Marrakech Partnership

Global Climate Action

Template for non-Party stakeholders' inputs for the Talanoa Dialogue

Question 3 - How do we get there?

This template is meant to guide non-Party stakeholders (organization(s), coalition(s), initiative(s) and/or sector(s) etc.) in providing inputs that are relevant and impactful to the Talanoa Dialogue process. Using such the template is not mandatory, however, the High-level Champions encourage non-Party stakeholders to use such a structure to facilitate capturing and highlighting the key messages across the three questions.

How do we get there?

Ways in which the UN Climate Change process can help you achieve your vision and goals, and how your actions can help in expediting sustainable transitions to climate neutral societies [Maximum 300 words]

The International Transport Forum (ITF) will continue to contribute key findings from its wide range of transport analyses across all modes to the UN Climate Change process, to inform Parties and to provide both quantitative evaluation of mitigation impacts and policy insights through its network of 59 Member countries and 28 Corporate Partnership Board partners.

Concrete solutions that have been realized while implementing your commitments, including lessons learnt from success stories and challenges, and case studies that are in line with the 1.5/2 degrees' goal and can support the Parties in achieving their NDC goals, enable higher ambition and inspire engagement of other non-state actors [Maximum 300 words]

Even if current policies contained in the ITF's Transport Outlook baseline scenario can only be expected to slow the growth in CO_2 emissions, solutions for maintaining emissions at their 2015 levels exist. The low-carbon scenario in ITF's analysis combines the most optimistic scenarios for CO_2 emissions for all modes and sectors, including higher efficiency gains for all vehicles (including alternative fuels for ships), higher fuel taxes, full benefits of vehicle optimisation for road freight and land use and public transport planning in the urban sector. In this scenario, emissions in 2050 amount to 7 370 million tonnes compared to 13 600 in the baseline. Accounting for surface transport only, the total emissions in 2050 amount to 5 900 million tonnes. However, it is still far from the 2 000 million tonnes proposed as a target for the 1.5 degree scenario. Therefore, higher ambitions are required in order to reach the 1.5 degree goal. Accelerated innovation and radical policy choices on issues such as shared mobility, changes in supply chains and new transport modes are required.

Collaboration models with other stakeholders and, in particular, between non-Party stakeholders, national governments and the UN Climate Change process that have been successful in helping you, or can help you, achieve your commitments [Maximum 300 words]

Opportunities to further scale up action and means to address barriers that can enable even further action by non-Party stakeholders based on the actions you have taken to implement your commitments. ("We've made progress and have made new commitments as described above. This is what I need from national governments, other non-Party stakeholders and the UN Climate Change process to take even further action…") [Maximum 200 words for each item below]:

- *Policy levers*

Political ambition is greatly needed as emissions from the transport sector, contrary to other sectors, are still growing and have only recently started to decrease in developed countries.

- *Collaboration/cooperation opportunities*

- *Lessons learned based on the experience and progress so far*

The mitigation efforts in the ITF's low-carbon scenario resulted from two main areas: road and maritime transport. In the road sector, efficient technology, combined with modal shift strategies in cities and optimisation and sharing measures for freight fleets have a mitigation potential of almost 2 billion tonnes of CO_2 per year by 2030. In the maritime, it is the more optimistic efficiency gains for ships, which deliver close to 800 million tonnes of avoided CO_2 emissions by the same year. These are two sectors that will have significant potentials for positive changes by 2030.

- *Public and private financing models*

- *Impact on non-Party stakeholders if these actions by national level governments and the UN Climate Change process and other opportunities are implemented and how much further they could go*

ITF Transport Outlook 2017

OECD

International Transport Forum

ITF Transport Outlook 2017

OECD
BETTER POLICIES FOR BETTER LIVES
International Transport Forum

Please cite this publication as:
OECD/ITF (2017), *ITF Transport Outlook 2017,* OECD Publishing, Paris.
http://dx.doi.org/10.1787/9789282108000-en

ISBN 978-92-82-10799-7 (print)
ISBN 978-92-82-10800-0 (PDF)

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Editorial

For the first time, the *ITF Transport Outlook* assembles scenarios for future transport demand and related CO_2 emissions from all sectors and modes of transport. Starting from long-term projections produced by the OECD as well as non-OECD bodies, it analyses how socio-economic changes will affect the demand for transport under different policy scenarios. Several key trends emerge from these, such as the intensifying shift in transport activity towards developing economies, with Asian countries representing an ever increasing share of total transport demand for both freight and passengers.

The level of uncertainty in all areas of transport is also striking. Uncertainties related to the pace of economic and trade development, the price of oil, technology and innovations all render the future of the transport world difficult to fathom. The different outcomes of the scenarios should not be read as forecasts for the coming 35 years. Rather, they describe several possible futures. Whether future reality comes closer to one or the other will depend on the actions policy-makers take. At a time when the international commitments, such as the Paris agreement on climate change, need to be transformed into actions, the scenarios of the *ITF Transport Outlook* show that an efficient decarbonisation of the transport sector can only occur if a wide range of measures come into force for both freight and passengers. All policy levers, *Avoid* (unnecessary transport demand), *Shift* (to sustainable transport options) and *Improve* (efficiency), must be put into action.

Building the comprehensive scenarios in this *Outlook* is only the very first step of a larger enterprise undertaken by the International Transport Forum to understand how the transport sector can play its part in decarbonising the economy. ITF's Decarbonising Transport project aims to build a catalogue of efficient mitigation measures and assess them under a coherent framework, in order to help countries transform their ambitions into actions, by building a commonly accepted framework for climate policy assessment, and by helping countries to develop sustainable transport solutions.

At the same time, the efforts towards greener transport need to be balanced with the role transport plays as an enabler of sustainable development. There is a growing recognition that better transport is not about increased mobility and tonne-kilometres but about providing equitable access to jobs, opportunities, social interactions and markets, contributing to healthy and fulfilled lives. Transport policies should focus on accessibility, not only time savings. This *Outlook* showcases how to analyse policies in terms of access in two areas, urban and international air travel.

Providing efficient, equitable access while respecting the pledge to decarbonise transport will prove challenging. Policy-makers need to act now to ensure a sustainable future for transport, but with a strategic long-term vision. They must avoid the trap of short-term energy savings which will prove inefficient in the long-term, especially those involving large investment, for instance in infrastructure.

Policy makers should also be ready to tap into the potential of innovative technologies in terms of access and green transport. The impact of digitalisation is already felt strongly across much of transport. The next transport revolution is underway, based on real-time data that make it easier and more efficient to match supply and demand. The coming decades will witness the arrival of more disruptive technologies, vehicle automation and on-demand transport first and foremost. Car-sharing has the potential to increase accessibility in a sustainable way. Such solutions need to be promoted and accompanied by sound policies. Without these, vehicle automation could lead to more cars onto the roads, with all the associated problems of air pollution, CO_2 emissions, congestion, inequitable transport…

Sustainable transport enables sustainable development. It is fundamental for meeting the needs of people in their personal lives and economic activities while safeguarding the ability of future generations to meet their own needs. Providing sustainable transport will be a challenge and will require sound governance from all stakeholders. In this respect, I hope that this *Outlook* can enhance the knowledge about the issues at stake and become the basis for enlightened discussions about solutions.

José Viegas
Secretary-General
International Transport Forum

Foreword

The 2017 Edition of the ITF Transport Outlook *builds and expands on the previous editions to give a comprehensive overview of the future transport demand and related carbon dioxide (CO_2) emissions up to 2050. The scenarios in this* Outlook *are built with the International Transport Forum's (ITF) in-house modelling tools, developed over the course of several years. Contrary to most transport-energy modelling framework, the ITF models start by analysing transport demand, estimating what are the mobility needs and the freight demand coming from the future population, economic and trade projections (Annex 2.A). Mode choice, energy use and CO_2 emissions only come at a later stage.*

Rather than attempting to establish a likely central forecast for the evolution of transport volumes, the ITF Transport Outlook *focuses on scenarios to illustrate the potential impact of policies on transport demand and related CO_2 emissions. This edition covers all modes and combines them into coherent scenarios. In particular, it gives a* low-carbon *scenario, which results from the combination of the most optimistic scenario from all modes and points to a lower bound for CO_2 emissions for 2050 with currently foreseen technology and mode choice trajectories.*

Compared to the 2015 edition, this publication adds several new elements. Most noteworthy are the chapter dedicated to international aviation (Chapter 4), as well as the expansion of our analysis of urban mobility to all the cities of the world (Chapter 5). This Outlook also brings into focus the issue of accessibility, both for air transport and in cities. Accessibility has become a key angle from which to analyse transport policies and the Outlook *gives some insights into the long-term trends for accessibility, and how they relate to policy packages.*

Acknowledgements

The *ITF Transport Outlook* was prepared by the ITF Statistics and Modelling Unit, with the support from numerous persons and partner organisations. The publication was coordinated by Vincent Benezech, under the supervision of Jari Kauppila (Head of Statistics and Modelling). The main authors for each chapter are the following:

Chapter 1. The transport sector today	Vincent Benezech, Christian Pollok, Jari Kauppila
Chapter 2. Overview of long-term Outlook	Vincent Benezech, Guineng Chen, Jari Kauppila
Chapter 3. International freight	Ronald Halim, Jari Kauppila, Luis Martinez, Olaf Merk
Chapter 4. International aviation	Vincent Benezech
Chapter 5. Mobility in cities	Guineng Chen (global mobility model), Nicolas Wagner, Olga Petrik and Christian Pollok (accessibility), Wei-Shiuen Ng (Asian cities)

Statistical and research assistance was provided by Claire Alanoix, Mario Barreto, Ryan Hunter and Rachele Poggi. Cecilia Paymon, Janine Treves and Margaret Simmons supported the publication process. Suzanne Parandian copy-edited the manuscript.

The *Outlook* was reviewed by the Joint Transport Research Centre Committee and the *Outlook* team is very grateful for their commnents and contribution. The authors are also grateful for the help of other ITF staff, in particular, Jagoda Egeland, Seiya Ishikawa, Alain Lumbroso, Olaf Merk, Stephen Perkins and Daniel Veyrard. The ITF also benefited from the help provided by the following bodies of the OECD: the Ship Building Unit, the Environment Directorate and the International Energy Agency.

Several partners have been valuable in developing the methodologies and providing data: The International Council for Clean Transportation (ICCT) for the work on local pollutant emissions; The Energy and Resources Institute India, (TERI), China Academy of Transportation Sciences (CATS), Japan International Cooperation Agency (JICA), Transportation Planning Research Institute China and the Asian Development Bank (ADB) for their help with data in Asian cities; Economic Commission for Latin America (ECLAC) and Development Bank of Latin America (CAF) for data on Latin American cities and trade; the Road Freight Lab of World Business Council on Sustainable Development (WBCSD) with whom we worked on the freight optimisation; the International Civil Aviation Organisation (ICAO) and the Airport Council International Europe (ACI Europe) for their help with aviation forecasts and emissions; SkyScanner for generously providing a database on fares from the aviation sector.

Finally, the ITF Secretariat is grateful for contributions provided by several individuals, including Dr Tristan Smith (University College London), Sainarayan Ananthanarayan and Antonin Combes (ICAO), Lloyd Wright, Melissa Cardenas and Alvin Mejia (ADB), Dr Cristiano Façanha (ICCT), Pierpaolo Cazzola (IEA), Jean Chateau and Karin Strodel (OECD) and Sudhir Gota (Clean Air Asia).

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Executive summary

Background

The *ITF Transport Outlook* provides an overview of recent trends and near-term prospects for the transport sector at a global level. It also presents long-term projections for transport demand to 2050 for freight (maritime, air and surface) and passenger transport (car, rail and air) as well as related CO_2 emissions, under different policy scenarios.

It specifically looks at how the main policy, economic and technological changes since 2015, along with other international developments such as the establishment of the UN Sustainable Development Goals, are shaping the future of mobility. A special focus on accessibility in cities highlights the role of policies in creating sustainable transport systems which provide equal access to all.

Findings

CO_2 emissions from transport could increase 60% by 2050, despite the significant technology progress already assumed in the *Outlook*'s baseline scenario. If no additional measures are taken, CO_2 emissions from global freight alone could increase by 160%, as international freight volumes grow threefold in the baseline scenario, which builds on OECD trade projections. This is largely due to increased use of road transport, especially for short distances and in regions that lack rail links, such as South-East Asia. Optimising routes or sharing trucks and warehouses between companies would allow higher load factors and fewer empty trips. Such efficiency gains could reduce truck CO_2 emissions by up to one third.

Air passenger numbers will continue to grow strongly as cities around the world become more accessible by air. Over the next 15 years, passenger air traffic could grow between 3% and 6% annually, with intra-Asian routes growing fastest at almost 10%. CO_2 emissions from international aviation could grow around 56% between 2015 and 2030, even with much improved fuel efficiency. Liberal air service agreements and more low-cost intra-regional flights will enable the network to expand and prices to fall, thus driving growth. Cities around the world will become more accessible as travel times shorten. Strong regional discrepancies in accessibility by air remain, but investment in regional airports and better surface links between airports and cities can address this.

Motorised mobility in cities is set to double between 2015 and 2050, rising 41% to 2030 and 94% by 2050 in the *Outlook*'s baseline scenario. The share of private cars will continue to increase strongly in developing regions and fall only slightly in developed economies. In the alternative policy scenarios where public transport is incentivised, motorised passenger-kilometres reach similar levels, but with buses and mass transit covering more than 50% of the total demand.

Policy insights

The 2016 Paris climate agreement must be translated into concrete actions for the transport sector.

A wide range of policies and measures will need to be implemented to maintain transport CO_2 emissions at their 2015 levels. All policy levers will need to be pulled: *avoid* unnecessary transport demand, *shift* to sustainable transport options and *improve* efficiency. Market-based mechanisms, such as the offsetting scheme for international aviation decided by the International Civil Aviation Organisation, will also be needed. It is still possible to limit global warming to 2 degrees Celsius above pre-industrial levels with such measures, according to the assumptions of the International Energy Agency on the mitigation efforts by sector, but not to the 1.5 degrees aspired to by the Paris agreement.

Policy will need to embrace and respond to disruptive innovation in transport.

Technological innovations such as electric mobility, autonomous vehicles or new shared mobility solutions are likely to change mobility patterns radically, notably in cities. Some of these innovations provide opportunities to significantly reduce the CO_2 footprint of transport and improve inclusive and equitable access. In the freight sector, autonomous trucks could dramatically shift the competitive advantage among the different modes towards road freight. Policy and planning need to account for these changes to avoid building expensive infrastructure soon to become obsolete, or locking in carbon-intensive or inequitable development pathways.

Reducing CO_2 from urban mobility needs more than better vehicle and fuel technology.

Technological progress alone will not achieve a reduction of CO_2 emissions in cities. Behaviour-changing policies such as fuel taxes, low transit fares or land-use policies that limit urban sprawl are needed to generate the additional CO_2 mitigation required. Lower CO_2 emissions from urban mobility can also come as positive side effects of policies targeting local air pollutants and congestion, which are the most pressing transport challenges in many cities.

Targeted land-use policies can reduce the transport infrastructure needed to provide more equitable access in cities.

Providing equitable access to jobs and services is one of the targets of the United Nations Sustainable Development Goals. In many cities, the flexibility offered by private cars means that they provide better accessibility (as measured by the number of opportunities reachable in a given amount of time) than public transport, even when taking congestion into account. Yet, public transport has the ability to provide inclusive access to opportunities where it is itself accessible to all travellers and its coverage is properly planned. As dense cities make public transport systems more efficient, targeted land-use policies can contribute to improving access.

Governments need to develop planning tools to adapt to uncertainties created by changing patterns of consumption, production and distribution.

Agile planning procedures grounded in a long-term, strategic vision help to adapt to uncertainties associated with shifting patterns in global demand, production and shipping routes. Timing is crucial for good infrastructure planning and the phasing-in of capacity to smoothen the lumpiness of infrastructure investment, for instance in ports. Such plans should set the direction for future development, prioritise investments and identify potential future bottlenecks. They can also form the basis for the reservation of land, for instance for future port and corridor development.

PART I

Global outlook for transport

PART I

Chapter 1

The transport sector today

This chapter provides an overview of recent trends and near-term prospects for the transport sector at a global level. It starts by reviewing the main policy, economic and technological changes since 2015, along with other international developments that will shape the future of mobility. It outlines the impact of three current macroeconomic trends on transport: GDP growth, international trade and oil prices. The chapter then focuses on recent trends and the near-term outlook for freight (maritime, air and surface), passenger transport (car, rail and air), CO_2 emissions and investment in inland infrastructure, providing the basis for the scenarios and long-term projections developed in the following chapters.

The last two years have seen a series of major international developments that will help define a pathway for transforming the world's mobility in the coming decades. In December 2015, at the 21st Conference of Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC), 193 governments adopted the Paris Agreement on Climate Change, the first step towards a long-lasting and legally binding treaty against the adverse effects of climate change. In addition, 162 countries submitted Nationally Determined Contributions (NDCs) reinforcing the strength of the process by quantifying the mitigation efforts of each country and publicly outlining the policies they intend to adopt to reach their goals. Around three-quarters of the NDCs mention transport explicitly as a potential mitigation source with 10% of the agreements including transport-specific mitigation targets (SLoCaT, 2015). The Paris Agreement, with its five-year review process, has created momentum for the transport sector to develop a roadmap towards carbon neutrality. Some of the world's largest economies, including the People's Republic of China (hereafter "China") and the United States, have already ratified the treaty, sending a strong signal to the world.

The commitments of the Paris agreement now need to be transformed into actions. Emissions from the transport sector are growing rapidly and represented, in 2015, around 18% of all man-made CO_2 emissions. With even developed economies struggling to curb emissions from the transport sector, the challenge is huge. However, tackling this issue will bring large co-benefits to the sector, reducing both congestion and the health impacts of local pollutants. It also provides an opportunity for economic growth. Congestion and unreliability impose real costs on individual users and have significant impacts on productivity and growth (ITF, 2010). The economic cost of air pollution from road transport in OECD countries is estimated at close to USD 1 trillion per year, measured in terms of the value of lives lost and ill health (OECD, 2014).

Another important recent development was adoption of the Agenda for Sustainable Development by the United Nations General Assembly in 2016, which highlights the role of transport in economic development (see Box 1.1). The 2030 Agenda is composed of 17 Sustainable Development Goals (SDGs) which are supported by 169 targets. Sustainable transport is implicit in seven of the 17 goals and is covered directly by five targets and indirectly by seven. The targets are wide reaching and cover, among other issues, road safety (Target 3.6), enhancing the visibility, urgency and ambition of global road safety policy. This is essential as today over 1.2 million people die in road crashes every year, with millions more injured.

Another target (11.2) highlights a profound change likely to transform urban passenger transport. Aiming to "provide access to safe, affordable, accessible and sustainable transport systems for all" by 2030, this targets touches upon road safety, infrastructure development and the need to pay special attention to people in vulnerable situations, such as women, children, persons with disabilities and older persons. It underlines the need to shift the focus of policies and investment from time savings and transport demand to accessibility. Under this new paradigm, equal access for all to jobs, services and other opportunities takes precedence over small changes in travel times or passenger-kilometre numbers. This new approach deeply modifies the perceived role of transport infrastructure and services, as well as the policy appraisal process.

Box 1.1. **United Nations Sustainable Development Goals**

In September 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development. The 2030 Agenda is composed of 17 Sustainable Development Goals (SDGs) which are supported by 169 targets. Sustainable transport is implicit in 7 of the 17 goals and is covered directly by 5 targets and alluded to in 7 other targets (see Table 1.1).

Table 1.1. **Transport related targets in the UN Sustainable Development Goals**

Goal	Target
SDG 2 Zero hunger	**Target 2.3**. Double the agricultural productivity and income of small scale food producers (access to markets)
SDG 3 Good health and well-being	**Target 3.6**. Halve number of global deaths and road injuries from traffic accidents
	Target 3.9. Reduce deaths and illnesses from pollution
SDG 7 Affordable and clean energy	**Target 7.3.** Double the global rate of improvement in energy efficiency
SDG 9 Industry, innovation and infrastructure	**Target 9.1.** Develop sustainable and resilient infrastructure
SDG 11 Sustainable cities and communities	**Target 11.2.** Provide access to safe, affordable, accessible and sustainable transport systems for all
	Target 11.6. Reduce the adverse environmental impact of cities
SDG 12 Responsible consumption and production	**Target 12.c.** Rationalise inefficient fossil-fuel subsidies
SDG 13 Climate action	**Target 13.1.** Strengthen resilience
	Target 13.2. Integrate climate change measures into national plans

Source: High-level Advisory Group on Sustainable Transport (2016), *Mobilizing Sustainable Transport for Development*.

These goals set a pathway for transforming the world's mobility over the next 10 to 15 years. However, the targets are diverse. Some targets are straightforward – such as SDG target 3.6 which sets the goal of halving global deaths and injuries from road traffic accidents by 2020. On the other hand, target 9.1, "developing quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure", does not specify a clear quantifiable target.

An important part of the negotiations on the post-2015 development agenda will be on the indicators for targets under each sustainable development goal. An Inter-Agency and Expert Group on the Sustainable Development Goal Indicators (IAEG-SDGs) has been tasked to develop an indicator framework for the goals and targets of the post-2015 development agenda at the global level, and to support its implementation.

Along with these major events in the international transport agenda, the past two years have also seen the emergence of several technological innovations. Electric vehicles have developed into an increasingly mainstream alternative to fossil-fuel powered vehicles, with more than 1.3 million electric cars on the road worldwide in 2015. Autonomous vehicles too no longer appear to belong to a distant future. In addition, new forms of mobility, such as car-sharing and carpooling, are emerging that increasingly separate mobility from car ownership. There is much hope that digital innovation will pave the way for mobility as a service, where the traveller is provided with time-responsive, multi-modal information on the best way to make their trip, including planning and payment (see also Chapter 5 for a discussion on shared mobility). Private and public transport modes, including ride and vehicle-sharing services, are increasingly joining forces to transport people in an efficient and sustainable way. Several countries have already started exploring the potential of this paradigm shift. This has implications for road infrastructure development as assets that are built today could be obsolete in 10-20 years.

Transport and the economic environment

Despite political will and technological progress, demand for transport still primarily responds to the economic environment. Historically, there has been a close statistical correlation between the growth of Gross Domestic Product (GDP) and growth in transport, both passenger and freight (Bannister and Stead, 2002). Growth in per-capita income levels has had a positive effect on the ownership and use of private vehicles, tending to increase reliance on private vehicles to meet mobility demand, particularly in emerging economies.

The period since the last edition of the *ITF Transport Outlook* (ITF, 2015a) has been characterised by three main macroeconomic trends, each with a major impact on the transport sector. Economic growth remains lower than expected and is subject to continued downside risks and uncertainties. International trade is now growing at the same rate as GDP whereas prior to the 2008 economic crisis trade grew twice as fast as GDP. Oil prices have also sunk to levels unseen since the beginning of the previous decade. Weak trade has particularly impacted the shipping sector which has been pushed into a serious crisis. Shipping suffers from overcapacity, partly driven by use of larger ships. This is causing ripple effects to the whole supply chain as many countries have overinvested in ports, partly unsuited to the largest vessels, while hinterland connections increasingly suffer from congestion.

Economic activity and trade are the main drivers of transport demand. Low oil prices have sustained passenger mobility, yet the freight sector has suffered heavily from the below-par economic environment. Maritime transport, the back-bone of worldwide trade, continued to grow at a much slower rate than expected in 2015 (KPMG, 2016). The increasing number and size of container ships is adding to the problem of overcapacity and decreasing container freight rates. Air freight, too, slowed considerably in 2015, when compared to the previous year. In contrast, world air passenger traffic grew strongly at 6.8% in 2015, supported by the decline of oil and jet fuel prices.

Gross Domestic Product

Eight years after the financial crisis, the world economy is still struggling to find a durable recovery. Global GDP slowed to around 3% in 2015 and is expected to remain largely unchanged in 2016 (OECD, 2016). Projections up to 2020 by the OECD, World Bank and International Monetary Fund (IMF) have been revised down, suggesting that global GDP growth will only modestly improve with expectations between 3.3% and 3.6% in 2017 (Table 1.2).

Advanced economies are forecast to expand by less than 2% on average for 2016-17. Supportive macroeconomic policies and continued low commodity prices might lead to a modest recovery in advanced economies but this assumes that wages and business investment will increase and financial markets stabilise (OECD, 2016). The marked slowdown in emerging economies masks significant divergences among countries. China is rebalancing with a slightly stronger outlook than previously forecast due to resilient domestic consumption and robust growth in services (IMF, 2016). The economic downturn in Brazil was more severe than anticipated, while Russia has been in recession since 2015 with negative spill-overs to other transition economies.

Table 1.2. **GDP growth, percentage change over previous year**

	2014	2015	2016	2017
OECD				
World	3.3	3.0	3.0	3.3
OECD countries	1.9	2.1	1.8	2.1
Non-OECD countries	4.6	3.7	3.9	4.4
China	7.3	6.9	6.5	6.2
World Bank				
World	3.4	3.1	3.1	3.6
High income countries	1.7	1.6	1.5	1.9
Developing countries	4.9	4.3	4.3	4.9
IMF				
World	3.4	3.1	3.2	3.5
Advanced economies	1.8	1.9	2.0	2.0
Emerging economies	4.6	4.0	4.1	4.6

Note: Figures for 2016 and 2017 are projections.
Source: OECD (2016) *Economic Outlook*, *http://dx.doi.org/10.1787/eco_outlook-v2016-1-en*; World Bank (2016) *Global Economic Prospects* (*www.worldbank.org/en/publication/global-economic-prospects*) and IMF (2016) *World Economic Outlook* (*www.imf.org/external/pubs/ft/weo/2016/02*).

Any global economic recovery in the near term is likely to be slow and gradual. The main risk factors are a sharper slowdown in emerging markets and further slowing of activity in advanced economies, the increase of the volatility of the financial market, geopolitical tensions and decreasing trust in policies to stimulate economic growth (World Bank, 2016). The de-facto exit of the United Kingdom from the European Union (Brexit), following the referendum held on 23 June 2016, could result in considerable additional volatility in financial markets and an extended period of uncertainty, with negative consequences for the United Kingdom, the European Union and the rest of the world (OECD, 2016).

Taking these developments into account, the *ITF Transport Outlook 2017* revises all economic forecasts downward from the previous 2015 edition. These revisions only reflect changes in economic projections between 2015 and 2021, but the impact can be observed up to 2050 (see Table 1.3). As a consequence, most of the forecasts for transport demand in this *Outlook* are lower than in the previous edition (see Chapter 2).

Table 1.3. **Annual GDP growth**

Compound annual growth rate, %

	2015 edition	2017 edition
Between 2013 and 2017		
World	3.7	2.4
OECD countries	2.1	1.9
Non-OECD countries	5.5	4.0
Between 2015 and 2050		
World	3.1	2.5
OECD countries	2.0	1.9
Non-OECD countries	4.0	3.6

International trade

World trade growth remains much weaker than previously expected. The year 2016 will mark the fifth consecutive year of global trade growth in volume below 3%, currently at 2.8% remaining unchanged from 2015 (Table 1.4). Expectations at the beginning of 2014, of 4.7% and 5.3% growth respectively for years 2014 and 2015, have proven over-optimistic. Import volumes expanded in developed economies by 4.5% in 2015, whereas developing and emerging economies were marked by stagnation. Exports are following a similar path. Trade is expected to accelerate slowly reaching 3.6% in 2017. However, the projected rate is still below the 5.0% average of the 1990s and subject to considerable downside risks, such as a further slowdown in emerging economies and the volatility of financial markets (WTO, 2016).

Table 1.4. **World merchandise trade, 2012-17**

Annual % change

	2012	2013	2014	2015	2016*	2017*
World	2.2	2.4	2.8	2.8	2.8	3.6
Exports						
Developed economies	1.1	1.7	2.4	2.6	2.9	3.8
Developing and emerging economies	3.8	3.8	3.1	3.3	2.8	3.3
North America	4.5	2.8	4.1	0.8	3.1	4.0
South and Central America	0.9	1.2	-1.8	1.3	1.9	1.9
Europe	0.8	1.7	2.0	3.7	3.1	4.1
Asia	2.7	5.0	4.8	3.1	3.4	4.0
Other regions	3.9	0.7	0.0	3.9	0.4	0.4
Imports						
Developed economies	-0.1	-0.2	3.5	4.5	3.3	4.1
Developing and emerging economies	4.9	5.0	2.1	0.2	1.8	3.1
North America	3.2	1.2	4.7	6.5	4.1	5.3
South and Central America	0.7	3.6	-2.2	-5.8	-4.5	5.1
Europe	-1.8	-0.3	3.2	4.3	3.2	3.7
Asia	3.7	4.8	3.3	1.8	3.2	3.3
Other regions	9.9	3.7	-0.5	-3.7	-1.0	1.0

Note: *Figures for 2016 and 2017 are projections; Asia includes Japan and South-Korea.
Source: WTO (2016), *www.wto.org/english/news_e/pres16_e/pr768_e.htm*.

Figure 1.1 highlights the difference in trade growth between emerging and advanced economies, with the former on a higher growth path since the early 2000s and the high growth resumed post-2008. The low growth rates of global trade in recent years can be attributed to tepid export growth from advanced economies and in particular to weak demand in these economies, with low import demand growth and – correspondingly – slower growth of exports from emerging economies. Since the last update, the gap between emerging and developed economies has grown further.

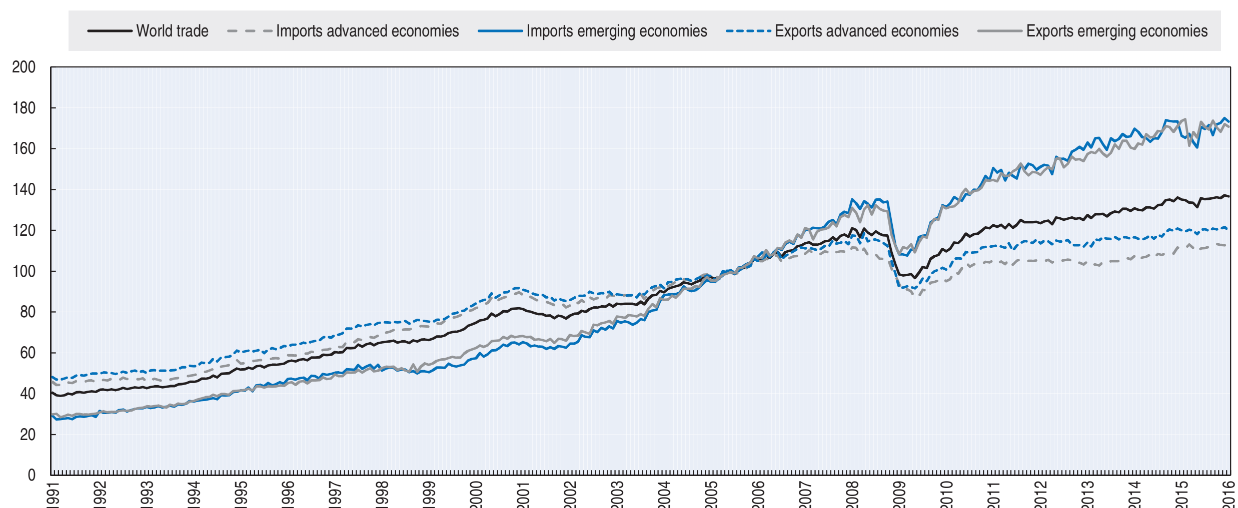
While merchandise trade volume grew in 2015, its value has been declining. Trade, measured in current dollar values, decreased by 13% to USD 16.5 trillion in 2015 from USD 19 trillion in 2014 (WTO, 2016). This decline was due to fluctuations in commodity prices and exchange rates, driven to some extent by slowing economic growth in China and resilient oil production in the United States. The broad category of fuels and mining products accounted for more than half of the decline in trade values in 2015.

World trade has slowed not only in absolute terms but also in relation to GDP. In the two decades preceding the financial crisis, world trade expanded rapidly and outpaced

GDP growth. Trade has continued to grow faster than GDP since 2008-09 but the relationship between them has weakened (see Figure 1.2). The slowdown has been widespread and holds even for low growth areas and when the decline in trade prices is taken into account (IMF, 2016). According to the IMF, the ratio of average import volume growth to GDP growth, which measures the income elasticity of import demand, is below its 2003-06 average during the years 2012-15 in 65% of the countries, accounting for 74% of global imports. Weakening import income elasticities have been more pronounced in emerging markets than in advanced economies. Developing economies in Asia, including China, have been experiencing trade weakness, despite the region's high-income growth.

Figure 1.1. **Monthly index of world trade, advanced and emerging economies**

2005 = 100, seasonally adjusted volumes



Source: CPB (2016) World Trade Monitor, *www.cpb.nl/en/figure/cpb-world-trade-monitor-august-2016.*

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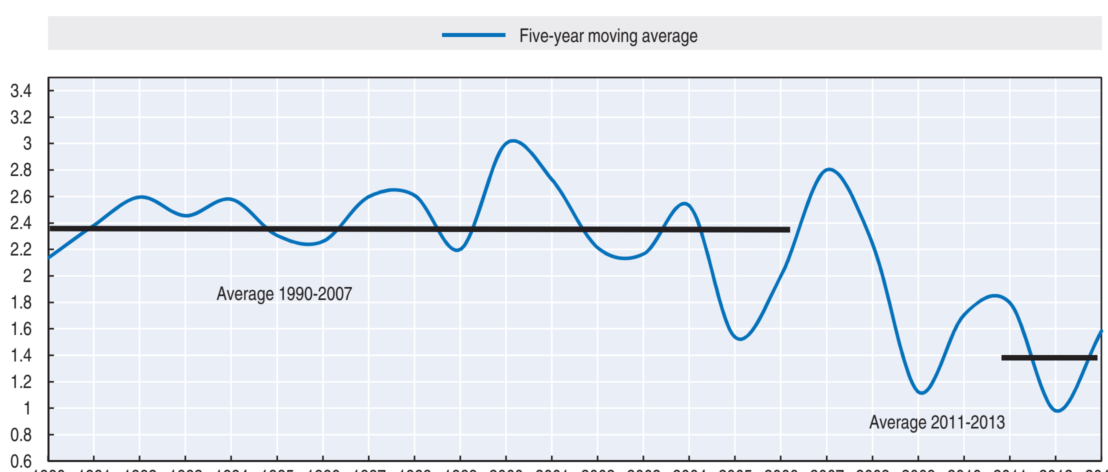
Figure 1.2. **Elasticity of global trade to GDP**



Source: Based on World Bank (2016), World Development Indicators, *http://data.worldbank.org/data-catalog/world-development-indicators.*

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The changing relationship between trade and income growth in recent years has caused much debate about the underlying factors and the implications for the near and longer term. To some extent, trade weakness can be explained by cyclical factors, notably the low volumes of trade-intensive demand components such as business investment, since the financial crisis (ECB, 2014). From a historical perspective, however, it may be that the unusually strong elasticity observed during the 1990-2007 period is attributable to pro-trade structural factors that that are no longer present. For instance, decreasing transport costs, reduction of trade barriers, and declining relative prices of traded commodities and services that boosted trade prior to 2000 had already levelled off by the mid-1990s, so it may be a natural consequence that current trade volumes are no longer as responsive to a given level of income growth.

A more recent structural factor accounting for the trade slowdown has been the slower rate of expansion of global supply chains (Constantinescu et al., 2015). Greater fragmentation of production, especially by the United States (USA) and China, contributed to the higher trade elasticity in the 1990s, but this trend has moderated since the middle of the 2000s. The effect of rising global value chains can be shown by comparing the gap between gross and value-added trade. As trade flows are measured in gross terms, outsourcing of production might lead to double counting of tradable items, whenever an international border is crossed. The gap increased from 33% in 1995 to 51% by the time of the financial crisis, suggesting that global value chains added 0.2% to the elasticity of global trade during this time (ECB, 2014).

Chapter 3 discusses this issue in more detail and assesses the long-term implications of the change of relationship between economic growth and trade for the freight sector.

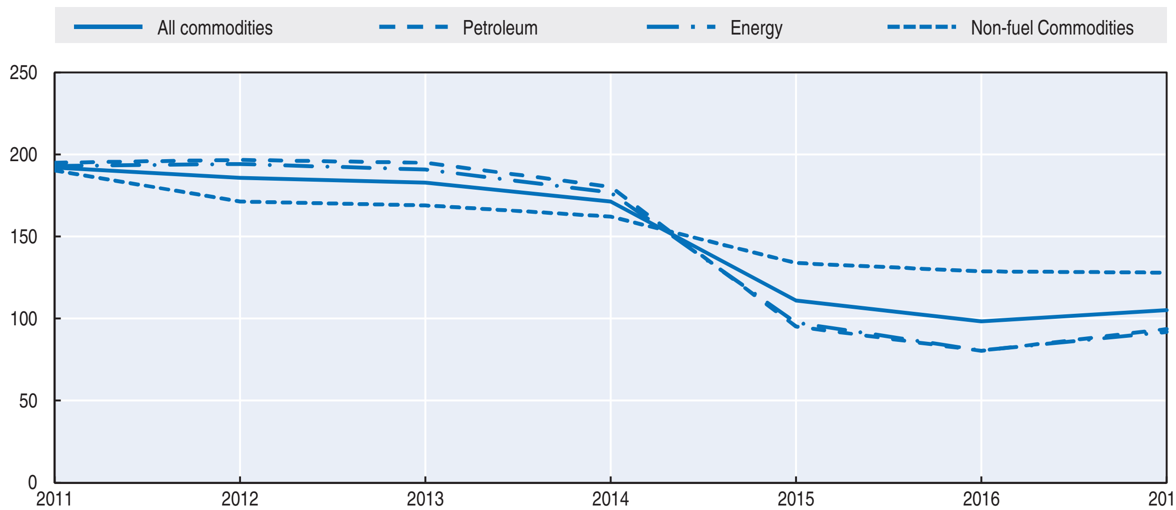
Oil prices

The decline in crude oil prices was particularly sharp in 2014 and 2015, due to a combination of increasing oil supply and weaker global demand, in part resulting from improved energy efficiency. Crude oil prices, averaging U.K Brent, Dubai and West Texas Intermediate, decreased by 47% in 2015 over the previous year (Figure 1.3). It is expected to decline by a further 16% in 2016. While average crude oil prices are projected to rebound by 16% in 2017, it is not expected that they will reach anywhere near their historical high levels any time soon. The IMF forecasts the cost of a barrel at only USD 35 in 2016 and USD 41 in 2017, less than half the 2000-17 average (IMF, 2016). Whether a supply driven decline in oil prices might have positive effects on the world economy remains debatable. A previous scenario by the IMF implied that a positive oil supply shock could be beneficiary to global economic activity, due to a higher marginal propensity to consume in countries benefitting from oil in contrast to exporting countries. While this scenario could increase global GDP by 1% by 2021, weakening global demand would more than offset the net positive effect. Moreover, assuming fiscal and financial stress in major oil-exporting countries could lead to lower public consumption and investment to absorb negative shocks by lower prices (IMF, 2016).

While short-term projections suggest a slow but gradual recovery of oil prices for 2017, uncertainty remains for when and at what price level a new equilibrium might be reached. Increasing demand and slowing supply are expected to lead to a rebalancing of oil prices in the near to medium term. The New Policy Scenario by the International Energy Agency (IEA) assumes that a new equilibrium for oil price will be reached at USD 80 per barrel by 2020 (IEA, 2015). In contrast, according to an alternative Low Oil Price Scenario a low price level ranging between USD 50 and USD 60 per barrel could persist into the 2020s. At this

Figure 1.3. **Primary commodity price indices, 2011-17**

Constant USD, 2005 = 100



Note: Petroleum refers to petroleum crude spot: the average of spot prices for U.K. Brent, Dubai and West Texas Intermediate.
Source: IMF Primary Commodity Prices, *www.imf.org/external/np/res/commod/index.aspx.*

StatLink http://dx.doi.org/10.1787/888933442224

price level, global oil demand from the transport sector could be much higher and incentives to switch from oil to alternative fuels largely diminished. In the aviation sector, for example, the Low Oil Price Scenario implies that the annual average rate of increase of fuel efficiency is reduced by 0.1%.

The impact of oil prices in the transport sector cannot be underestimated. In the short to medium term, low oil prices are a threat towards the various commitments made against climate change: they encourage fossil fuel burning, put investments in clean energy and technology at risk and are a major challenge for firms seeking to introduce clean-energy technologies. Since the beginning of 2015, when prices fell below USD 60 per barrel, sales of SUVs have rebounded from previous lows. Car vehicle-kilometres have picked up in many countries where the trend was previously towards less use of private vehicles (see also the section below on passenger transport).

However, the current low oil prices could also be a chance for clean investments in the longer term. As the competition with conventional fuel hardens, truly cost-competitive clean mobility solutions may emerge. The IEA estimates that the energy efficiency market will continue to grow, even in the current context of lower oil prices (IEA, 2015). This could be an opportunity to invest in research and development, through policy incentives and subsidies, in order to develop technologies which will not require subsidies later on. The current period of prolonged low oil prices could also be beneficial if governments use it as an opportunity to enact rigorous pricing policies, which are more easily accepted at times when petrol is inexpensive.

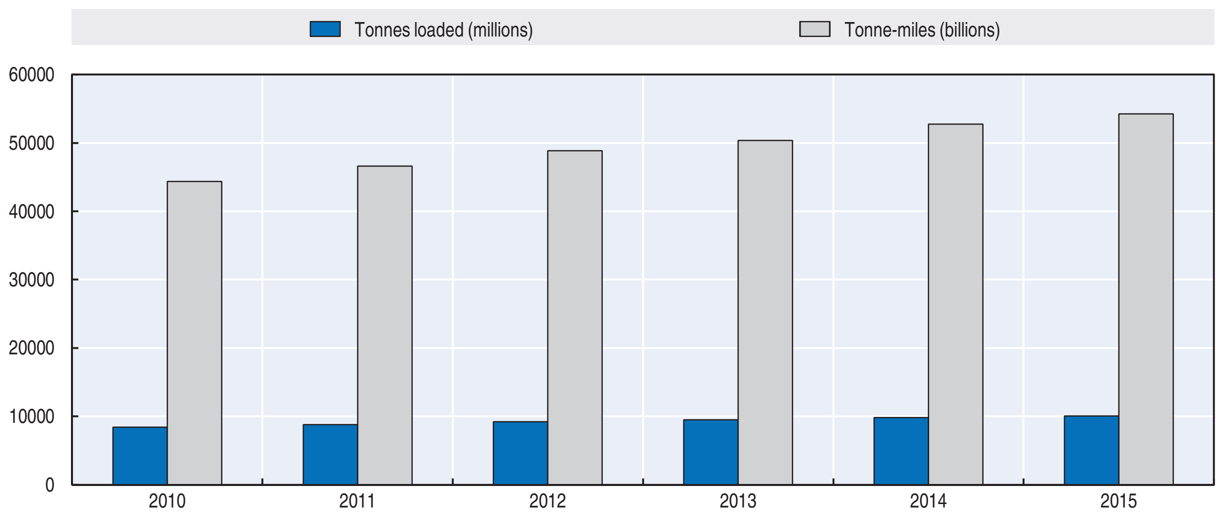
Freight

Maritime freight

Maritime shipping remains the main transport mode for long-distance trade, accounting for around 80% in volume and over 70% in value of global trade. World seaborne trade volumes grew at 2.1% in 2015 (last year for which data are available) – notably slower than in previous years (Figure 1.4). The volume surpassed for the first time 10 billion tonnes in 2015, representing almost two-thirds of world merchandise trade (UNCTADstat). Seaborne trade expanded by 2.9%, when measured in tonne-miles, which provides a better insight on demand for shipping services and tonnage. The persistence of lower commodity prices, linked to a slowdown in emerging economies and dampening import demand from China might translate into much lower freight rates for shipping in the coming years (IHS, 2015).

