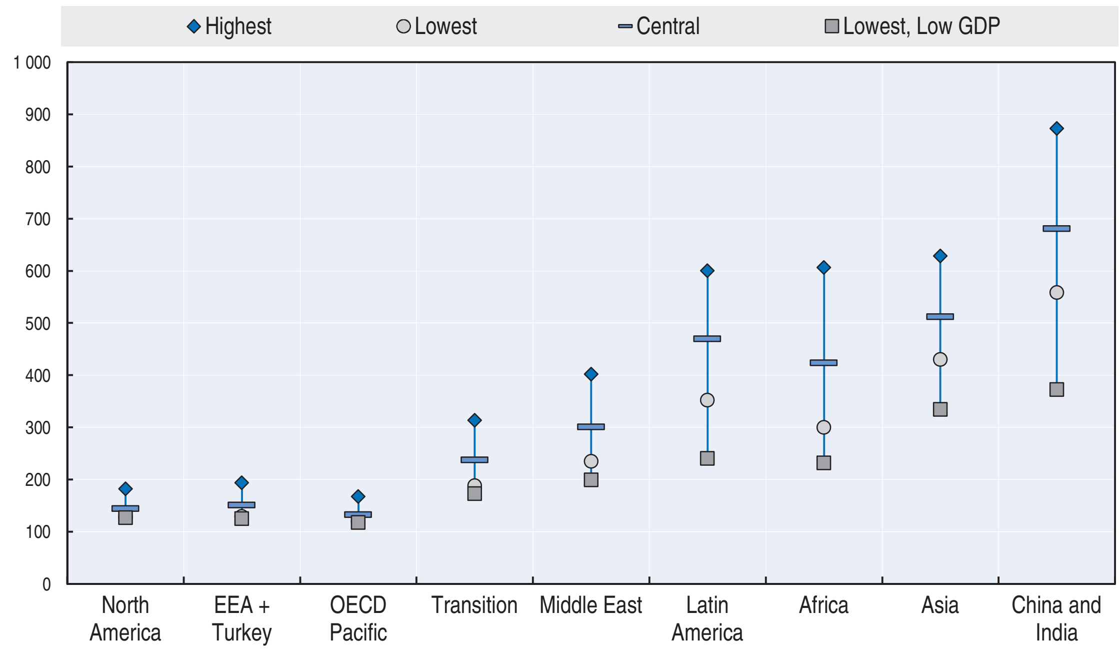

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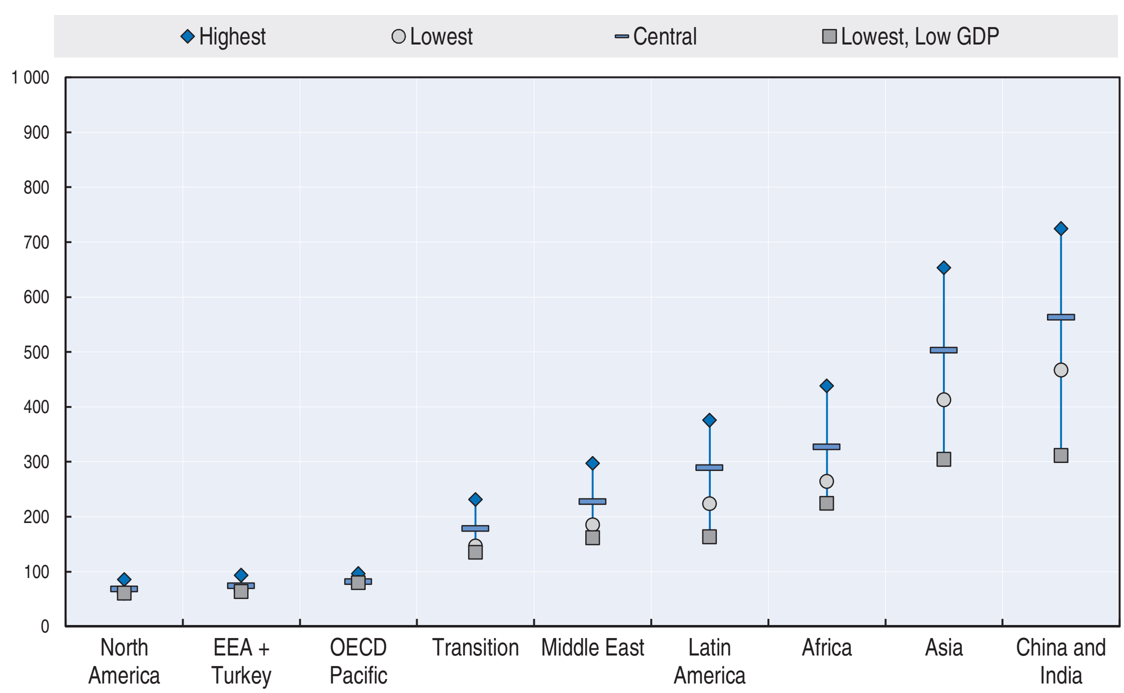
Figure 2.33. **CO_2 emission growth for passenger transport by region, 2050**
Different urban pathways and alternative economic scenarios, 2010=100