Figure 1.4. **World seaborne trade**

Million tonnes and billon tonne-miles



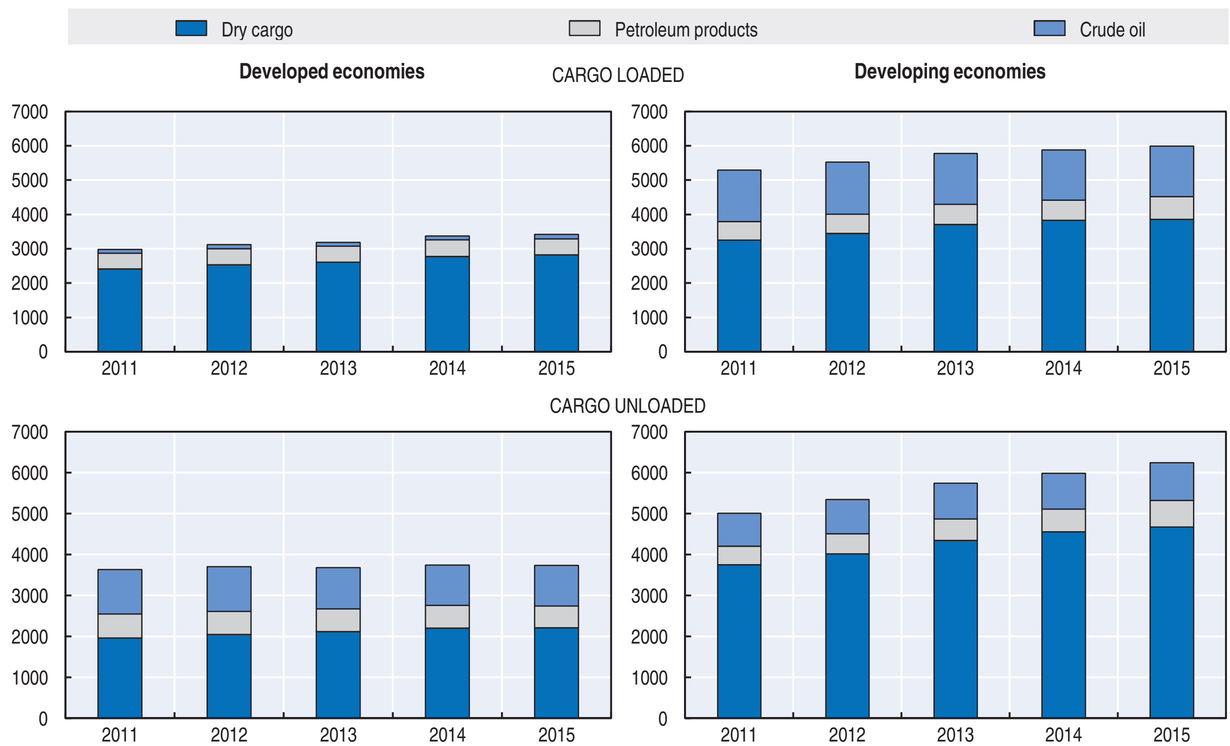
Source: UNCTAD (2015), *Review of Maritime Transport and UNCTADstat.*

StatLink http://dx.doi.org/10.1787/888933442234

Looking at the evolution by commodity, dry cargo shipments represented 70.7% of total international seaborne trade volumes, followed by tanker trade, including crude oil, petroleum and gas. Growth in dry cargo shipments slowed to 1.2% in 2015, down from 5% in 2014 (Figure 1.5). This reflects a fall in shipments of major commodities, notably coal, and the slowdown and decline in construction and infrastructure investment by China (UNCTAD, 2016). Minor bulk increased slowly at 1.5% and other dry cargo at a slower pace of 2.6% compared to 2014. In contrast, tanker trade experienced its best performance since 2008, due to a large supply of oil cargo and lower oil prices. Following two years of contraction crude oil shipments increased by 3.8% in 2015. Petroleum and gas doubled its pace from 2.6 in 2014 to 5.2% in 2015. Developing countries continue to be a growing source of demand for maritime freight. This country group contributed to 60% of loaded and 62% of unloaded goods in 2015. Asia remained the main region for loading and unloading in 2015 followed by the Americas, Europe, Oceania and Africa for loaded good. Europe received larger volumes of unloaded goods, than the Americas, followed by Africa and Oceania.

Growth in containerised trade was particularly strong at 5.6% in 2014, and now represents 15% of global seaborne trade (Figure 1.6). Container port throughput is growing and becoming more concentrated as ships grow in size. UNCTAD estimates that 182 million full containers were transported globally in 2014. In the same year, overall container port

Figure 1.5. **World seaborne trade by type of cargo and country group**
Million tonnes



Source: UNCTADstat.

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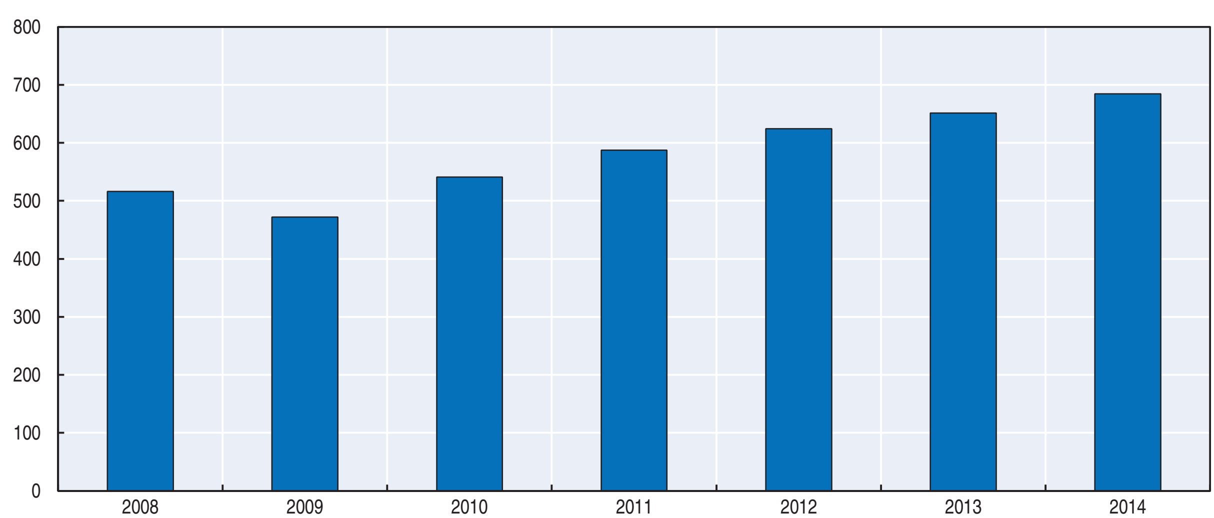
Figure 1.6. **World container throughput**
Million TEU (Twenty Foot Equivalent Unit)



Source: UNCTADstat.

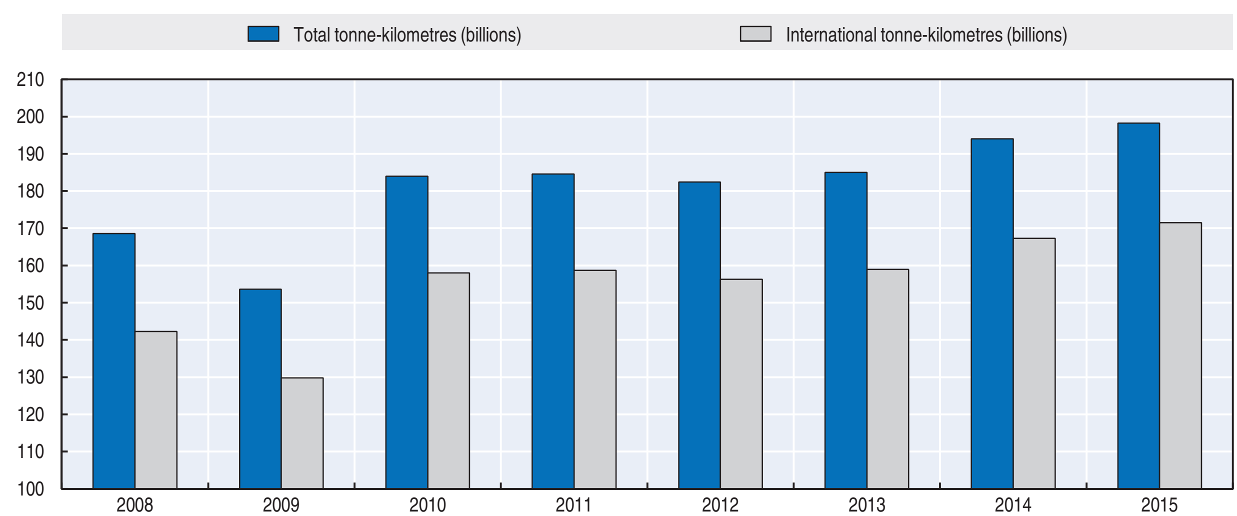
StatLink http://dx.doi.org/10.1787/888933442254

throughput was more than double, suggesting that a significant number of empty containers are repositioned (UNCTAD, 2015). This observation can be linked to the emergence of mega-ships, which have dramatically increased container ship capacity in recent years (ITF, 2015b). Since 2000, container ships have doubled slot capacity every seven years and are estimated to reach a capacity over 21 million TEUs by 2017 (Reuters, 2015). While previous waves of containerisation facilitated global trade by reducing maritime transport costs, the current round of mega-ships is seen to contribute to overcapacity, since new capacity is unlikely to be absorbed in the current context of low and stagnant growth. An increasing gap between supply and demand might lead to lower freight rates (see also Box 3.1 in Chapter 3), fewer profits for the shipping industry and a challenge for ports and hinterland transport capacity, especially when handling larger peaks (ITF, 2015b).

Air freight

World air freight volumes slowed significantly in 2015. Total air freight, measured in freight tonne- kilometres, expanded by only 2.2%, less than half the pace of 2014 (Figure 1.7). Sluggish GDP growth and slowing trade development especially in Europe and Asia-Pacific contributed to the slowdown in 2015 (IATA, 2016a). Previous forecasts from the International Air Transport Association (IATA) and the International Civil Aviation Organisation (ICAO) expected a positive near-term outlook for the next five years with annual growth rates between 4% and 4.5% (IATA, 2015; ICAO, 2013). However, the slowdown in 2015 signals a downside risk for air freight, which is likely to expand at a much slower pace in the coming years, reflecting the current economic situation and the trade developments in the near-term.

Figure 1.7. **World air freight traffic 2008-15**



Source: Based on ICAO (2014, 2015b), *Annual Report of the Council 2014* and *Annual Report of the Council 2015* and IATA (2013), *Air Freight Analysis December 2013*.

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Air freight load factors further declined in 2015, at 43.5%, compared to 50% in 2014 (ICAO, 2016b). This results from the ever-increasing supply of belly-freight, which is growing as demand for passenger aviation shows no sign of weakening. While the decline of oil values contributed to a drop in jet fuel prices, it did not translate into lower unit costs. Industry-specific hedging practices and the depreciation of currencies against the US dollar are major factors delaying and offsetting the potential benefits of lower US dollar-based oil prices (IATA, 2016b). The slowing of air freight volumes was also reflected in a drop in revenues, which were down by 10.7% in 2015 since the peak of USD 67 billion in 2011 (IATA, 2016a).

Among regions, Middle Eastern carriers registered the highest growth rate with 11.3% in 2015. Network expansion into emerging markets and supportive local economic conditions suggest a robust growth path for 2016 despite uncertainties stemming from political instability and the drop in oil prices. Airlines from the Asia-Pacific region, which account for 39% of world air freight traffic, expanded moderately by 2.3%. With the reform of the Chinese economy to focus increasingly on services and domestic consumption, decreasing export orders for Chinese manufacturing contributed to the weakened freight growth in the Asia-Pacific region. Air carriers in Latin America registered an air traffic decline of 6.0% in 2015, partly due to the uncertain political situation and deteriorating economic conditions in Brazil (IATA, 2016a).

Surface freight

Surface freight volumes strongly correlate to the economic environment. It is well established that surface freight (road and rail) volumes grow with GDP (Garcia et al., 2008; Meersman and Van de Voorde, 2005; Bennathan et al., 1992). Freight transport is directly tied to the supply chain (both finished and intermediate goods) and the transport of goods reflects growth in sales or activity in the manufacturing sector. As a consequence, surface freight volumes were deeply affected by the economic crisis. Overall, they have been growing since, reaching their pre-crisis levels in 2011 or 2012, but this hides contrasting situations depending on the mode and the region (see Figure 1.8).

Recent studies also suggest that the relationship between GDP and tonne-kilometres may not be as enduring as supposed, resulting, for example, in revisions of road traffic forecasts in some countries (McKinnon, 2007; Tapio, 2005). There is also strong evidence that the elasticity of freight tonne-kilometres to GDP decreases as per capita incomes grow (see also Chapter 2). However, whether the decoupling of economic growth and freight demand has already occurred in some countries is debated.

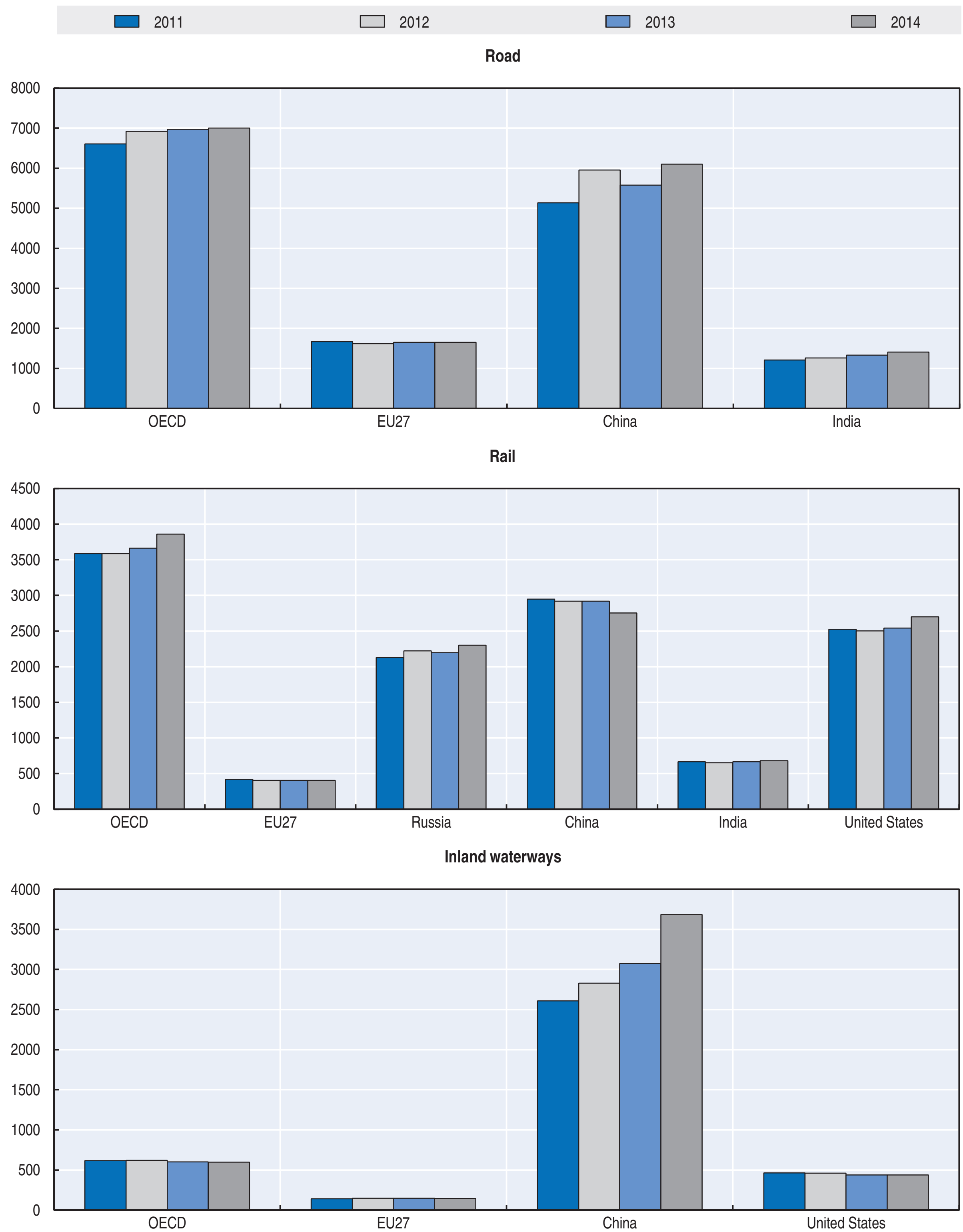
In Europe, road and rail freight volumes have remained more or less constant since 2010 but this is happening in a depressed economic environment. In previous decades, characterised by an expansion of the European Union which led businesses to diversify the locations of their suppliers, warehouses and plants, increase in freight demand was driven by longer average distances. Now that the expansion phase is over, freight demand is not forecast to increase significantly in the near future.

In developing countries, however, freight demand has been increasing steadily since 2009 and is forecast to continue growing in the coming years. As the countries move towards higher value goods, it is expected that the freight intensity of these economies may decrease but the date at which this may happen is very uncertain (see also Chapter 2). While road and rail are both expected to increase, higher value goods tend to be transported by road, rather than rail.

The modal shares of road and rail are, to a large extent, determined by the type of commodities transported, and the distance over which they move. As rail is still used predominantly within countries, due to inter-operability issues, the transport of bulk commodities in large countries represents most of the world rail freight demand. At the global level, the performance of the sector is predominantly shaped by three countries: the United States, China and Russia, which account for nearly 80% of total estimated global rail freight

Figure 1.8. **Surface freight volumes by mode of transport**

Billion tonne-kilometres



Note: Data for some countries are estimated for 2013 or 2014.

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(see Figure 1.8). Following the 2012 slowdown, rail freight started growing again in 2013 and continued to increase in 2014 and 2015, albeit very slowly. The large increases witnessed in 2014 and 2015 in the United States and Russia could drive a more intense recovery in the coming years, but this will also depend on the situation in China, where rail freight decreased due to a slowing in industrial output after having stagnated for several years.

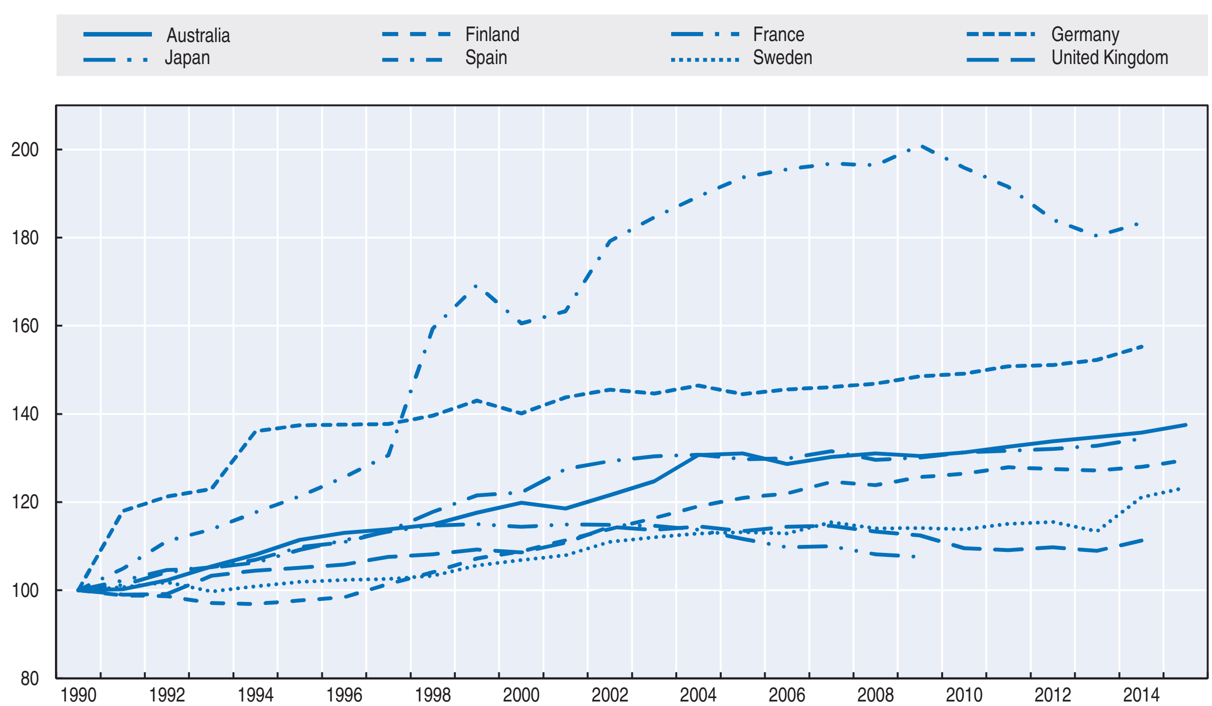
Passenger transport

Car use

The growth of car use, measured in passenger-kilometre, has decelerated in several high-income economies and, in some, growth has stopped or turned negative (Figure 1.9). In most countries, the lower reliance on cars in urban areas explains the lower kilometres travelled with private vehicles. In particular, an increasing number of large cities have been introducing restrictive policies discouraging the use of cars in favour of public transport or active modes. They aim at reducing congestion, noise, accidents and emission of local pollutants. While experiences remain limited to a small sample of cities, such as London, Singapore and Stockholm, initial evidence suggests that congestion charging mechanisms tend to reduce traffic volumes and increase travel speeds in the targeted areas (Santos, 2005; ITF, 2010; Herczeg, 2011). Reduction in the space allocated to cars can also lead to reductions in overall traffic and emissions of local pollutants, even though such measures often increase congestion and have disputed spill-over consequences on the neighbouring areas (AIRPARIF, 2013). Furthermore, slowing population growth, population ageing and increasing urbanisation contribute to the change in car use in several countries.

Figure 1.9. **Passenger-kilometres by private car**

1990 = 100



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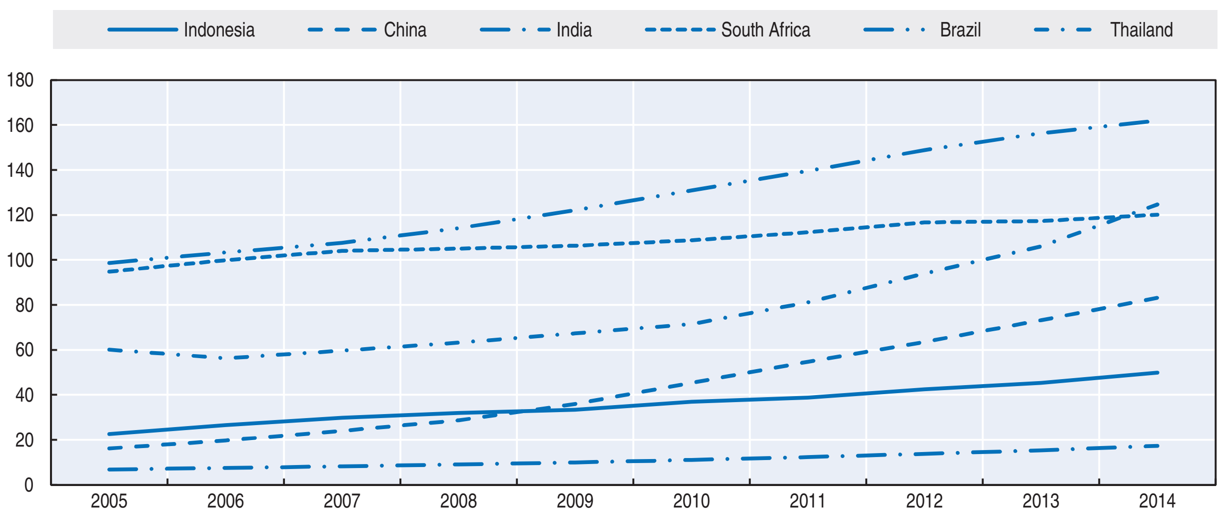
Preliminary numbers for years 2014 and 2015 seem, however, to suggest that car use has picked up in many countries, possibly due to the low price of fuel. This appears to be the case in Sweden or in France, for instance (see Figure 1.9). If confirmed, this trend could have major implications in the fight against climate change, as it reinforces the appearance of a strong correlation between the price of oil and emissions from the transport sector (see also the discussion in the "CO_2 Emissions from transport" section below).

Figure 1.10. **Motorisation rates in selected developing countries**

Private cars per thousand inhabitants



Source: International Organisation of Motor Vehicle Manufacturers.

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In developing economies, increases in GDP per capita and disposable income drive up motorisation rates, albeit at a different pace among countries. Car ownership has been growing particularly fast in countries with a low motorisation rate (Figure 1.10). Motor vehicle ownership has been increasing particularly quickly in China, from 16 cars per 1 000 inhabitants in 2005 to 83 in 2014. This has led many countries to impose drastic measures to control the growth of car use, which comes with many negative externalities, such as pollution, congestion and traffic accidents. Some of China's major cities are limiting the number of vehicle registrations, with auctions or lotteries to allocate the limited amount of registration rights to the population (see also the section on Asian cities in Chapter 5). However, the economic downturn in emerging countries point to lower increases than expected. Growth in car sales slowed from a 16% gain in 2013 to 7.3% in 2015. Car sales in Brazil declined by 30% in 2015 since its peak in 2012 (PwC, 2016).

Several technological innovations could radically alter the passenger mobility sector, and in particular the way people use car. Most notably, the advent of shared mobility on a large scale could change travel patterns in cities and improve accessibility significantly. A recent ITF study suggested the car fleet needed for daily commuting could be reduced to 3% of today's fleet if all trips were made using a comprehensive shared mobility platform (ITF, 2016c). As discussed earlier, car-sharing services are already gaining ridership and in some countries represent a significant share of trips.

Box 1.2. **Towards zero deaths and serious injuries**

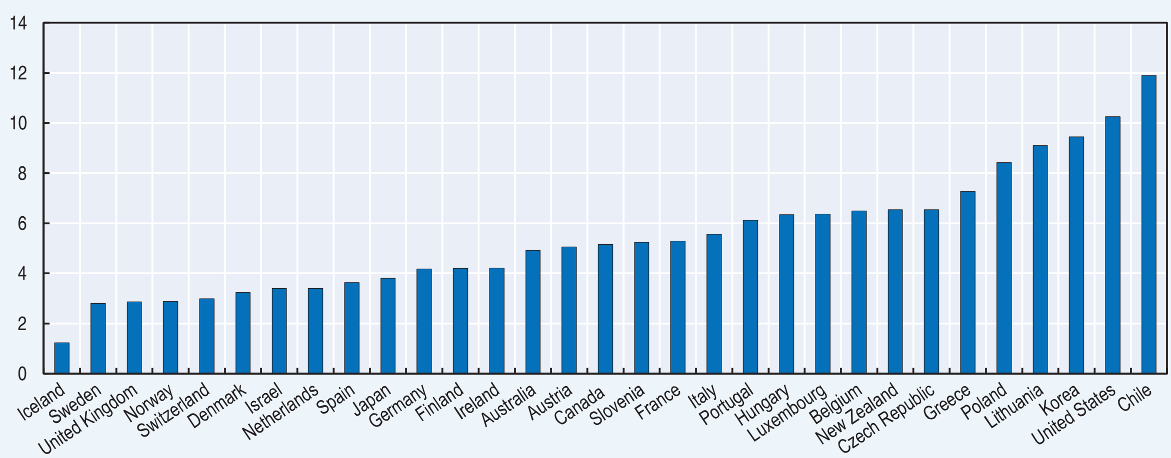
Each year, more than 1.2 million people die in road crashes. Road safety has become a global public health issue, with road crashes being the number one cause of death among young people aged 15-29. Latest figures are alarming: in 2015, the number of fatalities went up in 19 out of the 28 countries where data is available. An ITF report (ITF, 2015c) suggests that the casualty reductions obtained in most OECD countries since 2008 were not solely the fruit of determined road safety policies, but also the effect of the economic downturn. Without a sustained leadership on road safety, the economic recovery may put an end to casualty reduction trends.

The report *Zero Road Deaths and Serious Injuries: Leading a Paradigm Shift to a Safe System* (ITF 2016a), launched in October 2016, gathers lessons from the best performing countries. The Safe System approach acknowledges that humans inevitably make mistakes and are vulnerable. In a Safe System, all stakeholders assume a share of responsibility and no element of the system is neglected.

To implement the Safe System approach, it is essential to build capacity for crash data collection and analysis. As part of this effort, the ITF manages the International Traffic Safety Data and Analysis Group, also known as IRTAD (ITF, 2016b). With around 70 members and observers from 40 countries, IRTAD has become a central force in the promotion of international co-operation on road crash data and its analysis. Inspired by the IRTAD group, 10 Latin American countries are also engaged in a road safety benchmarking analysis.

Figure 1.11. **Road fatalities per 1 000 inhabitants**

2014



Source: ITF (2016b), *Road Safety Annual Report 2016.*

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A Safe System is particularly important in cities, where pedestrians, cyclists and motorcyclists make up the vast majority of traffic fatalities. A number of cities are implementing ambitious strategies to reduce the number of people killed and seriously injured. The Safer City Streets project (*www.itf-oecd.org/safer-city-streets*) aims to monitor their progress, and to assess their road safety situation against other cities globally. Launched by ITF and funded by the Fédération International de l'Automobile (FIA), the project will result in a city-level database on road safety and mobility and bring together experts to make policy recommendations adapted to the urban context.

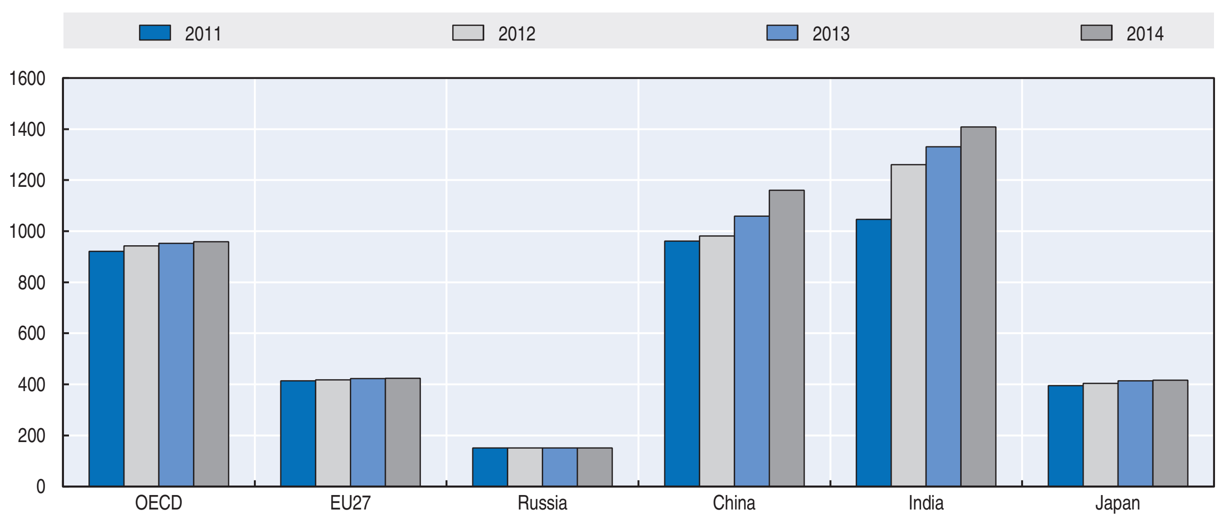
Rail passenger traffic

The economic crisis has had a relatively small impact on rail passenger transport in all regions of the world. However, while developing regions have been experiencing a surge in demand since then, rail passenger-kilometres have not progressed much in OECD countries.

In China and India, which account for more than 70% of global rail passenger-kilometres, significant growth is occurring (see Figure 1.12). In China, the expansion of the high-speed rail (HSR) network substantially alleviated the capacity constraints in the passenger rail sector and boosted the demand. In 2012, 13 000 kilometres of HSR lines in China were in service, more than the rest of the world combined. According the Chinese National Statistics (NBSC, 2015), the HSR's annual ridership grew from 7.3 million passengers in 2008 to 529.6 million in 2013 so that more passengers are now travelling with HSR than via the air. According to the revised plan of the Ministry of Railways (MOR, 2008), the HSR network will to connect all of China's provincial capitals and cities with more than 500 000 residents in 2020, giving access to HSR to more than 90% of the country's population. Added to the strong projected economic development, this implies that the growth in rail demand should remain strong in the coming years.

Figure 1.12. **Rail passenger traffic**

Billion passenger-kilometres



Note: Data for Belgium, Japan, Korea, Mexico and Switzerland are estimated for 2014.

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In the European Union, rail travel has significantly increased in the decades preceding the economic crisis, largely thanks to the building of a large high-speed rail network, including between neighbouring countries. For some city pairs, high-speed rail has completely replaced aviation, for instance between Paris and Brussels.

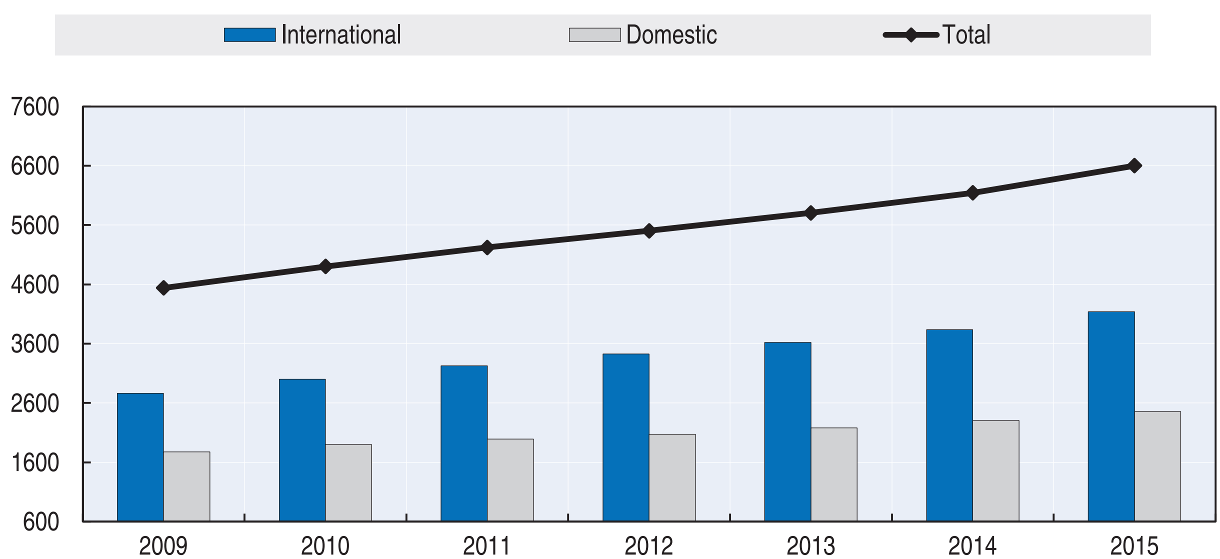
However, rail travel in Europe has stagnated since 2010, with some countries even witnessing decreasing numbers of rail passenger-kilometres. Rail travel faces significant difficulties, in the form of high infrastructure maintenance costs, which push up ticket prices, and low oil prices, which stimulate car and air travel. New mobility solutions, such as inter-urban car-sharing, are also challenging long distance rail travel. Crude estimates from the published figures of Blablacar, the main car-sharing company in Europe, show that car-sharing services are already equivalent to more than 1% of total rail passenger-kilometres travelled in the region. In some countries, such as France, car-sharing represents more than 1.5% of all long-distance trips in the country, or about 10% of rail passenger-kilometres (CGDD, 2016). Car-sharing is also growing in developing countries, with the number of car-sharing trips growing extremely quickly in India for instance (Times of India, 2016). The long-term impact of car-sharing on rail usage, and on the use of private vehicle travel, is difficult to predict. However, it is likely that, while taking passengers off trains, it will not reduce significantly vehicle-kilometres by cars through an increased load factor (see also the section on inter-urban passenger travel in Chapter 2).

Air passenger transport

World air passenger traffic grew by 6.8% and reached about 6 562 billion revenue passenger-kilometres in 2015 (ICAO, 2015a). Passenger aviation has consistently grown at a higher rate than GDP in past decades, but 2015 represented the highest growth rate since the post-recession rebound in 2010 (Figure 1.13). International air passenger traffic grew at almost the same rate as the total at 6.7%. While international traffic in and out of the Middle East showed the highest growth rate with 12.1%, Europe contributed to the largest share of global revenue passenger-kilometres with 37% in 2015. In all markets, lower fares due to the drop in oil prices kept demand for air passenger traffic strong despite only moderate economic growth. Airlines were able to expand their services and improve their efficiency. The air passenger load factor reached its highest level within the last decade at 80.2% in 2015 (ICAO, 2016a).

Figure 1.13. **World air passenger traffic, international and domestic**

Billion passenger-kilometres



Source: ICAO (2015b), Annual Report of the Council 2015.

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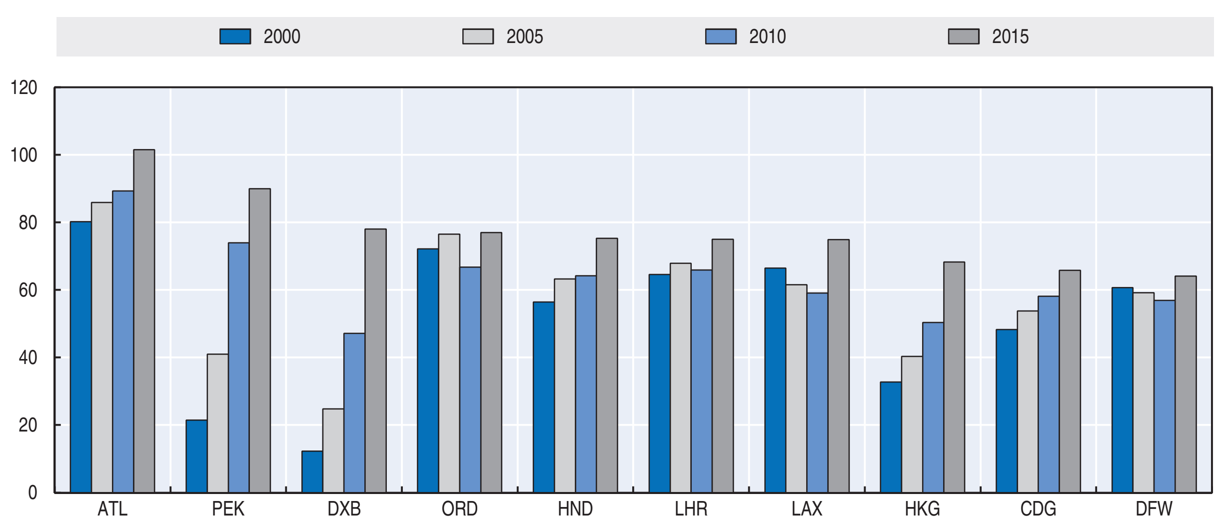
The Asia-Pacific region grew by 10.3% in 2015, mainly driven by China and India. India registered the highest growth in domestic passenger traffic with a 20.2% increase in 2015. At the end of 2015, India implemented a new civil aviation policy to make air travel more affordable and increase the number of airlines which operate in India. This policy removes the previous regulation obliging domestic air carriers to operate for at least five years before flying abroad, and could also encourage foreign carriers to enter India's market (IATA, 2016c; Reuters, 2016).While increasing demand from China and India is expected to keep passenger volumes growing in the short term, the overall growth outlook for emerging markets remains diverse, with Brazil and Russia facing adverse macroeconomic conditions (ACI, 2016a).

Preliminary data from the Airports Council International underline the importance of domestic and international hubs for air passenger traffic (Figure 1.14). Atlanta airport confirmed its dominance as the main hub of United States, and the world's largest domestic air passenger market; its air passenger traffic increased by 5.5%, moving more than 100 million passengers in 2015 (ACI, 2016b). Atlanta benefited from its central position as a hub in the domestic air network; 80% of the U.S. population is within a two-hour flight of Atlanta. Dubai maintained its position as the busiest airport for international air traffic in 2015, increasing by 10.7% and now surpassing London in overall traffic.

Figure 1.14 also reveals the rapidly changing character of the air passenger industry. While the ranking for airports relying on domestic traffic has remained relatively stable, several new international hubs have emerged since the 2000s, such as Beijing, Dubai and Hong Kong airports. Istanbul Ataturk airport, for example, now ranking as the eleventh busiest airport, overtook Frankfurt in 2015 and with rapid expansion of passenger volumes and plans by Turkish Airlines to double the fleet size by the end of 2021, could become Europe's main airport in the medium term, ahead of London Heathrow and Paris Charles de Gaulle (Bloomberg, 2016).

Figure 1.14. **Top 10 busiest airports in 2015 and evolution from 2000**

Million passengers



Note: Airports, from left to right: Atlanta Hartsfield-Jackson, Beijing Capital, Dubai, Chicago O'Hare, Tokyo Haneda, London Heathrow, Los Angeles, Hong-Kong, Paris Charles de Gaulle, Dallas/Fort Worth.

Source: Airports Council International.

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CO_2 emissions from transport

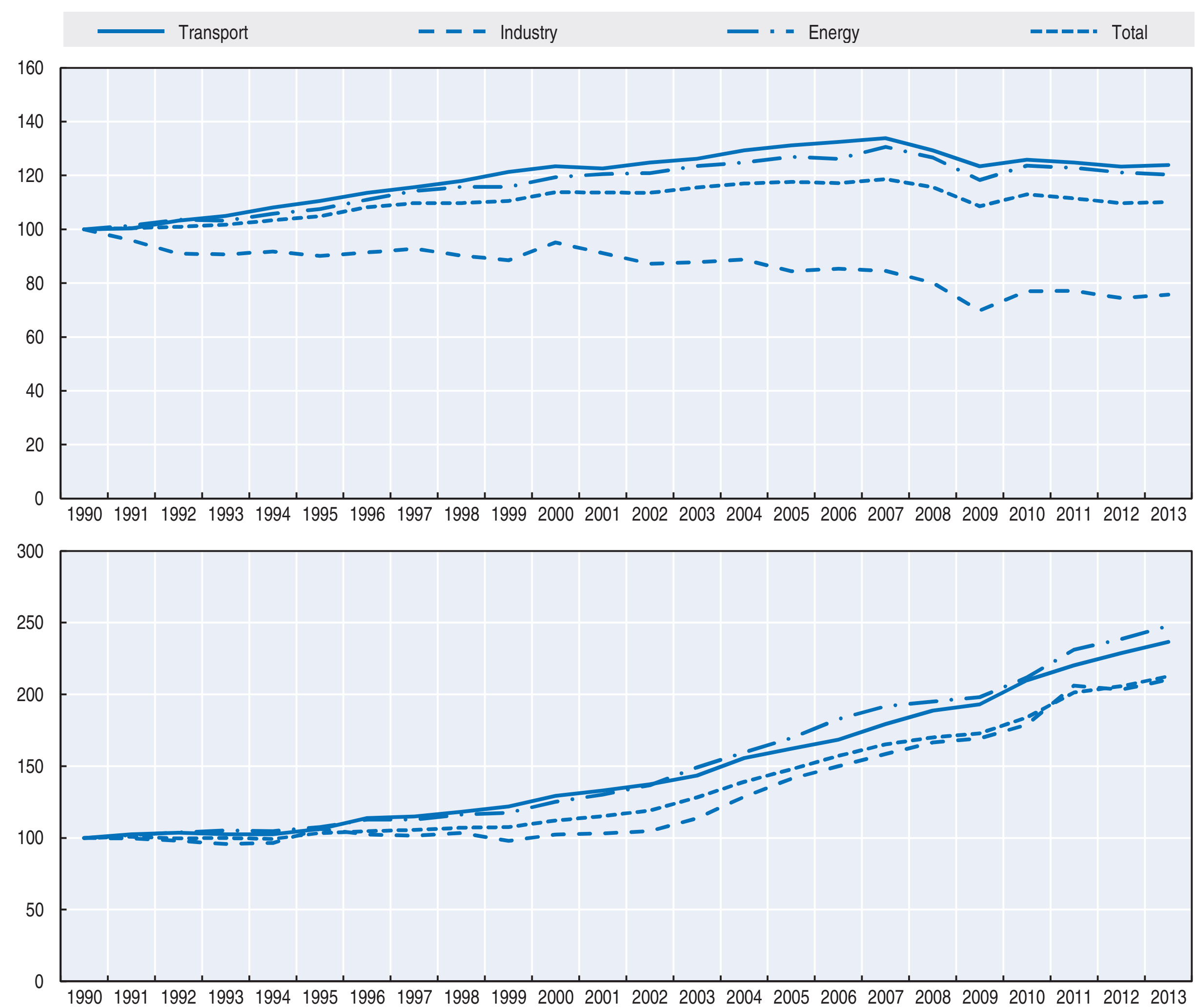
While the Paris Agreement does not reference transport explicitly, the topic was not absent from discussions, being mentioned by several heads of state at the official tribune and discussed in numerous side events. The necessity of decarbonising transport also appears in the Nationally Determined Contributions (NDCs), which frequently mention transport policies or the role of fuel-efficient technologies and alternative fuels. Some NDCs even mention specific targets for the transport sector.

Against this backdrop of discussion and raised awareness around the critical role of transport in the global decarbonisation process, emissions from the transport sector keep on rising globally. At 7.5 billion tonnes in 2015, the sector represents 23% of fuel-burn CO_2 emissions globally, or 18% of all man-made CO_2 emissions (IEA, 2015). The higher efficiency of transport in developed economies does not compensate the much higher rate of travel and freight movements. On average, inhabitants of OECD countries emitted around 2.8 tonnes of CO_2, whereas in non-OECD countries, the figure is only 0.5 of a tonne. As the demand for transport in developing economies, it is expected that their CO_2 emissions rise to levels comparable with OECD countries.

Figure 1.15 shows the evolution of emissions from the transport sector, and compares it with that of other sectors. It highlights the difficulty to decrease the CO_2 emissions from

Figure 1.15. **CO_2 emissions by sector**

OECD countries (top) and non-OECD economies (bottom), 1990 = 100



Source: IEA (2016), CO_2 *Emissions from Fuel Combustion Statistics* (database), *http://dx.doi.org/10.1787/data-00430-en.*

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transport. Indeed, the volume of emissions is 60% higher than in 1990, and emissions are overall growing more quickly than other sectors, especially in OECD countries. Even in the European Union, where emissions have been decreasing since the 1990s, those from the transport sector only peaked in 2006 and have remained stable since. Moreover, the year when emissions from the transport sector started to decrease coincide with the first year of high oil prices. In the European Union, where data for years after 2013 is available, emissions from transport are on an upwards curve again, now that oil prices have been low for several years.

The difficulty developed economies face in decarbonising their transport sector, combined with the projected economic development of some countries, show the magnitude of the challenge ahead. Countries will need to combine a wide range of policies, from support to technology research and development to behavioural measures; the so-called *avoid* (travel) and *shift* (mode) measures. These have gained momentum through their inclusion in many NDCs, the conclusions of the UN High Level Advisory Panel on Sustainable Transport and a recent UNFCCC document for policy makers. While our scenarios for the future of transport demand and CO_2 emissions, detailed in Chapter 2, show that technology is likely to remain the main mitigation contributor up to 2050, it is not enough on its own to reach the established climate targets.

A greater political awareness around *avoid* and *shift* measures may also enable unlocking their full potential. Such measures have so far been applied mainly to the urban sector because of the congestion and health issues surrounding the use of cars in cities. The NDCs reflect the pre-eminence of the urban sector in transport policies: it is very often quoted, with quantitative targets on the share of public transport. However, other sectors, including the heavily emitting freight and inter-urban passenger sectors, are generally absent from policies and the public debate around the climate impact of transport.

Spending on inland transport infrastructure

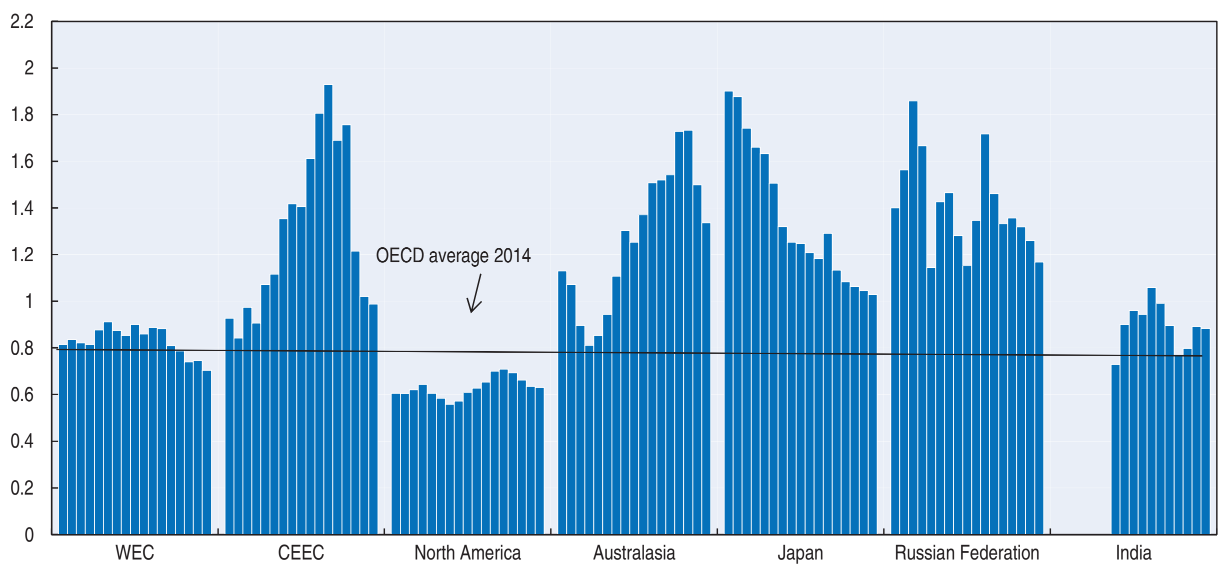
The economic impact of transport infrastructure has been the subject of a body of literature over the past decades (for a summary of empirical literature, see Kamps, 2005; Jong-A-Pin and de Haan, 2008; Crafts, 2009). However, output effects from infrastructure investment are highly context-specific, and not every investment should be expected to produce strong output growth. One possible explanation for the absence of robust findings on growth effects from transport spending in aggregate data is that the growth effects are too diffuse over time and space to be traceable in such data. Alternatively, it may be the case that in fact there is no strong effect on average. Nevertheless, there is some evidence that the productivity of public capital has been declining in advanced economies. This is intuitively logical as the more complete the network becomes, the lower the average impact of another segment. However, even in a context where the average impact is low, individual projects may have a high economic rate of return and be worth pursuing.

In 2014, the average OECD country spent 0.75% of its GDP on gross capital formation (investment) in inland (road, rail, inland waterways) transport infrastructure. This figure is on a declining trend for the OECD as a whole, even though a surge in spending was noticeable in 2008 and 2009 because of the economic stimuli decided by many countries following the economic crisis. Part of the drop can be attributed to a decline in Japan, which followed a different trajectory from the rest of the OECD before 2007. Japan’s expenditure was affected by general budget cuts towards the end of the 1990s. Subsequently, a reduction in the allocation of revenues from gasoline tax, earlier earmarked for highway development and maintenance, led to a further cut in investment in roads in Japan.

In Western European countries, the investment share of GDP has consistently declined since the 1970s, when it was typically close to 1.5%. However, several natural factors help explain this. First, the end of the 70s and beginning of 80s correspond to the completion of some key infrastructure projects in some of the largest countries, such as the motorway network of France and Germany. As these core transport networks were finished, levels of investment declined naturally. Second, many European countries are working with limited budgets, especially since the beginning of the 2000s and the maintenance of the existing networks take larger shares of national budgets (see also Figure 1.16). Finally, it is worth noting that only the share of investment in GDP is decreasing. The spending volume in OECD countries is generally stable or increasing (except in Japan, where it has declined since 1995); the growth of GDP explains the downward curve for the share.

Figure 1.16. **Investment in inland transport infrastructure by region 1998-2014**

As a percentage of GDP, at current prices and exchange rates



Note: Western Europe includes Austria, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey and the United Kingdom. Central and Eastern Europe include Albania, Bulgaria, Croatia, Czech Republic, Estonia, FYROM, Hungary, Latvia, Lithuania, Montenegro, Poland, Romania, Serbia, Slovakia and Slovenia. North America includes Canada, Mexico and the United States. Australasia includes Australia and New Zealand.

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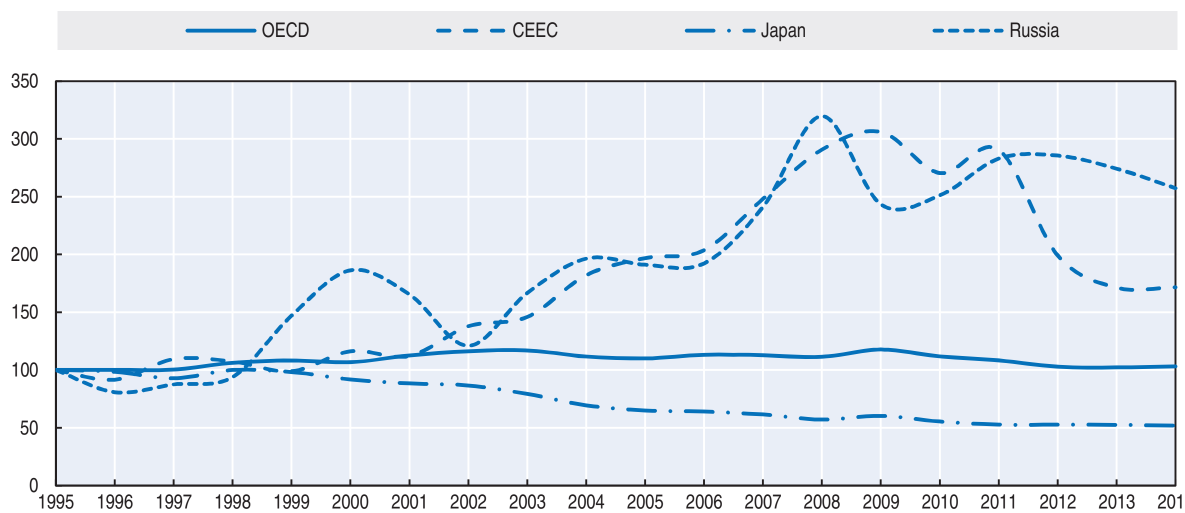
The share of transport infrastructure spending for developing countries generally is above that of developed countries. Most of these countries are catching up, developing their infrastructure supply in quantity and quality to levels observed in developed economies. In Eastern European countries, the availability of European development funds also helps to explain the higher than average figures. The share of investment in inland transport infrastructure in Central and Eastern European countries (CEECs), which until 2002 had remained at around 1.0% of GDP, grew sharply to 2009, reaching 2.0% (Figure 1.16). However, according to our most recent data, investment levels have nearly halved since 2009 in real terms, dropping below 1.0% of GDP in 2014.

The rail share of total inland investment in OECD countries increased from 17% in 1995 to 27% in 2014 according to our estimates. This trend is mainly determined by developments in Japan, North America and Europe where rail investment has grown faster than investment in roads. The trend observed in our data for Western Europe is partly a reflection of the ongoing political commitment to developing railways. In contrast, most developing countries spend a higher percentage of their investment on roads. The share of roads in inland transport infrastructure investment in Eastern Europe and the Russian Federation has been higher than in Western Europe since the end of the 1990s. However, data for the last few years suggest a gradual reversal of this trend, with road investment's share falling back to 71% in 2014, the same level as in 1999.

Figure 1.17. **Volume of investment in inland transport infrastructure by region 1995-2014**
Constant 2005 prices, 1995 = 100



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Information on spending on infrastructure maintenance is scarcer than investment data. This is partly due to the difficulty to draw a line between investment and maintenance spending. Further, there is limited data available on private maintenance.

The share of maintenance appears to be generally increasing in OECD countries. As the stock of infrastructure grows, and in many cases ages, more effort is required to maintain the quantity and the quality of the infrastructure. In spite of this shift, observers in many countries have raised concerns about underfunding of infrastructure maintenance. Road maintenance is often postponed on the expectation that it will be made up for in the future and there is no risk of immediate asset failure. The available data seem to suggest that while there are quite significant cyclical variations, the balance between road maintenance and investment has been relatively constant over time in many regions. We estimate the share of maintenance in total road expenditure to be between 25% and 40% in Western European, North American and Central and Eastern European countries. However, there are significant differences between regions as illustrated in Figure 1.19. Lack of data on the condition of road assets makes it difficult to verify possible underfunding of road assets.

Figure 1.18. **Distribution of infrastructure investment across rail, road and inland waterways**

Percentages computed from current prices, current exchange rates

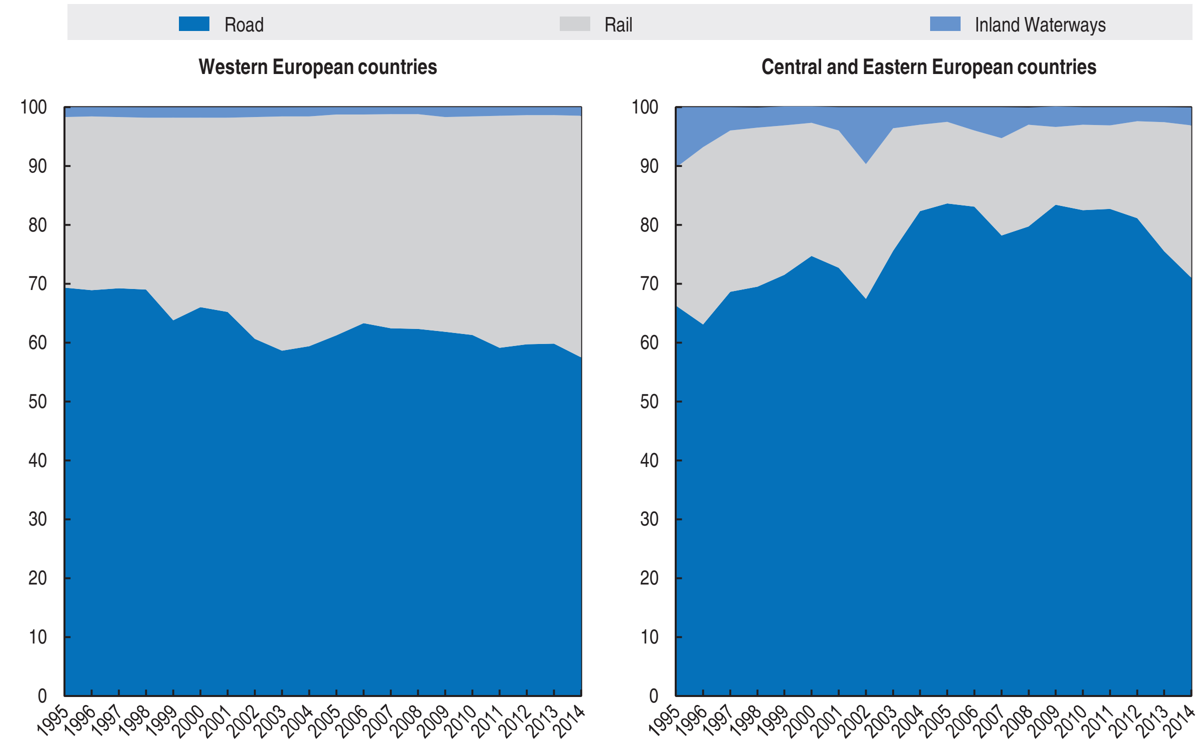

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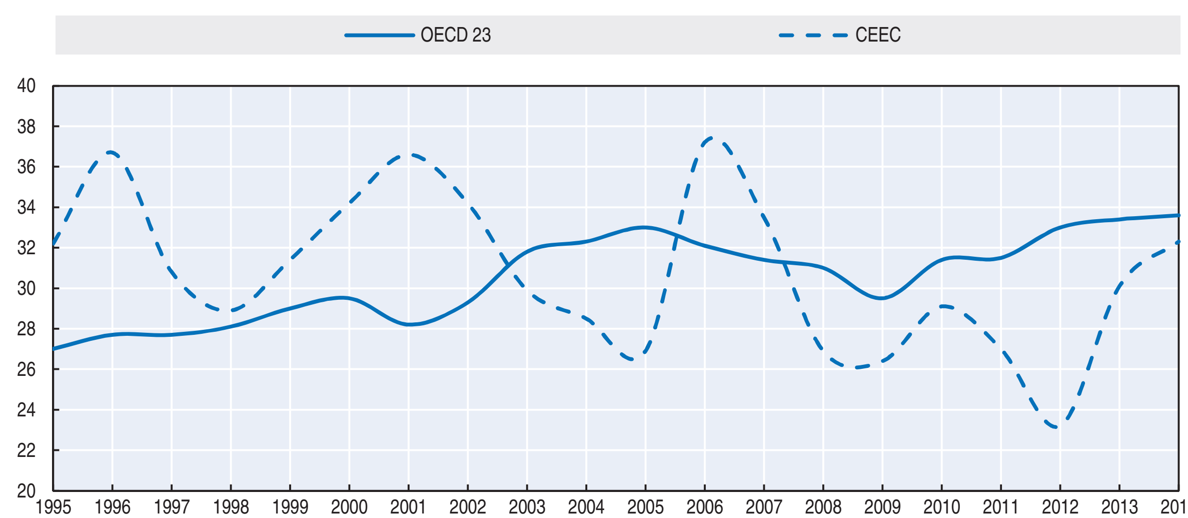
Figure 1.19. **Share of public road maintenance in total road expenditure**

Current prices, current exchange rates (%)



Note: OECD 23 include Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Hungary, Iceland, Italy, Japan, Luxembourg, Mexico, Norway, Poland, Portugal, Slovakia, Slovenia, Sweden, Turkey, the United Kingdom and the United States. CEEC (Central and Eastern European Countries) include Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia.

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References

ACI (2016a), "Airports Council International releases 2015 World Airport Traffic Report. The busiest become busier; the year of the international hub airport", *ACI Media Releases*, 9th September 2016, *www.aci.aero/News/Releases/Most-Recent/2016/09/09/Airports-Council-International-releases-2015-World-Airport-Traffic-Report-The-busiest-become-busier-the-year-of-the-international-hub-airport*.

ACI (2016b), "ACI releases preliminary world airport traffic rankings", Airports Council International, Press release, 4 April 2016, *www.aci.aero/News/Releases/Most-Recent/2016/04/04/ACI-releases-preliminary-world-airport-traffic-rankings-*.

Airparif (2013), *Évolution de la qualité de l'air à Paris entre 2002 et 2012*, Airparif : Surveillance de la qualité de l'air en Ile de France, Juillet 2013, *www.airparif.asso.fr/_pdf/publications/rapport-pdp-130703.pdf*.

Bennathan, E., J. Frase, L. Thompson (1992), "What Determines Demand for Freight Transport?" *World Bank Policy Research Working Paper*.

Bloomberg (2016), "Istanbul Ataturk beats Frankfurt to climb Europe's airport rank", 1 May 2015, *www.bloomberg.com/news/articles/2016-01-15/istanbul-ataturk-beats-frankfurt-to-climb-europe-s-airport-ranks*.

CGDD (2016), "Covoiturage longue distance : état des lieux et potentiel de croissance", *Collection « Etudes et documents » du SEEIDD*, Mai 2016, *www.developpement-durable.gouv.fr/IMG/pdf/ED146.pdf*.

Constantinescu, C. et al. (2015), "The Global Trade Slowdown: Cyclical or Structural?", *IMF Working Paper*, WP/15/6, *www.imf.org/external/pubs/ft/wp/2015/wp1506.pdf*.

CPB (2016), *World Trade Monitor,* Netherlands Bureau for Economic Policy Analysis.

Crafts, N. (2009), "Transport Infrastructure Investment: Implications for Growth and Productivity", *Oxford Review of Economic Policy*, 25, pp. 327-343.

ECB (2014), *Understanding Gobal Trade Elasticities: What has changed?*, *Monthly Bulletin*, ECB, *www.ecb.europa.eu/pub/pdf/other/mb201407_focus01.en.pdf*.

Garcia, C. et al. (2008), "Correlation between Transport Intensity and GDP in European Regions: A new Approach", 8th *Swiss Transport Research Conference*, Monte Verità/Ascona, October 15-17, 2008.

Herczeg, Marton (2011), *Experience with congestion charges*, Copenhagen Resource Institute. *www.scp-knowledge.eu/sites/default/files/Herzog%202011%20Experience%20with%20congestion%20charges%20.pdf*.

High-level Advisory Group on Sustainable Transport (2016), *Mobilizing Sustainable Transport for Development, https://sustainabledevelopment.un.org/content/documents/2375Mobilizing%20Sustainable%20Transport.pdf*.

IATA (2016a), "Air Freight Growth Slowed to 2.2% in 2015", Press Release No. 3, 3 February 2016, *www.iata.org/pressroom/pr/Pages/2016-02-03-01.aspx*.

IATA (2016b), *Annual Review 2016*, *www.iata.org/publications/Documents/iata-annual-review-2016.pdf*.

IATA (2016c), *India's aviation policy could relaunch the industry,* IATA Airlines International, 25th April 2016, *http://airlines.iata.org/analysis/indias-aviation-policy-could-relaunch-the-industry*.

IATA (2015), *IATA Cargo Strategy, August 2015*, *www.iata.org/whatwedo/cargo/Documents/cargo-strategy.pdf*.

ICAO (2016a), *2015: Air Transport Yearly Monitor (Preliminary)*, *www.icao.int/sustainability/Documents/Yearly%20Monitor/yearly_monitor_2015.pdf*.

ICAO (2016b), *May 2016: Air Transport Monthly Monitor*, *www.icao.int/sustainability/Documents/Monthly%20Monitor_Latest/MonthlyMonitor_latest.pdf*.

ICAO (2015a), *Continuing Traffic Growth and Record Airline Profits Highlight 2015 Air Transport Results*, Press release 22 December 2015, *www.icao.int/Newsroom/Pages/Continuing-Traffic-Growth-and-Record-Airline-Profits-Highlight-2015-Air-Transport-Results.aspx*.

ICAO (2015b), *Annual Report of the Council: 2015*, International Civil Aviation Organization. Appendix 1, Tables relating to the world of air transport in 2015, *www.icao.int/annual-report-2015/Documents/Appendix_1_en.pdf*.

ICAO (2014), *Annual Report of the Council: 2014*, International Civil Aviation Organization. Appendix 1, Tables relating to the world of air transport in 2015, *www.icao.int/annual-report-2014/Documents/Appendix_1_en.pdf*.

ICAO (2013), *Forecasts of Scheduled Passenger and Freight Traffic. Medium-Term Passenger and Freight Traffic Forecasts*, *www.icao.int/sustainability/pages/eap_fp_forecastmed.aspx*.

IEA (2016), *CO_2 emissions by product and flow*, IEA CO_2 Emissions from Fuel Combustion Statistics (database), *http://dx.doi.org/10.1787/data-00430-en* (accessed on 19 October 2016).

IEA (2015), *World Energy Outlook 2015*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/weo-2015-en*.

IHS (2015), *Five trends shaping the global maritime industry*, *www.ihs.com/pdf/Global-Trends-Impacting-the-Maritime-Industry_235788110915583632.pdf*.

IMF (2016), *World Economic Outlook, April 2016*, International Monetary Fund, Washington, DC, *www.imf.org/external/pubs/ft/weo/2016/01/*.

IMF (2015), *World Economic Outlook, April 2015*, International Monetary Fund, Washington, DC, *www.imf.org/external/pubs/ft/weo/2015/01/*.

ITF (2016a), *Zero Road Deaths and Serious Injuries: Leading a Paradigm Shift to a Safe System*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789282108055-en*.

ITF (2016b), *Road Safety Annual Report 2016*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/irtad-2016-en*.

ITF (2016c), "Shared Mobility: Innovation for Liveable Cities", *International Transport Forum Policy Papers*, No. 21, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5jlwvz8bd4mx-en*.

ITF (2015a), *ITF Transport Outlook 2015*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789282107782-en*.

ITF (2015b), "The Impact of Mega-Ships", *International Transport Forum Policy Papers*, No. 10, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5jlwvzcm3j9v-en*.

ITF (2015c), *Road Safety Annual Report 2015*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/irtad-2015-en*.

ITF (2010), *Implementing Congestion Charges*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789282102855-en*.

Jong-A-Pin, R. and J. de Haan (2008), "Time-varying impact of public capital on output: New evidence based on VARs for OECD countries", *EIB Papers*, Vol. 13, No. 1, pp. 56-81.

Kamps, C. (2005), "Is there lack of public capital in the European Union?", *EIB Papers*, Vol. 10, No. 1, pp. 72-93.

KPMG (2016), *KPMG Transport Tracker. Global transport market trends and views*.

McKinnon, A. (2007), "The Decoupling of Road Freight Transport and Economic Growth Trends in the UK: An Exploratory Analysis", *Transport Reviews*, Volume 207, Issue 1, 2007, pp. 37-64.

Meersman, H. and E. Van de Voorde (2005), "Decoupling of Freight Transport and Economic Activity: Realism or Utopia?" 16th *International Symposium on Theory and Practice in Transport Economics: 50 Years of Transport Research: Experience Gained and Major Challenges Ahead*, Budapest 29-31 October, ECMT, Paris.

MOR, China's Ministry of Railway (2008), *Mid-to-Long Term Railway Network Plan*, *www.china-mor.gov.cn/tljs/tlgh/201012/t20101228_731.html* (accessed 11.21.10) (in Chinese).

NBSC (2015), *China Statistical Yearbook 2015*, China Statistics Press, Beijing.

OECD (2016), *OECD Economic Outlook, Volume 2016 Issue 1*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/eco_outlook-v2016-1-en*.

OECD (2014), *The Cost of Air Pollution, Health Impacts of Road Transport,* OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264210448-en*.

PwC (2016), *Industry perspectives*, 2016 Auto Industry Trends, PwC Strategy.

Reuters (2015), *Mega-ships are worsening overcapacity in the container market*, 23rd September 2015, *www.reuters.com/article/us-shipping-mega-ships-kemp-idUSKCN0RM2AS20150923*.

Reuters (2016), *India overhauls aviation rules to boost air travel*, 15th June 2016, *http://in.reuters.com/article/india-airlines-aviation-policy-idINKCN0Z10QC*.

Santos, G. (2005), "Urban Congestion Charging: A Comparison between London and Singapore", *Transport Reviews*, Vol. 25/5, pp. 511-534.

SLoCaT (2015), *SLoCaT Preliminary Analysis of NDCs Sees Potential for Ambitious Action on Climate Change in the Transport Sector*, available at *www.slocat.net/news/1589*.

Tapio, P. (2005), "Towards a theory of decoupling: Degrees of decoupling in the EU and the case of road traffic Finland between 1970 and 2001", *Transport Policy*, 12, pp. 137-151.

Times of India (2016), "BlaBlaCar: India could soon be our biggest market", *Times of India*, 18 April 2016, *http://timesofindia.indiatimes.com/tech/tech-news/BlaBlaCar-India-could-soon-be-our-biggest-market/articleshow/51873962.cms*.

UNCTAD (2015), *Review of Maritime Transport 2015*, United Nations Conference on Trade and Development, *http://unctad.org/en/PublicationsLibrary/rmt2015_en.pdf*.

World Bank (2016), *Global Economic Prospects*, June 2016, World Bank, Washington, DC, *http://pubdocs.worldbank.org/pubdocs/publicdoc/2016/5/842861463605615468/Global-Economic-Prospects-June-2016-Divergences-and-risks.pdf*.

WTO (2016), "Trade growth to remain subdued in 2016 as uncertainties weigh on global demand", Press Release, 7th April 2016, *www.wto.org/english/news_e/pres16_e/pr768_e.htm*.

PART I

Chapter 2

Transport demand and CO_2 emissions to 2050

This chapter provides an overview of the long-term prospects for transport demand. Based on projections from the International Transport Forum's (ITF) suite of models, it presents the baseline trajectory for transport demand to 2050 and outlines its projections for CO_2 emissions from the sector. The chapter starts with the baseline scenario projections for passenger transport demand, broken down by mode, for both urban and non-urban areas, between 2015 and 2050. It then focuses on the outlook for freight for the same period, looking at surface freight (rail and road), maritime and air. The chapter concludes with the projections for the CO_2 emissions from transport to 2050, by sector, and a brief review of the ITF's contribution to the Paris Agreement with its Decarbonising Transport project.

The International Transport Forum (ITF) has developed a suite of models to build scenarios for the future of transport demand and related CO_2 emissions up to 2050. The scenarios for passenger demand result from the combination of several sub-models, distinguishing between mobility in cities, domestic intercity travel and international passenger aviation. The ITF's International Freight Model (see Chapter 3) derives the footprint of global trade on the freight transport network, all modes combined. While each model focuses on a different mode or type of mobility, they collectively form a coherent framework for the analysis of long-term global trends. Annex 2.A explains this framework and how it can yield cross-sectorial results.

This chapter takes advantage of the compatible nature of the different models to give an overview of the future of transport demand and CO_2 emissions for all modes, both passenger and freight. It analyses the relative importance of the different sectors and compares their probable evolution. The figures in this chapter result from the baseline scenario for transport demand, which is a projection of current trends and includes current policies and policy developments. The low-carbon scenario, discussed at the end of the chapter, corresponds to the aggregation of the least CO_2-intensive pathways for each sector. A more in-depth discussion of alternative scenarios for international freight and aviation, as well as for mobility in cities, can be found in the three chapters of Part 2 of this publication.

Passenger transport

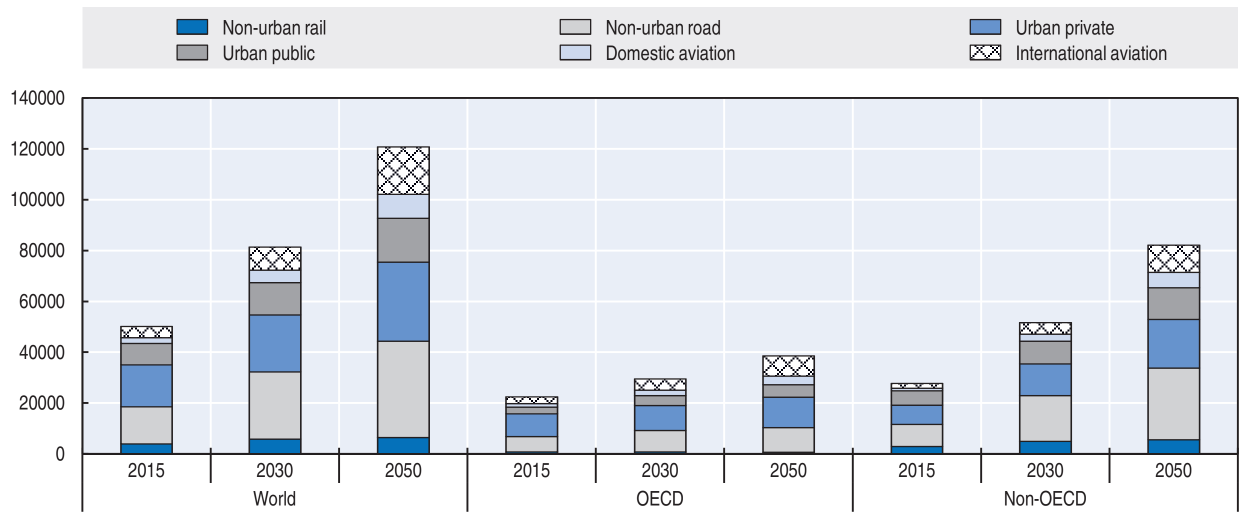
According to our projections, global passenger demand will more than double between 2015 and 2050, from 50 000 to 120 000 billion passenger-kilometres (Figure 2.1). It increases in all regions and for all modes, but the growth is not uniformly distributed. Most of the growth occurs in Asia, which will represent around a third of all passenger transport demand in 2050. In contrast, the low growth rates observed in all OECD countries mean that these countries will only represent 25% of travel demand in 2050, compared to 45% in 2015. Similarly, all modes do not grow at the same speed. Global average growth rates range from less than 2% annually for inter-urban rail to almost 5% for international passenger aviation.

Economic development is the main driving force behind the expected modifications of the passenger mobility landscape. The global increase in Gross Domestic Product (GDP) projected in this *Outlook*, albeit slower than estimated in the previous edition (see also Table 1.2), still induces large-scale changes, both quantitative and qualitative. However, it only constitutes a medium scenario in an uncertain economic environment. Similarly, future oil prices are a major unknown in the equation. This *Outlook* considers several pathways for oil and fuel prices. The baseline scenario considers a moderate increase of oil prices, in line with the current projections of the International Energy Agency's (IEA) 4DS scenario (see Glossary).

The advent of new transport solutions or radically different technology could also overhaul current mobility systems. In the urban sector, for instance, making ride-sharing the norm rather than the exception would completely change the role of cars in urban

Figure 2.1. **Demand for passenger transport by mode**

Billion passenger-kilometres, baseline scenario



Note: International passenger numbers are divided equally between the country of origin and the country of destination.

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mobility systems. A case study for the city of Lisbon established that 3% of the current car fleet would be sufficient to provide the same mobility; it could reduce congestion and vehicle-kilometres, as well as the average travel times (ITF, 2016). Higher utilisation of fewer vehicles means that fuel-efficient or other innovative technology could penetrate the markets more quickly than they are currently. Such transformative transport solutions are unlikely to be implemented in the short term and are not considered in the modelling framework of this *Outlook*. But they will reshape transport systems at some point. Their timing and consequences constitute another uncertainty, making the design of efficient transport policies even harder.

Domestic non-urban transport

All modes together, domestic non-urban transport is expected to grow from 20 000 billion passenger-kilometres in 2015 to around 50 000 billion passenger-kilometres in 2050. Per capita, this represents a growth from less than 3 000 kilometres to more than 5 000 kilometres per person and per year. While the average distance only marginally changes in OECD countries, it more than doubles in non-OECD countries.

If all modes contribute to this trend, domestic aviation will grow the most in percentage terms, at 4.1% annually between 2015 and 2050 (Table 2.1). In 2050, more than one-fifth of all domestic non-urban passenger-kilometres will be made by plane, up from one-tenth in 2015 (Figure 2.2). The growth of domestic aviation is particularly high in China and India, where, much like in the United States (USA), surface modes are not relevant for many internal trips because of the size of the countries. According to our projections, these three countries will represent more than 75% of global domestic aviation demand in 2050.

Transport policies typically aim at facilitating domestic aviation, through deregulation or welcoming fiscal packages for low-cost airlines at regional airports. Domestic aviation is both seen as a significant economic player, especially in terms of employment, and a strong vector for regional development. Its comparatively low share of transport CO_2 emissions reduces further the incentive to manage demand in this sector. In past decades, the domestic

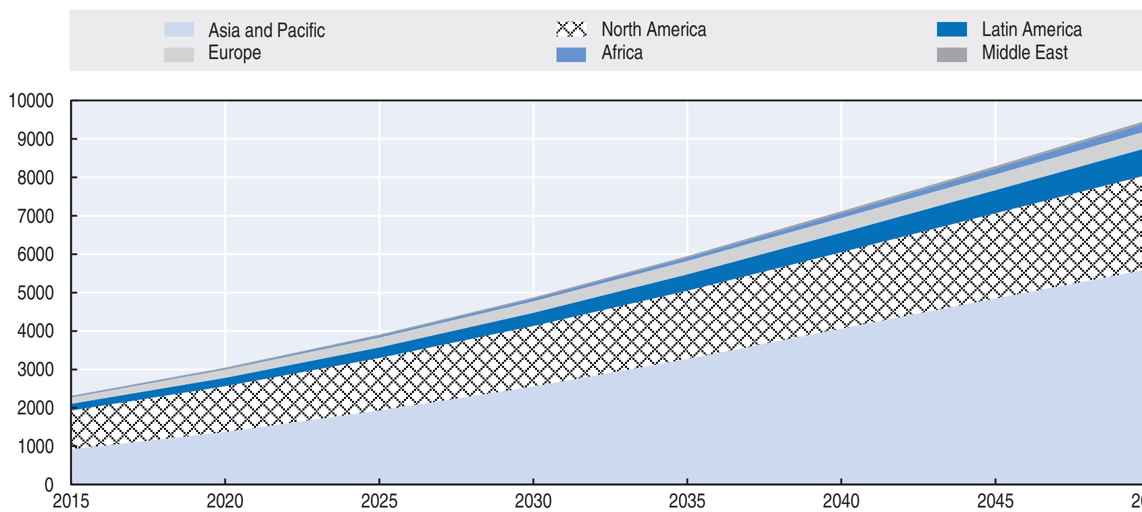
Table 2.1. **Growth in GDP and domestic transport demand**

Global compound annual growth rate (%), baseline scenario

	2015-30	2015-50
GDP	2.7	2.5
Passenger transport demand	3.3	2.5
Domestic non-urban		
Rail	3.3	2.0
Road	4.1	3.4
Aviation	5.1	4.1

Figure 2.2. **Domestic aviation by region**

Billion passenger-kilometres, baseline scenario



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markets in the USA underwent strong deregulation movements, which greatly benefited the sector. Similar changes are occurring or likely to occur in other major markets, giving an overall very positive outlook for domestic aviation. Of course, downside risks remain because of the uncertainties in economic growth and oil prices but the 2010-15 period shows that airlines are able to adapt and grow even during an economic downturn.

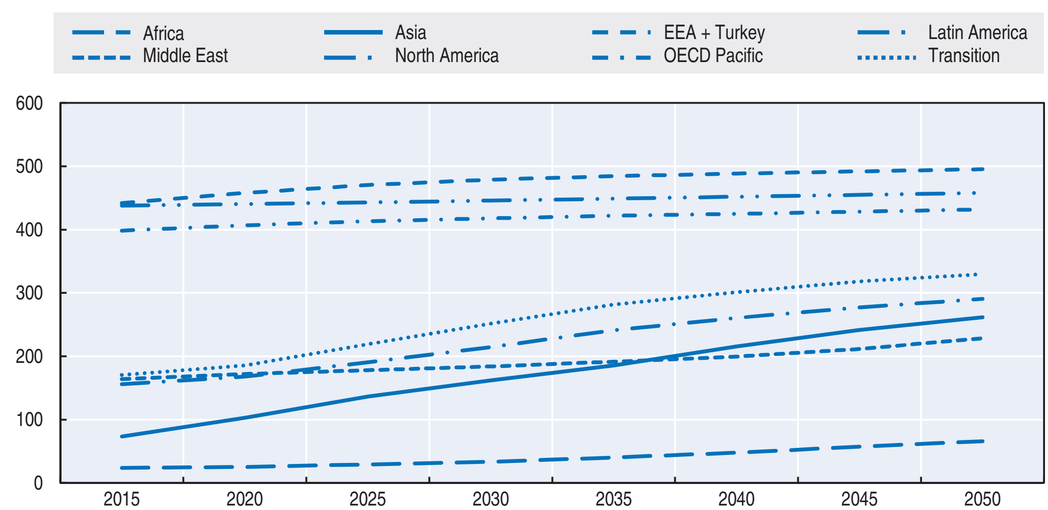
The lack of probable technological or organisational revolutions in the domestic aviation market also reinforces the optimistic forecast. While high-speed rail is able to compete on medium distances (typically between 200 km and 1 000 km), the cost of infrastructure will prevent it from having a large-scale impact on aviation demand. Other high-speed surface modes, such as the Hyperloop, are still at the very early stages and there are strong doubts about their viability, both technological and financial. In the aviation sector itself, there does not seem to be plans for major changes either.

However, the price of oil remains very uncertain and rail may become an attractive investment again if fuel stays expensive for a long period. However, in the absence of evidence to this effect, this *Outlook* assumes only a moderate increase in the price of oil in the baseline scenario, encouraging the use of private vehicles and aviation. In absolute values, travel demand by car increases the most out of all non-urban modes: an additional 45 000 billion passenger-kilometres between 2015 and 2050.

This increase in motorisation results from the rising income levels in developing countries (Figure 2.3). The stock of passenger cars grows from approximately 1 billion in 2015 to around 1.7 billion in 2030 and 2.4 billion in 2050 in the baseline scenario. While some developed economies have reached saturation in terms of car ownership, and some urban areas are actually witnessing a decrease in the number of cars per inhabitant, population and economic growth in developing economies will continue to bring more cars onto the roads in these regions. By 2050, developing countries will own over three-quarters of the world's vehicles, compared with slightly less than half in 2015. In particular, in our baseline projection, the total car stock in China and India will increase nearly five-fold reaching 877 million in 2050. Strong regulation of car use, especially in cities where local government struggle with congestion and the adverse health impacts of local pollutants, could limit the growth of car ownership, even if they do not manage to totally stop it.

Figure 2.3. **Passenger car ownership by region**

Passenger car per thousand inhabitants, baseline scenario



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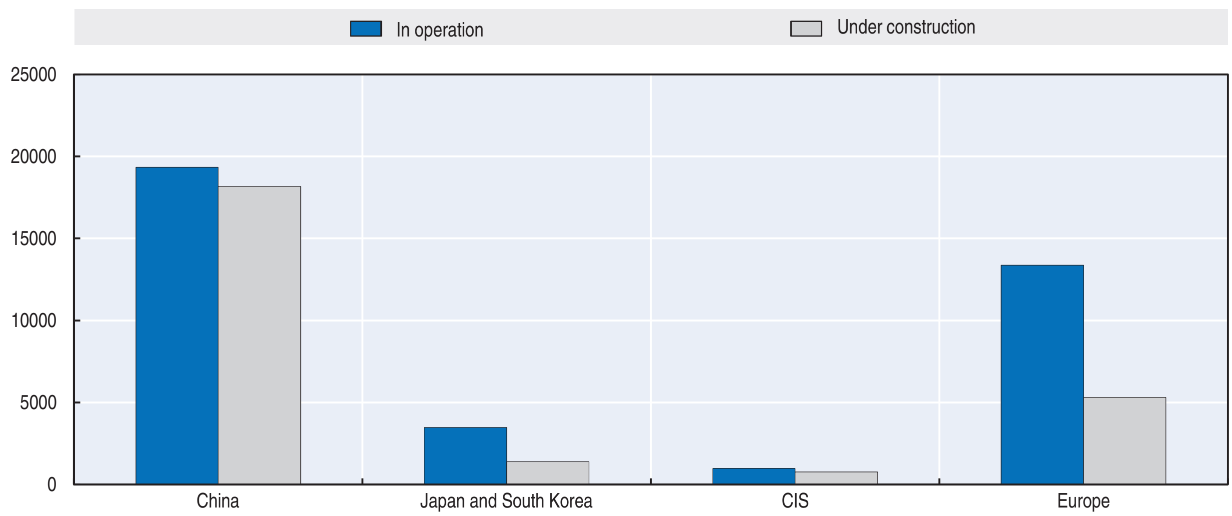
While the negative impacts of rapidly increasing motorisation are the focus of much attention in cities, there are very few transport policies aiming specifically at inter-urban transport. Indeed, the negative externalities commonly associated with road transport have less impact on the population there. Some behavioural changes may occur as a result of restrictions in car usage, for instance through high fuel prices, or through urban policies, which can have spill-over effects on inter-urban transport. However, this can lead to reductions in overall mobility as there are few alternatives to road transport in many cases.

Rail, and especially high-speed rail, can be relevant for some inter-city travel. In some countries, well calibrated high-speed rail lines changed the mode share of inter-city travel away from planes and, to a lesser extent, from cars. In Europe and in China, many high-speed rail projects have resulted in a decrease in air traffic. In some cases, rail travel has completely replaced air travel, save for a few flights used as feeder services to a large hub. This has happened in Spain, between Madrid and Seville, in France, between Paris and Lyon or in China, between Wuhan and Nanjing. However, this is limited in scope, and will only concern pairs of large cities which are between 200 and 1 000 km apart, where high-speed rail is competitive against aviation. This only forms a small part of all non-urban traffic.

As a result, the outlook for non-urban rail is nuanced. If it grows at 3.3% annually up until 2030, boosted by large infrastructure development in China (Figure 2.4), the average overall growth rate for the 2015-50 period is likely to be limited to 2% annually, which is lower than the forecasts for GDP. The lack of foreseeable areas for further infrastructure development, coupled with the rise of domestic aviation, explain this low projection. Moreover, contrary to what happened in European countries during the 19th and 20th century, developing countries are unlikely to invest in extensive conventional rail networks as private cars are now available.

Figure 2.4. **Length of high-speed rail network in selected countries or regions**

January 2016, kilometres



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Car-sharing could also help reduce the number of vehicles on the road without penalising mobility, but the impact of this new form of transport is likely to remain marginal for a while. If large-scale car-sharing could increase the average occupancy rate of private cars, it could also trigger opportunistic usage of private cars to the detriment of rail. A recent study commissioned by the French government (CGDD, 2016) estimates that, between passengers shifting from rail and passengers incentivised to drive by the additional revenues that car-sharing generates, the effect on the use of private vehicles is likely to be null.

Urban mobility

One of the most certain global evolutions of the coming decades will be the process of urbanisation, especially in developing countries. It will change all aspects of urban life, and make the organisation of efficient transport in cities a challenge. In 2050, 66% of the population will be urban, up from 54% in 2014. The concentration of wealth in cities will also continue. Cities above 300 000 inhabitants represent 31% of the world population and 50% of the world GDP, growing to 37% and 56% in 2050.

Mechanically, the demand for urban travel will grow. In the baseline scenario, it is 95% higher in 2050 than in 2015, reaching more than 50 000 billion passenger-kilometres in that year (Figure 2.5). The increase in urban mobility will overwhelmingly take place in developing countries, where the process of urbanisation is the strongest. While the population of cities in OECD countries only marginally evolves, Asian cities, for instance, double in size to represent

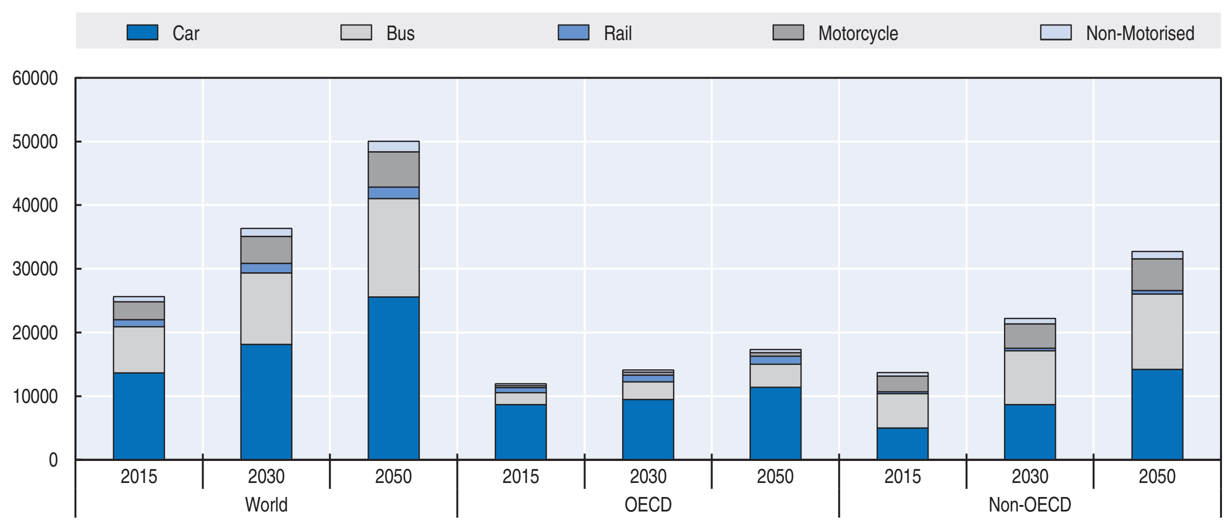
Table 2.2. **Urban transport by mode compared to economic growth**

Compound annual growth rates of passenger-kilometres (%), baseline scenario

	2015-30	2015-50
Urban GDP		
OECD	2.1	1.9
Non-OECD	4.2	3.6
OECD urban transport demand		
Private cars	0.7	0.8
Two-wheelers	2.4	1.8
Bus	2.6	1.9
Rail and metro	2.1	1.4
Non-OECD urban transport demand		
Private cars	3.7	3.0
Two and three-wheelers	2.9	2.0
Bus	3.1	2.3
Rail and metro	2.3	1.7

Figure 2.5. **Urban transport demand by mode**

Billion passenger-kilometres, baseline scenario



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20% of the world population in 2050. Compared with 2015, the mobility by car will only grow 32% by 2050 in OECD countries, against 185% in non-OECD countries.