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Freight transport projections

Underlying the surface freight scenarios presented in figures 2.34 – 2.35 are assumptions on the correlation of tonne-kilometres transported to overall economic production, and on changes in the volume of economic production itself. There is a strong (unitary) correlation between GDP and tonne-kilometres transported or that the transport intensity of the economy weakens. We examine the effects of these on global transport volumes and emissions by geographical regions.

A reduction in the transport intensity of GDP can result from a dematerialisation of production. Growing service sector shares in advanced economies or increasing production and trade of lighter weight goods like electronic devices reduces actual tonnages shipped. These same traits have accompanied globalisation of the economy, with higher value-goods able to be shipped over longer distances and larger and more global service sectors facilitating de-localised production across the globe. At the same time unbundling can incur transaction costs and economies of scope may work to keep production tasks together (Lanz et al, 2012).

The range of outcomes in terms of tonne-kilometres of surface freight transported in our scenarios is large, especially outside the OECD, and reflects mainly uncertainty over future growth paths.

To construct a central case we pooled historical data from the World Bank World Development Indicators on surface freight volumes, GDP volumes at PPP and per capita incomes at PPP and covering the period 1990–2010. This allows us to cover a broader set of countries than using other datasets, which is important as it contains more observations on different levels of per capita incomes. We use this dataset to estimate the transport intensity of GDP for different per capita income levels[15], by grouping countries into 3 broad income categories: low, middle and high.[16] We find that at the lowest income levels overall GDP correlates over-proportionally (coefficient of 1.13) with surface freight tonne-kilometres and that this relation successively decreases as per capita incomes grow. It is reduced to 0.78 for the high income countries and lies at just below parity (0.96) in the middle income bracket. In the unitary GDP correlation scenario we assume that each additional unit of GDP translates into one additional unit of transport throughout the projected time period and for all regions. For surface freight this can be considered an upper bound. Together with baseline GDP growth, this forms our high scenario. In the decoupling scenario lower correlations are assumed throughout. On average they imply a correlation ranging between 0.65 and 0.85 for the OECD and non-OECD economies, which is slowly decreasing over time. These follow the transport intensity of GDP used in the IEA’s New Policy Scenario. Applied to our low growth GDP scenario this forms our lowest case.

The range of results shown by region illustrate the highest scenario in which there is baseline GDP growth and a unitary correlation with transport, all the way down to the lowest scenario where there is strong decoupling and lower GDP growth. As central cases, and to illustrate the importance of economic production in determining freight transport, we apply the central case transport intensities to baseline and low GDP growth. For regions in which there is a large shift to middle income brackets in both scenarios, this means that surface freight demand will be towards the low scenario, especially for the low central case.

In the high-income countries of EEA + Turkey, North America and the OECD Pacific we see the lowest average economic growth and corresponding growth in tonne-kilometres which are in some cases negative. All countries in these regions are affected more strongly by decoupling than other parts of the world in the central case. This is also the case in the low GDP scenario, since the correlation with GDP remains the same. In the OECD Pacific region surface freight remains important as a link to outside economies especially for land-mass countries as well as providing the capacity for domestic production. Naturally, due to a smaller range of outcomes in growth, the range of outcomes in terms of tonne-km is tighter as well.

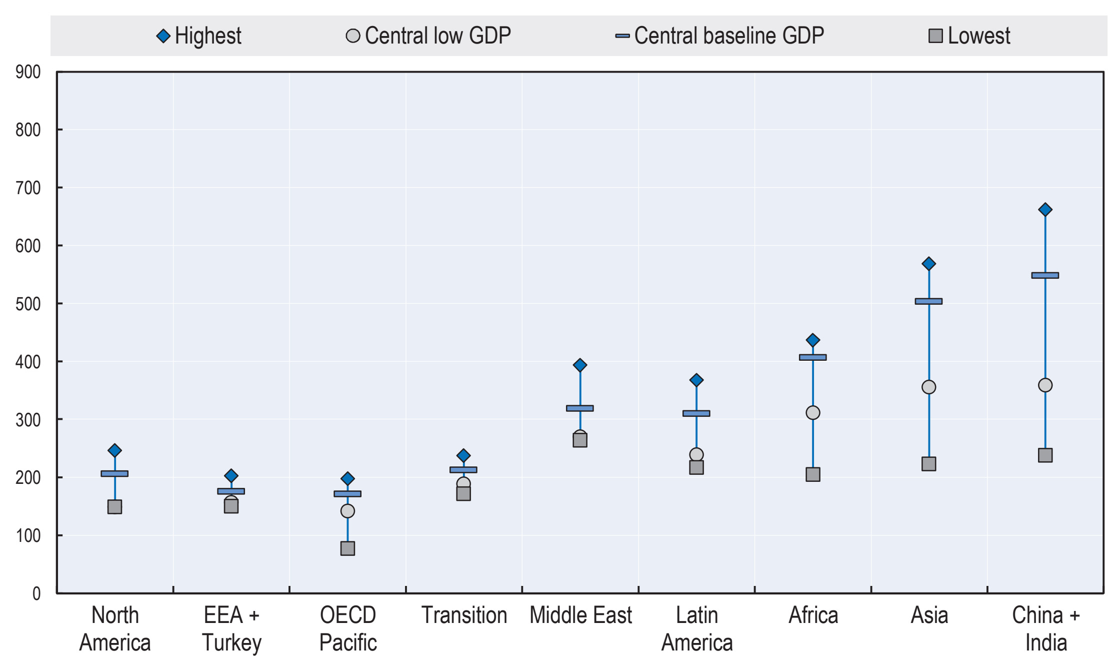
In the middle-income countries of Latin America, the Middle East and the Transition Economies tonne-kilometres also see moderate growth. Parts of these regions enter high income ranges by 2050, meaning that in our central scenario surface freight tonne-km begin to decouple from growth more strongly. All three regions rely strongly on trade in raw materials, but much of these materials leave via sea routes, except on the large land-mass countries of Central Asia and Eastern Europe. Future freight transport demand will depend to some extent on the development path chosen, with the existence of a strong service based economy alongside raw materials industries (the Australian case) or a more diversified economic structure including a manufacturing base (more similar to China or United States) having strong influences on freight transport demand, also in terms of mode choice. In part this will also depend on efforts of regional integration which determine the size of effective domestic markets and the possibilities for stronger industrial and consumer bases.

Low-income countries in the regions of Africa, Asia and China + India see stronger growth of GDP meaning that a large share of the population sees middle-income levels throughout the projected time period. On average (including South Africa in the Africa aggregate) all regions are in the middle income bracket between 2010 and 2050. In China growth is considerably stronger until later in the projected time period and it surpasses 17 thousand 2007 USD at PPP by 2025.

The downward risk of GDP growth in parts of these regions is also high in our scenarios which lead to a broad range of outcomes in terms of tonne-kilometres by 2050. Due to stronger per capita income growth in China, the central scenarios show larger reductions in tonne-km there in 2050 than Africa or other developing Asia compared to the baseline scenario. In our central scenario and assuming slower GDP growth, tonne-km are to grow approximately 3 times in all three regions.

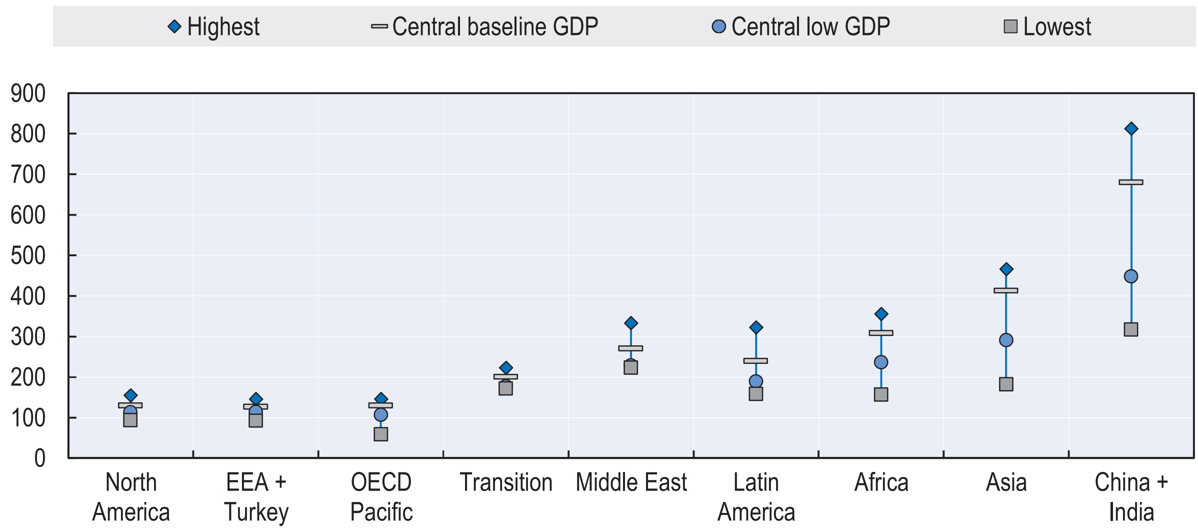
Overall, we see that low income regions are particularly susceptible to changes in future growth paths and that outcomes in the freight transport sector vary strongly with them.