Computed on a yearly basis, the growth rates for urban mobility can appear quite small. However, many cities, in particular in the developing world, will have trouble accommodating this new mobility. The additional cars will be driving on already congested roads. To tackle this, many policy instruments target the negative effects of car use in urban areas. This means that the baseline scenario, which mimics the current evolution of transport policies, is already quite restrictive for urban transport in some areas. Indeed, the growth rate of urban mobility by public transport in this scenario is 105%, slightly higher than the urban mobility by private modes (90%).

Current policies in some Asian countries even include vehicle registration restrictions or plans for heavy investment in transport infrastructure, including public transport. The increase in motorisation and its impact on emissions in Asia are clearly just at the start, as current projections show a continuous growth over the next few decades in the baseline scenario. Since different Asian cities are growing at different rates, Chapter 5 looks at a group of cities with unique characteristics and constraints that will enable a better understanding of the broad range of transport challenges and solutions in Asia.

If public policies can influence demand and induce some behavioural changes, the effects of such changes are likely to remain small. Any effort to provoke modal shift will struggle to make a real impact because the growth in demand for private cars is stronger. With 30 million additional cars arriving on the roads each year, changing modal shift by 1% remains a significant challenge. The intensity of economic growth in developing regions, and of the increase in transport demand that comes with it, constitutes a groundswell against which current policies can appear derisory, especially when the effects are measured on a global scale.

However, the scenario analysis of passenger transport in cities (see Chapter 5 for details) shows that strict policies targeting land use planning, development of public transport and economic instruments have the capacity to directly influence demand and behaviour. On top of being an additional source of CO_2 mitigation, these measures help reduce congestion and can improve air quality. In the most public-transport oriented scenario which we consider, the Integrated Land-Use and Transport (LUT) scenario, emissions of CO_2 and local pollutants are contained at their 2015 levels until 2050, whereas they grow between 50% and 120% in the baseline scenario.

These positive outcomes are only possible through a combination of three types of measures in favour of sustainable transport: *avoid* (unnecessary travel) *improve* (efficiency of vehicles) and *shift* (to low-carbon modes such as public transport). In the LUT scenario, the average travel distance is reduced because of higher density and better land-use planning (avoid); the efficiency pathways for all vehicles follow the IEA 2 degree scenario rather than the less stringent 4 degree scenario (improve); the average mode share of public transport is 150% higher than in the baseline because of fiscal policies and investment in public transport (shift). In Asian cities, where most of the growth in demand occurs, the share of cars could be reduced from 28% in 2015 to 21% in 2030 and 16% in 2050 in the LUT scenario, whereas it will grow to 35% in 2030 and 40% in 2050 in the baseline scenario.

Strict regulation of car use, along with the deployment of ambitious public transport strategies, can increase accessibility within cities while diminishing congestion and emissions. On the contrary, promoting accessibility by car raises many issues, not least because of congestion. The road infrastructure required to accommodate a car-oriented accessibility can be very difficult to build and maintain, especially in dense cities. Public transport, on the other hand, can deliver accessibility to the greatest number. The analysis of a global accessibility indicator in Chapter 5 shows that, while cars remain the most efficient way to travel in most cities, the development of efficient public transport systems is the only way to provide equitable access, especially in developing regions where car ownership remains very low.

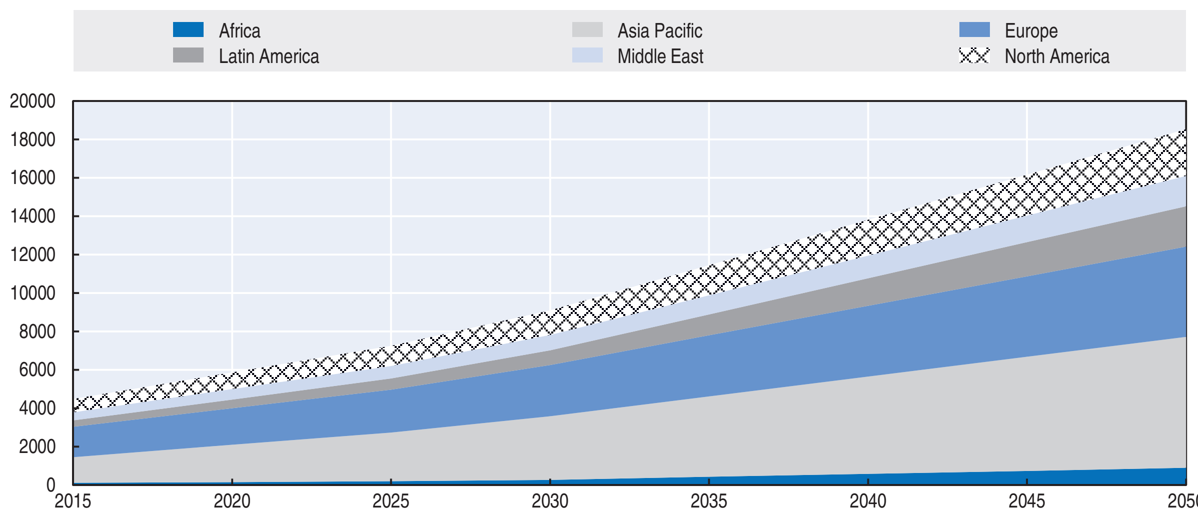
Sprawling cities are fuelling the reliance on cars and necessitate the investment in transport infrastructure that is not environmentally and financially sustainable, especially in Asia and Latin America. Stringent land control policies are needed as they reduce infrastructure needs and ease the implementation of efficient public transport systems. The development of public transport in areas with high urban population density is a way to reduce congestion and emissions and, especially in developing cities, public transport provides services at a lower cost to the user than driving.

International aviation

In percentage terms, air transport will grow the most out of all modes, with an average annual growth rate of 4.7% for the period between 2015 and 2030 in the baseline scenario, and 4.1% between 2015 and 2050. The total demand for aviation in 2050 reaches 19 000 billion passenger-kilometres, up from 4 200 billion passenger-kilometres in 2015 (Figure 2.6). As for all transport modes, the expected growth is concentrated within developing countries, in particular in Asia where the emergence of a large middle-class boosts the number of air travellers. The number of international travellers to and from Asian countries is likely to be multiplied by five while at the same time the number of domestic travellers in the region triples.

Figure 2.6. **International air transport demand by region**

Billion passenger-kilometres, by region of origin, baseline scenario



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Economic growth in itself only explains part of the increase in demand for air travel. The very quick development of the air network also plays an important role in this effect. Because of the uncertainty in the development of the international air network, this *Outlook* introduces three scenarios for international passenger aviation. Alongside the baseline scenario, which prolongs the trends observed during the 2010-15 period, the static network scenario assumes no evolution on the supply side from 2015 onwards while in the dynamic network scenario the network grows even more quickly than in the baseline.

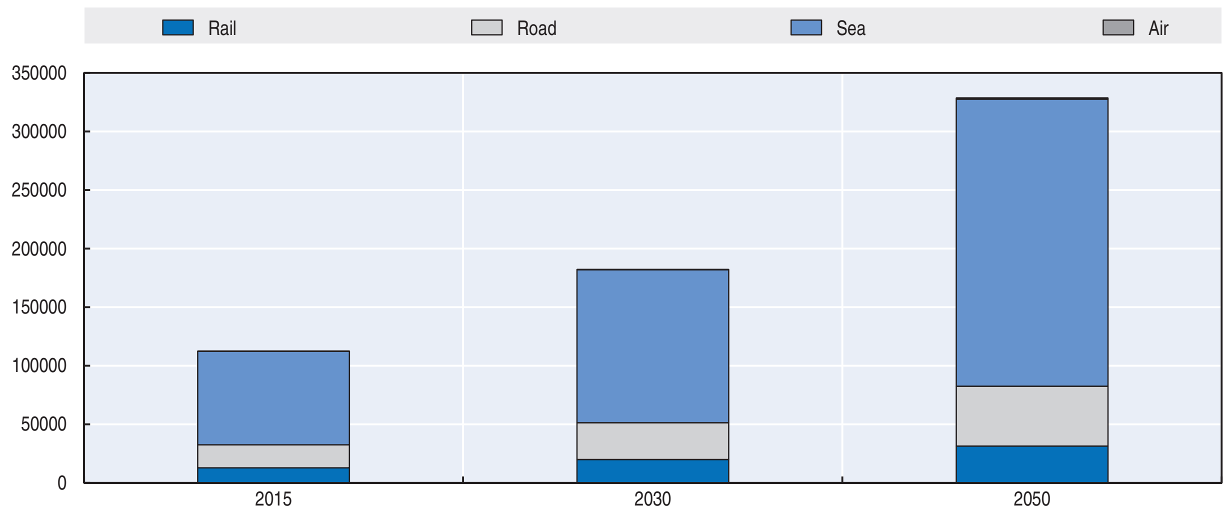
There are very large differences in the expected growth in demand between the scenarios, highlighting the crucial role played by network flexibility. Annual growth rates of 5% are only conceivable in the coming decades if the air network can adapt to the demand. The high growth rates also result from the network creating additional demand, especially low-cost carriers for intra-regional markets. In many markets, air liberalisation has not only enabled the supply of air services to better accompany the evolution of the demand but also created new demand through lower prices and the operation of flights previously deemed uneconomical. Increased competition levels, the arrival of low-cost carriers and, more recently, low oil prices are allowing airlines to operate between thinner and thinner markets. Technological changes, and in particular the advancement of fuel-efficient airplanes, also contribute to this trend.

Freight transport

In the baseline scenario, total freight demand (domestic and international) triples from 112 000 to 329 000 billion tonne-kilometres (Figure 2.7). Demand for freight transport is still primarily driven by economic growth. We find that GDP and surface freight intensity are highly correlated. The average long-term elasticity in the panel of countries we have studied is 0.98 (ITF/OECD, 2015).

Figure 2.7. **Freight transport demand by mode**

Baseline scenario, billion tonne-kilometres



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The global freight transport demand grows at 3.3% annually prior to 2030, while for the 2015-50 period the average growth rate is slightly lower, affected by lower growth in the underlying economic projections. Air freight volumes grow faster than other modes, at 5% annually. This growth is driven by changes in the underlying composition of trade with an increasing share of higher value goods making up the total. Maritime transport accounts for the largest share of tonne-kilometres. In our baseline scenario this grows from 71% in 2015 to 75% by 2050. Road and rail account for the remaining shares while air freight, measured in tonne-kilometres, only represents a marginal proportion.

Table 2.3. **Annual growth rate for freight transport demand, compared to GDP**

Global compound annual growth rate (%), baseline scenario

	2015-30	2015-50
GDP	2.7	2.5
Freight transport demand	3.3	3.1
Rail	3.0	2.6
Road	3.2	2.8
Aviation	5.6	5.4
Sea	3.4	3.3

These projections are clouded with much uncertainty and hinge on various assumptions which may not hold. Economic growth remains lower than expected and is subject to increased downside risks and uncertainties. International trade is now growing at the same pace as GDP while prior to the 2008 economic crisis trade grew twice as fast as GDP. The most recent work suggests that the pace of trade liberalisation, and more specifically increase in trade restrictions, is an important factor in the overall slowdown in world trade growth. Results from the previous *Outlook* (ITF, 2015) suggest that a multilateral trade liberalisation could increase freight volumes by 10% compared with the baseline. However, the difficulties faced by countries in negotiating new trade agreements point towards the lower estimates as being the most probable. Further moves towards protectionism would necessitate adjusting the freight estimates downwards.

Projected trade and freight flows to 2050 highlight the need to assess the capacity of existing national infrastructure to deal with potential bottlenecks. Looking at the traffic forecast to 2030, the largest capacity increases would be needed for Asia in particular. However, plans for capacity development are already sufficient to accommodate future traffic growth, with the exception of South Asia.

Maritime transport

According to our projections, the modal share of maritime transport in international freight will stay constant to 2050, at approximately 80%. The traditional trade routes between developed economies will grow relatively slowly, whereas the growth of the trade corridors connecting developing economies will average 17% annually. By 2050, the transportation corridor between the United States and Asia will be subject to the highest flow of goods in both directions.

Shipping will remain the main or sole solution for the long-distance transport of low value goods, for instance raw materials. This also concerns most shipping from Asia into developed economies. However, new surface transport routes are now emerging, echoing some changes in trade patterns. Shipping time via the traditional maritime route is becoming uncompetitive for some categories of products, such as high-tech goods. This effect is exacerbated by factories in China and elsewhere moving inland, further increasing the shipping time to Europe through increased road haulage and sometimes uncompetitive port handling times. New road and rail routes through Kazakhstan, Russia and then Europe have been developed to answer these issues and they have proved popular with intermediate countries such as Kazakhstan, which are willing to benefit from Eurasian trade (see also KOTI/ITF, 2015).

The growth rates for shipping since 2010 are not as high as projected by ship-owners and the evolution in the coming year is also lower than expected, as exemplified by the downwards revision of the projections between the previous edition of the *Outlook* and this one. As a consequence, maritime shipping faces severe problems due to overcapacity. In 2015, the extent of the oversupply corresponds to approximately a quarter of the world shipping capacity and the future delivery of current orders, combined with the difficulty to inventory vessels, mean that overcapacity will not resorb in the short term (see Box 3.1). Overcapacity will have significant impact on shipping networks, as the shipping industry tries to cut costs. For instance, shipping companies may try to reduce the number of ports in which they call, and the frequency of their movements.

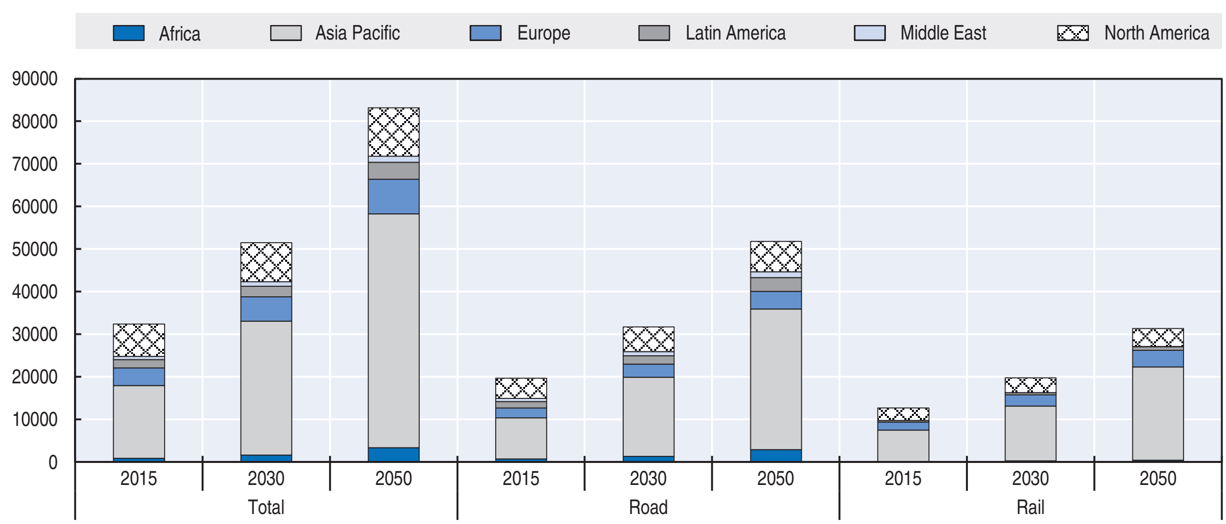
As shippers concentrate their routes onto a narrower selection of ports, the issue of port capacity may also arise. Our results show that, at the regional level, planned capacity improvements from ports are sufficient to accommodate container demand in 2030, save for a few areas, most notably South Asia. However, the aggregate figures hide disparities within regions, and additional capacity may be required at some ports which concentrate demand. Moreover, there are very large uncertainties regarding the future level of demand. Agile planning procedures with a strategic vision for the long term help to adapt to these uncertainties as timing is crucial for good port planning, as infrastructure development is by essence lengthy, lumpy and irreversible. Such plans need to set the direction for future development, prioritise investments and identify potential bottlenecks early in advance. They can also form the basis for land reservations for future port development.

Surface freight

The total surface freight (road and rail) is expected to grow from 32 000 billion tonne-kilometres in 2015 to around 83 000 billion tonne-kilometres in 2050, accounting for around 25% of the total global freight demand (Figure 2.8). Freight transport increases in all regions but there are major differences between OECD and non-OECD economies. Most of the growth will occur in developing economies, volumes tripling in the non-OECD economies to represent nearly 80% of all surface freight transport demand in 2050. Freight transport demand in OECD countries will grow by a factor of 1.6 during the same period. Road is estimated to account over 60% of the total.

Figure 2.8. **Surface freight tonne-kilometres by region**

Baseline scenario, billion tonne-kilometres



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Regionally, the fastest growth takes place in Africa, where tonne-kilometres from surface freight will increase by a factor of 3.7 from 2015 to 2050, albeit starting from very low levels, at less than 1 000 billion tonne-kilometres in 2015. In Asia, tonne-kilometres from surface freight will increase by a factor of 3.2 from 2015 to 2050 accounting for over two-thirds of all surface freight globally. Growth is far from uniform within the broad region of Asia with a significant difference between growth in Japan (around 50%) and other Southeast Asian countries (growth by a factor of 3.5). High-income countries in North America and Europe witness lower increases in tonne-kilometres. In Europe, the volumes are still projected to grow by 100% while they will only grow by 50% in North America. Latin America and the Middle East also show moderate growth, with surface volumes growing by 90% in Middle East and doubling in Latin America.

Our results, especially for emerging regions, differ quite significantly from the previous edition of the *ITF Transport Outlook*. This is mainly explained by the lower underlying GDP projections between the editions. It also reflects difficulties in predicting the evolution of freight intensity as GDP per capita grows. Future freight growth will strongly depend on the future path of development in these countries, especially in terms of their development towards more service-oriented economies.

The surface freight projections assume a reduction in the transport intensity of GDP, mainly driven by the growing contribution of services to GDP. Our estimates show that the relative importance of the service sector in the economy can explain the difference in freight intensities between countries. Since long-term projections for the percentage of services in GDP are not available, our scenarios for future surface freight volumes are based on freight intensity as a percentage of income. According to our estimates, the long-term elasticity (freight intensity) depends significantly on income level; freight intensity decreases from around 1.2 for low-income economies to 0.8 for high-income economies (Table 2.4).

Table 2.4. **Freight intensity as a function of GDP per capita**

Income group (2005 International USD)	Freight intensity
0-4 000	1.18
4 000-20 000	0.98
20 000-40 000	0.87
40 000-	0.82

Except in the case of possible disruptive innovation (see also Box 3.2 about the physical internet), road freight will remain irreplaceable, especially for short distances. In the baseline scenario, around half of the freight-related vehicle-kilometres are estimated to take place in urban areas. However, the number of vehicle-kilometres need not increase at the same pace as the tonne-kilometres.

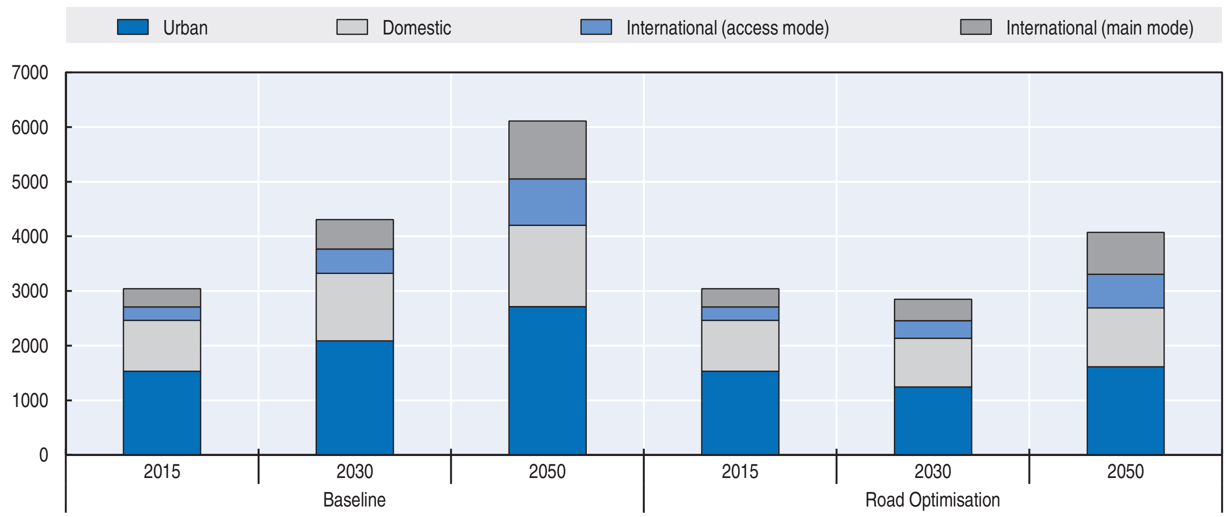
Figure 2.9 details the vehicle-kilometres by road in the baseline scenario and in a scenario where freight operations are optimised. In this scenario, based on computations by the World Business Council for Sustainable Development (Route Monkey, 2016), freight transport operators optimise their load factors and decrease the number of empty trips via a collection of measures. These include route optimisation, asset sharing between companies (warehouses, trucks, IT systems). Moreover, it is assumed that delivery windows are relaxed, which has a large impact, especially for urban freight. In the road optimisation scenario, the number of vehicle-kilometres in 2050 is around 60% of those of the baseline, with urban traffic decreasing most.

For non-urban freight, higher capacity vehicles have the potential to improve fuel efficiency and reduce emissions in addition to operational efficiency gains. They also reduce the amount of truck traffic on the roads, with benefits for safety and the environment (OECD/ITF, 2011).

Finally, the freight sector is not exempt from potential disruptive innovations. Autonomous trucks may arrive on the roads as early as the 2020s, radically changing the competition between the different modes. Rail, in particular, may suffer from the lower costs of road shipping. Autonomous trucks may also pave the way for the Internet of Things, where goods of standardised sizes are transported on a common network, the same way information is transported on the Internet. There are already some trials of such a system on

Figure 2.9. **Road freight activity by sector**

Billion vehicle-kilometres



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a small scale, which point towards significant cost and environmental benefits (Hakimi et al., 2012). However, the development of the Internet of Things on the scale of a continent would require strong commitments by policy makers to enforce the standardisation of goods and the cooperation between companies, in particular around the newly built logistics centres.

CO_2 emissions

One of the most successful outcomes from the twenty-first session of the Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC) is the adoption of the Paris Agreement. In addition, 162 Nationally Determined Contributions (NDCs) were submitted. This process has created a political pathway for climate change mitigation efforts by setting up a five-year review cycle for national decarbonisation commitments starting in 2020. Out of all the submitted NDCs, 75% acknowledged the transport sector's role. Some of the more commonly found commitments include public transport improvement, the use of low-carbon fuel, such as biofuels, Liquid Petroleum Gas (LPG), or Compressed Natural Gas (CNG), the development of electric mobility, and the establishment of national mode share, energy consumption or renewable energy targets.

Political ambition is greatly needed as emissions from the transport sector, contrary to other sectors, are still growing and have only recently started to decrease in developed countries. In 2015, CO_2 emissions from the transport sector amounted to 9 000 billion tonnes, or about 18% of all man-made emissions. Freight represented slightly less than passenger transport in the total. Putting aside international modes, which are difficult to allocate to individual countries, CO_2 emissions in OECD countries amounted to slightly less than 4 billion tonnes in 2015, representing 42% of all transport-related CO_2 emissions. In per-capita terms, this translates into approximately 3 tonnes of CO_2 per inhabitant and per year, against 0.5 for non-OECD countries (Table 2.5).

In the baseline scenario, emissions increase 60% by 2050 (Figure 2.10). Emissions from freight increase most and represent half of all emissions in 2050. This alarming evolution takes place despite the large expected gains in energy efficiency. Indeed, the average CO_2 intensity of transport decreases significantly between 2015 and 2050. In the baseline

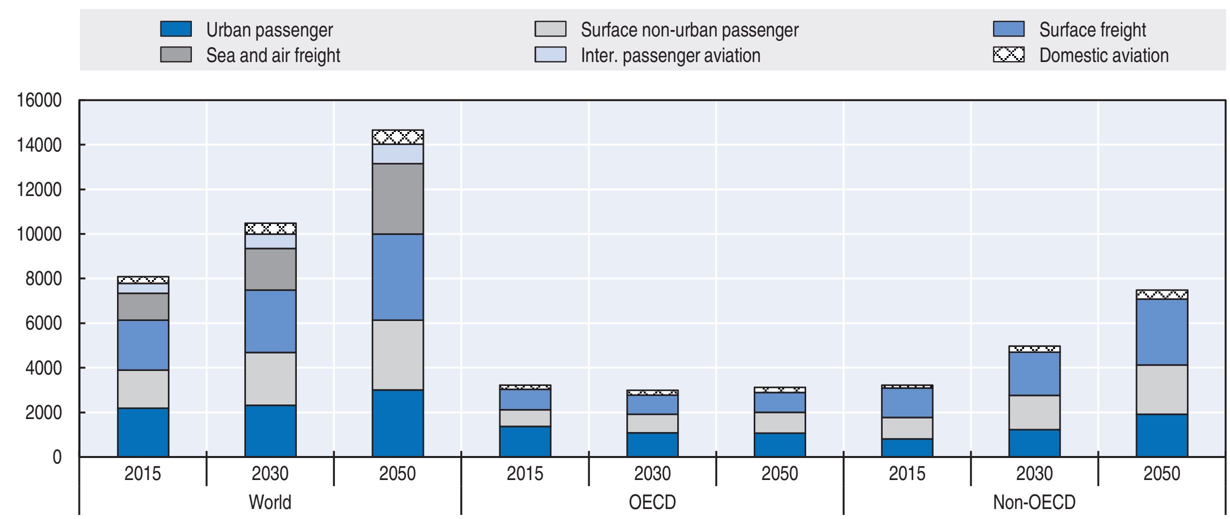
Table 2.5. **Per capita emissions from transport**

Tonnes of CO_2 per inhabitant and per year

	2015	2030	2050
Domestic modes			
OECD	3	2.2	1.8
Non-OECD	0.5	0.8	0.9
International modes	0.2	0.3	0.4

Figure 2.10. **CO_2 emissions by sector**

Million tonnes, baseline scenario



Note: Emissions from international modes are not divided between OECD and non-OECD countries.

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scenario, passenger travel emits 60 g of CO_2 per passenger-kilometre in 2050 on average, compared to 100 g in 2015. Similar improvements occur for the freight sector. However, because of the expected strong growth in transport demand, this is far from sufficient to stop the growth in emissions, let alone reverse the trend.

CO_2 emissions grow in almost all sectors. The emissions from road transport, both freight and passenger, grow by more than 70% between 2015 and 2050; those of international modes (aviation and maritime) almost triple. The situation in cities is markedly different. In the baseline scenario, they remain stable between 2015 and 2030 because local governments have already started to combat the many negative externalities associated with private cars. Indeed, the most efficient way to control the level of emissions in cities is to make sure that the policies targeting local pollutants or congestion, which are acceptable to inhabitants, have CO_2 reduction as a co-benefit. This is not automatic as improvements in fuel efficiency generally lead to increases in the emissions of local pollutants, and *vice-versa*. Diesel cars, while being more fuel efficient, emit substantially more Particulate Matter (PM) than cars running on petrol. Modal shift policies can have unintended consequences if the public transport option consists mainly of diesel buses.

Even if current policies contained in the baseline scenario can only be expected to slow the growth in CO_2 emissions, solutions for maintaining emissions at their 2015 levels exist (see Box 2.1). The low-carbon scenario in this *Outlook* (Figure 2.11) combines the most optimistic scenarios for CO_2 emissions for all modes and sectors: higher efficiency gains for all vehicles

Box 2.1. ITF's Decarbonising Transport project

The signature of the Paris Agreement in December 2015 created a political pathway for climate change mitigation efforts by setting up a five-year review cycle for national decarbonisation commitments starting in 2020. ITF's Decarbonising Transport (DT) project will help economies close the gap between their commitments and mitigation actions, by establishing commonly acceptable pathways to reduce transport CO_2 emissions by 2050.

The DT project directly responds to the needs of all actors to identify effective policies for CO_2 reduction and evaluate the impact of NDCs on CO_2 emissions, the United Nations Sustainable Development Goals (SDGs) and other measures, with a focus on the transport sector. The project is structured according to an inclusive approach that encompasses all types of partners. This approach is founded upon the recognition of the large scale of the challenge and on the need to mobilise the capacities and resources of many sectors and organisations globally in order to be able to tackle them successfully. The DT project is a dialogue process supported by quantitative evidence on the effectiveness of different policies, measures and actions to reduce CO_2 emissions.

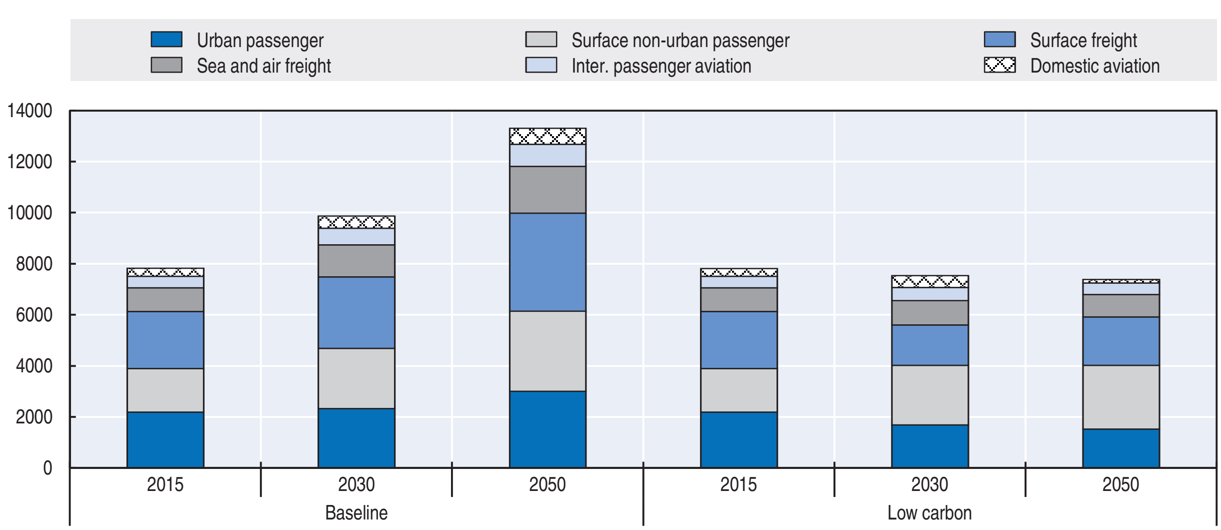
The outputs from a suite of transport models developed by the ITF will produce policy insights that can be integrated into national climate mitigation strategies and used for developing new NDCs. The project outputs will prepare the transport sector for the climate negotiation process in 2020 and contribute towards the decarbonisation of various types of transport systems. The project will contribute to international cooperation by supporting the implementation of the decisions and resolutions of UNFCCC through various dissemination and communication tools, including the ITF website and via ITF member countries, services and events.

The project also aims to build an inclusive and non-prescriptive dialogue with the many public and private entities whose decisions on policy, investment, operating rules, business models, etc. have a strong influence on the performance of transport systems. It aims to build a growing engagement towards carbon-neutral transport systems which support the achievement of the SDGs.

As the only intergovernmental organisation that covers all modes of transport, the ITF is the premier platform for global transport policy exchange. It has wide geographic diversity and a varied CO_2 emissions profile amongst its members. In 2014, it established a Corporate Partnership Board (CPB) with, as of June 2016, 23 leading international companies, engaging with the private sector on subjects of interest both to the private sector and to governments.

Figure 2.11. **CO_2 emissions by sector and scenario**

Million tonnes



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(including alternative fuels for ships), higher fuel taxes, full benefits of vehicle optimisation for road freight and land use and public transport planning in the urban sector. In this scenario, emissions in 2050 amount to 7 370 million tonnes compared to 13 600 in the baseline. Accounting for surface transport only, the total emissions in 2050 amount to 5 900 million tonnes, which is slightly above the 2DS target proposed by the IEA. However, it is still far from the 2 000 million tonnes proposed as a target for the 1.5 degree scenario (Gota, forthcoming).

The mitigation efforts in the low-carbon scenario come from two main areas: road and maritime transport. In the road sector, efficient technology, combined with modal shift strategies in cities and optimisation and sharing measures for freight fleets have a mitigation potential of almost 2 billion tonnes of CO_2 per year by 2030. In the maritime, it is the more optimistic efficiency gains for ships which deliver close to 800 million tonnes of avoided CO_2 emissions by the same year. The three chapters of Part 2 of this publication detail the mitigation potential in each sector.

For passenger travel, technology brings most of the CO_2 emission savings. It represents between 60% and 80% of the mitigation effort in the urban scenarios, close to 100% in the inter-urban. However, strong uncertainties remain as to the pace of penetration of fuel-efficient technologies and alternative fuels. Except in the case of electric vehicles, current technology is already lagging behind the 2DS scenario, from which emissions are derived in the low-carbon scenarios of this *Outlook* (IEA, 2016). This makes the evolution of technology in the coming decades hard to fathom. The uncertainties in technology directly come from the uncertainties regarding the future price of fuels and economic growth. Low oil prices strongly disincentivise the acquisition of more fuel efficient vehicles by individuals and companies. Likewise, they are likely to delay the development of industrial solutions for the production of biofuels, which are currently much more expensive than conventional fuels (see also the emission section of Chapter 4 on aviation). Additionally, low economic growth puts a high risk on investment, which includes investment in clean technology or alternative-fuel facilities.

References

CGDD (2016), “Covoiturage longue distance : état des lieux et potentiel de croissance”, *Collection « Etudes et documents » du SEEIDD*, Mai 2016, *www.developpement-durable.gouv.fr/IMG/pdf/ED146.pdf*.

Gota (forthcoming), *Implications of 2DS and 1.5DS for Transport Sector Emissions in 2050*.

Hakimi, D. et al. (2012), “Simulating a physical internet enabled mobility web: The case of mass distribution in France (p. 10 p.)”, the 9th *International Conference on Modeling, Optimization & SIMulation – MOSIM’12*, retrieved from *https://hal.archives-ouvertes.fr/hal-00728584/document*.

IEA (2016), “Tracking Clean Energy Progress 2016” in *Energy Technology Perspectives 2016*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/energy_tech-2016-en*.

ITF (2016), “Shared Mobility: Innovation for Liveable Cities”, *International Transport Forum Policy Papers*, No. 21, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5jlwvz8bd4mx-en*.

ITF (2015) *ITF Transport Outlook 2015,* OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789282107782-en*.

KOTI/ITF (2015), *Transport and Trade: Connecting Continents*, Summary of the KOTI-ITF seminar, Seoul, 24 March 2015.

OECD/ITF (2011), *Moving Freight with Better Trucks: Improving Safety, Productivity and Sustainability*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789282102961-en*.

Route Monkey (2016), *Demonstrating the GHG reduction potential of asset sharing, asset optimization and other measures*, Report of the Road Freight Lab, prepared on behalf of WBCSD members in the Low Carbon Technology Partnership initiative.

SLoCaT (2015), *SLoCaT Preliminary Analysis of NDCs Sees Potential for Ambitious Action on Climate Change in the Transport Sector*, available at *www.slocat.net/news/1589*.

ANNEX 2.A

The ITF modelling framework

The *ITF Transport Outlook* presents long-run scenarios, up to 2050, on the development of global passenger mobility and freight volumes. Scenarios on both passenger and freight activity are constructed using ITF modelling tools, which have been revised and extended compared to earlier editions of the *Outlook*. The ITF tools are unified under single framework where both input and output data are consistent.

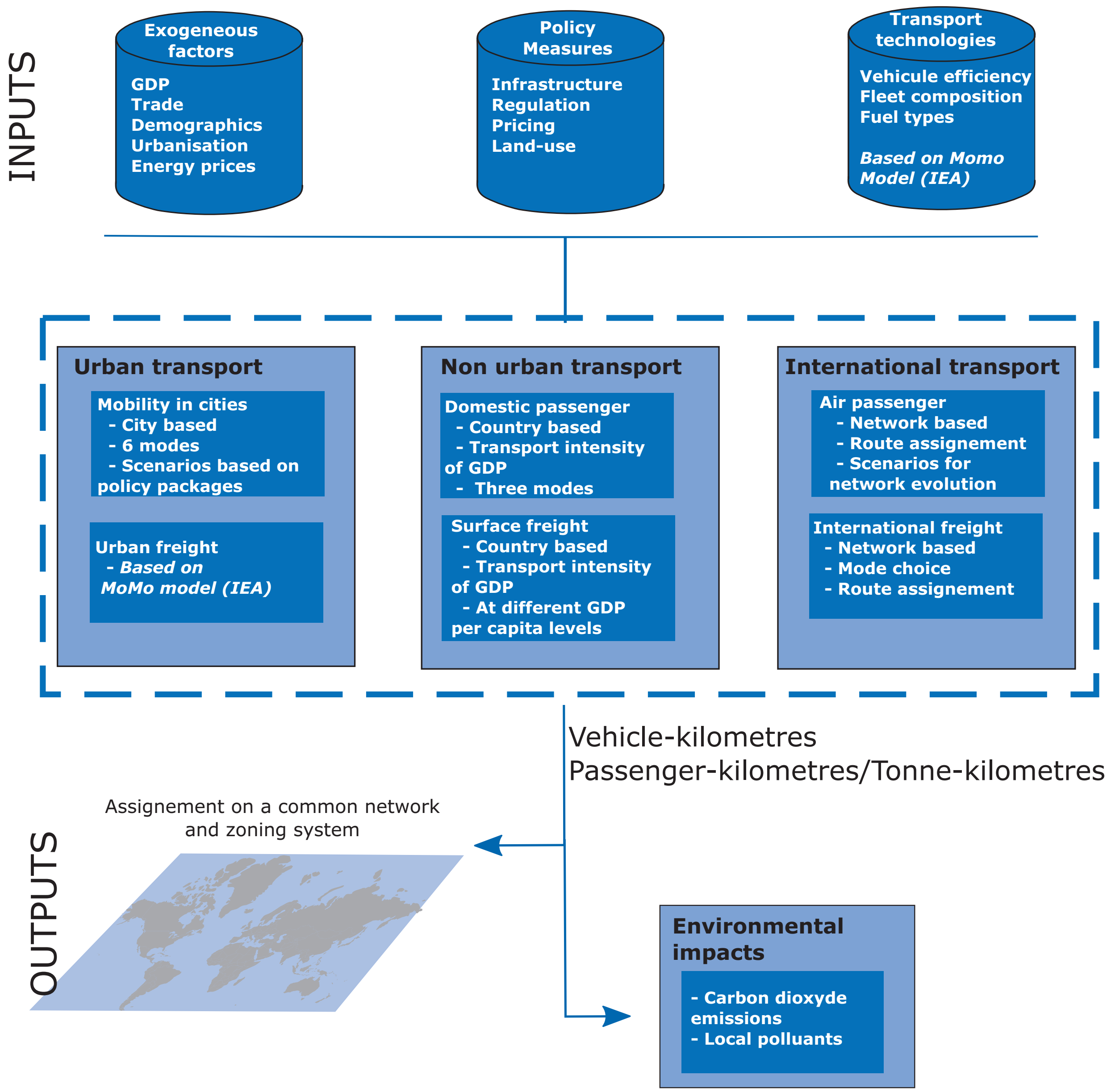
As described in Figure 2.A1, the framework allows modelling a disaggregated, exhaustive and global description of current and future transport volumes. Domestic, and urban, non-urban domestic and international are forecasted in separate sub-models with consistent scope to avoid any double counting. Population and gross domestic product (GDP) are key drivers of a scenario. Population scenarios are based on world population projections by the United Nations. GDP scenarios are based on long-term projections developed by the OECD Environment Directorate. Moreover the ITF framework can assess the effect of a large range of policies and exogenous impacts. In particular urban policies, such transit infrastructure provision, parking or land use strategies can have significant impacts on simulated modal distribution in cities.

Urban transport is estimated via a model based on the 1 667 cities with 300 000 inhabitants or more and results are extrapolated to all urban areas of the world. The model simulates the evolution of variables that shape transport demand in cities – such as population growth, economic activity, fuel prices, land use, availability of roads, quantity and quality of public transport. The model derives levels of transport activity and modal shares that would result under different scenarios, e.g. for policies that favour public transport or for declining fuel prices. It is calibrated on a dataset resulting from an extensive collection from various institutions and covering all the main regions of the world.

International transport is simulated by two distinct network models. The international freight model projects transport activity in tonnes-km and related CO_2 emissions up to 2050 based on alternative trade liberalisation scenarios. It takes as input the value flows from the ENV Linkage model, the general equilibrium model of Environment directorate of the OECD that are split into according modes and then converted into tonnes using a weight to value module. Finally flows are divided between routes using a capacity constrained assignment procedure. The model takes in account flows of 19 commodities on a zoning system of 333 regions.

The ITF air passenger model is a forecasting tool to study aviation policies. The model derives the evolution of international passenger volumes (number of passengers and revenue passenger-kilometres) up to 2050 according to different policy scenarios. The

Figure 2.A1. **The ITF modelling framework**



model combines a gravity-type module to assess passenger demand to a route choice module which splits the demand between two regions among the different possible itineraries. Both models are calibrated with on-flight demand data provided by ICAO. Because the model is geographically very detailed – 310 regions – it also allows the analysis of more specific analysis at the regional, country or airport level.

Inter-urban transport derives from a statistical analysis of country level aggregates. Both freight and passenger activities take GDP as the main explanatory variables of transport volumes. The elasticities to GDP vary according to the income level of a country and are estimated using regression analysis on panel data from ITF and the International Road Federation (IRF).

PART II

Sectoral outlook

PART II

Chapter 3

International freight

This chapter presents results from the International Transport Forum's (ITF) International Freight Model with projections for international trade-related freight flows and CO_2 emissions up to 2050. The chapter highlights uncertainties in future trade projections and discusses their implications for freight movements. It then presents alternative scenarios for future CO_2 emissions from international freight. The chapter also discusses the impacts of growing transport demand on capacity needs in ports and hinterland connections. It addresses the challenges of hinterland transport and finally provides guidelines for decision makers when planning for the future of international freight.

World trade growth remains weak and the volume of international trade-related freight movement is growing at a significantly slower pace than prior to 2008. The drop in global trade demand and increased protectionism, combined with aggressive ordering of additional and larger ships over recent years, has pushed the shipping sector further into a crisis. Overcapacity in shipping has reduced ocean freight rates to very low levels. This decrease in the cost of maritime transport has not resulted in significantly more trade, but rather has driven the shipping industry into unsustainable debt, resulting in bankruptcy for several shipping companies. In container shipping, increasing ship size has intensified consolidation of the sector and increased cooperation via alliances.

This crisis has ripple-effects for the whole global supply chain. Many countries have overinvested in ports, having used the same optimistic demand projections as shipping companies. As a result, ports suffer from overcapacity and the financial performance of the terminal sector is under pressure. In container shipping, the cargo concentration due to mega-ships and alliances has resulted in less frequent port calls and rationalisation of shipping services, leaving an increasing number of ports and terminals with less or no cargo to handle. At the same time, this concentration of container port throughput has resulted in increased congestion for hinterland transport in some regions.

In the medium and long term, trade growth will likely pick up, but projections are clouded with much uncertainty. Our projections show that by 2050 international trade-related freight could still triple, but this hinges on various assumptions that may not hold. The carbon emissions from international trade-related freight transport could grow by 120% by 2050 if no additional actions are taken. Because of the international nature of shipping and aviation, their emissions are not part of the current negotiations under the aegis of the United Nations Framework Climate Change Convention (UNFCCC). Instead, they are dealt with in the context of the International Maritime Organisation (IMO) and International Civil Aviation Organisation (ICAO), both specialised agencies of the United Nations. The challenge will be to reduce the carbon intensity of freight transport. Although this might be feasible using optimisation of networks and more stringent technologies, new policy measures and alternative fuels would be needed to reach such a pathway.

Investment needs in ports and trade-related surface transport networks are also significant but planning is difficult due to this current uncertain climate. Evidence suggests that estimated capacity improvements currently announced are sufficient while several regions actually have over planned these needs.

Transport actors will need to find ways to adapt to these uncertainties. Rather than considering the future as an extrapolation of the past, freight transport companies and policy makers will need to plan for uncertainties and divergent possible scenarios for the future. In particular for long-term transport planning, both in the private and public sector, knowledge and understanding the possible implications of the evolving trends outlined above will be essential.

Underlying trade projections

The conditions for global trade have worsened since the International Transport Forum's (ITF) *2015 Transport Outlook*. In 2016, global trade growth retracted and the short term outlook has not improved. Recent years have seen an increase in trade restrictions and rising challenges to finalise negotiations on trade agreements, such as the Trans-Pacific Partnership (TTP) and Transatlantic Trade and Investment Partnership (TTIP). Moreover, we seem to have reached the limits of a global outsourcing model: the proliferation of global value chains has halted and manufacturing has become more regionalised.

As discussed in Chapter 1, world trade has slowed not only in absolute terms but also in relation to Gross Domestic Product (GDP) in recent years. In the two decades preceding the financial crisis, world trade expanded rapidly and outpaced GDP growth. This relationship has declined since 2008-09 (Figure 1.2 in Chapter 1). In our underlying economic projections, growth in trade is still expected to outpace GDP growth over the next 40 years, although at a lower scale than during the pre-crisis decades. World trade is estimated to grow at around 3.5% annually (compared with 6.9% over the period 1990-2007), implying a permanently lower elasticity of trade to GDP.

Several reasons, both cyclical and structural, have been put forward to explain the changes in trade elasticity (for discussion on trade elasticities, see OECD, 2016; Constantinescu et al., 2015; ECB, 2014). The cyclical reasons take root in the state of the global economy following the global crisis. The crisis hit advanced economies, and especially the EU, hardest and their contribution to trade elasticity fell sharply during the crisis. Investment, the most trade-intensive component of domestic demand, also suffered during the crisis. However, these are more the manifestation of a decline in the overall global activity rather than of changes in trade elasticity.

Other longer-term structural changes can explain the observed shift in elasticity. Emerging economies are moving up in the value chain resulting in an increase in the domestic value-added component of exports. The main contributors to world growth over the next half century will rely less on export-led growth than in the past decades. It also reflects that the intensity of fragmentation of global value chains is slowing down as there are likely physical limits on how much a product and tasks can be fragmented (Fontagné and Fouré, 2013). Indeed, there is evidence of consolidation of global supply chains since 2008, rather than fragmentation as previously observed.

The most recent work by the Organisation for Economic Co-operation and Development (OECD) suggests that the pace of trade liberalisation is an important factor in the slowdown of world trade growth (OECD, 2016). This would seem to support the notion that there is some evidence of increasing protectionism since the start of the economic crisis. This study also finds evidence that the consolidation of global value chains has played a role in the slowdown of word trade.

The results further suggest that growth and income convergence consistent with our underlying GDP projections will generate a trade to GDP ratio of 1.1, which could be considered as the lower limit provided GDP per capita continues to grow and protectionism does not increase further. Assuming full trade liberalisation would result, on the basis of the OECD's long-term baseline projections in a trade to GDP ratio of 1.4. This constitutes the upper bound for the long-term ratio (OECD, 2016).

To capture interdependencies between global trade patterns and freight flows, we present two alternative trade scenarios: *Low elasticity* and *High elasticity,* corresponding to the lower and upper bounds mentioned above. The high elasticity scenario was presented in the previous edition of *ITF Transport Outlook*. The main difference between the two scenarios is the elasticity of trade to GDP, which has incidence on the growth in the value of trade (Table 3.1). The product composition and the geographical patterns also vary between the two scenarios. The low elasticity scenario, which constitutes our baseline scenario and reflects the recent slowdown in trade, is characterised by more pronounced structural changes in both trade patterns and product composition.

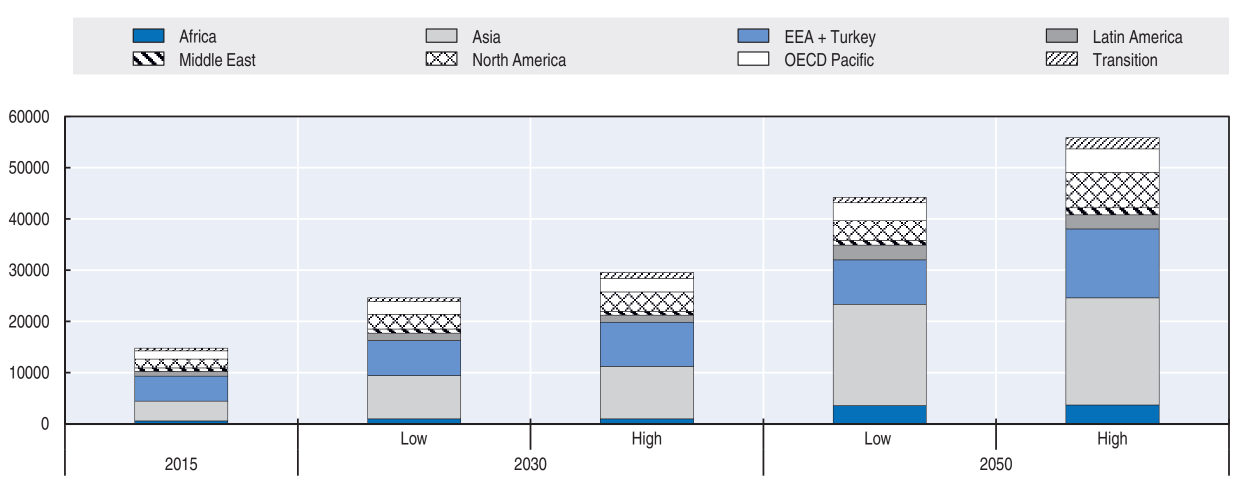
Table 3.1. **Comparison of the alternative trade scenarios for the 2015-50 period**

	Low elasticity	High elasticity
Growth factor of trade	3.0	3.5
Trade elasticity to GDP	1.2	1.4
Annual growth rate for trade	3.0%	3.6%

The two scenarios also differ in terms of the changes in the magnitude of trade activity by world regions. In the high elasticity scenario, developed economies will see a gradual decline in their share in world exports while developing economies, in Asia and Africa, will increase their share in world export values (Figure 3.1). In the low elasticity (baseline) scenario, the change in the export share composition takes place even more rapidly. By 2050, China and India will dominate global trade with 27% of global export flows produced from these countries. The share of export values of the European Economic Area (EEA) and Turkey is reduced to 20% of the global export flows in 2050 as compared to 33% in 2015. Furthermore, other developing countries in Asia and Africa gain a significant increase in their export shares. By 2050, Asia (excluding China and India) will contribute to 18% of global trade, Africa to 8%.

Figure 3.1. **Value of trade by region**

Billion 2004 USD



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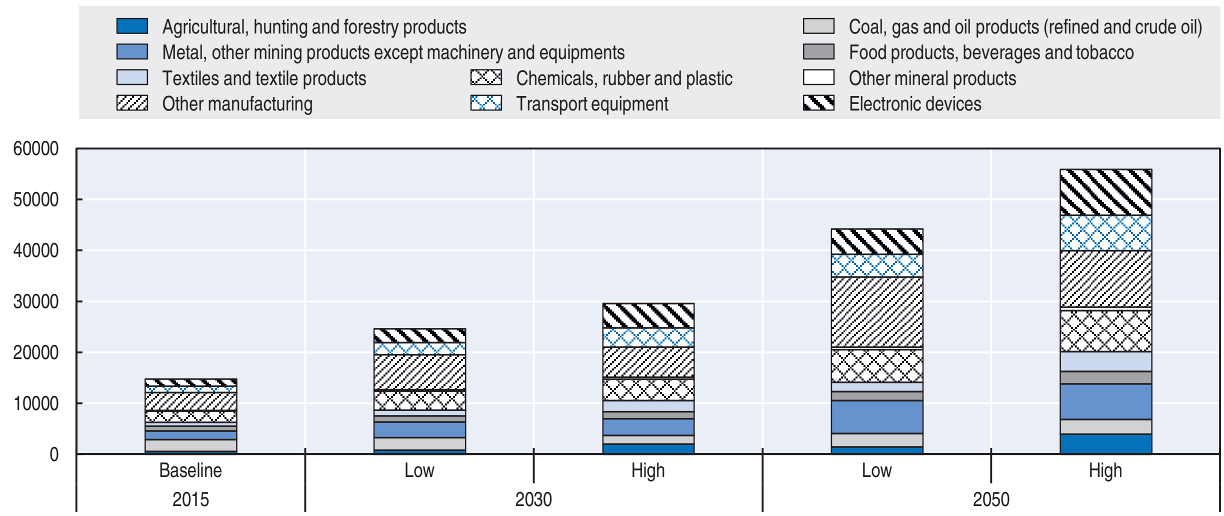
The differences are even more pronounced in terms of trade composition. In the high elasticity scenario, trade composition only undergoes a small change in the 2015 to 2050 period. The other manufacturing commodity (Figure 3.2) constitutes the highest share of the

Figure 3.2. **Value of trade by commodity**

Billion 2004 USD



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total in value, amounting up to 20% of all trade. This is followed by other commodities, such as electronic devices (15%), chemicals (14%), transport equipment (13%), and textiles (8%).

On the contrary, the low elasticity (baseline) scenario presents a radical change in the product composition of trade (Figure 3.2). The share of other manufacturing commodities will grow significantly to 31% of the total by 2050. Oil products, such as crude oil, refined oil, gas and chemicals as well as rubber and plastic, will in turn decline in their share in the total global trade. This is primarily caused by emerging economies (which by 2050 will constitute the largest global economies) moving up in the global value chain with a shift in the production and consumption patterns. The scenario does not account for changes caused by mitigation policies on oil or coal trade. As the GDP of China, India and other Asian countries increases, the production and consumption of low-value manufacturing products shift gradually towards high-value manufacturing products.

International freight transport to 2050

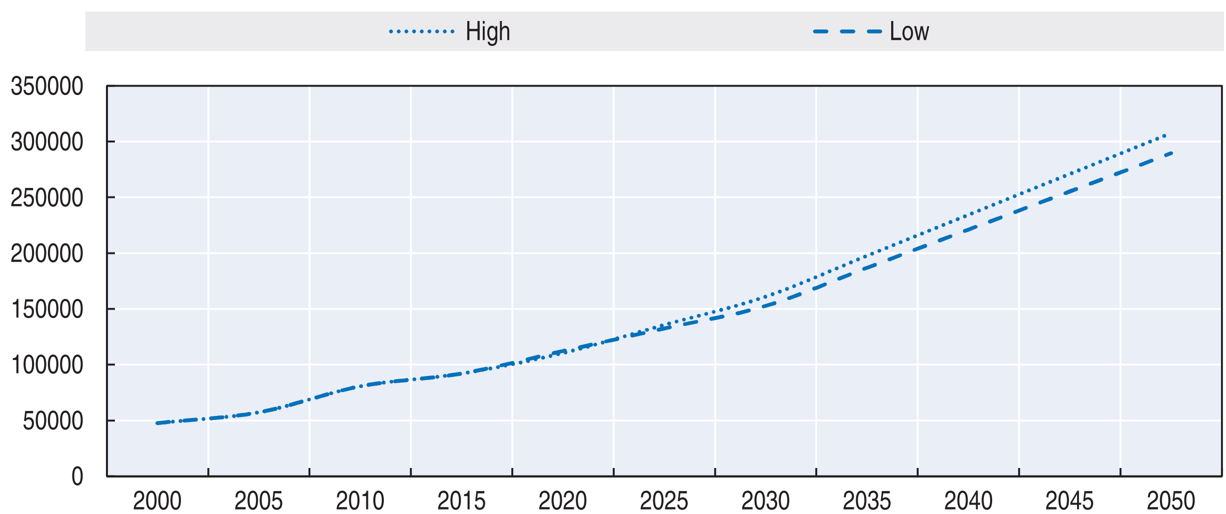
To understand the future evolution of freight flows under the different trade projections, ITF has developed a global freight model which converts trade flows in monetary terms into freight volumes and related CO_2 emissions. The complete workflow consists of four main steps, detailed in Annex 3.A, along with other information on model validation.

International trade in 2011 resulted in 81 000 billion tonne-kilometres of global freight movements. Maritime transport is the main mode of transport, accounting for 87% of total tonne-kilometres. These calculations also include freight movement at the domestic link of international freight, usually carried by road. Road, rail and air transport account for 8%, 5%, and 0.1% of the global tonne-kilometres respectively.

Lower trade elasticity has only a relatively small impact on the overall freight volumes, measured in tonne-kilometres. In the low elasticity scenario, a growth in the value of world trade by a factor of 3 between 2015 and 2050 corresponds to a growth in total tonne-kilometres by a factor of 3.1 for the same period. In the high elasticity scenario, trade grows by a factor of 3.5 but translates to a growth factor of 3.3 in tonne-kilometres between 2015 and 2050. Figure 3.3 summarises the resulting tonne-kilometres under the two trade projections.

Figure 3.3. **Freight transport demand in alternative trade elasticity scenarios**

Billion tonne-kilometres, 2000-50



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The lower trade elasticity to GDP does not necessarily translate to significant reductions in overall freight volumes. The geographical patterns and product composition of trade are more relevant factors explaining the growth in the volume and distance of goods moved. Tonne-kilometres in the low scenario are only 6% below the high scenario by 2050 because the average hauling distance increases by 15% by 2050, compared to 12% only in the high elasticity scenario.

There are no major differences in the mode share of the two scenarios, nor do they change significantly over time. Maritime transport will remain the primary mode of transport, followed by road and rail. Figure 3.4 shows the modal shares for global freight movements for the low elasticity scenario for the years 2015, 2030 and 2050. Despite considerable differences in the composition of the traded commodities between the two scenarios, the modal shares are similar.

As discussed above, the spatial patterns of trade will change between 2010 and 2050 in both scenarios. We divide the world into 12 transport regions/corridors to investigate the impact of these changes on freight movements (Figure 3.5). The growth in international freight volume is far from uniform, being significantly stronger in maritime routes and inland connections in Asia.

Among all the corridors, the North Pacific corridor facilitates the highest volume of international freight flows in 2015. This is primarily due to the high volume of international trade from China to the United States. It is estimated that the volume of freight in the North Pacific corridor will increase significantly, reaching 76 000 billion tonne-kilometres by 2050. A significant increase in freight volumes also occur in the Indian Ocean. Flows through the North Atlantic are also projected to increase considerably, pushed by the increase in trade between Europe and North-America. The increase in trade between Europe and Asia is responsible for the dynamics of the Mediterranean corridor.

Figure 3.4. **International freight volume by mode**

Low elasticity scenario, billion tonne-kilometres, 2015-50

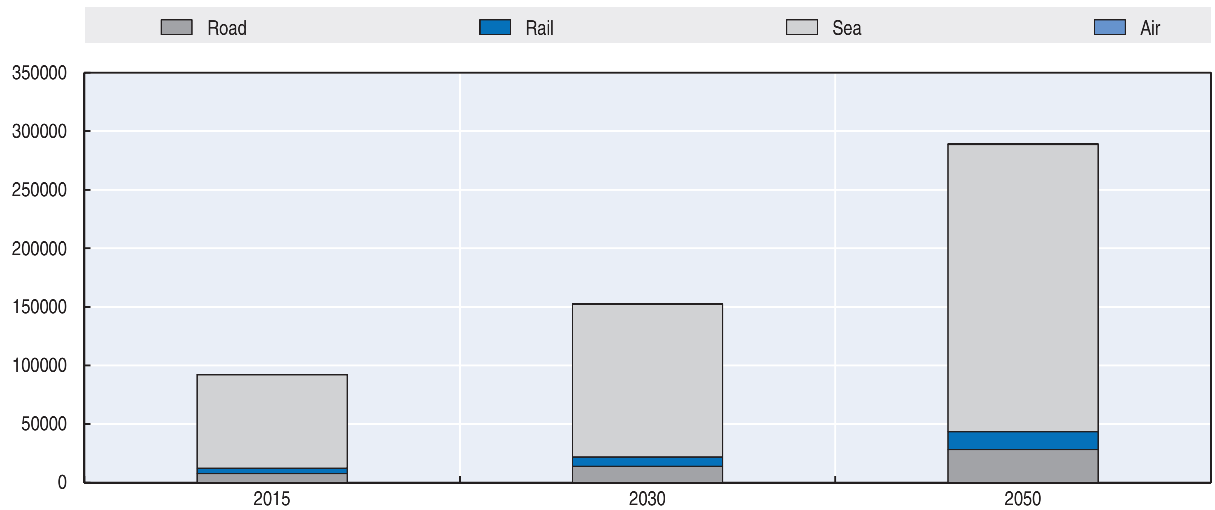

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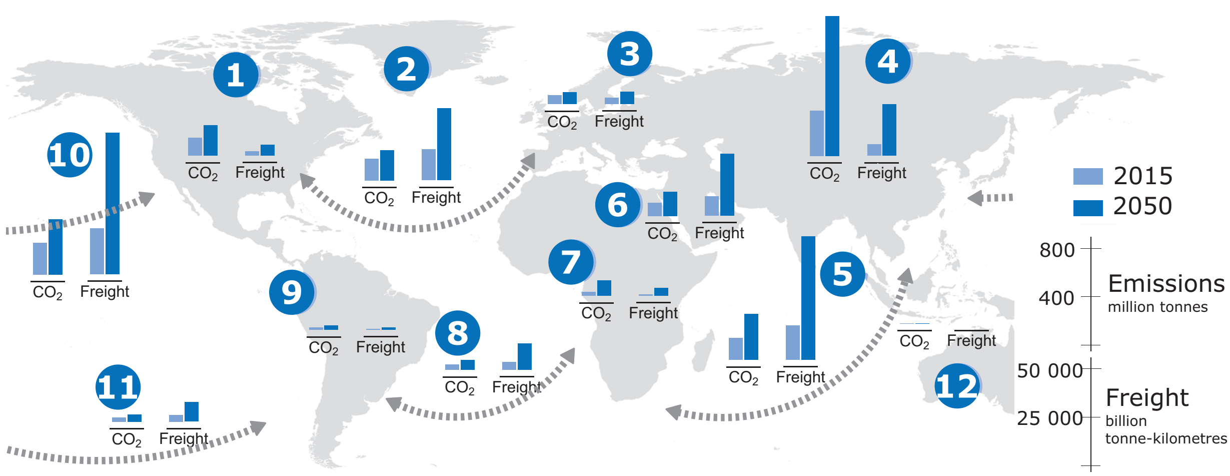
Figure 3.5. **International freight and related CO_2 emissions by corridor**



1. North America; 2. North Atlantic; 3. Europe; 4. Asia, including Japan and South-Korea; 5. Indian Ocean; 6. Mediterranean and Caspian seas; 7. Africa; 8. South Atlantic; 9. Latin America; 10. North Pacific; 11. South Pacific; 12. Oceania.

Increasing trade will also bring about an increase in the volume of the intra-regional freight flows by road or rail within continents. The highest growth will occur in Asia and Africa, in line with the projections for GDP. Intra-Asian tonne-kilometres grow, in the baseline scenario, by a factor of 4.5 while in Africa this growth factor is 6.5. Because rail networks are underdeveloped in these regions, except in China and India, most of the trade will take place by trucks with significant impacts on CO_2 emissions as discussed in the following section.

CO_2 emissions from international freight

Quantifying emissions

We estimate that international trade-related freight transport is responsible for around 1 600 million tonnes (Mt) of CO_2 emissions from fuel burn in 2015 (over 5% of total global emissions from fuel combustion). Maritime shipping accounts for around half of the emissions (830 Mt), trucks 40% (630 Mt), air 6% (97 Mt), and rail 2% (35 Mt).

Because of the international nature of shipping and aviation, their emissions are not part of the current negotiations under the UNFCCC. In the IMO, countries have reached agreements on improving fuel efficiency of ships, mainly through ship design and efficiency standards (known as Energy Efficiency Design Index [EEDI], and Ship Energy Efficiency Management Plan [SEEMP]). The International Civil Aviation Organization (ICAO) has been working with its member countries to define a set of measures to limit climate change impacts. These measures range from operational efficiency improvements to the introduction of a global market-based measure, adopted at the 39th ICAO Assembly in October 2016. These measures aim to limit emissions from international aviation to their 2020 levels (see also Chapter 4).

For this *Outlook*, the carbon footprint from international freight is obtained by using data on emission efficiency in grams of CO_2 emitted per tonne-kilometre for each mode. For road and rail, we use the information provided in the International Energy Agency's (IEA) Mobility Model (MoMo). For shipping, information on performance efficiency is obtained from Smith et al., (2014) and Smith et al., (2015). For aviation, emission data are obtained from EEA, 2014 (see also Table 3.2 for a summary of scenarios and assumptions).

Table 3.2. **Alternative scenarios for CO_2 emissions**

Scenario assumptions	Baseline	Stringent technology	Road optimisation
Trade to GDP elasticity	Low elasticity: 1.2	Low elasticity: 1.2	Low elasticity: 1.2
Aviation	1.5% Annual CO_2 Efficiency Improvement	2% Annual Efficiency Improvement + 50% biofuel in 2050	2% Annual Efficiency Improvement + 50% biofuel in 2050
Trucks	IEA 4DS: average 20% improvement in EEOI by 2050	IEA 2DS: average 35% improvement in EEOI by 2050	IEA2DS + Vehicle routing optimisations, flexible delivery windows and shared assets
Rail	IEA 4DS: average 39% improvement in EEOI by 2050	IEA 2DS: average 47% improvement in EEOI by 2050	IEA 2DS
Sea	50% improvement in EEOI up to 2050	70% improvement in EEOI as a result of biofuel availability	70% improvement in EEOI as a result of biofuel availability

There has been a major revision in the shipping-related efficiency figures since the previous edition of *ITF Transport Outlook*. The overall operational CO_2 intensity of shipping is dependent on several components: speed, utilisation, ship design and fleet composition. Since the financial crisis, the widely reported phenomenon of slow steaming has had a major impact on shipping CO_2 intensity. The 3rd IMO Green House Gas study estimates that the average reduction in at-sea speed relative to design speed was 12% and the average reduction in daily fuel consumption was 27% (IMO, 2014). Whether this is a permanent phenomenon remains to be seen. If demand increases, a natural response for ships could be to increase their speed.

In the *Baseline scenario,* the efficiency of road and rail follows the 4°C Scenario (4DS) emission factors from the IEA. This scenario takes into account recent pledges by countries to limit emissions and improve energy efficiency, aiming to limit the long-term temperature increase to 4°C. In many respects the 4DS is already an ambitious scenario, requiring significant changes in policies and technologies. For maritime transport, the baseline assumes an efficiency improvement of 50% over 2012 fleet average levels in 2050, based on IMO (2014). For aviation, we apply an annual efficiency gain of 1.5% per tonne-kilometre, corresponding to the industry goal (ATAG, 2016).

The *Stringent technology scenario* assumes vehicle technology uptake according to the 2DS scenario. The 2°C Scenario lays out an energy system deployment pathway and an emissions trajectory consistent with at least a 50% chance of limiting the average global temperature increase to 2°C. This scenario also applies the high biofuel scenario from LR (2016). The shipping industry adopts biofuels through combining targets and mandates for fossil fuels. For aviation, the yearly efficiency gain is 2%, corresponding to the resolution of ICAO member states in 2013 (ICAO, 2013) and the penetration of biofuels in 2050 is 50%. While this scenario reflects a more stringent technology, we acknowledge it is still not ambitious enough for the 1.5 degree scenario proposed in the Paris agreement.

The *Optimisation scenario* draws from a recent study by the World Business Council for Sustainable Development (WBCSD) which investigates the efficacy of different measures that can be adopted by private road freight operators to reduce their CO_2 emissions (Route Monkey, 2016). In this scenario, we incorporate impacts of the measures, in combination with the stringent technology scenario. The measures include: 1) optimisation of vehicle routing and resource allocations; 2) avoidance of narrow delivery windows, and 3) asset sharing between freight transport operators, for instance depots and vehicles.

Optimisation of vehicle routing and resource allocation is aimed at minimising the total operational costs and distance of freight transport using top-tier optimisation software. WBCSD estimates that this measure could result in a 12.5% reduction of vehicle kilometres for the road mode by 2030. Based on the assumptions of the WBCSD study, we apply this reduction factor to 80% to 90% of freight movements, depending on the type of goods and the place of transport (e.g. transport from ports to cities and vice versa). We also apply the impact of using shared assets, which leads to a 20% reduction in road vehicle-kilometres by 2030 for 80% of all transport. Lastly, the study also concludes that 25% of road vehicle-kilometres, mostly concentrated in cities, can be reduced by means of a business model that avoids a narrow delivery time window by 2020.

Long-term outlook for CO_2 emissions

The projected tripling of freight transport will translate to a significant increase in related CO_2 emissions by 2050. In the baseline scenario, emissions are projected to grow by 120% over the period 2015-50. A significant change will take place in the modal composition of emissions. In both the low and the high scenarios, international trade related road freight will become the largest emitter, accounting for 45% of all emissions in the low elasticity scenario and 49% in the high elasticity scenario. In both scenarios, maritime transport accounts for around 40% of the total CO_2 emissions from international trade-related freight by 2050. Per unit of transport the emissions from shipping are far lower than for road freight.

Higher trade growth (high elasticity scenario) does not necessarily lead to higher emissions. Rather, the results depend on other factors, such as the product composition of the trade. This is illustrated by our findings from the low elasticity scenario, where the total CO_2 emissions are slightly above the high elasticity scenario (Figure 3.6). According to our projections, CO_2 emissions will reach 3 533 million tonnes by 2050 in the low elasticity scenario and 3 501 million in the high scenario. Our calculations indicate that the commodity composition is a key factor contributing to the higher emissions. The low elasticity scenario is characterised by a higher volume of commodities that are transported using vessels with higher emission factors. These commodities include transport equipment, other manufacturing, and electronic devices which are assumed to be shipped by vehicle and container ships (Figure 3.7). The potential for energy-efficient transport is much dependent on the type of goods transported. Figure 3.7 presents the CO_2 emissions of the commodities for both for the low elasticity and high elasticity scenarios.

Figure 3.6. **CO_2 emissions from international freight by mode**

Million tonnes, 2015-50

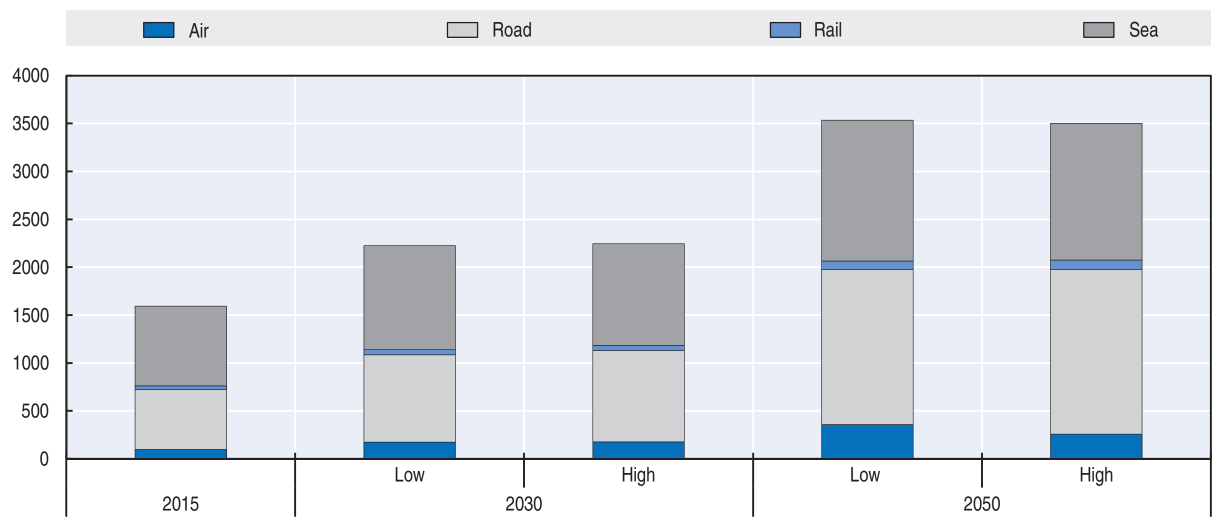


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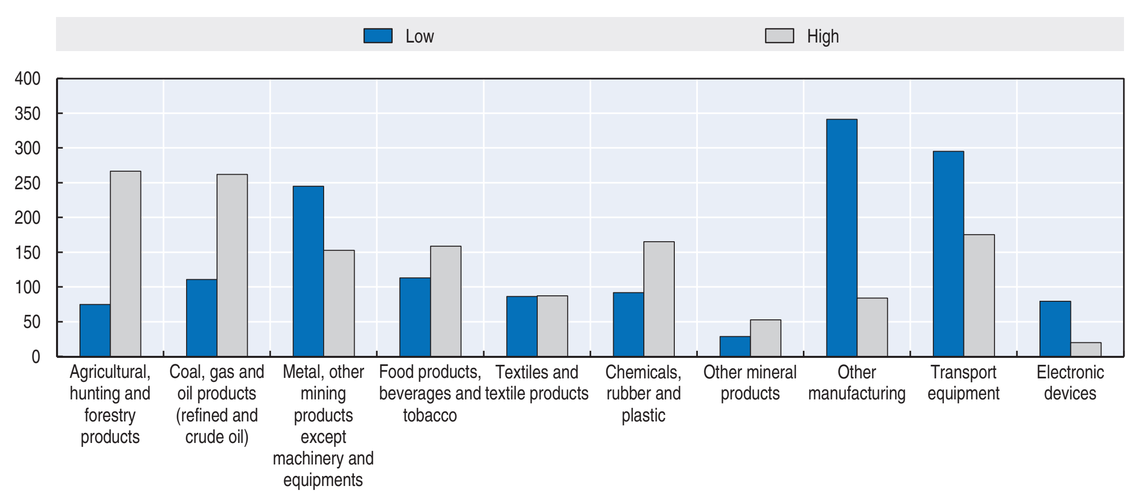
Figure 3.7. **CO_2 emissions from maritime transport by commodity**

Million tonnes



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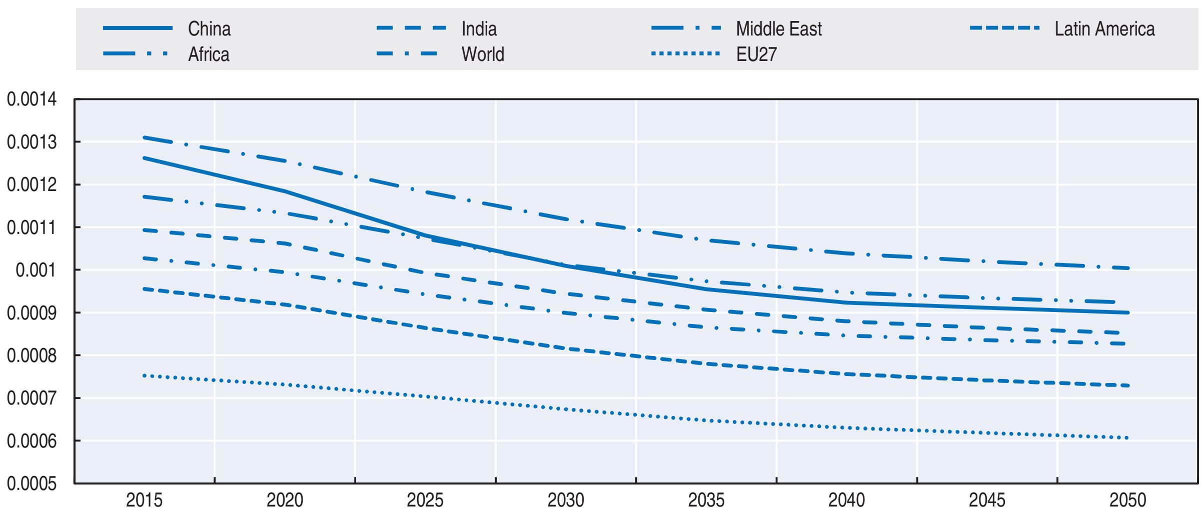
The growth of CO_2 emissions is not proportionate to the growth of freight volumes in the different corridors (Figure 3.5). Emissions from intra-continental trade, especially in Asia and Africa, grow more in relation to the growth in freight volumes. By 2050, the CO_2 emissions in intra-Asian freight are projected to grow 210% by 2050. This has roots in the lack of alternative, more environmentally-friendly modes for trucks for the movement of goods in these regions, except in China and India. Another factor contributing to this trend includes the slower adoption of more environmentally friendly fuel technologies. Figure 3.8 shows the rate of reduction of CO_2 emission intensity for different regions in the world in our baseline scenario, based on the IEA's Mobility Model.

Figure 3.8. **Road freight CO_2 intensity by region in the 4 degree scenario of the IEA Mobility Model**

Tonne of CO_2 per vehicle-kilometre



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As a result, CO_2 emissions across intra-regional corridors are generally higher per unit of transport compared with other corridors. This is seen for example in the case of the North Pacific and Indian Ocean corridors where the total tonne-kilometres are among the highest but their CO_2 emissions are below what is produced in the intra-Asia corridor (Figure 3.5).

Alternative pathways

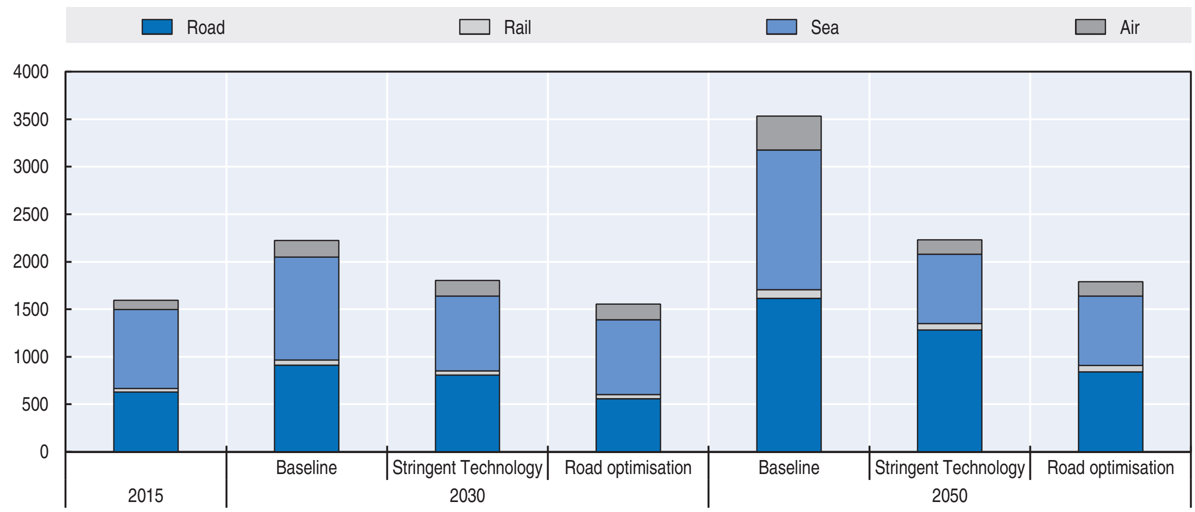
While trade composition is a significant driver of related transport CO_2 emissions, policies and operational measures have a major effect on future emissions.

Figure 3.9 presents the comparison of the impact of different measures on CO_2 emissions, by mode, for the years 2030 and 2050. With the Stringent technology scenario, total emissions would still grow by nearly 40% from 2015. This is driven by still increasing emissions from the road freight where technology improvements comparable to the 2DS scenario are not sufficient to curb the growth in emissions. However, combined with operational improvements in the road sector, the emissions would remain almost at their 2015 levels.

The stringent technology scenario results in a significant reduction in total CO_2 emissions, compared with the baseline scenario. This reduction is driven by reduction in the use of fossil fuel. By 2030, the mid-range market penetration of biofuels, other energy efficiency measures and availability of hydrogen for the shipping industry will lead to a 27% reduction in CO_2 emissions from international shipping compared with the baseline. By 2050, this reduction is even more significant, reaching up to 50% of the baseline. As a

Figure 3.9. **The impact of policy measures on emissions**

Million tonnes of CO_2



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result, total emissions would remain close to those of 2015 by 2030 while in 2050 emissions would be reduced by 12% compared with the base year.

Substituting the volume of fossil fuels used by shipping today is a significant challenge. There are significant uncertainties in terms of the energy that can be sourced from biomass and the relative price between biofuels and fossil fuels (LR, 2016). Also, the experience so far with Liquified Natural Gas (LNG) has to some extent shown that there are challenges, especially in terms of the storage, handling and infrastructure required for alternative fuels.

Furthermore, our calculations show that the optimisation scenario can adequately reduce the CO_2 emissions from road transport by 2050. This measure results in an additional 31% reduction of total road transport emissions by 2030 and a 34% reduction by 2050 compared with the stringent scenario. While road and rail transport are estimated to produce considerably less CO_2 emissions in 2050, these reductions are not as significant as those from maritime transport in the total CO_2 emissions.

Measures to reduce shipping emissions may be effective but come with a cost. A 2016 ITF study calculated the fuel costs of the global 0.50% sulphur cap for shipping, to be introduced in 2020. Our calculations show that costs could increase between 20% and 85%, depending on the assumptions regarding speed, fuel price and ship size. The relatively large margin is largely due to the uncertainty surrounding the availability of low-sulphur ship fuel. The 2020 requirements could add annual total costs in the order of USD 5 billion to 30 billion for the container shipping industry. Such cost increases may have an impact on sectors that are sensitive to changes in shipping costs. In high-cost scenarios the cost increases of the goods value due to the 2020 requirements are 4% for manufactured goods, 9.5% for agricultural goods and 20% for industrial raw materials (ITF, 2016a).

Even under the more stringent scenarios, CO_2 emissions from the freight transport grow from their 2015 levels. There is a gap between the mitigation ambition and the results shown above. Continued efforts should be made to improve the efficiency of the transport system through optimising supply chain structures, increasing vehicle utilisation, reducing the emission intensity of existing vehicle fleets or developing alternative modes of transport especially for hinterland connectivity. Fuel economy standards for trucks are currently limited to four countries (United States, China, Japan and Canada) but they are gaining momentum. According to the ICCT (Muncrief, 2014), countries considering the introduction of efficiency regulations concern 80% of all trucks. An integrated approach to improving the efficiency of new trucks combine three policy elements: information measures (such as fuel economy or CO_2 emissions labelling); standard setting for vehicle fuel economy and CO_2 emissions; and fiscal measures (such as vehicle taxes/tax incentives and fuel taxes).

CO_2 reduction strategies focus typically on vehicle technology, and technological improvements can do much to de-carbonise transport. Yet there are many other contributing measures the sector can implement, including vehicle maintenance, driver training, vehicle loading, routing and scheduling. Higher capacity vehicles have a potential to improve fuel efficiency and reduce emissions. Improving the efficiency of operations can have a significant contribution to emission reduction while making business more profitable. Better route planning, for example, can deliver significant efficiency gains for companies through reduced fuel costs, while contributing at the same time to emission reduction. Making more use of shared transport options and opportunities can results in reductions of both cost and CO_2 by creating logistics synergies and limiting empty runs.

To meet climate mitigation goals, it is important to align policies across supply chains to decarbonise transport. In addition to international agreements, national policies are needed for reducing CO_2 emissions. Economic measures, regulation, infrastructure and land-use policies at the national level need to be aligned with industry actions to improve vehicle design and utilisation, shared loading or use of alternative fuels. Improving logistics and optimising supply chains can have a significant impact on reducing CO_2 emissions form international trade related freight transport.

Impact of trade liberalisation

Trade is an important engine of growth. The related expansion of global value chains, together with trade, boost economic growth through increased productivity by improving resource allocation, increasing scale and specialisation, encouraging innovative activities, facilitating knowledge transfer, fostering the expansion of more productive firms and the exit of least productive ones. Impact of trade liberalisation on trade and growth is studied extensively in the literature and empirical literature suggest that trade liberalisation continuing at the same pace as during the 1990s could boost world trade growth by 1-2% per year.

However, the objective of trade growth might contradict the objectives for more sustainable transport. The research on the impact of trade liberalisation on international freight volumes, the geographical composition of that freight and related CO_2 emissions is limited. The 2015 edition of the *Transport Outlook* assessed the impact of two alternative trade liberalisation scenarios on freight volumes and related CO_2 emissions (ITF, 2015a).

In the *Bilateral liberalisation scenario*, a free-trade agreement is established in 2012 between the North American Free Trade Area (NAFTA), the European Free Trade Area (EFTA), Australia, New Zealand, Japan and Korea. Tariffs and transaction costs (such as handling at customs) are progressively phased out in this region. Tariffs on goods are abolished by 2060 and transaction costs for goods are reduced by 25% more than in the baseline by 2060. In

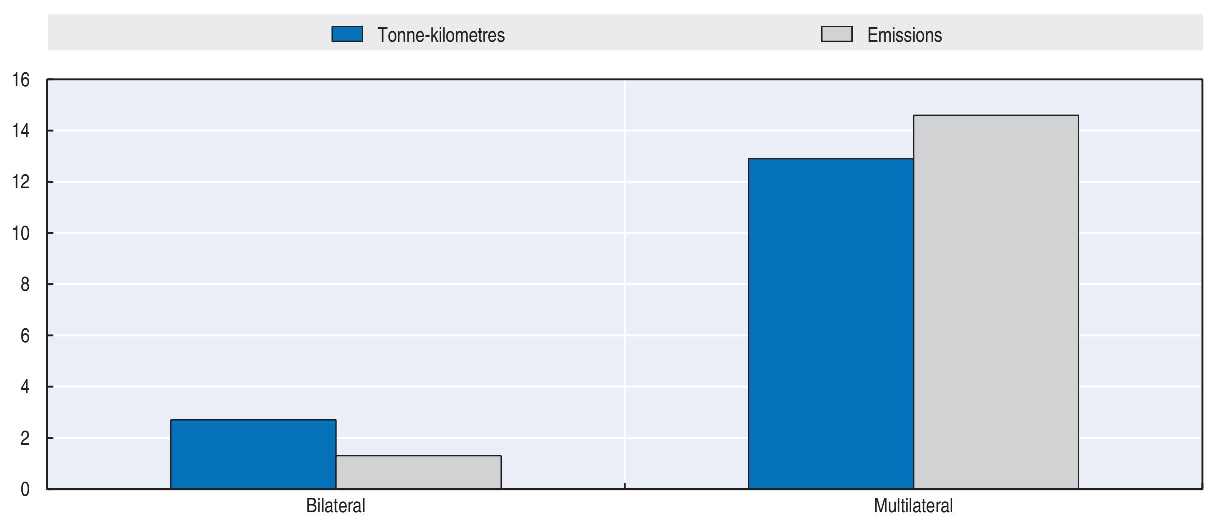
2030, bilateral trade agreements are negotiated with key partners of the free trade area including South Africa, The Russian Federation, Brazil, China, India, Indonesia, other countries of the Association of Southeast Asian Nations (ASEAN) and Chile. With these countries, the free trade area bilaterally reduces tariffs by 50% progressively, until 2060.

In the *Multilateral liberalisation scenario*, tariffs on goods are reduced on a multilateral global basis by 50% by 2060 and transaction costs are reduced by 25% more than in the baseline by 2060. From 2013 agricultural support is reduced by 50% by 2060 in the European Union, the Unites States, Japan, Korea, Canada and EFTA countries (for details on liberalisation scenarios, see Johansson and Olaberria, 2014).

The results show that a bilateral trade liberalisation will not significantly affect freight volumes. By contrast, in the multilateral liberalisation scenario trade is reoriented towards the non-OECD area, reflecting comparatively larger reductions in tariffs than in OECD countries as well as stronger underlying growth performance in this area. As a result, the growth in global freight volume will be 10% higher than in the baseline by 2050 (Figure 3.10). This growth translates into 15% more CO_2 emissions compared with the baseline. Multilateral trade liberalisation results in significantly more transport volumes especially in Africa, South America, the South Atlantic, Indian Ocean and to some extent Asia. The results are driven in part by the increasing intensity of trade and in part by growth in average distance.

Figure 3.10. **Impact of trade liberalisation on tonne-kilometres and CO_2 emissions**

Bi-lateral and multilateral trade liberalisation scenarios compared to the baseline in 2050 (%)



Source: ITF (2015), *ITF Transport Outlook 2015*, *http://dx.doi.org/10.1787/9789282107782-en*.

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Challenges in container shipping

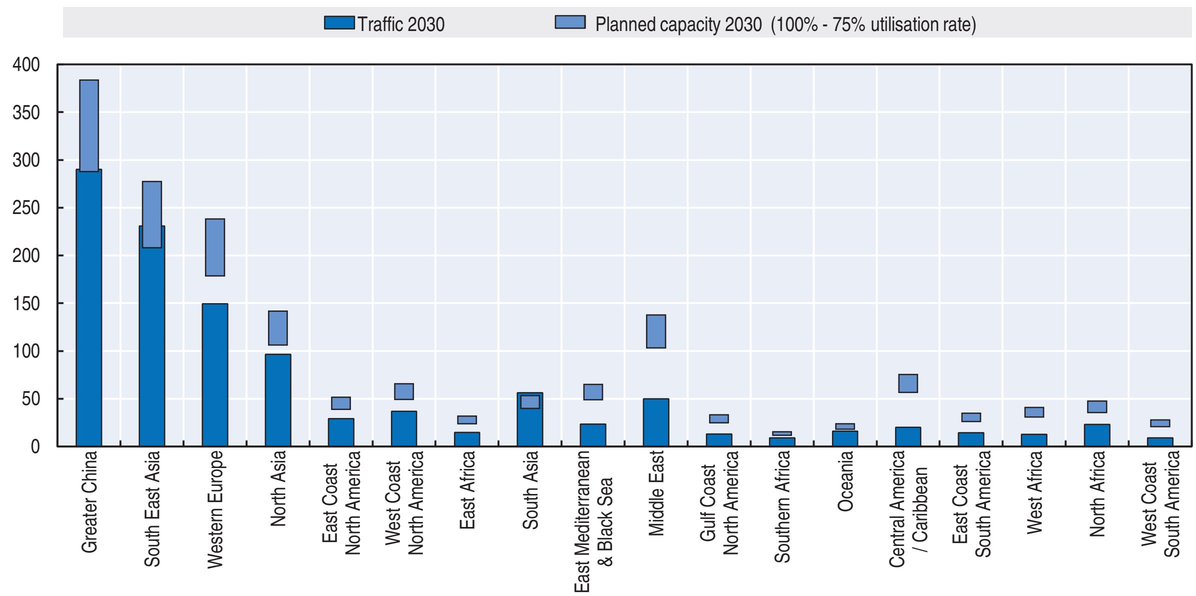
Container port capacity

Projected trade and freight flows to 2050 highlight the need to assess the capacity of existing national infrastructure such as port terminals, airports or road and rail infrastructure to deal with the bottlenecks that may emerge.

Our results suggest that the container traffic related to international trade could grow, under the high scenario, by 73% by 2030. This translates into over 1 billion TEU by 2030 and to nearly 2.2 billion TEU by 2050. Looking at the traffic by 2030, the greatest increases in

Figure 3.11. **Expansion plans compared with traffic projections by sea area**

Million TEUs



Source: ITF (2016b), *Capacity to Grow: Transport Infrastructure Needs for Future Trade Growth*, *http://dx.doi.org/10.1787/5jlwvz8jlpzp-en.*

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absolute terms are for Southeast Asia (143 million TEU), China (94 million TEU), North Asia (54 million TEU), Western Europe (52 million TEU), and South Asia (37 million TEU) by 2030. In relative terms, the largest capacity increases would be needed in South Asia (193%), Southeast (163%), North Africa (138%) and West Africa (137%).