Figure 2.34. **Surface freight tonne-kilometres by region, 2050**
2010=100



StatLink http://dx.doi.org/10.1787/888932944768

Figure 2.35. **CO_2 emissions from surface freight by region, 2050**
2010=100



StatLink http://dx.doi.org/10.1787/888932944787

NOTES

1. Latin America's working-age population is projected to expand continuously until it peaks in the 2040s.

2. 500 thousand–1 million population; 1–5 million population, 5–10 million population, and >10 million population.

3. 5-year cohorts.

4. The functional form of the S-curve used is that of a quasi-logistic function with saturation of 1 (100%): $GDP\ concentration = 1/(1 + \exp(-x1) * population\ concentration^{-x2})$.

5. This exercise was based on information from "Demographia", adjusted with information from the Urban Mobility Observatory (CAF, 2010). The values used for surface are those reported as urban surface of the metropolitan region. Paths were established for those countries where enough information was available: Argentina, Brazil, Colombia, Mexico, Chile, and Peru. Other countries where assumed to follow the path to which the few urban centres available seem to be closer to, or the path calculated when using all available information for the region.

6. Simple average across city types.

7. Initial weights of each country`s public transport service explain the fact that although per capita levels by country are set to be 1.5 times their 2010 levels, this does not translate into a 1.5 per capita growth for the whole region.

8. Several additional sources to build assumptions on kms in BRT segregated corridors where used: Global BRT Data, available at: http://www.brtdata.org/; SIBRT Technical Data sheets, available at: www.sibrtonline.org/en; "Lessons learned from major bus improvements in Latin America and Asia"World Resources Institute-EMBARQ, 2010; "Bus Rapid Transit Planning Guide"Institute for Transportation and Development Policy, 2007.

9. In per capita terms.

10. The general form for both light-duty vehicle and motorcycle ownership is the following:
$$ownership = Saturation/(1 + \exp(-1 * x1) * \left(\frac{GDP}{population}\right)^{-x2} * fuel\ prices^{-x3})$$
where $= S1 + s2 * roadprovision$; $x1 = vkms\ public\ transport\ service + x1a * share\ of\ service\ by\ rapid\ modes$; Variables $x1a$ and $x2$ where allowed to adjust according to the category of urban agglomeration.

11. A scenario presented in the *World Energy Outlook* that sets out an energy pathway consistent with the goal of limiting the global increase in temperature to 2°C by limiting concentration of greenhouse gases in the atmosphere to around 450 parts per million of CO_2, www.iea.org.

12. Non-urban ownership rates were calculated using non-urban GDP/capita calculated by the Latin American urban transport model included in MoMo.

13. Changes in oil and technology scenarios were calculated running a regression for a coefficient that weighted by the urban share in Latin American countries would shift the Dargay income-ownership pathway in the same magnitude than the baseline with high infrastructure in the Latin American module. Such a coefficient shifts the income-ownership pathway by modifying the α term of the Gompertz function used by Dargay and Gately.Public transport scenarios were simulated in a similar way. However, the calculated coefficient modifies the β term of the Gompertz function. Finally, for road infrastructure scenarios the sole Dargay urbanisation coefficient was used in the case of the high road expansion scenario. As this coefficient already multiplies

urbanisation rates, what was calculated is the magnitude by which such a coefficient would be higher in a low infrastructure expansion case.

14. Quasi-logistic functional forms were utilised based on Button et al. (1993).

15 This is done with the regression $\log(\text{surface tkm}) = \text{constant} + \log(\text{GDP}) + \text{Dinc} * \log(\text{GDP})$, where Dinc is a dummy variable equal to one according to the per capita income groupings. The lowest income group is the control group. The coefficient on GDP thus captures the relation effect on surface freight tonne-km for the low income category and is reduced by the coefficient on the interaction variable for other income groupings.

16 Per capita income ranges between 0 and 3 thousand GDP at 2005 USD PPP in the low, between 3 and 17 thousand in the middle and anything above 17 thousand in the high. These brackets do not correspond with commonly used World Bank groupings, and should be viewed in terms of a ranking rather than a definition of income status.

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