There are already numerous plans for port expansion. The Global Container Terminal Operators from Drewry (2014) as well as reports from Ocean Shipping Consultant (2012a, 2012b, 2012c) forecast port capacity developments until 2025-30 based on announced expansions in the coming decade. These data form our baseline for port capacity increase for all types of cargo up to 2030. Based on the estimated capacity developments up to 2030 it seems that there is sufficient capacity planned in most regions to accommodate future traffic growth. Several regions appear to have severely over planned capacity increases. Only in South Asia are our projections for future freight higher than the estimated capacity expansion for the region (see Table 3.3).

These projections are subject to several uncertainties regarding future economic growth and trade elasticities, among others. We carry out sensitivity analysis with regards to the effect of lower utilisation rates of ports at 75% (instead of 100%).

Figure 3.12 details these results by world region. When accounting for a lower utilisation rate, there is still overcapacity in 2030 for most regions. But for several other regions, the capacity difference between future traffic and capacity is less significant: especially in South Asia and Southeast Asia, current improvement plans may not be sufficient to cover the future growth in trade-related container movements.

The global container shipping network

There is much uncertainty regarding the demand, especially for container port capacity. In addition, some possible developments in terms of shipping business models,

Table 3.3. **Container traffic by sea area in 2030 and 2050 and planned capacity 2030**

Sea area	Traffic 2013 MTEU	Traffic 2030 MTEU	Traffic 2050 MTEU	Estimated capacity 2013 MTEU	Planned capacity 2030 MTEU	Traffic – capacity 2030 MTEU
Greater China	196.4	290.0	494.1	248.3	383.8	-93.8
Southeast Asia	88.0	231.0	520.3	124.4	277.3	-46.3
Western Europe	97.8	149.4	257.5	168.1	238.2	-88.8
North Asia	43.0	96.5	146.0	70.9	141.6	-45.1
East Coast North America	23.9	29.1	34.7	42.4	51.7	-22.6
West Coast North America	24.9	36.8	32.2	43.2	65.5	-28.7
East Africa	8.2	14.6	46.2	13.0	31.9	-17.3
South Asia	19.2	56.2	143.8	29.1	53.1	3.1
East Mediterranean & Black Sea	16.8	23.6	50.7	27.5	65.1	-41.5
Middle East	36.7	50.0	108.4	50.9	137.6	-87.6
Gulf Coast North America	7.4	13.2	58.1	11.8	33.1	-19.9
Southern Africa	4.7	8.9	18.6	7.8	15.5	-6.6
Oceania	11.2	16.2	36.3	17.1	23.9	-7.7
Central America / Caribbean	19.6	20.2	58.5	29.5	75.4	-55.2
East Coast South America	13.2	14.3	28.8	19.0	35.0	-20.7
West Africa	5.4	12.8	36.6	8.8	40.9	-28.1
North Africa	9.8	23.3	87.0	13.2	47.4	-24.1
West Coast South America	7.9	9.2	19.3	14.0	27.8	-18.6
TOTAL	634.3	1095.2	2177.1	938.7	1744.9	-649.5

Note: MTEU stands for Million Twenty Foot Equivalent Unit.
Source: ITF (2016b), *Capacity to Grow: Transport Infrastructure Needs for Future Trade Growth*, *http://dx.doi.org/10.1787/5jlwvz8jlpzp-en*.

containerisation rate, ship size and shipping routes could alter the projections. An important limitation of the approach we used to measure port capacity is that our modelling framework does not take into account the impact of changes in global trade on the global maritime shipping networks. Research in Halim (2016) has investigated the impact of changes in global trade patterns on the global maritime shipping networks and the competitive position of ports worldwide. The results for different scenarios show that a sudden and profound change in port competitiveness is possible as a result of changing network structures.

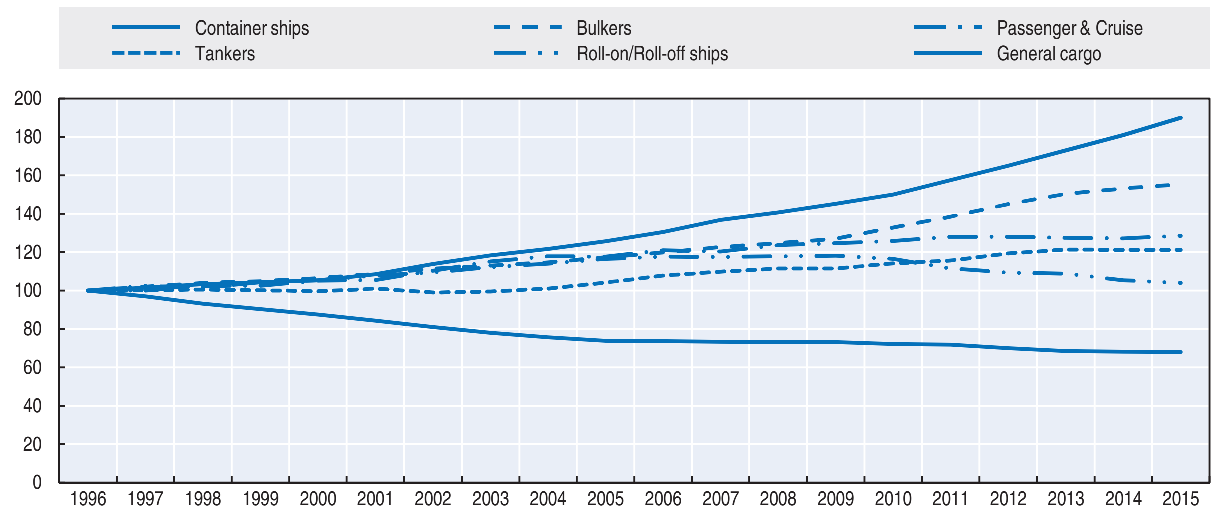
The structure of the global maritime shipping network continuously adapts to support growing trade. One notable trend is that liner shipping companies are increasingly using bigger ships. As more ships with larger capacity come into service, opportunities to better exploit economies of scale also increase. In turn, this stimulates shipping companies to take strategic moves to reduce the unit transport cost further.

The number of ships largely exceeds what is actually needed: shipping suffers from overcapacity (see Box 3.1 for more detail). The tendency to use ever larger ships is partly responsible. In the container sector, which has witnessed the largest increase in ship size over the recent years (Figure 3.12), this has been a major driver of the current gap between demand and supply. Around half of the new container ships that will be delivered in the 2016-18 period have a capacity larger than 13 000 TEUs. A 2015 ITF report assessed the impacts of mega container ships on the whole transport chain and concluded that the total system costs related to mega-ships exceed the cost savings for shipping lines from these bigger ships. The system costs include the adaptations related to bigger ships (in terms of dredging, quays, yards and port hinterland connections) and peak effects of bigger ships (ITF, 2015b).

In container shipping, increasing ship size has intensified consolidation of the sector and more intense co-operation via alliances. The concentration rate of the industry has

Figure 3.12. **Ship size development of various ship types 1996-2015**

Ship size in dead weight tonnes, 1996 = 100



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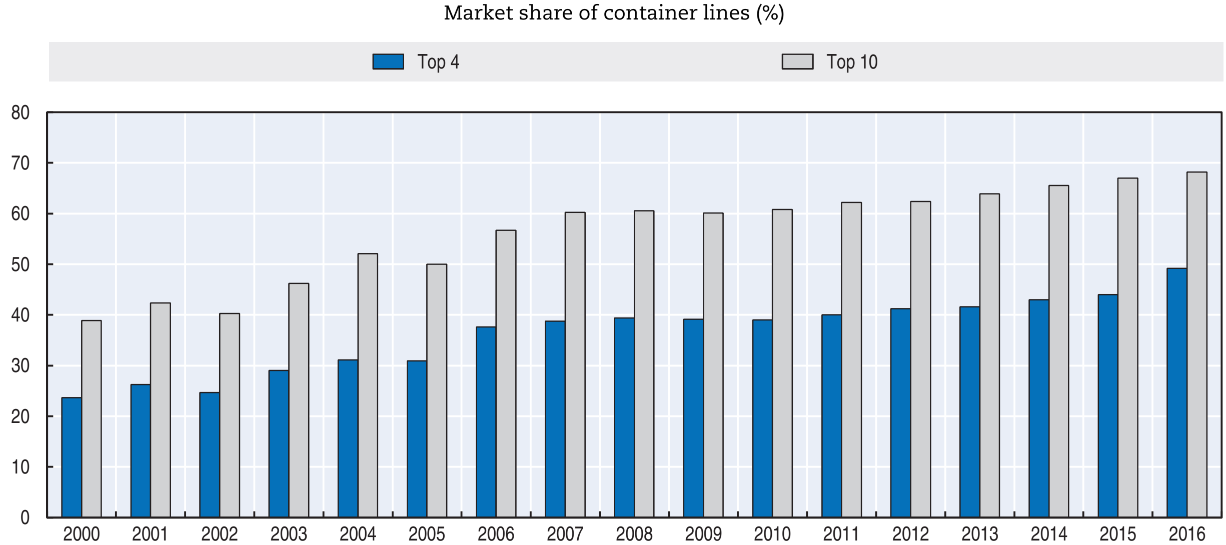
increased: the top 4 carriers had a 23% market share in 2000 and almost 50% in 2016 (Figure 3.13). In addition, alliances have become much more important: more services than previously are shared between different shipping lines. Whereas most of the largest shipping lines stayed out of such vessel sharing arrangements in the 1990s and 2000s, there is currently only one shipping line in the top 15 that is not part of an alliance. Due to consolidation of container shipping lines, the composition of alliances has changed regularly over recent years. In 2017, the current structure of four alliances will make place for three alliances (2M, Ocean Alliance and The Alliance), provided that competition agencies provide regulatory approval.

Figure 3.13. **Market concentration of container shipping lines 2000-16**

Market share of container lines (%)



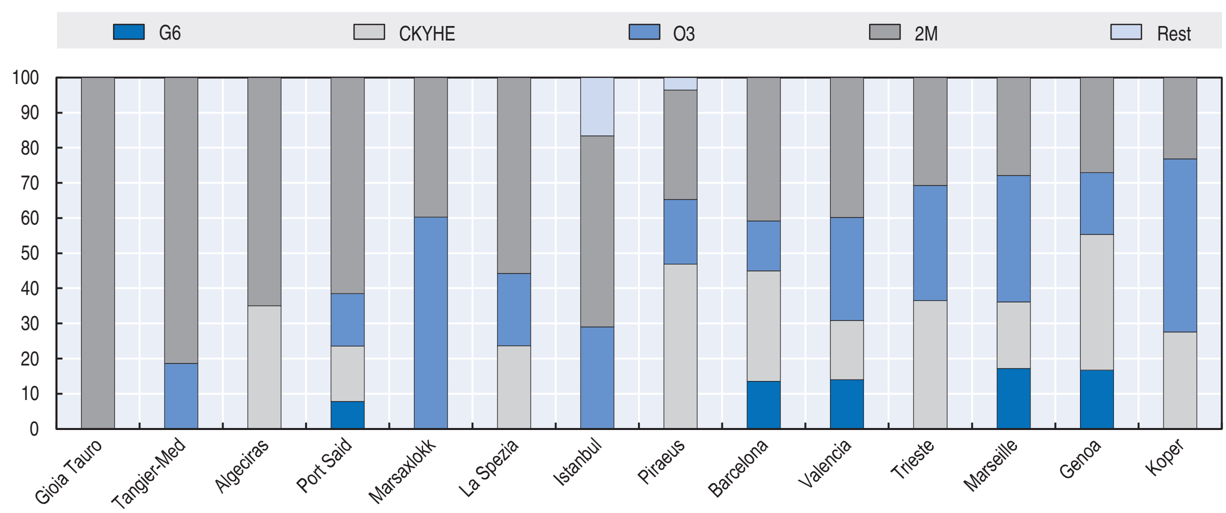
Source: ITF (forthcoming), *Maritime supply chain governance in the mega-ship era* (working title).

StatLink http://dx.doi.org/10.1787/888933442616

The changing character of the maritime industry has a ripple effect on the whole supply chain. In container shipping, the cargo concentration due to mega-ships and alliances has resulted in more vulnerability to cargo shifts by container lines, less frequent port calls and rationalisation of shipping services. The number of weekly Asia-Europe services has declined from 38 in 2013 to 33 in 2016, and the number of direct port pairs between Asia and Europe has declined from over 560 in 2013 to less than 490 in 2016 (ITF, forthcoming). The declining number of services, combined with larger cargo loads due to increased ship size, has left an increasing number of ports and terminals with less cargo to handle – and sometimes without any cargo at all. Various container ports, such as Taranto and Malaga are examples of this. The risk of such events happening has increased due to the large dependence of ports on just one or two alliances: half of the main Mediterranean container ports get more than half of their containerised cargo from Asia from just one alliance (Figure 3.14).

Figure 3.14. **Container ship capacity on Far East-Mediterranean route by alliance and by port (2015)**

Percentage of total capacity



Source: ITF (forthcoming), *Maritime supply chain governance in the mega-ship era* (working title).

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Challenges of hinterland transport

All international freight flows require intermodal transport both at the origin and destination of the products. Our freight model accounts for this part of the trade. We estimate that around 7% of the international trade related freight, in tonne-kilometres, takes place within national borders, from ports (and airports) to cities or from factories to ports. This share is estimated to remain around the same over the period 2015-50. However, there are great differences between regions, depending on the geographic location of the main producers/consumers in each country. For instance, in China, where most of the economic activity is still concentrated in coastal areas, the domestic link represents 9% of the total international trade-related freight volumes. In India, on the other hand, where production and consumption centres are located inland, the share is 14%.

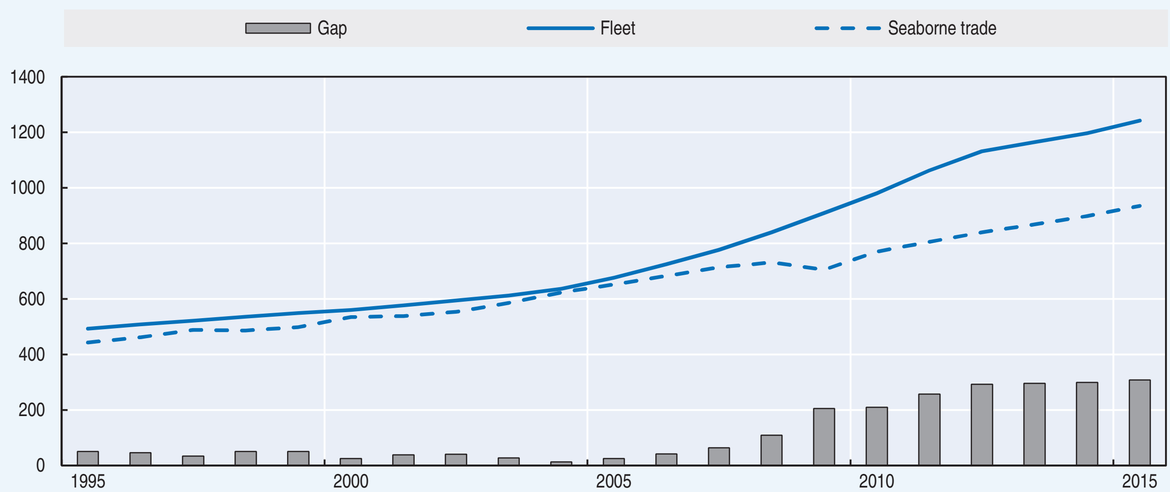
Two major issues are associated with hinterland transport: infrastructure congestion and emissions. While accounting for less than 10% of the total tonne-kilometres, domestic

Box 3.1. **Global oversupply of vessels**

Internal research results by OECD's shipbuilding unit show that the global ship market has accumulated a massive excess vessel supply. The 2008 financial crisis, which led to a contraction of world trade, has widened the gap between vessel supply, proxied by global merchant fleet in gross tons (gt) and vessel demand, proxied by seaborne trade in gross tonnes (see Figure 3.15). Ship completions decreased sharply after 2012 but insufficiently to rebalance the market. Today, the extent of oversupply corresponds to around 307 million gt representing almost one quarter of the world fleet in 2015.

Figure 3.15. **Global merchant fleet and seaborne trade, 1995-2015**

Million gross tonnes



Source: Based on IHS Seaweb and Clarkson.

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The oversupply situation is still worrisome for most large vessel categories, notably tankers, bulkers and containers. In 2015 cumulated excess supply of tankers reached around 88 million gt (36% of tanker fleet in 2015), oversupply of bulkers amounted to approximately 122 million gt (29% of bulker fleet) and overproduction of containers reached about 56 million gt (26% of container fleet).

Without a reduction in vessel supply or a sharp increase in ship demand, the current situation of excess supply of vessels is likely to persist for the next twenty years. Until 2035, total new building requirements are expected to reach around 1 230 million gt: 420 million gt for tankers, 550 million gt for bulkers and 264 million gt for containers. On the basis of these results, future vessel requirements are only expected to equal the peak of completions of the boom year 2011 in 2035.

Potential reasons for such market imbalances in the global ship market are not only of cyclical nature, such as negative economic shocks as experienced during the global economic crisis. Slight supply-demand imbalances already existed before the crisis, implying that oversupply has supplementary roots.

Structural characteristics of the shipbuilding industry hamper the market from rebalancing. The industry features time lags of 2-3 years from order to delivery. As ship owners face difficulties in precisely predicting future economic growth, the capacity of new vessels may surpass future actual demand at the time of delivery. Moreover, yards hardly have the capacity to inventory vessels. High costs of building up an inventory of unused vessels and the tailor-made nature of certain ships force yards to sell the vessel to the market (even at low prices), rather than store it in case of cancellation.

Box 3.1. **Global oversupply of vessels** *(cont.)*

Non-market related factors also contribute to oversupply, for instance restrictive trade policies, preferential treatment for national firms or direct and indirect subsidies. The global shipbuilding industry faces historically low capacity utilisation rates of yards of about 57% in 2015 down from its peak of 85% in 2008. Subsidies help governments to keep their strategically important, national shipbuilding industry competitive and maintain employment. Such government support, however, stimulates vessel supply, exacerbating the oversupply situation further.

freight transport related to international trade accounts for 80% of the total transport costs (Rodridgue and Noteboom, 2012) and nearly 30% of the total trade-related CO_2 emissions. Because most of the transport of goods from ports to consumption centres is by road, the CO_2 intensity of this freight is significantly higher than for other corridors. These emissions in the domestic link of international trade are further amplified by shipping emissions at ports. Shipping related CO_2 emissions in ports represent only about 2% of total international shipping CO_2 emissions. Locally, shipping emissions have important health impacts. Local emissions are projected to grow significantly, especially for CH_4, CO, CO_2 and NO_x emissions, which could grow even four-fold by 2050 if no additional measures are taken (ITF, 2015a).

Some bottlenecks may also emerge. Existing national infrastructure already faces issues of insufficient capacity in some regions of the world, especially in port cities. Projected trade flows to 2050 and the growing freight volumes highlight the need to assess the capacity of existing national infrastructure, in particular hinterland road and rail infrastructure, to deal with potential bottlenecks that may emerge.

Capacity requirements (for hinterland connections) are first measured against the total capacity available by region (measured in lane-km and track-km for road and rail respectively), even if not located along the main freight corridors. However, congestion occurs near ports and the main production and consumption centres, where cargo has to be handled and distributed. Congestion also often concentrates on small distances and it may not significantly impact the overall performance of the freight network. So, we also compare surface freight traffic to freight activity, but only in areas less than 50 km away from ports, consumption and production centres.

Comparing freight volumes to overall capacity by region does not seem to imply large infrastructure needs, except in Asia and Africa (Table 3.4), which are also the regions where intra-regional freight increases most. In these regions, the lack of infrastructure may become an impediment to trade, especially in the longer term.

The results for congestion around ports, consumption and production centres are in Table 3.5. Capacity needs now appear more clearly for all regions. In 2050, infrastructure in Asia and Africa around ports, production centres and cities will almost need to triple to go back to the performance levels of 2010. Overall capacity requirements need not be very high but spatially focused.

While the pressure on hinterland connections is a challenge, it can also be an opportunity. In comparison with, for example, maritime transport which is regulated by international agreements and policy decisions require international agreements, the domestic component of the international trade and supply chains is an area where national policies can make a significant difference in the environmental and economic sustainability.

Table 3.4. **Capacity needs for surface freight by continent**

	Freight (billion tonne-kilometres)			Required capacity increase compared to 2010 (%)	
	2010	2030	2050	2030	2050
Europe	4 318	8 345	13 123	11	23
North America	2 763	5 097	9 320	6	15
Asia	8 956	26 202	58 092	35	67
Oceania	118	226	441	1	3
South America	619	1 044	1 913	3	9
Africa	630	2 024	7 853	12	46

Source: ITF (2016b), Capacity to Grow: Transport Infrastructure Needs for Future Trade Growth, *http://dx.doi.org/10.1787/5jlwvz8jlpzp-en.*

Table 3.5. **Capacity needs for surface freight by continent within 50 km of centroids and ports**

	Freight (billion tonne-kilometres)			Required capacity increase compared to 2010 (%)	
	2010	2030	2050	2030	2050
Europe	1 458	2 616	4 009	23	44
North America	472	867	1 630	10	22
Asia	1 761	4 858	10 769	68	186
Oceania	32	64	113	2	12
South America	166	276	500	15	41
Africa	112	326	1 104	40	165

Source: ITF (2016b), Capacity to Grow: Transport Infrastructure Needs for Future Trade Growth, *http://dx.doi.org/10.1787/5jlwvz8jlpzp-en.*

In addition to the technological and operational measures described in previous sections, studies suggest that a strategic reconfiguration of port-hinterland distribution networks could have a significant impact on the efficiency of hinterland freight. Most international freight transport generally involves intermodal transhipment and storage activities at logistic hubs such as terminals or distribution centres. Optimising the locations of the distribution centres and the way they are connected to the ports and to the economic regions can lead to a reduction in the total tonne-kilometre of hinterland freight movements.

According to Halim et al. (2016), the use of more centralised distribution centres in Europe could lead to a considerable reduction of total logistics cost by at least 12% with a slight reduction in average service level (8%). Reduction in the total logistics costs also translates into reduction in the total tonne-kilometres. The efficiency gain from reconfiguring port-hinterland distribution networks depends on the scale and the coverage of the networks. The use of centralised distribution centres among major companies with larger markets can lead to higher efficiency gain than if the reconfiguration takes place only at the national level. Nevertheless, national governments that have a large area with multiple hinterland corridors can employ reconfiguration of distribution networks by establishing shared and centralised distribution centres at the national level.

Pushing reconfiguration further leads to the Physical Internet (see Box 3.2). The Physical Internet requires the commitment of regions or countries within the same continent to share standardised protocols. There are currently few incentives and many barriers to establishing shared and open distribution centres so the establishment of a wide-scale physical internet network seems out of reach, at least in the medium term. In the longer term, however, the establishment of global standardised protocols for the transfer of goods has a very large potential to reduce the number of vehicle-kilometres travelled.

Box 3.2. **The Physical Internet**

Recent areas of research have proposed a new vision and solution for tackling sustainability challenges in logistics – the Physical Internet (Montreuil, 2011). The Physical Internet is an open logistic system founded on exchange protocols that allow goods to be transported on a common network, the same way information is transported on the Internet. The physical internet relies on standardisation, of the size of parcels and of the information attached to it, so that goods can freely move, using the different transport modes, regardless of the sender or recipient. The information contained on the goods allow them to be directed when inter-connection is necessary. In the end, large efficiency gains can be expected.

The implementation of open and shared distribution networks could result in a significant reduction in both total logistics costs and CO_2 emissions of freight transport activities. Preliminary evidence for the efficacy of such measures at national levels can be found in (Hakimi et al., 2012). The successful reductions of freight tonne-kilometre as indicated by these studies show that higher scale application at a larger geographical level is a promising research avenue.

Within the context of improving port-hinterland connectivity, the Physical Internet concept can be translated into an open, connected, and shared port-hinterland mobility network which may significantly improve hinterland transport efficiency and sustainability. In practice, the open mobility network of Physical Internet could be implemented by the use of shared and centralised distribution centres for different freight transport providers at larger geographical scale such as at a continental or regional scale.

Decision making under uncertainty

Various observers speculate that trends are continuing to shift which would result in less trade than the above projections have indicated. Their argument is based on the premise that fundamental changes are taking place in consumption, production and energy sources. For example, an element of consumption has now become virtual, immaterial and shared. A share of production has become more local, facilitated by innovations such as 3D-printing and tendencies towards a more circular economy. Energy production has also become more localised, focused on renewable energy sources; and many countries have adopted the vision of a zero-carbon future which requires a more stringent move away from fossil fuels. All these developments could change the volume and composition of global trade flows in a way that no model has been able to fully account for as yet.

Consumption patterns

Behaviour of consumers is changing in various ways, expressed in the emergence of more local consumption, more virtual consumption and more shared consumption. An example of localised consumption relates to food. Local food markets have gained momentum in the US and elsewhere, leading to increased consumption of local food products. E.g. two-thirds of the French population consume more local food products than five years ago. Consumption has also become increasingly virtual with the development of all kinds of electronic goods, such as e-books, online music and newspapers that have to some extent replaced the physical goods: in 2015 e-books generated similar sales revenues as physical books. Finally, a considerable share of consumption is about shared services, such as car-sharing. The number of car share users in Europe is predicted to reach 15 million by 2020. All these developments have an effect on the demand for traded goods.

In the examples given here, there is less need for trade and the transport of food, paper pulp, cars and various other consumer goods. If these trends continue and intensify, they could have a substantial impact on cargo transport. Another reason to believe that this could be the case is that many of these trends, such as the shared economy, are predominantly urban phenomena – and the share of the world population living in cities is expected to rise to 70% by 2050, according to UN-Habitat.

Production patterns

There are also sufficient reasons for believing that production and manufacturing will become increasingly localised. As mentioned earlier, the limits of the global value chain model seem to have been reached (OECD, 2016). This aligns with expectations of business executives: 54% of US executives are considering re-shoring some of their activities by 2020. Such re-shoring would be facilitated by technologies such as 3D-printing that promises production closer to major consumption centres. According to a PwC study (2015), 37% of ocean container shipments might be threatened by 3D-printing. A considerable share of the commodities needed for local production could be sourced locally if a more circular economic model takes off. In such a circular economy scenario, the need of primary material consumption in 2050 could be half of the current level (McKinsey, 2016).

Energy production

A large share of current global trade flows are from coal and oil. More and more countries have committed to zero-carbon strategies and reoriented their energy mix towards more renewable energy sources. E.g. coal consumption in the United Kingdom and in France is 70% lower than in the 1970s. According to the IEA, renewable energy could make up half of the global energy mix by 2050. Most of this renewable energy could be locally sourced via wind or solar energy, so a strict global zero-carbon scenario could result in a substantial decrease of maritime transport.

Alternative shipping routes

The projections in this *Outlook* assume that current shipping routes will continue to be used. Various projects in discussion may change these routes. The Kra Canal could provide a supplement to the flows currently going through the Malacca Straits; the Nicaragua Canal could provide an alternative to the Panama Canal and would be better able to accommodate the biggest container ships. Various proposed land bridges in Latin America could also provide new options to connect the Atlantic and Pacific Oceans.

The Northern Sea route might also be able to accommodate more shipping, even if the prospects for regular liner services seem limited. Long-range rail corridors might also at some point become an alternative for certain maritime trade routes. This is currently not the case, considering that ocean shipping is so much cheaper and that most of the goods are fairly time insensitive. Long-distance freight rail has so far been more in competition with air cargo but the equation could change considering the increased costs that maritime transport could have to face, such as the low sulphur regulations.

In short, any study of capacity constraints cannot forego the analysis of potential sources of uncertainty, some of which have been discussed above. For all key actors in the transport sector, in particular those responsible for long-term transport planning, both in the private and public sector, knowledge and the ability to understand the trends outlined above as they are unfolding will be vital. This will require more flexibility especially in infrastructure planning and delivery. Port and hinterland infrastructures will need to be designed in a way that is more closely linked to actual cargo flow and that which can reasonably be expected in the near future, while leaving enough room for adaptation should new developments require.

The projections presented above should therefore be interpreted with caution. Indeed, there is much uncertainty related to consumption and production patterns, energy production and shipping routes, which make decision making difficult.

References

ATAG (2016), *Aviation benefits beyond borders*, Air Transport Action Group.

Cambridge Systematics (1998), *Transmode Consultants, National Cooperative Highway Research Program*, American Association of State Highway and Transportation Officials, Multimodal corridor and capacity analysis manual (No. 399), Transportation Research Board, Washington, DC, USA.

Constantinescu, C., A. Mattoo and M. Ruta, (2015), "The Global Trade Slowdown: Cyclical or Structural?" *IMF Working Paper*, International Monetary Fund, January 2015.

Drewry Shipping Consultants (2014), *Annual Review of Global Container Terminal Operators 2013*, London.

ECB (2014), "Understanding global trade elasticties: What has changed?", *ECB Monthly Bulletin*, European Central Bank, July 2014.

FHWA (2009), *Estimation of 2007 VIUS Variable*, Office of Freight Management and Operations, 15 October 2009.

Fontagné, L. and J. Fouré (2013), "Opening a Pandora's Box: Modelling World Trade Patterns at the 2035 Horizon", *CEPII Working Papers*, No. 22. CEPII Research Center, Paris.

Hakimi, D. et al. (2012), "Simulating a physical internet enabled mobility web: the case of mass distribution in France (p. 10 p.)", the 9th *International Conference on Modeling, Optimization & SIMulation – MOSIM'12*, Retrieved from *https://hal.archives-ouvertes.fr/hal-00728584/document*.

Halim, R.A. et al. (2016), "A Strategic Model of Port-Hinterland Freight Distribution Networks", *Transportation Research Part E: Logistics and Transportation Review*.

Halim, R.A. (2016), *Strategic Modeling of global container transport networks*, PhD thesis, Delft University of Technology, the Netherlands.

HCM (2010), *Highway Capacity Manual 2010*, Transportation Research Board, National Research Council, Washinton, DC, USA.

ICAO (2013), "Consolidated statement of continuing ICAO policies and practices related to environmental protection – Climate change", *ICAO resolution* No. A37-19.

IEA (2014), *The IEA Mobility Model*, IEA, Paris, *www.iea.org/media/transport/IEA_MoMo_Presentation.pdf*.

International Maritime Organisation (IMO) (2009), *Second IMO GHG Study 2009*, International Maritime Organization, London, UK.

International Maritime Organisation (IMO) (2014), *Third IMO GHG Study 2014*,International Maritime Organization, London, UK.

ITF (forthcoming), *Maritime supply chain governance in the mega-ship era* (working title).

ITF (2016a), *The Carbon Footprint of Global Trade, Tackling Emissions from International Freight Transport*, *www.itf-oecd.org/sites/default/files/docs/cop-pdf-06.pdf*.

ITF (2016b), "Capacity to Grow: Transport Infrastructure Needs for Future Trade Growth", *International Transport Forum Policy Papers*, No. 19, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5jlwvz8jlpzp-en*.

ITF (2015a), *ITF Transport Outlook 2015*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789282107782-en*.

ITF (2015b), "The Impact of Mega-Ships", *International Transport Forum Policy Papers, No. 10,* OECD Publishing, Paris, *http://dx.doi.org/10.1787/5jlwvzcm3j9v-en*.

Johansson, Å. and E. Olaberria (2014), "Long-term patterns of trade and specialisation", *OECD Economics Department Working Papers*, No. 1136, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5jz158tbddbr-en* .

LR (2016), *Low carbon pathways 2050*, Lloyd's Register, *www.lr.org/lcp2050*.

Martinez, L.M., J. Kauppila and M. Castaing (2015), "International Freight and Related Carbon Dioxide Emissions by 2050:New Modeling Tool", *Transportation Research Record: Journal of the Transportation Research Board*, No. 2477, pp. 58-67.

McKinsey (2016), *The circular economy: Moving from theory to practice*, McKinsey & Company, USA.

Montreuil, B. (2011), "Toward a Physical Internet: meeting the global logistics sustainability grand challenge", Logistics Research, 3(2-3), 71-87, *https://doi.org/10.1007/s12159-011-0045-x*.

Muncrief, R. (2014), *Truck efficiency standards and the potential for Latin America, Overview of the Global Green Freight Action Plan*, presented at the CCAP MAIN-Latin American Regional Dialogue Mitigation Action Implementation Network, Washington, DC, October 28, 2014.

Ocean Shipping Consultants (2012a), *North European Containerport Markets to 2025*.

Ocean Shipping Consultants (2012b), *East Asian Containerport Markets to 2025*.

Ocean Shipping Consultants (2012c), *Middle East Containerport Markets to 2025*.

OECD (2016), "Cardiac Arrest of Dizzy Spell: Why is World Trade so Weak and What Can Policy Do About It?", *OECD Economic Policy Paper*, September 2016, No. 18, *http://dx.doi.org/10.1787/5jlr2h45q532-en*.

PwC (2015), *2015 Commercial Transportation Trends, Industry perspectives*, *www.strategyand.pwc.com/perspectives/2015-commercial-transportation-trends*.

Rodrigue, J.-P. and T. Notteboom (2012), "Dry ports in European and North American intermodal rail systems: Two of a kind?", Res. Transp. Bus. Manage., Vol. 5, pp. 4-15.

Route Monkey (2016), *Demonstrating the GHG reduction potential of asset sharing, asset optimization and other measures*, Report of the Road Freight Lab, prepared on behalf of WBCSD members in the Low Carbon Technology Partnership initiative.

Smith, T.W.P. et al. (2015), *The Existing Shipping Fleet's CO_2 Efficiency*, International Maritime Organisation, London, UK, March, 2015.

Smith et al. (2014), *Low Carbon Shipping – A Systems Approach*, Final Report, University College London.

ANNEX 3.A

ITF International Freight Model

The International Transport Forum's (ITF) International Freight Model projects international freight transport activity and related CO_2 emissions up to 2050 based on global trade projections. The model includes six main components, each feeding into the subsequent calculation:

- A general equilibrium model for international trade, covering 26 world regions and 25 commodities of which 19 require transport
- A global freight transport network model based on 2010 data
- Global production/consumption centroids
- An international freight mode choice model calibrated using Eurostat and ECLAC data
- A weight/value model to convert trade in value into weight, calibrated for each commodity and transport mode, and
- CO_2 intensities and technology pathway by mode.

The final outputs of the model are freight tonne-kilometres by transport corridor by mode and related CO_2 emissions. Each of the model components are described in more detail below.

Transport network model

The model consolidates and integrates all freight transport networks based on open GIS data for different transport modes. Seaports and airports are physically connected to road and rail networks with data on intermodal dwelling times. Travel times by type of infrastructure and dwelling times between transport modes are estimated using average speeds based on available information by region. The model then computes the shortest paths between each production/consumption centroid for each transport mode (for the modes available for each link), generating two main inputs:

- The average travel time and distance by mode for each origin destination pair. For countries with multiple centroids, a weighted average of all centroid pairs is used
- The shortest path between each centroid for each transport mode.

Centroids

The underlying trade projections are done with a regional aggregation of 26 zones. This introduces significant uncertainties from a transport perspective as it does not allow a proper discretisation of the travel path used for different types of product. Therefore, we disaggregate the regional origin-destination (OD) trade flows into a larger number of production/consumption centroids. The centroids were identified using an adapted p-median procedure for all the cities around the world classified by the United Nations in 2010 relative to their population (2 539 cities). The objective function for this aggregation is based on the minimisation of a distance function which includes two components: GDP density and geographical distance. The selection was also constrained by allowing one centroid within a 500 km radius in a country. This resulted in 294 centroids globally, with spatially balanced results for all continents.

Freight mode choice model

The mode share model (in value) for international freight flows assigns the transport mode used for trade between any origin-destination pair of centroids. The mode attributed to each trade connection represents the longest transport section. All freight will require intermodal transport both in the origin and destination. This domestic component of international freight is usually not accounted in the literature, but is included in our model. The model is calibrated using a standard multinomial logit estimator including a commodity type panel term, variables on travel times and distances taken from the network model while two geographical and economic context binary variables are added, one describing if the OD pair has a trade agreement and the other for the existence of a land border between trading partners.

Weight/value model

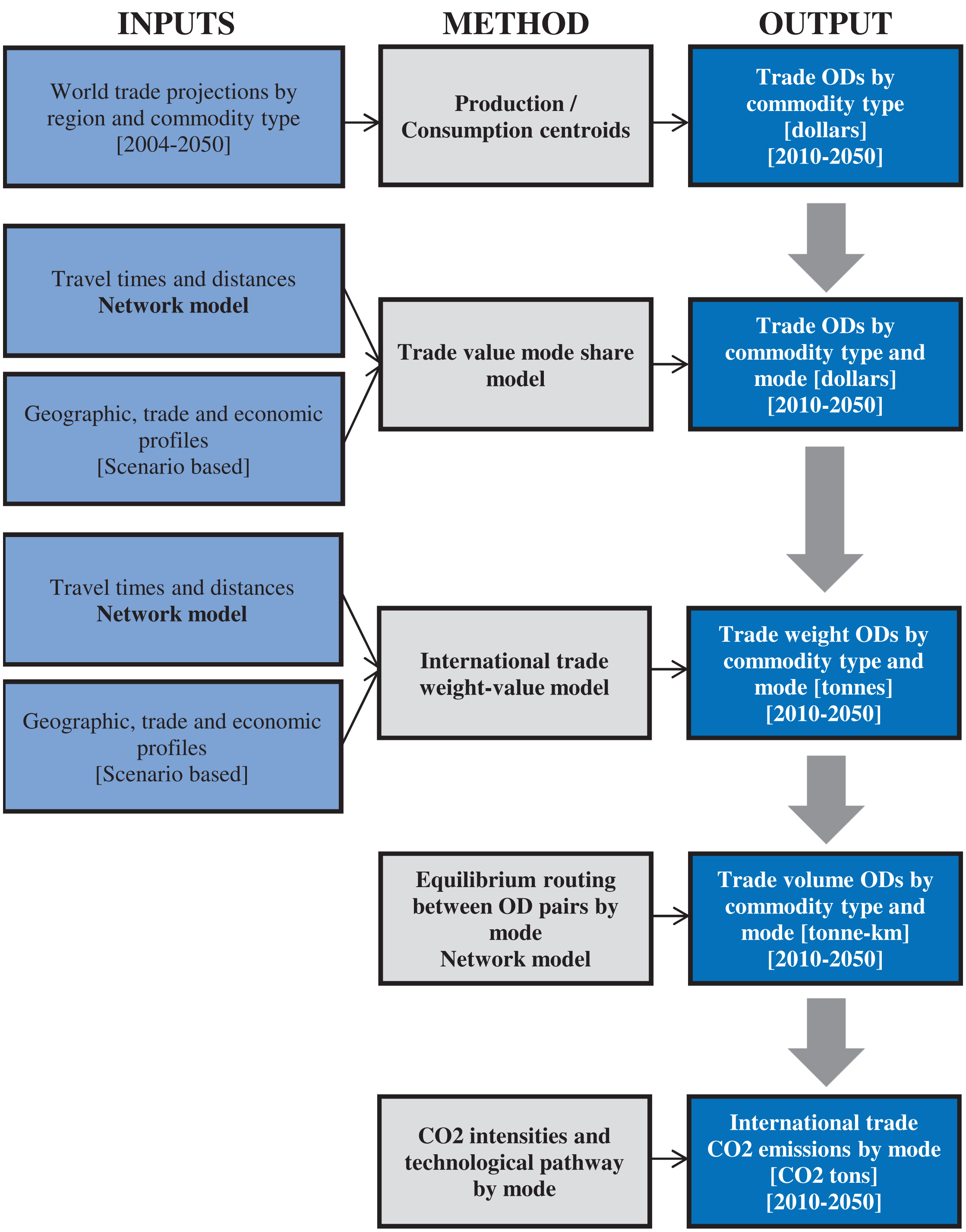
We used a Poisson regression model to estimate the rate of conversion of value units (dollars) into weight units of cargo (tonnes) by mode, calibrated using Eurostat and Latin American data on value/weight ratios for different commodities. We use the natural logarithm of the trade value in millions of dollars as an offset variable, a panel terms by commodity, travel time and distances, and geographical and cultural variables: the binary variables for trade agreements and land borders used above and a binary variable identifying if two countries have the same official language. Moreover, economic profile variables were included to describe the trade relation between countries with different types of production sophistication and scale of trade intensity. The resulting dataset was then divided according to each transport mode, leading to different calibrations by mode.

Generation of the model outputs

The model components result with the value, weight and distance travelled (with path specification) between 2010 and 2050, for each centroid pair, mode, type of commodity and year, stemming from international trade. The tonne-kilometres are then combined with information on related CO_2 intensities and technology pathways by mode, obtained from the International Energy Agency's MoMo model (IEA, 2014) and the International Maritime Organisation (IMO, 2009). In case of road and rail, these coefficients and pathways are geographically dependent, while the maritime and air CO_2 efficiencies are considered to be uniform worldwide.

For technical details of the model, as well as some validation results, see Martinez, Kauppila, Castaing (2014).

Figure 3.A1. **Schematic description of the ITF international freight model**



Freight transport network: A detailed representation

Assessing potential capacity constraints with precision is made possible within our modelling framework through the inclusion of a detailed global freight transport network based on data from Geographic Information Systems (GIS). This allows the model, although global, to describe network conditions at a detailed scale. Our main contribution is the consolidation and integration of all different modal networks into a single, routable freight network, and the association of capacity constraints to links and nodes.

The freight network comprises links and nodes for all four main modes: a global road network, containing the primary and secondary road networks (i.e. motorways, main roads and trunk roads); a rail network; an air network, including all commercial air links between international airports; a maritime network; and a global inland waterways system with navigable rivers (see Figure 3.A2). In order to estimate travel times for the different types of infrastructure, as well as dwelling times between transport modes, we use average speeds based on available information by region.

GIS data for the global network model are available online:

- The road network information integrates two main sources: Global Roads Open Access Data Set (gROADS) (*http://sedac.ciesin.columbia.edu/data/set/groads-global-roads-open-access-v1*) and OpenStreetMap (*www.openstreetmap.org*).
- The rail network was collected from the Digital Chart of the World (DCW) (*http://statisk.umb.no/ikf/gis/dcw/*) project, integrated and updated with the OpenStreetMap data on rail lines and rail stations as intermodal points of connection between road and rail.
- The actual maritime routes are taken from the Global Shipping Lane Network data of Oak Ridge National Labs CTA Transportation Network Group (*www-cta.ornl.gov/transnet/Intermodal_Network.html*), which generates a routable network with actual travel times for different sea segments. We connect this network to ports, based on data from the latest World Port Index Database of the National Geospatial-Intelligence Agency (*http://msi.nga.mil/NGAPortal/MSI.portal*).
- The commercial air links between international airports were integrated using data from OpenFlights.org database on airports, commercial air links and airline companies (*www.OpenFlights.org*).
- The inland waterways network was obtained from the CIA World DataBank II (*www.evl.uic.edu/pape/data/WDB/*), and combined with information on the navigability for each river.

The different networks are consolidated into a single, routable network, and connected to the centroids using the road network and rail stations. The Annex presents statistics related to the number of links and the network length for each mode (see Table 3.A1).

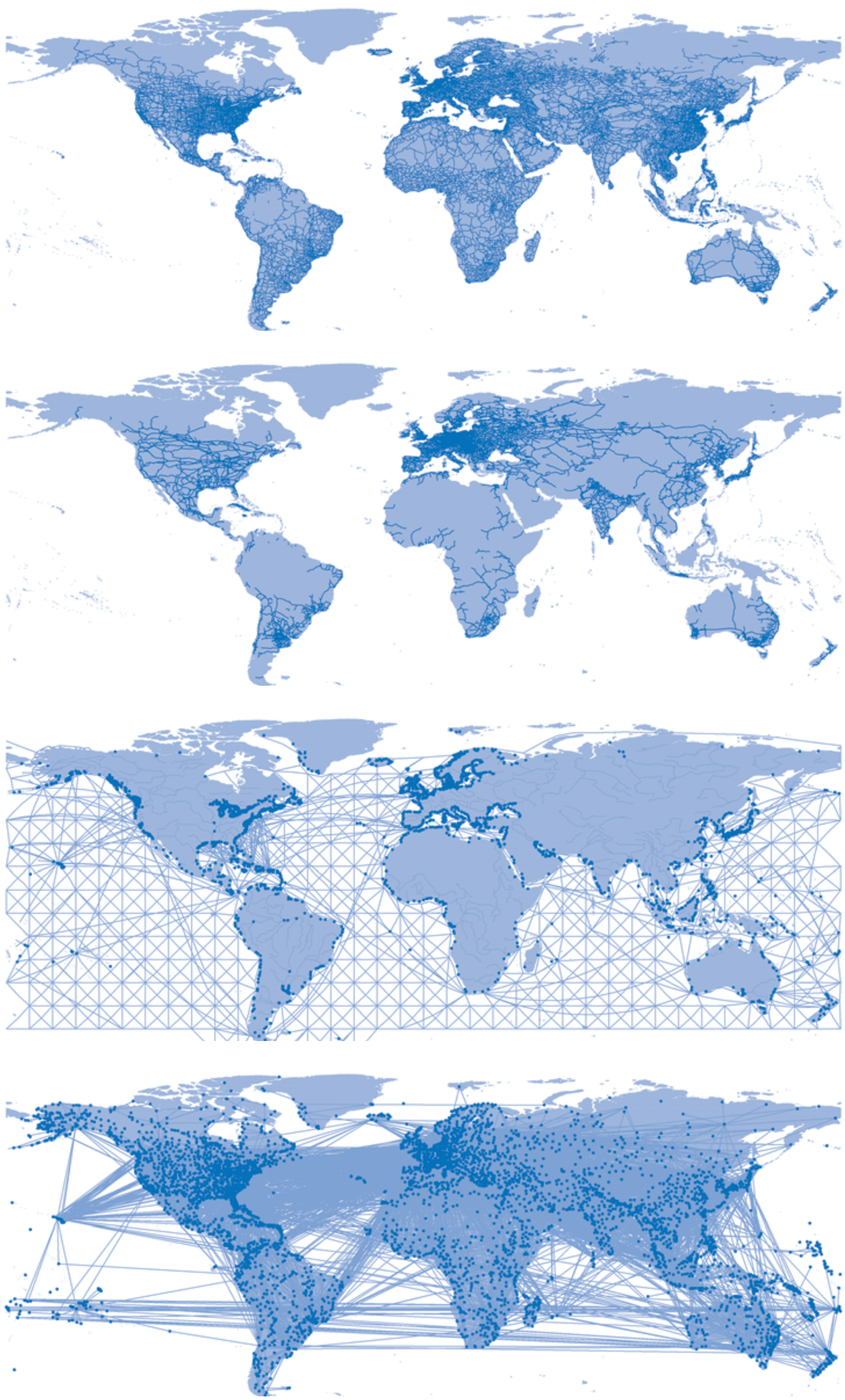
Port capacity

To assess future port infrastructure needs, the ITF built a detailed database of current port capacity, along with planned capacity increases. The data come from the combination of several sources: Drewry (2014), OSC (2012a, 2012b, 2012c) and Clarkson port database. These publications are complemented with data from national port authorities for the United States, Australia, New-Zealand and Brazil, as well as data from Eurostat for European ports.

For each port, we differentiate five types of cargo: containarised cargo, liquid bulk, dry bulk, break bulk and Ro/Ro. Each commodity is associated to one cargo type. The capacity figures introduced in the model are in TEU for containerised goods and in tonnes for non-containerised goods. The data collection focuses mainly on large ports (above 500 MTEU) for which data is freely available. The global coverage is 75% in terms of TEU, with numbers ranging from 53% in Scandinavia, where small and medium ports make the bulk of port

Figure 3.A2. **Freight transport networks**

From top to bottom: road, rail, maritime and waterways, air



Source: ITF (2016b), *Capacity to Grow: Transport Infrastructure Needs for Future Trade Growth*, *http://dx.doi.org/10.1787/5jlwvz8jlpzp-en*.

capacity, to close to 100% in regions of the world such as North America or China where large ports are predominant for international freight movements.

Road and rail capacity: Adding constraints

Data on planned port expansions are derived from the Global Container Terminal Operators from Drewry (2014) as well as reports from Ocean Shipping Consultant (2012b, 2012c) which forecast port capacity developments until 2025-30 based on announced expansions in the coming decade.

Road capacity, especially of highways, is a very well documented subject. The Highway Capacity Manual (HCM, 2010) constitutes a reference in the field, giving simplified formulas for the capacity of a link depending on the number of lanes. The road network data categorises road links into seven groups, each group being assigned a fixed number of lanes and thus capacity (see Table 3.A1).

Table 3.A1. **Statistical and capacity characterisation of road network**

Road type	No. of lanes	No. of links	Network length (km)	Hourly capacity per lane (vehicles/hour)	Hourly heavy vehicles capacity (vehicles/hour)	Yearly heavy vehicles capacity (vehicles/year)
Beltway	2	1 228	9 553	1 600	3 520	1 284 800
Bypass	1	30	189	1 400	1 540	562 100
Major highway	3	37 570	689 206	2 000	6 600	2 409 000
Road	1	27 906	968 172	1 200	1 320	481 800
Secondary highway	2	34 054	963 477	2 000	4 400	1 606 000
Track	1	80	9 396	800	880	321 200
Unknown	1	56 026	2 222 592	600	660	240 900

Source: ITF (2016b), *Capacity to Grow: Transport Infrastructure Needs for Future Trade Growth*, *http://dx.doi.org/10.1787/5jlwvz8jlpzp-en*.

To apply these capacity constraints to our model, we make two additional assumptions. First, we set the maximum share of heavy vehicles in the overall traffic up to 25%. Second, there is a single average truck load by commodity, which takes account of empty movements. These assumptions come from a rough assessment of the mix of traffic in the United States (FHWA 2009) but can easily be refined (by region or even link) in subsequent versions of the model.

Rail capacity depends on several attributes of the rail infrastructure, the mix of traffic between passenger and freight and the rules of priority which apply. For the global freight model, which works with a very large scale, we apply simple rules coming from the Multimodal Corridor and Capacity Analysis Manual (Cambridge Systematics, 1998). The manual defines capacity for rail infrastructure at a very high level using only a few attributes of the infrastructure, such as the number of tracks, the availability of an Automatic Block Signal system or the level of centralisation of traffic control.

The rail network in the global freight network model does not contain all the attributes needed to apply the formulas in the Manual. However, it includes an attribute regarding the quality of the infrastructure, a single figure ranging from four to ten. We connected this level of quality to the availability of Automated Block Signal System and the number of tracks. For instance, rail tracks of level four in the network are assigned to high-speed rail with at least double tracks. Table 3.A3 gives the correspondence between the quality of the infrastructure and the yearly container capacity.

Table 3.A2. **Rail line engineering capacity**

Number of tracks	Automatic Block Signal System		Traffic Control Centralised	
	Trains per day*	Gross tonnes per year** (millions)	Trains per day*	Gross tonnes per year** (millions)
Single	40	62	60	93
Double	120	186	160	250

* Total both directions; **Gross tonnes per route mile, total both directions; Source: Cambridge Systematics (1998).
Source: ITF (2016b), *Capacity to Grow: Transport Infrastructure Needs for Future Trade Growth*, *http://dx.doi.org/10.1787/5jlwvz8jlpzp-en*.

Table 3.A3. **Rail infrastructure classification and freight capacity estimation**

Scale rank code	Class characterisation	Double track	Automatic Block Signal System	Traffic control centralised	Network length (km)	Yearly container capacity (TEU/year)
4	High speed rail tracks	Yes	Yes	Yes	6 200	16 666 667
5	High performance rail tracks (speed >= 120 km/h)	Yes	Yes	Yes	23 000	16 666 667
6	High capacity tracks	Yes	Yes	No	85 000	12 400 000
7	Conventional tracks with traffic control centralised	No	Yes	Yes	59 447	6 200 000
8	Conventional tracks with no traffic control centralised	No	Yes	No	182 842	4 133 333
9	Conventional tracks with no automatic safety systems (speed >= 50 km/h)	No	No	No	256 618	1 333 333
10	Conventional tracks with no automatic safety systems (speed < 50 km/h)	No	No	No	391 292	1 333 333

Source: ITF (2016b), *Capacity to Grow: Transport Infrastructure Needs for Future Trade Growth*, *http://dx.doi.org/10.1787/5jlwvz8jlpzp-en*.

PART II

Chapter 4

International passenger aviation

International aviation continues to expand, contributing positively to the economy, but bringing with it challenges for the environment. This chapter starts by describing the process for modelling future global passenger demand and then presents three scenarios for the evolution of this demand and the related CO_2 emissions. The three scenarios correspond to different mechanisms for the evolution of the air network and combine assumptions on the rules governing the geographical expansion of the network and on future competition levels. The chapter continues by considering projections for CO_2 emissions from international passenger aviation up to 2030 as well as an overview of the longer-term prospects. The final section starts with an analysis of the current level of air accessibility, finishing with a global outlook for accessibility by air to 2030.

The number of passengers carried on international flights has more than doubled in the past two decades, benefitting from economic growth and an ever-growing network. Air transport has also benefited from a large liberalisation movement in the past four decades, increasing the economic activity of the sector and bringing significant advantages to consumers in the form of lower prices and extended possibilities of travel. In the absence of any significant constraints on the network, such as stalled liberalisation of air services agreements, similar growth rates could materialise in the twenty years to come.

The rapid development of international aviation brings a significant climate challenge. In 2015, international aviation represented about 2% of all CO_2 emissions from fuel-burn and, if unchecked, this figure could rise to 22% by 2050 under the IEA 2DS scenario (European Parliament, 2015; see Glossary for details on 2DS). However, there is a strong commitment by the industry and countries to limit emissions to their 2020 levels, through a basket of measures, from CO_2 efficiency standards for new aircrafts to a global market-based measure agreed on at the General Assembly of the International Civil Aviation Organisation (ICAO) in October 2016.

International aviation benefits from strong support from policy makers. Airport and airport-related sectors directly generate output and employment in their neighbourhoods, and indirectly through attracting other businesses, which local policy makers appreciate. Aviation is valued for the connectivity it provides, creating workplaces that on average are much more productive than in other areas of the economy. Aviation also facilitates the movements of goods and services, workers and tourists, investment and ideas. Analysis carried out for this *Outlook* (see the last section in this chapter) shows that, thanks to the development of the air network, accessibility by air is improving in all regions, but still remains very unequal.

Modelling global passenger demand

At the global level, several long-term aviation forecasts are produced by stakeholders, most notably aircraft manufacturers. The two main ones, the Boeing Current Market Outlook (Boeing, 2016) and the Airbus Global Market Forecast (Airbus, 2016) both foresee a large increase in demand in the coming decades, resulting in an equally large demand for aircrafts. ICAO (2016) and the International Air Transport Association also produce projections. All the above forecasts share the view that the average yearly growth in global Revenue Passenger Kilometres (RPKs) in the two coming decades will be around 5%, continuing the trend of the years 2010-15. Despite the 6.5% growth recorded in the year 2015, these forecasts have been revised down each year, most notably due to lower economic projections.

Most, if not all, available global forecasts use a time-series approach. The model in this *Outlook* adopts a more structural approach, inferring the role of different socio-economic or industry drivers by comparing the demand between the different regions of the world in a single year. It also focuses on the role of the air network in creating demand, through the application of different network evolution scenarios.

In this new modelling framework (see also the methodological Annex 4.1), passenger demand results from the combination of two sub-models: a gravity-type model for the prediction of origin-destination passenger volumes and a route-choice model for the assignment of the latter onto the air transport network. The models apply to a world divided into 333 regions, each region corresponding to a main centre of economic activity and having no more than one major airport. Aggregating the air network to these regions forms a synthetic network on which the model is based. The gravitational model expresses passenger demand between two regions as a function of socio-economic variables, such as GDP, population, trade, cultural relationships (language sharing, emigration volumes, etc.) and the generalised cost of travelling between the two regions. The generalised cost of travel is itself a function of minimum travel time, minimum number of transfers and some proxies for price. The model then divides demand between all possible itineraries by comparing their quality of service, defined as a combination of travel time, number of transfers, frequency and price.

Supply variables enter the demand prediction models (minimum travel time, price, etc.). As a consequence, forecasting future passenger demand levels requires a detailed knowledge of the future state of the network. However, the evolution of the air network is dependent on phenomena that are difficult to forecast, such as the extent of future liberalisation and its impacts on traffic rights and price setting, or the emergence of new business models based on different airline economics or new aeroplanes.

This *Outlook* forecasts future passenger demand according to three network evolution scenarios, with different assumptions regarding the future levels of competition and the expansion of the air network. The following sections take a look at some historical trends and derive modelling rules for competition and network expansion, useful in defining the assumptions of the three network evolution scenarios, which are then described. The section ends with a discussion of access restrictions and the impact they may have on the scenarios.

Competition

Lower prices naturally lead to more demand for passenger transport, as they make flying available to people with less purchasing power. The sensitivity of travel demand to fares is well documented (see IATA, 2008 for instance). The strong growth in passenger transport resulting from the arrival of low-cost airlines in North-America and Europe bears testimony to this phenomenon. However, acquiring a comprehensive and coherent set of ticket prices is a difficult task, due to the high volatility and business sensitivity of airline fares. An online travel agent comparator, SkyScanner, provided a database of prices for the year 2014. While this data was sufficient to assess the role of the different drivers behind airline fares, it could not form the basis of a globally consistent fare model for forecasting.

Instead, the model includes two proxies for the price of airlines. The first is an indicator of competition, the so-called h-index (see Box 4.1); the second is the presence or absence of a low-cost carrier on the route. Available literature suggests that both indicators impact prices negatively (e.g. Fu et al., 2010). In the SkyScanner fare data, both variables are significant in explaining fares. For instance, for direct flights, there is a GBP 0.02 difference in the average kilometric price between region pairs, depending on the value of the h-index between 0 and 1, when the average kilometric price in the sample stands at GBP 0.15. The presence of a low-cost carrier on a route writes off one-third of the ticket price on average (see also Benezech et al., 2016).

Box 4.1. **Quantifying competition in the air market**

Competition drives efficiency and the removing of restrictions on market entry, for example by liberalising air service agreements or expanding congested airports, and is indicated where existing agreements are restrictive. At the same time, competition in aviation takes several forms and markets are to some extent segmented. Hub airlines have arisen as a result of network economies whereby feeder traffic from short-haul routes helps fill intercontinental flights, permitting a wider range of profitable long-haul flights and greater frequencies of service on these routes. Other airlines, many of them following a low-cost business model, focus on point to point services, competing for long-haul traffic in some cases but more often on the short haul routes in competition with each other and the hub airline feeder services. Hub airlines have responded on price and quality and maintained most of their services but at a certain point the erosion of margins means routes have to be abandoned. This is not a linear process because of the interdependency of routes in the network. The anti-trust immunity accorded alliances of hub carriers when air service agreements are opened to more entry also complicates the overall scope for and impact of competition. Relieving capacity constraints at congested airports could have a more straightforward effect in enabling competition by reducing scarcity rents (usually accruing to incumbent airlines) and bringing down prices.

In practical terms, there is much debate about the best way to measure competition in the aviation market, relating to what constitutes a market and which airlines actually compete on each market segment.

The question of actual competition versus potential competition has arisen because of the emergence of global alliances and the development of code-sharing. Here, the constraint lies in the data available. The Innovata flight database indicates the operating airline but does not give full information about code-shares. We compute competition at the level of the alliance, or that of the airline for airlines outside of alliances, with a single indicator: the Herfindahl-Hirschman Index (HHI), or h-index. The h-index varies between 0 and 1, with 0 corresponding to atomistic competition and 1 to a monopolistic situation.

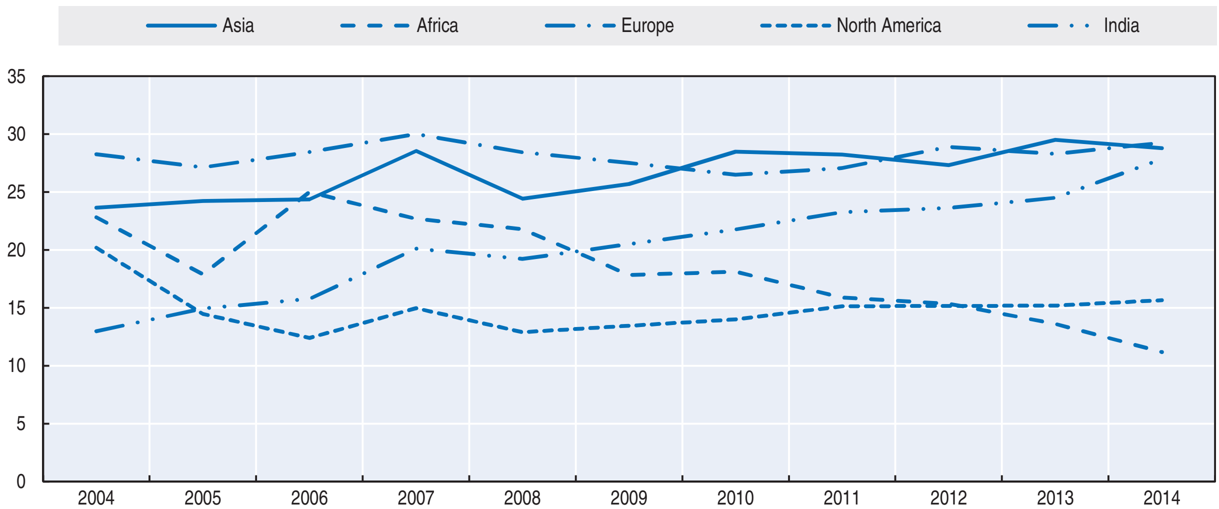
To take into account indirect routes, an h-index weighted for quality of service is used. This idea was first introduced by Veldhuis (Veldhuis, 1997) and is widely used in competition assessment (Lieshout and Matsumoto, 2012; Burghouwt et al., 2015). Using such weights, longer flights, or flights necessitating long layovers, are given less weight in the formula for the h-index.

Another crucial question lies in the way we define markets. Looking at airport or city pairs ignores competition between parallel routes, especially when low-cost carriers serve secondary airports (De Wit et al., 2009). Competition here is computed at the regional level, taking secondary airports into account.

If h-indices and the penetration of low-cost carriers do not capture all the effects related to competition, they still explain much of the differences in kilometric prices between origin-destination pairs. They can also be directly related to passenger demand. The explanatory power of the related coefficients in the demand model is significant and their evolution in the past decade has been particularly strong in regions where demand also surged. Figure 4.1 presents the evolution of an aggregate competition indicator in some regions or countries. This indicator has been growing significantly in Asia, especially in India, where demand also spiked. In this region, it is now on par with Europe, where competition is notably strong. Similar trends can be observed for the penetration of low-cost carriers (see also Figure 4.3).

Figure 4.1. **Competition in international aviation**

Share of international city-pairs with h- index lower than 0.5, %



Note: The h-index is an indicator of competition, with values between 0 and 1. Lower values indicate higher competition levels (see also Box 4.1).

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Network expansion

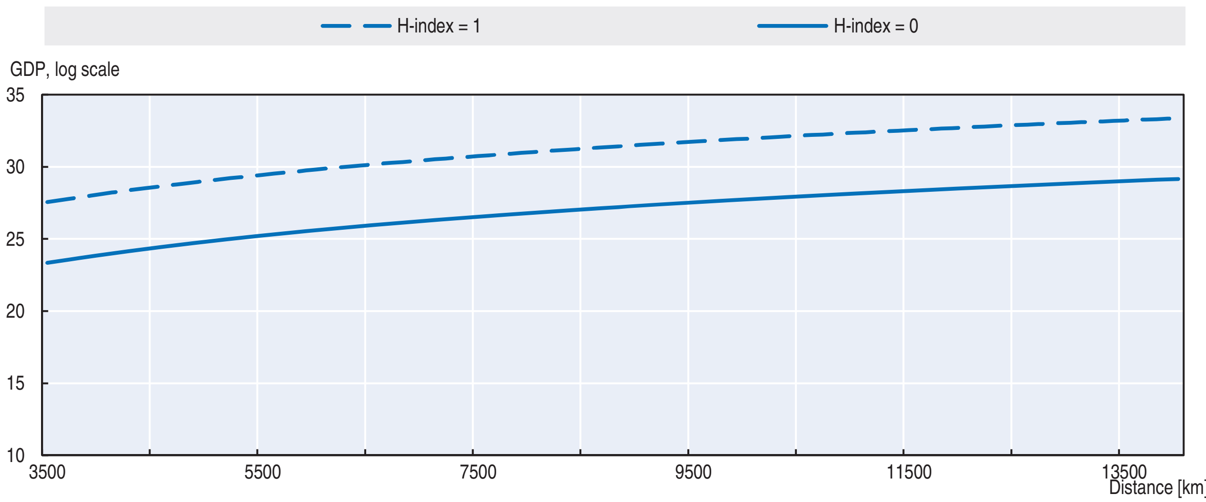
The second lever within the network evolution scenarios is the geographical extent of the network and the connectivity it offers. The ability of airlines to operate new flights easily when they think it may be commercially viable is a key enabler of the growth of air transport demand. Contrary to rail, the expansion of the air network does not always necessitate much investment in infrastructure.

The reasons for which an airline may choose to operate a new route depend on a myriad of factors related to expected costs and revenues, the integration of the route in the overall network and existing competition levels. Bilateral or multilateral agreements may also restrain the access of airlines or limit the number of seats they can offer. The network evolution scenarios do not intend to reciprocate such an intricate process. Rather, it looks at the evolution of the global air network from a very aggregate viewpoint, allowing several key trends to emerge.

An analysis of the distribution of direct connections in the global air network shows that there is a clear relationship between the presence of a direct link and the economic activity of the origin and the destination. The economic mass of the link (product of the GDP of the origin and that of the destination) captures the potential for travel at both ends of the link. However, the threshold from which a link becomes viable and airlines start operating flights depend on many other factors, several of them relating to operating costs.

More competitive environments lead to lower operating costs and the easier creation of direct links. This trend appears when modelling the relationship between the probability of existence of a direct connection and competition. Figure 4.2 shows the economic mass which corresponds to a 0.5 probability of existence as a function of distance, in differing environments. Competition has a significant impact on this threshold, reflecting at an aggregate level the impact of more competition on operating costs. As a result, airlines are able to operate between regions with lower economic power.

Figure 4.2. **Relationship between distance, GDP and air connections**



Note: H-index is an indicator of competition, with values between 0 and 1. Lower values indicate higher competition levels (see also Box 4.1).

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Technology may also be responsible for quicker network expansion. Newer aircrafts consume less fuel, which has the twofold effect of decreasing emissions per plane-kilometre within the same airplane class, and per passenger-kilometre, rendering viable the operation of flights between regions with lower economic mass.

Three alternative scenarios for network evolution

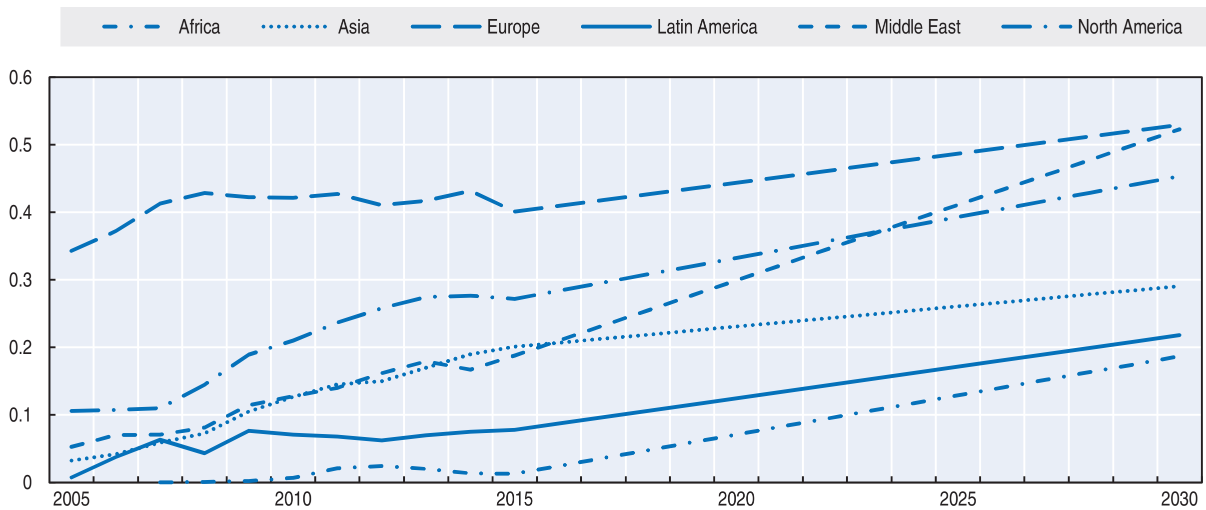
The extent of future liberalisation and its impacts on traffic rights and price setting, or the emergence of new business models based on different airline economics or new airplanes are difficult to forecast. To assess the full range of possible outcomes for international air passenger demand up to 2050, future passenger demand is projected according to three network evolution scenarios. They consist of a lower bound (*static network scenario*), an upper bound (*dynamic network scenario*) and a *baseline scenario*.

In the *static network scenario*, there is no change in the supply side from 2015 onwards. The growth in air travel demand in this scenario comes from the changes in exogenous factors, such as population or GDP. In terms of competition, this means that low-cost carriers do not enter new origin-destination pairs and that h-indices remain constant throughout the period. In terms of connectivity, the number of direct connections remains the same between 2015 and 2050. The realisation of this scenario is very improbable. However, it helps to understand the role of the air network in the increase in air transport demand.

In contrast, the air network of the *dynamic network scenario* is fully flexible and there is a general decrease in prices. Connectivity increases and new links are created whenever the probability of the presence of a link is higher than 0.5 in the network evolution model. By 2050, low-cost carriers have penetrated all short-haul markets (see also Figure 4.3) and there is an overall increase in competition. By 2030, the h-index for all origin-destination pairs decreases to the lowest observed level in 2015 for each origin-destination pair of similar distance and which are part of the same pair of sub-continents. A primary assessment using the SkyScanner database indicates that this corresponds to an average

Figure 4.3. **Share of low-cost carriers in regional, international flights**

Historical data up to 2015 and projections according to the dynamic scenario



Note: The figure for North America is difficult to compare with other regions, as there are only two countries in the region (domestic low-cost flights are not included).

Source: FlightGlobal, ITF projections.

StatLink http://dx.doi.org/10.1787/888933442664

30% decrease in price for flights between Europe and North America between 2015 and 2050, everything else remaining constant. More pronounced decrease in prices happen in other markets, notably in Africa.

In the *baseline scenario*, the parameters of the network evolution model are set so as to imitate the evolution of the evolution of the air network between 2010 and 2015. There is no general decrease in prices from their 2015 levels and competition changes follow the trends of the 2010 to 2015 period. An additional parameter in the network expansion model limits the growth of the network to direct links for which the predicted demand is above a certain threshold, which depends on the distance. Finally, the share of low-cost carriers remains constant.

Passenger demand for air transport until 2050

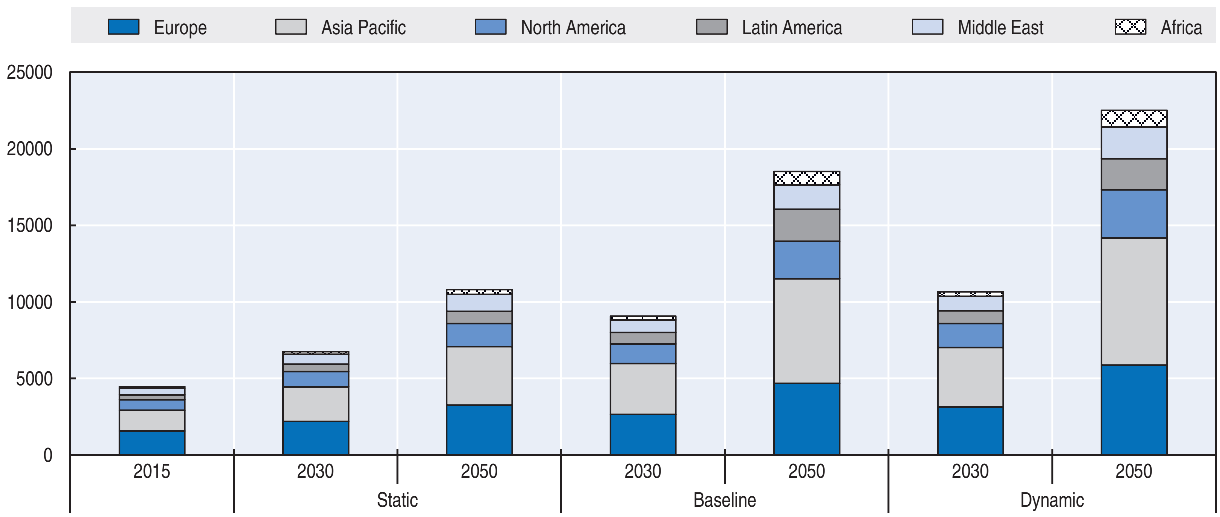
Analysis of global demand

Air passenger numbers continue to grow strongly until 2030 in all scenarios, albeit with significant differences between the three alternative scenarios, from 2.3% in the static scenario to 5.7% in the dynamic scenario (Figure 4.4). Passenger-kilometres grow at similar rates. In the baseline scenario, the number of passenger-kilometres doubles in the next fifteen years, reaching 9 000 billion kilometres. The global increase in demand is pushed by the large growth in the Asia-Pacific region, which comes to represent 40% of world passenger traffic in 2030, up from 30% in 2015.

The growth is generally higher between 2015 and 2030 than after that year. There are two main reasons for this slowing down. First, slower growth after 2030 is driven by the GDP and population projections, which are slowing down or even decreasing (for example population peaks in China in 2030). Second, in the baseline and dynamic scenarios, the network gradually reaches saturation, with fewer and fewer potential new links. This is especially true of very long distance links, for which the low-cost carrier business model

Figure 4.4. **Demand for passenger aviation by region**

Billion passenger-kilometres



StatLink http://dx.doi.org/10.1787/888933442672

could not be adapted. Regional networks have more capacity to grow. This is confirmed by analysing the evolution of the European air network between 2010 and 2015. At this time of very low growth, the number of intra-regional flights grew 2.5 times quicker than GDP, against 1.5 for inter-regional flights.

The large differences in the increase in air travel between the scenarios show that a sustained growth in international air passenger demand relies on the network being able to expand and stimulate traffic. This is particularly the case for developing regions (and especially Asia) where the air network is less mature and the difference between the scenarios is the largest. In general, projections by other organisations are close to the baseline scenario. Airbus (Airbus, 2016), for instance, gives an estimate of 4.5% annual growth rate for the period 2015-30, with slightly higher forecasts in the first decade.

The elasticity of travel demand to income

Following the trends observed in the past two decades, passenger aviation continues to grow much quicker than GDP in the baseline scenario. The apparent elasticity of air travel demand to GDP is 1.7 but the growth in passenger demand is actually the combination of two elements: the elasticity of passenger demand to GDP, keeping the network constant, which is around 0.95, and changes in the network. These include the addition of new direct links, as well as the increase of competition and the arrival of low-cost carriers on new routes, both of which are proxies of prices. If price changes can be assumed to be exogenous, the expansion of the network mostly results from economic growth. When this effect is taken into account, the GDP elasticity of passenger-kilometres becomes 1.3. This is consistent with most research, which finds elasticities between 1 and 2 (Gallet and Doucouliagos, 2014), with methodological, regional and market-segmentation differences explaining the range.

The model gives a value of 1.4 for the ratio between the growth in demand and that of GDP. While this may sound high, it is still much lower than the historical value observed between 2010 and 2015, when international passenger-kilometres grew 2.5 times quicker than GDP. It is, however, in line with the long-term average observed during the two preceding decades (IATA, 2008). Assuming a simple GDP elasticity model, calibrated on the past five years only, leads to 16 000 billion passenger-kilometres by 2030, almost twice the amount found in the baseline scenario.

It is difficult to know if this favourable environment will continue in the coming decades. One obvious disruption may come in the form of high oil prices, which would impact fares and therefore demand. However, the airline industry proved very resilient during the peak in oil prices around 2010. Despite fuel surcharges, there was no noticeable impact on global passenger demand. This may be the result of adaptation strategies from airlines, such as improvements in fuel efficiency or reduction in network developments (Hansman et al., 2014). Airlines also certainly allowed for lower profitability. The 6.1% growth registered for 2015, when oil prices were historically low, also suggests that any reduction in travel caused by higher fares in 2010 was hidden behind the excellent performance of the airline sector.

The predicted growth figures, akin to historical observations, rely on a significant expansion of the network, which may reach its limit sooner than expected. In the Asia-Pacific region, the network has been expanding at almost the same rate as the number of passengers, and the growth figures of this *Outlook* for the region (350% between 2015 and 2050 in the baseline scenario) necessitate a similar trend. Network expansion may run up against regulatory restrictions, higher operational costs or capacity constraints.

Regional differences

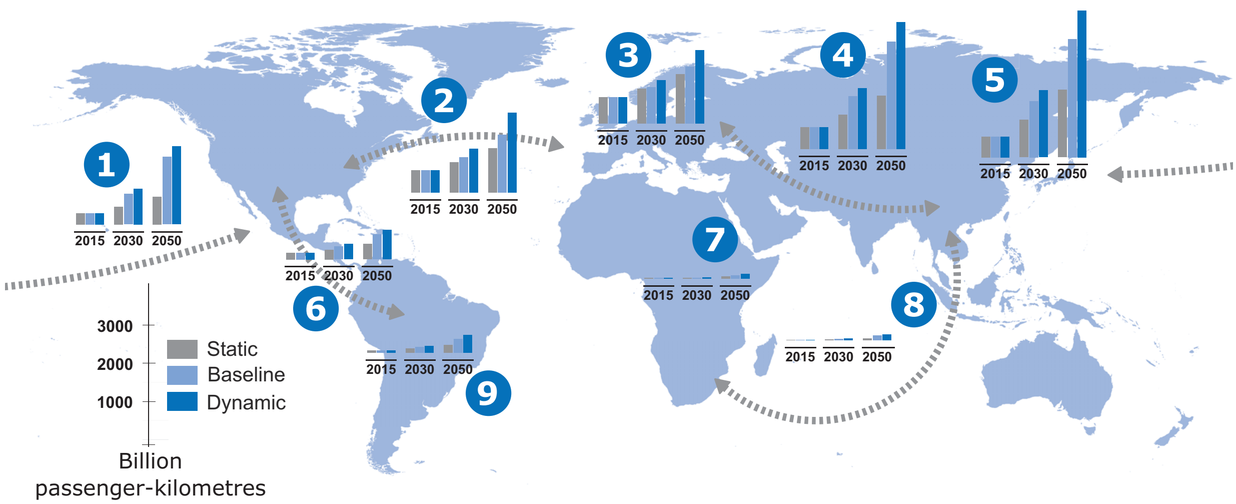
The average global figure hides significant disparity between markets. All developing regions will witness above world average growth rates in the coming decades. In Asia, this growth comes together with an already very high level of demand, with around 1 000 billion international passenger-kilometres in 2010. This could result in as many as 6 000 billion passenger-kilometres in 2050, representing more than a third of the world total. The difference between the static and dynamic scenario for Asia is among the highest observed, reflecting the potential of network development. This analysis is in agreement with all other forecasts.

At the corridor level, the differences are even more striking (see Figure 4.5). In the baseline scenario, average annual growth in passenger-kilometres for intra-Asian routes is 8%. Growth rates close to 10% also occur in some parts of Latin America and Africa, albeit from much lower initial levels. However, demand in relation to developed economies witness smaller than average growth rates in all scenarios, between 3% and 4% in the baseline scenario for the period between 2015 and 2030.

In general, demand grows most where the economy increases strongly and the network has the greatest potential for development. These two elements are of course encountered in some developing economies, where many large cities have only a very limited offering of international services (see also the Accessibility section below). In developed economies, economic growth is often slow; however, potential for development remains, especially in Europe where distances are relatively short. This explains the growth rate of 3.2% for the region in the baseline scenario, compared to 1.8% in the static scenario.

Because new direct flights gather in places where the network is less mature, the predicted demand increase is also not uniform within regions. In Asia, this means that passenger numbers at large airports are expected to grow at smaller rates than in secondary airports. These airports, many of them still largely dependent on domestic traffic in 2015, only recently started to accommodate international traffic. The growth is made possible by the arrival of regional flights, in particular from low-cost carriers. For instance, the number of international flights at Chongqing airport multiplied by five between 2010 and 2015, and passenger demand is expected to increase at a yearly rate of more than 15% in the region over the next two decades. This contrasts with the Beijing or Shanghai regions, where growth is already slowing down (less than 5% increase in international passenger numbers in the past years) and is expected to remain below the 5% limit in the future.

Figure 4.5. **Regional breakdown of passenger-kilometres**



1. Asia – North America; 2. Europe – North America; 3. Intra-Europe; 4. Europe – Asia; 5. Intra-Asia; 6. Latin America – North America; 7. Intra-Africa; 8. Africa – Asia; 9. Intra Latin-America. Asia includes Japan and Korea in this map.

Low-cost intra-regional flights are an important motor of the growth of secondary airports. As shown in Figure 4.3, the share of low-cost carriers in regional, non-domestic flights has been growing in the past two decades in all world regions, albeit at different paces. While this share is now almost stagnating in Europe, it is still growing quickly in Asia, Latin America and the Middle-East. If their expansion is not hindered by legislation, the proportion of low-cost carriers in these regions could quickly reach or exceed the levels observed in Europe.

The situation in Africa is different, where many countries' primary airports were still not well connected to the global air network in 2015. The absence of a dynamic regional market and of powerful low-cost carriers, hinder the potential for development of secondary airports. In the baseline scenario, primary airports continue to attract most of the demand and to concentrate the bulk of network development for the region, at least until 2030.

Impact of entry restrictions

Even if the three scenarios differ in the rules governing the evolution of the network, none of them takes into account potential restrictions to the establishment of a new route. When restrictive air service agreements (ASAs) are in place between two countries, the total number of flights and/or seats between these countries may be bounded and foreign airlines can be restricted in the airports from which they can operate. Another limiting factor brought by restrictive air agreements relates to competition. In the baseline and dynamic scenario, the increase in competition is not capped. When countries have airline designation rules, the number of airlines which can access the market is limited and some of the h-indices obtained by the model in the future may not be possible under the current rules. Moreover, some agreements include provisions regarding acceptable prices and a country's right to refuse certain prices.

The comparison of air services before and after the liberalisation of the UK-India agreement illustrates the above. The new agreement, which came into force in 2004, had a significant impact on both the level of service between the two countries and the number of direct routes offered (UK CAA, 2006). Shortly after liberalisation, the number of direct services between the UK and India had tripled, from 34 to 112 services per week. The number of direct routes increased from 6 to 10, with several new secondary points served. In addition, the number of carriers operating between the two countries grew from three to five, with an average decrease of 25% of the h-index at the country level. According to the UK Civil Aviation Authority, this increased competition resulted in average fares declining by 17% for leisure passengers and by 8% for business passengers. The lower fares and increased service caused passenger traffic between the two countries to increase by 108%.

The restrictions imposed by bilateral agreements between countries are difficult to model. A very large number of such agreements exist and their exact content is not always public. However, it is possible to have an idea of the magnitude of the restrictions by looking at the historical evolution of the air network, and compare it with a theoretical, estimated evolution on one side, and GDP growth on the other side. Table 4.1 gives the observed number of links originating in several countries in 2015 along with the estimated number of links for the same year, taking 2005 as a base year. In 85% of the countries, there is no more than a 30% difference between the two numbers. However, some cases stand out, either because the real number of links is significantly below the estimated number (as is the case in India) or above (e.g. Turkey, which positioned Istanbul airport as a transit hub).

Table 4.1. **International connectivity for selected countries**

Observed and estimated number of links in 2015, and evolution between 2005 and 2015

	Number of links 2015	Estimated number of links 2015	Growth in links 2005-15 (%)	GDP growth 2005-15 (%)
World	13 218	14 321	34	27
China	1 118	1 245	203	140
India	321	589	38	104
Vietnam	129	101	187	88
Japan	411	388	57	6
Turkey	879	748	148	49
Ethiopia	129	126	103	147

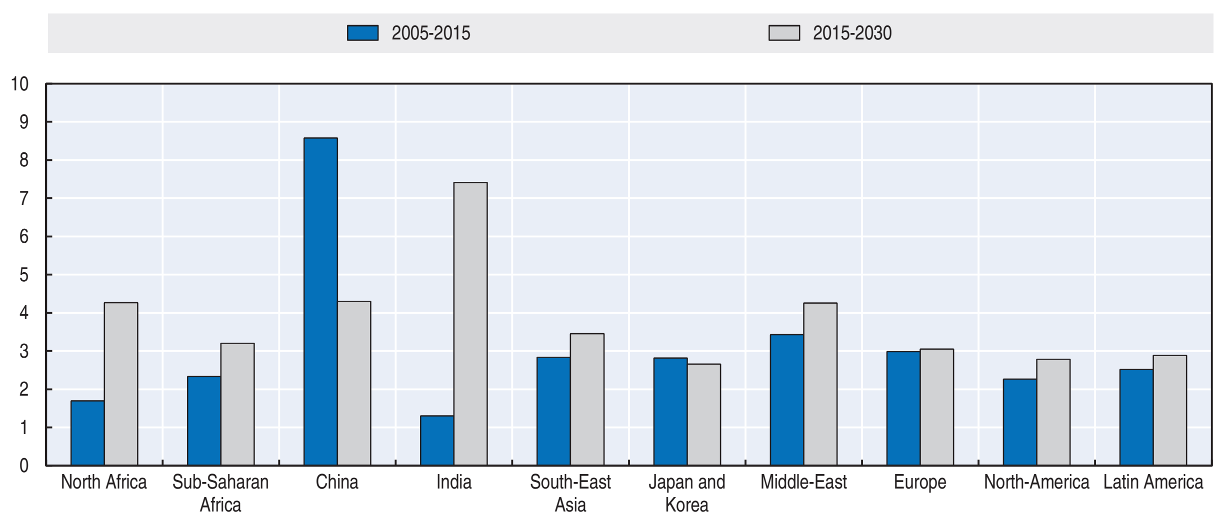
The discrepancies between observations and projections have different reasons depending on the country, but over-estimated countries tend to have more restrictive air agreements. This is especially the case when the ratio between the growth in the size of the air network and that of GDP is below one; it is close to or above one for 65% of all countries. In some cases, the ratio is below one while there is not a significant difference between the observed and estimated number of links, such as in Ethiopia. This most often applies to countries where the establishment of a large regional network is difficult, for instance because the economic growth of neighbouring countries is low. In contrast, countries such as Japan benefit from a dynamic regional environment, which partly explains why their air network expands despite low domestic economic growth.

In the dynamic scenario, the services required to sustain demand go beyond the current air service agreements for several bilateral relationships, especially in Asia. For instance, the required service frequency for the China to India market in the dynamic network scenario in 2030 is ten times higher than the limit set by a bilateral agreement in 2005 (China and India, 2005). It is still twice that amount in the static scenario, as the few existing routes grow and need additional frequency to accommodate the new passengers.

The comparison of past and predicted growth rates in the development of the network gives an indication of which regions could benefit most in a liberalisation of their air service agreements. Figure 4.6 compares the projected 2015-30 growth rate in the number of direct links with that between years 2005-15. While it is too simplistic to assume that each region should continue to follow the trends of the past decade, some differences are very large and indicate that the growth in passenger demand of the baseline scenario may not materialise, because the necessary network will not exist. It is also telling that the growth rates observed during the past decade in some regions, for instance in India and Sub-Saharan Africa, are closer to the static scenario than to the baseline scenario. If the case of India is striking because of the size of the Indian economy and of the growth rate in the country, the effect of restrictive bilateral agreements is not limited to this country. Other, smaller countries may also experience growth rates smaller than in the baseline scenario because of restrictions on the entry of foreign carriers.

Figure 4.6. **Annual growth of the size of the air network, by origin region**

Historical data (2005-15) and baseline scenario (2015-30), %



Source: FlightGlobal for 2005-15, ITF projections.

StatLink http://dx.doi.org/10.1787/888933442681

CO_2 emissions from international aviation

Currently, international passenger aviation is responsible for around 1.5% of man-made CO_2 emissions, at approximately 450 million tonnes (Mt) in 2015. With the predicted doubling of the number of airline passengers by 2030, new measures will be required to mitigate and offset CO_2 emissions from aviation and limit its impact on climate change.

Because emissions from aviation are not confined to the borders of one country, they are difficult to allocate and for this reason are not part of the Paris Agreement. Instead, the International Civil Aviation Organization (ICAO) has been working with its member countries to define a set of measures to limit climate change impacts. These measures range from operational efficiency improvements to the introduction of a global market-based measure (MBM), adopted at the 39th ICAO Assembly in October 2016. These measures aim to limit emissions from international aviation to their 2020 levels (carbon-neutral growth).

Under the proposed Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), countries can enter voluntarily from 2021. However, in 2027, the MBM will become compulsory for all countries, barring some exemptions, for instance the least developed or landlocked developing countries. Emissions above the baseline level for routes covered by the agreement (the average of emissions for 2019 and 2020) will have to be offset by aircraft operators of participating states. All routes having both their origins and destinations within participating countries will be covered. On top of the CORSIA agreement, ICAO also set up the first CO_2 efficiency standards for new aircrafts, driving improvements in the manufacturing side, even if the price of fuel does not pick up and fuel efficiency stops being among the priorities of airlines. Airports are also encouraged to curb their emissions, and work with airlines to limit the impact of aircraft operations in their surroundings (see Box 4.3).

Box 4.3. **Airport Carbon Accreditation Programme**

Airport Carbon Accreditation (ACA, see *www.airportco2.org*) is a carbon management programme designed specifically for the airport industry, while relying on international cross-industry standards such as the Greenhouse Gas Protocol. It establishes both a technical guidance for carbon management and a framework for public recognition of airports' achievements, according to four ascending levels of certification. Launched in 2009 by Airports Council International (ACI) EUROPE, it has expanded to all world regions since, with 170 airports now engaged in the programme. Those airports welcome one third of global air passenger traffic every year.

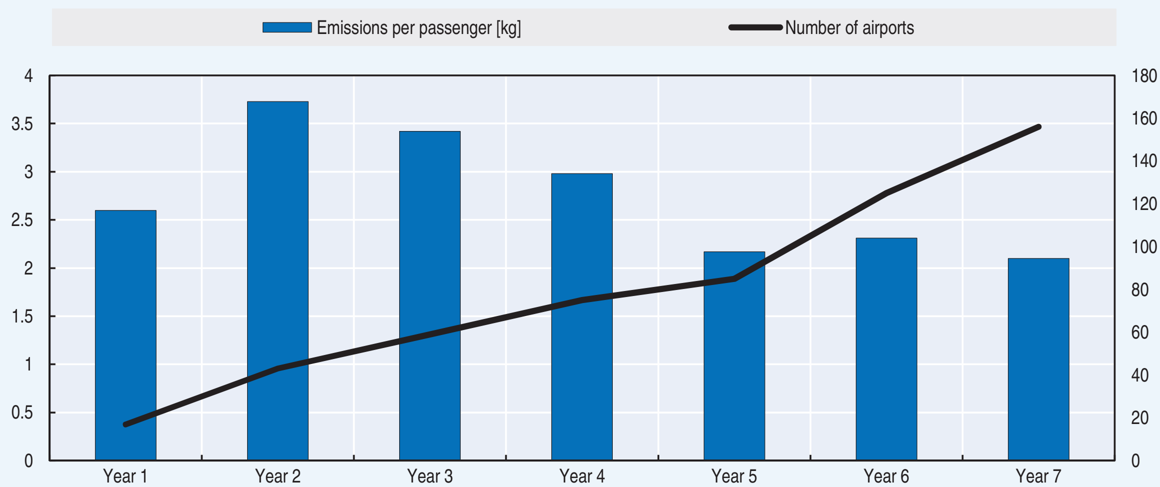
Airport Carbon Accreditation is managed jointly by ACI EUROPE and the other ACI regional offices and supervised by an independent Advisory Board, but the administration is carried by independent environment experts at WSP Parsons Brinckerhoff.

Across the four accreditation levels, airports have to comply with increasing obligations. The first two levels cover the emissions under an airport operator's direct control. In addition to this requirement, the third and fourth levels also require the airport to map emissions from third party stakeholders operating at the airport and to encourage them to manage and reduce their emissions too; this concerns notably airlines, ground handlers and retailers. The ultimate certification level – carbon neutrality – can be achieved if an airport offsets those CO_2 emissions stemming from sources under the airport operator's direct control. A key feature of the programme is that airports first have to reduce their own emissions as far as possible, with offsetting applying only to unavoidable, residual emissions. As of October 2016, 26 airports worldwide are certified as carbon neutral.

In the seventh programme year (May 2015-May 2016), the then 156 accredited airports have demonstrated a reduction of 206 090 tonnes CO_2 against their average emissions of the three previous years. Most importantly, a decrease of CO_2 emissions per passenger has been observed since the second programme year and this in spite of the growth in the number of certified airports, showing an increasing efficiency of operations of the accredited airports.

Box 4.3. **Airport Carbon Accreditation Programme** *(cont.)*

Figure 4.7. **CO_2 emissions from airports participating in the Airport Carbon Accreditation program**



Source: ACI (2016) Airport Carbon Accreditation Annual Report 2015-16, *www.airportcarbonaccredited.org/component/downloads/downloads/103.html*.

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Quantifying CO_2 emissions from aviation

Several sources corroborate that global aviation (excluding military aviation) emitted around 790 Mt of CO_2 in 2015 (ATAG, 2016; IEA, 2016), of which domestic civil aviation represents about 40%. To the best of our understanding, this figure does not include general aviation.

For this *Outlook*, the carbon footprint from scheduled airlines is obtained by mapping emission efficiency figures for various typical aircraft (EEA, 2014) with the aircraft type recorded in the global flight network database. No dedicated model tackles the emissions associated with belly freight, which is grouped with passenger transport.

For charter airlines, an estimation made by Southgate (2012) is adopted. In the absence of any information regarding the evolution of the global charter market, it is estimated that charter traffic, and its emissions, are constant, as is the case in Europe (EEA, 2016). It is also assumed that all charter planes are international. The emissions of dedicated freighters result from the difference between global emissions and emissions from passenger airlines. The figure obtained, 41 Mt, is close to the estimate obtained by Southgate in the abovementioned paper.

Table 4.2 below summarises the assumptions in this *Outlook* regarding the decomposition of emissions from the aviation sector.

Emission levels for future years in the baseline scenario are derived by applying an annual efficiency gain of 1.5% per passenger-kilometre to the current emission rates for passengers. This corresponds to the 1.5% goal of the industry (ATAG, 2016). It is, however, lower than the global average efficiency improvement between 2004 and 2013, which stands at 2.5% for tonne-kilometres (passenger and freight) and 3.7% for passenger-

Table 4.2. **Breakdown of CO_2 emissions from aviation**

Sector	Emissions (Mt)	% of total emissions
Domestic	300	38
Scheduled passenger	293	37
Dedicated freighters	7	1
International	490	62
Scheduled passenger	418	53
Charters	38	5
Dedicated freighters	34	4

kilometres. The lower figure of 1.5% is preferred in a baseline scenario because most of the efficiency gains from the past decade correspond to a single year, 2010, the other years seeing efficiency gains closer to 1.5%. Moreover, as passenger demand grows more quickly than freight, the share of belly freight in the total tonne-kilometres decreases, which mechanically decreases the efficiency gains for passengers.

Emissions are also computed in a low-carbon scenario, where the yearly efficiency gain is 2%, corresponding to the resolution of ICAO member States in 2013 (ICAO, 2013). In this scenario, we assume that the penetration of biofuel in 2050 is 50%. This percentage is slightly higher than the 40% indicated as a target in the European Union White Paper for transport (European Commission, 2011) and indicates a strong commitment to the use of sustainable low-carbon fuels in aviation.

In all scenarios, emissions from charter airlines are assumed to remain constant. Emissions from dedicated freighters grow according to the demand volumes estimated in Chapter 3, adjusted by the same 1.5% or 2% efficiency improvement per tonne-kilometre per year.

CO_2 emissions from passenger international aviation up to 2030

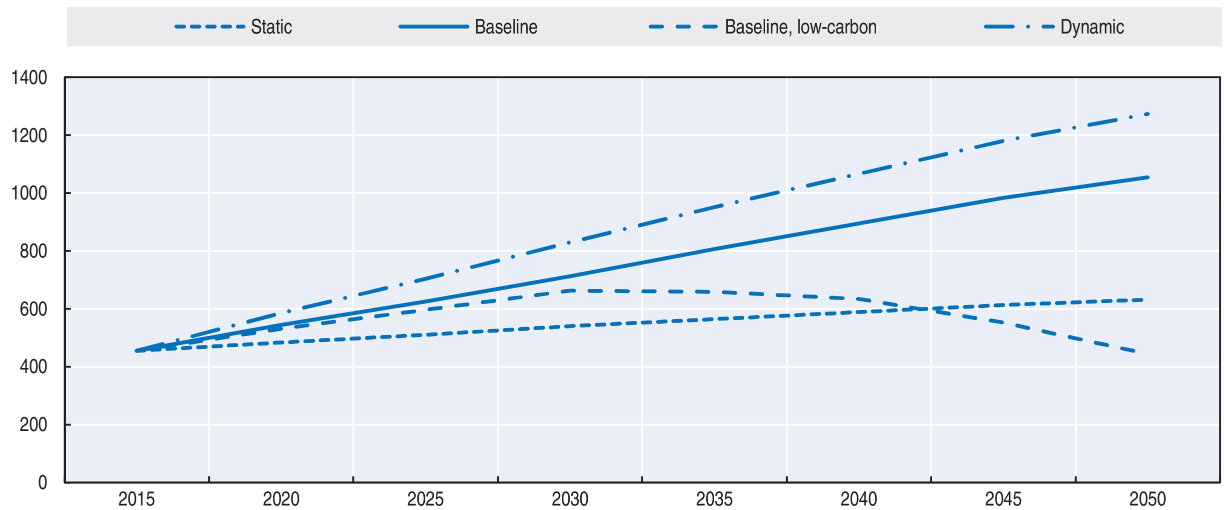
In the baseline scenario, emissions from international aviation go up 56% by 2030, to 710 Mt (Figure 4.8), excluding dedicated freighters. Mirroring the evolution of passenger demand, the growth in emissions is concentrated in developing countries. In 2030, the Asia-Pacific region will represent around 35% of global CO_2 emissions from international scheduled flights, up from 27% in 2015. Higher efficiency gains allow savings of 50 Mt annually, as shown by the low-carbon scenario.

While emissions in the static scenario are almost constant due to the efficiency gains being close to the rate of increase in demand, the additional passenger-kilometres in the dynamic scenario result in the addition of 110 Mt of emissions compared to the baseline scenario. However, it is likely that the efficiency gains would be higher if the dynamic scenario materialises, as it will necessitate the quicker introduction of new airplanes.

Achieving carbon-neutral growth for passenger international aviation from 2020 in the baseline scenario will require 1 000 Mt of cumulated carbon offsets during the decade between 2020 and 2030. In the year 2030 alone, the offsets required reache 200 Mt, or 220 Mt when including dedicated freighters. This is lower than suggested by work undertaken by the ICAO Committee on Aviation Environmental Protection (ICAO/CAEP, 2016), which gives figures between 288 and 376 Mt for the number of offsets required in 2030. There are two main underlying reasons. First, the average growth rate of the ITF scenario (4.7%) is lower than that of the study (around 5%). In the dynamic network scenario, the overall requirement for offsets to achieve carbon-neutral growth would be around 1 400 Mt of CO_2 with 270 Mt for the year 2030 alone. The second reason for the low offset requirement lies

Figure 4.8. **CO_2 emissions from international aviation**

Million tonnes of CO_2 per year, before offsets



StatLink http://dx.doi.org/10.1787/888933442706

in the non-linearity of the growth in demand. In the projections, it slowly decreases, at 5.6% in 2015 reducing further to 4.3% in 2030. It is also worth noting that the amount of offsets is very much dependent on the efficiency improvements. If they reach 2% annually, as in the low-carbon scenario, offsetting requirements for the whole decade drop to 800 Mt and only amount to 110 Mt for the year 2030.

At present, offset projects with the highest level of certification are those under the United Nations Framework Convention on Climate Change's (UNFCCC) Clean Development Mechanism (CDM). Projects registered in the CDM in 2014 only amounted to 100 Mt of Certified Emissions Units. However, an analysis of credits from planned CDM projects shows that it could cover up to 8 years of the offsets required to achieve carbon-neutral growth, under assumptions where emissions grow (Cames, 2015). Moreover, the peak observed in new offsetting project registrations in 2012, when the European CO_2 Emissions Trading Scheme was introduced, indicates that the supply in offsets shows strong responsiveness to demand surges. To ensure that the required supply of high-quality offsets materialises, mitigation efforts will need to be estimated and publicised well in advance.

The ITF projections assume that demand is unaffected by the cost of CO_2 mitigation. Available studies find that suppression is likely to be very small. Indeed, IATA estimates that the cost of offsetting emissions in 2025 will be lower than the impact of a USD 10 per barrel increase in the price of oil (IATA, 2016). The cost would be even lower in our case, as the number of offsets required is smaller than in the previously mentioned document. However, a very high price for carbon offsets might alter the picture as in competitive markets the cost will be passed on to passengers. This may arise if many sectors fall back on carbon offsetting, or if the number of regions implementing an Emissions Trading Scheme for other sectors increases.

Long-term prospects

In the longer term, the industry aims to bring aviation's CO_2 emissions down to half of their 2005 level by 2050. It foresees that the use of advanced biofuels will dramatically reduce CO_2 emissions from aviation. Biofuels might deliver significant emissions reduction after 2030 but they need to become cheaper and their production more efficient. There is a lot of uncertainty regarding the speed at which sufficient quantities of suitable biofuels can be phased in. There may also be competition from other modes, in particular from the freight sector (see also the section on emissions in Chapter 3).

Assuming biofuels have the same energy content as conventional fossil fuels, biofuels will need to represent around 80% of aviation fuels by 2050 and this share will only suffice if net CO_2 emissions of aviation biofuels are zero. Deane et al (2015) found a similar figure for Europe (77%), to reach the same target. If the carbon savings compared to conventional jet fuel were only 70% (a typical figure for current aviation biofuels) the industry target will require that biofuels power all international flights.

There are very large uncertainties around the potential for the development of commercially viable biofuels. An 80% share for biofuels in aviation is ambitious, considering its current marginal relevance and the planning assumptions of some government bodies. The previously mentioned article (Deane et al., 2015) estimates that the production of biofuels will have to triple in ten years between 2040 and 2050 to reach such numbers. Advanced second-generation aviation biofuels are produced from algae or non-food parts of crops, so do not compete with food production or necessitate the destruction of carbon sinks such as forests. However, this makes the production process significantly more complex and such biofuels cost up to twice as much as conventional kerosene. Cost is currently the biggest barrier to the broad introduction of biofuels in aviation. In the current context of low oil prices, airlines have little or no economic incentive to invest in alternative fuel technologies.

Accessibility by air

Aviation brings many benefits to the countries it serves and is not easily replaced with another, less polluting mode, especially for international flights. For businesses operating across borders there is often no real alternative to aviation as a mode of transport. It generates economic activity, through airlines, aircraft manufacturers and airports. A recent report (ATAG, 2016) estimates that the air transport industry generates around 10 million jobs. The same report estimates the GDP attributable to the aviation sector at 1 425 billion USD, or 2% of world GDP in 2015.

The aviation industry is also a key enabler of trade and of many other industries, the first of which is tourism. In 2015, more than half of international tourists arrived by air (UNWTO, 2015). This is especially important for developing countries, which are generally quite far from the countries where their tourists originate. Other research (Oxford Economic Forecasting, 2006) has suggested that air connectivity, by providing access to large markets and improving the links between businesses, can boost productivity. Air connectivity can also influence the choice of location for foreign direct investments or help attract the most talented individuals (Oxford Economic Forecasting, 2006).

If most of the studies above relate to developed economies, there seems to be a positive relationship between air connectivity and productivity for all countries (IATA, 2007). This relationship is even stronger for low-income countries. Considering the economic importance of aviation, there has been a general effort to define an indicator which best reflects the role of air travel in the economy.

Global indicator of accessibility by air

While air connectivity is the general term in usage, many indicators refer to accessibility by air. Within the general category of connectivity indicators, there is indeed a clear distinction between centrality indicators and accessibility indicators (Burghouwt and Redondi, 2013). The former, which describe the integration of an airport in the global air network, rely on topological indicators and can be of theoretical importance and help analyse the behaviour of transfer passengers. However, it is with the latter that one can measure the attractiveness of an airport, or the cities attached to it. Accessibility indicators measure how easily the world can be reached from an airport, for instance through the number of destinations accessible in less than a given number of hours, or the number of direct connections. They answer the question: How accessible are world markets from a given airport or country?

Because the wider economic impacts of aviation come from the links they provide to businesses, enabling them to access larger markets and to connect to other businesses, accessibility indicators provide a better insight into the potential role which aviation has on the economy. In addition, because the economic activity which aviation facilitates is more likely to be situated in urban centres than in rural areas or right next to airports, this *Outlook* proposes computing an accessibility indicator which measures how *cities* are connected to the air network, and not airports.

The accessibility indicator in this *Outlook* measures the travel time from the centre of urban agglomerations to a basket of cities around the world, the alpha-cities, as defined by the Globalization and World Cities Research Network (GaWCR, 2014). These cities are representative of the current main global economic centres of activity. The travel time is computed from the centre of urban agglomerations and includes both the time to access airports, measured on the road network, and the time in the air, including layovers when necessary (see also the methodological Annex 4.2).

The proposed indicator answers the need for a simple measure, expressed in a real-world unit (hours). It enables comparisons between cities of different regions of the world. For this *Outlook*, the indicator is derived for all cities above 300 000 inhabitants, the same sample of cities which is used in Chapter 5, in the section on urban mobility.

The methodology is flexible and can be adapted to different regional contexts, but these 61 alpha-cities, scattered over the five continents, are useful as destinations for having a globally coherent measure (see the map in Figure 4.A2 in Annex).

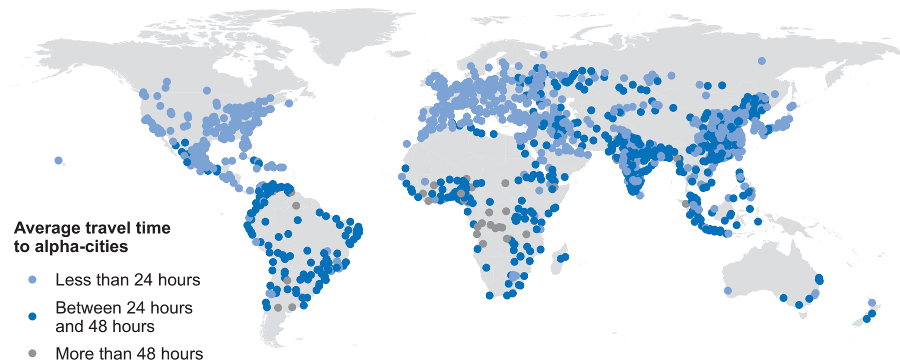
Air accessibility today

In 2015, the average time to reach an alpha-city ranged from 12 to 72 hours and, on average over all the urban agglomerations above 300 000 inhabitants, 32 alpha-cities were accessible in less than a day.

As expected from the geographical distribution of alpha-cities, developed countries concentrate most of the cities which have the best access to the main global economic centres (Figure 4.9). However, geography does not explain everything. The size of the accessibility gap between the most connected cities, which are mostly situated in developed countries, and the least connected ones in Africa can be explained by a combination of three factors.

The first factor is the time spent on the roads to access an airport with relevant services. It is much greater in developing economies than in developed ones due to the scarcity of airports, especially international airports, and to the lower quality of the road network. In 2015, the airport-access factor explained 40-50% of the difference in accessibility between developing countries and Europe. The second factor, accounting for around 35% of the same difference, is the lower quality of the air network serving the developing regions. Because airports in these regions have few direct connections, travellers need to make large detours

Figure 4.9. **Average travel time to the alpha-cities**



to reach their destinations. Waiting times at connections also tend to be longer due to the lower frequency of flights. Finally, geography, or the additional distance which people need to travel to reach the alpha-cities, explains the remaining 20-30%.

Accessibility by air has improved in all regions since 2015 (Figure 4.10). On average, the improvement between 2005 and 2015 was of two hours, 50% of which results from a decrease in the time to access airports.

In all developing regions, a large increase in the number of flights linking regional airports to international hubs explains most of the progress. The extension of the global network of airlines or airline alliances has greatly benefited accessibility worldwide. As an illustration, consider the number of airports in the world having at least one direct connection to one of the top 100 international airports (in terms of seat capacity). This number grew by almost 20%, from 1 795 airports in 2005 to 2 085 in 2015. This change impacts accessibility through two mechanisms. First, it shortens the access time because it improves the geographical coverage of airports offering good connections to the air network. And second, it decreases the flight time from these airports, while also reducing the need for two-transfer routes.

Some other effects are more region-specific:

- In Europe, the development of low-cost carriers has drastically reduced the need for connecting flights in the region, which concentrate many alpha-cities.
- The Middle-East is the only region where the decrease in flight time and access time are of similar scale. The massive network development of Gulf carriers explains this trend.
- In China, many airports are starting to see the operation of frequent, direct flights to several large Asian hubs, where previously the norm was to link to just one Chinese hub.

Outlook for accessibility by air

As accessibility by air has greatly increased in the past decade, it is expected that this trend will continue in the future if the air network keeps expanding. Figure 4.11 presents the outcomes in terms of accessibility of the three network evolution scenarios. While it is constant in the static network scenario, accessibility increases to similar levels in 2030 in the two other scenarios. The dynamic scenario brings most additional accessibility quickly, before 2020, but the improvements level off after that date. In the baseline scenario, the improvements are more linear and follow the historical trend.

Figure 4.10. **Average travel time to the alpha-cities by region, 2004-15**

Access and flight times, hours

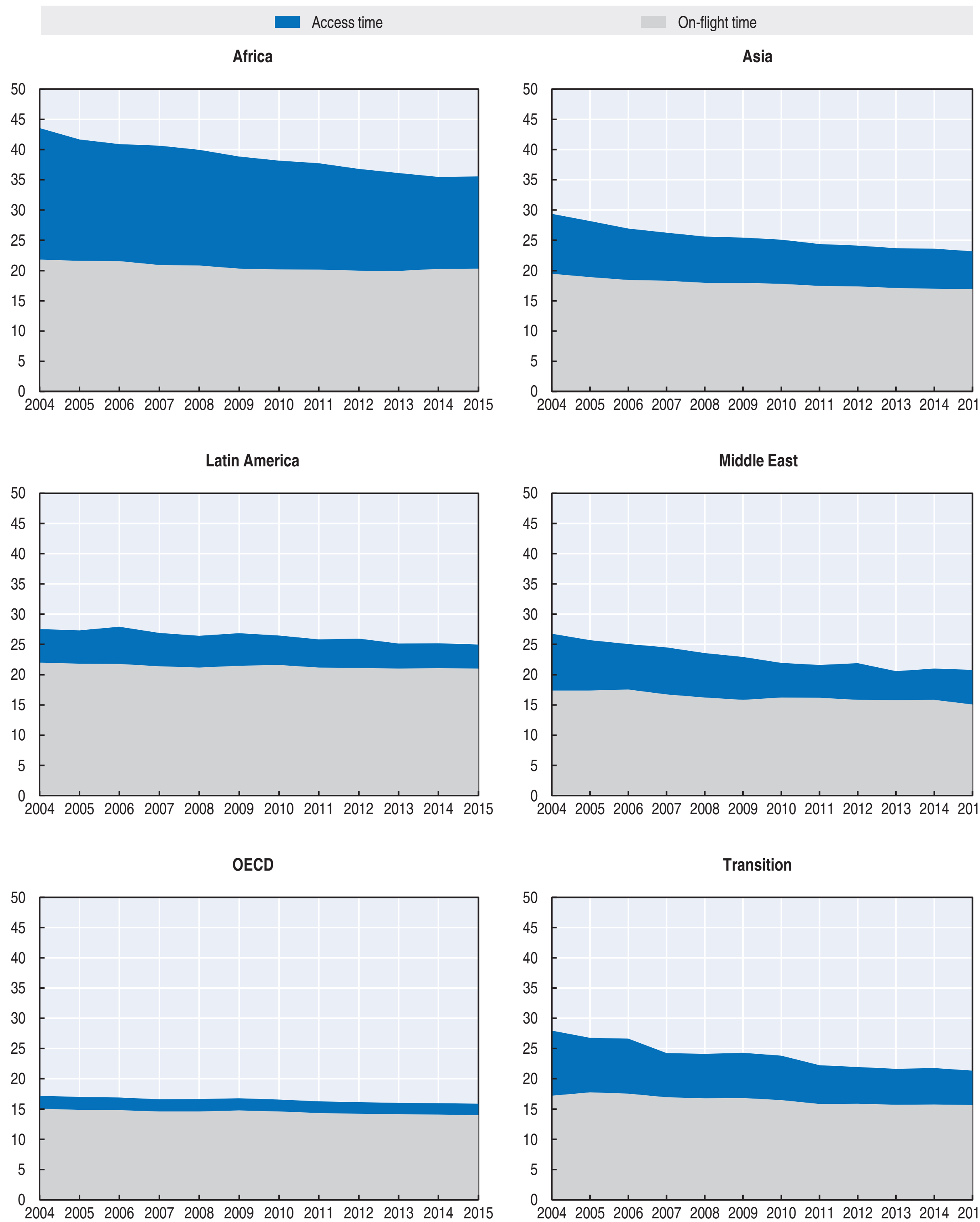


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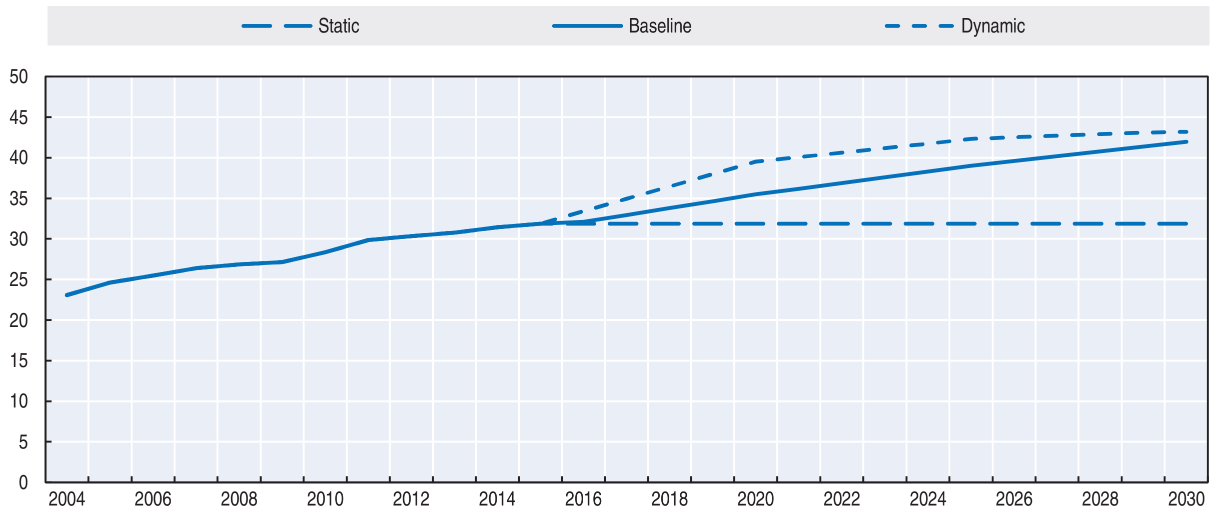
Figure 4.11. **Average number of alpha-cities reachable in less than 24 hours**



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The levelling-off in the dynamic scenario partly stems from the definition of the accessibility indicator. Because the indicator is the average of travel time to a limited set of cities, it admits a lower bound defined by the technological constraints of aircrafts. While all cities cannot have a direct flight to all alpha-cities by 2030, having access to two or three large hubs enables quick travel to all regions of the world. From 2 085 in 2015, the number of airports with a direct flight to at least one of the top 100 international airports grows to 2 413 in 2030 in the baseline scenario.

Improvements in accessibility can be directly traced back to efforts to liberalise aviation, both in historical developments and in the outlook. They result from the combination of the arrival of low-cost carriers, which significantly improve regional connectivity, and from the possibilities offered by less restrictive air service agreements. The latter enables the development of large international hubs, which have been and will be instrumental in the development of accessibility on a global scale.

Accessibility by air, as measured in this *Outlook,* does not evolve much after reaching a lower threshold. The expected saturation in the network development plays a role in the levelling off of the improvement of accessibility but it is mainly explained by the way the accessibility indicator is defined in this *Outlook*. Indeed, the number of destinations entering the indicator is small and does not evolve over time. The inclusion of additional cities, especially Asian cities as they gain global significance, would alter the result. Looking at regional accessibility, where all cities need to be connected to each other, would also give a different result.

References

Airbus (2016), *Flying by Numbers, Global Market Forecast 2015-34*.

ATAG (2016), *Aviation benefits beyond borders*, Air Transport Action Group.

Benezech, V., L.M. Martinez and J. Kauppila (2016), "Assessing the long-term impact of air liberalization on international passenger demand: A new model up to 2050", Presented at the 95th *Annual meeting of the Transportation Research Board*.

Boeing (2016), *Current market Outlook 2016-35*.

Burghouwt, G. and R. Redondi (2013), "Connectivity in air transport networks: an assessment of models and applications", *Journal of Transport Economic and Policy*, Vol. 47, pp. 35-53.

Burghouwt, G., P. Mendes De Leon and J. De Wit (2015), "EU Transport Liberalisation Process, Impacts and Future Considerations", *International Transport Forum Discussion Papers*, No. 2015/04, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5jrw13t57flq-en*.

China and India (2005), *Memorandum of Understanding on Civil Aviation between India and China*.

Cames, M. (2015), "Availability of offsets for a global market-based mechanism for international aviation", *Oko-Instititut briefing paper*.

Deane, P., R.O Shea and B.O Gallachoir (2015), "Biofuels for aviation", *Rapid Response Energy Brief*, INSIGHT_E.

De Wit, J., J. Veldhuis, G. Burghouwt and H. Matsumoto (2009), "Competitive position of primary airports in the Asia-Pacific rim", *Pacific Economic Review*, Vol. 14/5, pp. 639-650.

EEA (2014), *EMEP/EEA air pollutant emission inventory guidebook 2013, update July 2014 – Civil and military aviation*, European Environmental Agency.

European Commission (2011), *EU White Paper, Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*.

European Parliament (2015), *Emission Reduction Targets for International Aviation and Shipping*, Study for the ENVI Committee.

Fu, X., T.H. Oum and A. Zhang (2010), "Air Transport Liberalization and Its Impacts on Airline Competition and Air Passenger Traffic", *Transportation Journal*, Vol. 49/4, pp. 24-41.

Gallet, A.G. and H. Doucouliagos (2014), "The income elasticity of air travel: A meta-analysis", *Annals of Tourism Research*, Vol. 49, pp. 141-155.

GaWC (2014), *The World According to GaWC 2012*, list of cities accessible on the web at *www.lboro.ac.uk/gawc/world2012t.html*.

Hansman et al. (2014), *The Impact of Oil Prices on the Air Transportation Industry*, Report of the National Center of Excellence for Aviation Operations Research.

ICAO (2013), "Consolidated statement of continuing ICAO policies and practices related to environmental protection – Climate change", *ICAO resolution* No. A37-19.

ICAO/CAEP (2016), *Results of Technical Analyses by CAEP, presented at the ICAO Environment Advisory Group Meeting (EAG/15)*, January 2016.

ICAO (2016), *ICAO Long-Term Traffic Forecasts, Passenger and Cargo*, ICAO, July 2016.

IATA (2007), "Aviation Economic Benefits", *IATA Economics Briefing* No. 8.

IATA (2008), "Air Travel Demand", *IATA Economics Briefing* No. 9.

IATA (2016), *Comments on the cost-impact of the proposed global market-based measure (GMBM), submitted to the High-level meeting on a global market-based measure scheme*, ICAO Working paper.

IEA (2016), *IEA CO_2 Emissions from Fuel Combustion Statistics*, Database, *http://dx.doi.org/10.1787/co2-data-en*.

ITF (2014), "Air Service Agreement Liberalisation and Airline Alliances", *International Transport Forum Policy Papers*, No. 4, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5jlwvzf1vg41-en*.

Lieshout, R. and H. Matsumoto (2012), "New international services and the competitiveness of Tokyo International Airport", *Journal of Transport Geography*, Vol. 22, pp. 53-64.

Southgate, D. (2013), *Aviation Carbon Footprint: Global Scheduled International Passenger Flights – 2012*, published by the author.

Oxford Economic Forecasting (2006), *The Economic Contribution of the Aviation Industry to the UK*.

Oxford Economics and York Aviation (2013), *The Economic Value of International Connectivity*, report prepared for Transport for London.

UK CAA (2006), *UK-India Air Services: A Case Study in Liberalisation*.

UNWTO (2015), *Tourism highlights*.

Veldhuis, J. (1997), "The competitive position of airline networks", *Journal of Air Transport Management,* Vol. 3/4, pp. 181-188.

ANNEX 4.A

Modelling framework for international aviation (passenger)

Passenger demand projections: modelling framework

The international air passenger model projects international passenger volumes up to 2050 based on alternative network evolution scenarios. The model is structure around three main components: a gravitational model for the estimation of origin-destination demand; route choice model; and a network evolution model. An additional module assesses CO_2 emissions. Figure 4.A1 describes the functioning of the model.

The gravitational model estimates origin-destination passenger demand by looking at the different drivers of air travel. It expresses passenger demand between two regions as a function of socio-economic variables, such as GDP, population or trade, cultural relationships (language sharing, emigration volumes…) and the generalized cost of travelling between the two regions. The generalized cost of travel is itself a function of minimum travel time, minimum number of transfer and competition levels, which act as a proxy for fares.

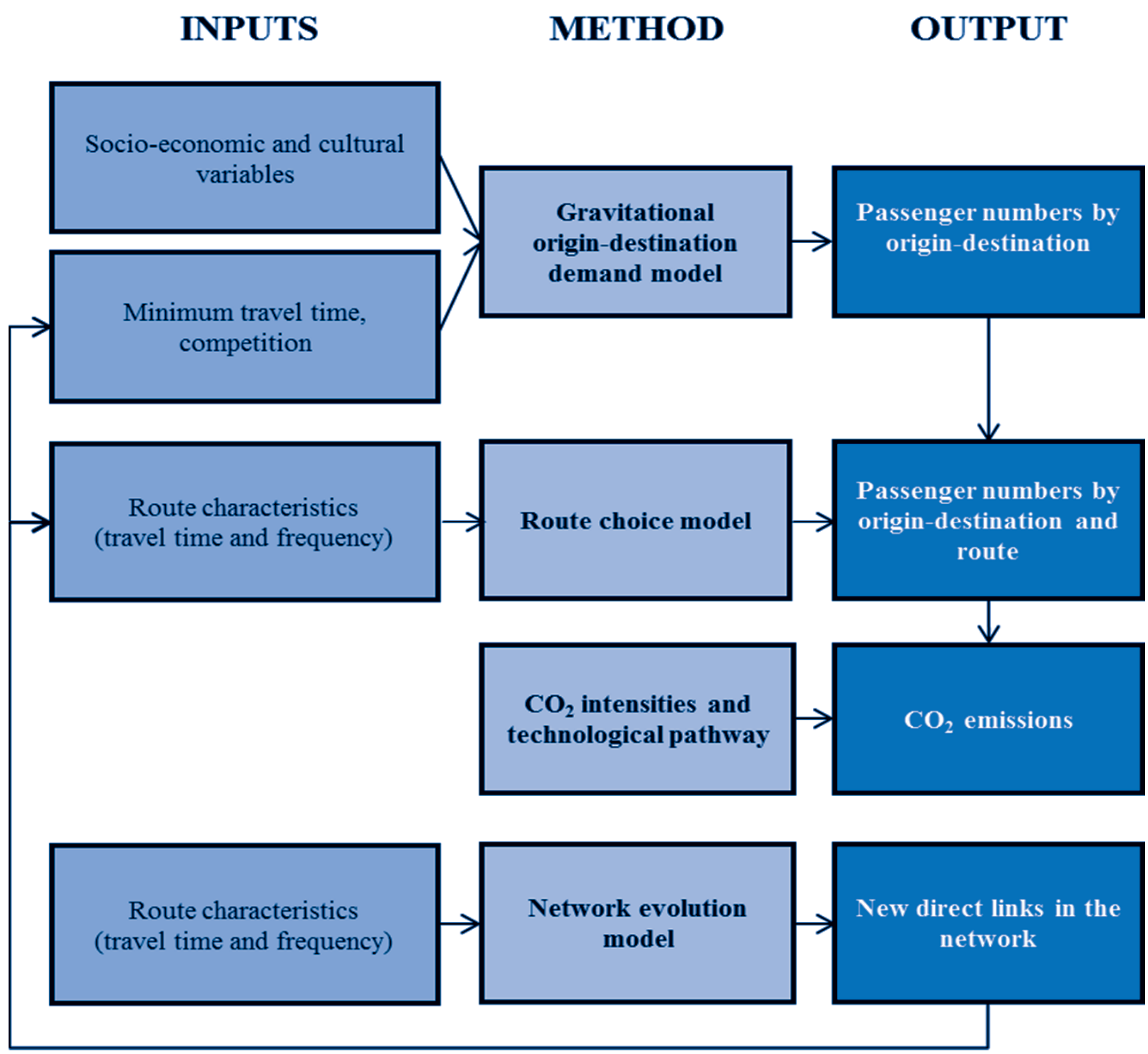
The route choice model assigns this demand onto the network by analysing the different possible routes between each origin and destination. It consists of two steps. First, origin-destination passenger numbers are divided between direct and indirect passengers, according to a logit model looking at the quality of service of the different types of routes: travel time, frequency, competition levels and so on. This gives passenger numbers for each origin-destination pair and each possible number of transfers (0, 1 or 2), which are then divided between all the possible paths using another logit model. This time, only travel time and frequency enter the model.

The network expansion model relates the probability of a presence of a direct link between two regions to the economic strengths of the regions and the existing competition environment. It is a binomial model with the presence/absence of a direct link as dependent variable and GDP, competition levels and distance as explanatory variables. The network expansion model is combined with several assumptions related to competition, evolution of the low-cost carrier.

CO_2 emissions

CO_2 emissions from scheduled airlines are computed using a bottom-up approach, by mapping scheduled traffic in 2015 with typical aircrafts as categorised in the database of the European Environment Agency. The database contains the average fuel-burn for each aircraft type and by distance band, which can be transformed into CO_2 emissions.

Figure 4.A1. **Schematic description of the ITF international aviation model**



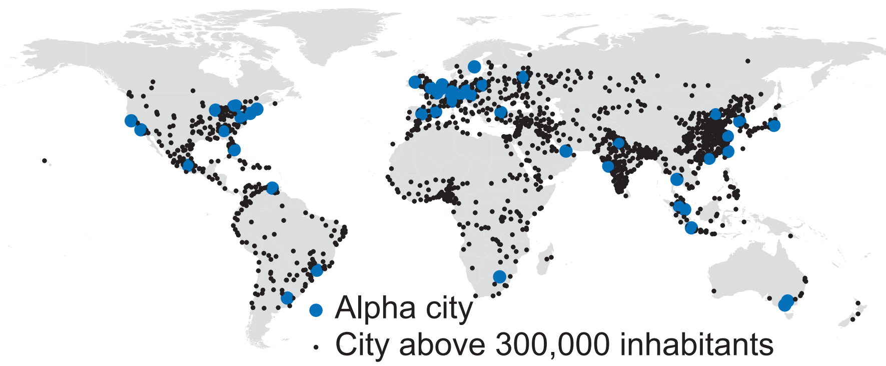
The quality of the computation is then checked using by comparing the results of the bottom-up estimation for some airlines which publish CO_2 forecasts. Small proportional adjustments correct the discrepancies when found.

Accessibility by air

The accessibility indicator in this *Outlook* consists in the average travel time to the 61 alpha-cities. Figure 4.A2 below shows the geographical distribution of the alpha-cities, as well as that of the cities above 300 000 inhabitants which form the origin points from which we measure accessibility.

The travel time between two cities is computed from the city-centre of the origin point. The travel time includes the time spent to access the airport which results in the shortest overall path. This path does not necessarily goes through the closest airport to the origin city, as airports further away may offer better services (either quicker or with better frequency). When computing this travel time, only routes having more than a 300 yearly frequency are considered.

Figure 4.A2. **Geographical distribution of cities and alpha-cities**



Travel time only gives a partial view of the accessibility issue. The ease of travel between two places incorporates many other elements, such as the frequency of flights or the fares. Depending on the region, the market segment (business vs. leisure) or the distance, these components differ in their role in a person's decision to take a trip. The standard modelling approach groups them together in the generalised cost of travel, which is a weighted sum of all the costs that passengers incur while travelling, the weights corresponding to passengers' preferences. While this approach is interesting from a theoretical point of view and provides information when computing the economic consumer's surplus linked to accessibility, it makes the interpretation of the results difficult.

Table 4.A1. **Data sources**

Name	Description	Source
Air network		
	Full network of scheduled airlines, with routes up to two stops reconstructed from the list of direct flights. Data also include carriers and differentiate between full-service and low-cost carriers.	Flight Innovata SRS Analyzer
Demand		
	On-flight passenger numbers for 2010, by city-pair	ICAO Form B and C, completed with schedule data (by ICAO)
	Origin-destination passenger numbers, 2015	Various open sources
	Route choice for a large sample of city-pairs for 12 months between 2014 and 2015. For each city-pair, all routes used during the period are recorded, along with the number of passengers.	OAG, provided by ICAO
Airline fares		
	Dataset of requests made on the website during 12 months between 2014 and 2015. Requests were made by users of the website for a sample of 10 000 origin-destination pairs, for various departure and advance-purchase dates. Requests correspond to price inquiries by customers but do not necessarily lead to a ticket purchase.	Skyscanner
Socio-economic variables		
	Total population, urban population by country, cities with population above 300K	UN Habitat, WUP2014
	GDP, GDP per capita projection by country	OECD Economics department
	Cultural variables (language	World Trade Organisation
	Emigration origin-destination matrix at the country level, 2010 and 2015	UN Department of Economic and Social Affairs, Population Division: migration datasets
Emission data		
	Fuel burn by aircraft type and distance	European Environmental Agency
	Airline emissions, to check the results obtained by the bottom-up approach	Various airline websites and CSR reports
Road network		
	All major roads	OpenStreetMaps

PART II

Chapter 5

Mobility in cities

This chapter presents long-term scenarios on the development of passenger mobility in cities and the related emissions up to 2050. The results, based on the new model for mobility in cities of the International Transport Forum (ITF), comprise modal shares, mobility levels and emissions of both CO_2 and local pollutants. The first section looks at the development of the modelling framework and analyses the impacts of different transport, environment and technology substitution measures on mobility. The long-term implications of the three policy scenarios in terms of accessibility are then analysed, using a new methodology to compute accessibility in cities. The chapter concludes with a case study on certain cities in Asia, applying the same policy scenarios on a subset of cities from China, India and Southeast Asia.

By 2050, there will be 2.4 billion additional urban dwellers compared to 2015, when 4 billion persons lived in urban areas. This rapid urbanisation process will create substantial new demand for mobility in cities, making the provision of efficient, sustainable and equitable transport even more of a challenge. The combined effects of rapid urbanisation, income growth and rising private vehicle ownership will result in a surge in emissions, congestion and public health issues. Under a business-as-usual scenario where no additional policies are implemented, CO_2 emissions are projected to grow by more than 26% between 2015 and 2050. This creates pressure to pursue energy savings and vehicular emission reductions, especially in developing countries, where 94% of the new urban dwellers will live.

At the same time, the increasing rate of urbanisation and the growing size of cities mean urban transport systems are unable to deliver the benefits they are expected to. Cities face strong pressure to maintain and expand transport systems to ensure good access to opportunities for their population, while keeping negative externalities such as congestion and pollution to a minimum. At a time when private cars and two-wheelers still provide the quickest way to move around in most urban areas, policy makers are facing a difficult choice between short-term economic efficiency and the long-term liveability of their cities.

This chapter presents a global snapshot and the outlook for mobility, accessibility and emissions in cities. It introduces three policy scenarios, describing three different pathways for urban mobility, from a baseline scenario where private cars remain the dominant source of mobility in cities to a scenario where all policies, from land-use and transport planning to fiscal instruments, align to deliver a low-carbon future.

Modelling passenger transport demand in cities

Population, urbanisation and economic development are the key drivers of passenger mobility demand, particularly at an aggregated level and in the long run. Population and urbanisation trends indicate that the additional mobility demand will be concentrated in urban agglomerations of developing economies. According to UN projections (United Nations, 2014), by 2050, the world population will reach 9.55 billion, of which 66%, or 6.34 billion, will be urban. Urban areas will have to accommodate 2.4 billion additional inhabitants and 94% of them will be moving to cities in developing regions.

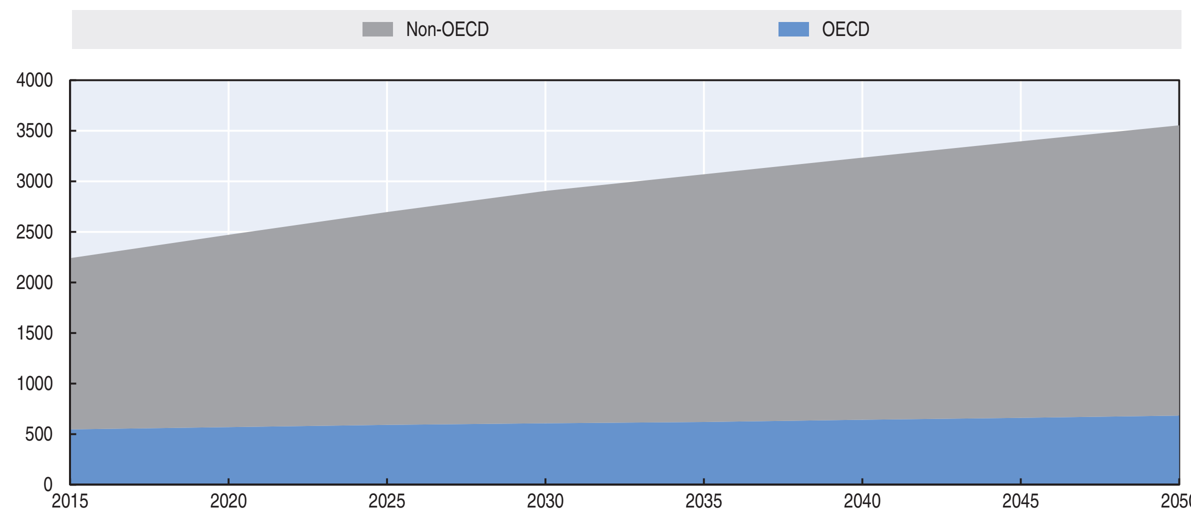
This *Outlook* considers all cities above 300 000 inhabitants in 2014, for which individual population projections are available (Figure 5.1). The total population of these cities amounts to 2.2 billion in 2015, making up 31% of the total world population and 57% of the world's urban population. This figure will reach 3.6 billion by 2050, representing more than 37% of the world population and remaining a stable share of 56% of the urban population. The share of population represented by these cities analysed in this chapter is stable across regions.

While amounting to less than a third of the world population, the total Gross Domestic Product (GDP) of all the cities in this study represents more than 50% of world GDP in 2015

(Figure 5.2). This share grows to 54% in 2030 and 56% in 2050. The GDP concentration in urban areas leads to urban populations reaching higher income levels sooner. For instance, in China, the GDP per capita of Beijing is more than three times the national level in 2015. Income will grow more slowly in cities than rural areas in most developing regions, as cities are starting from a higher base. By 2030, the national GDP per capita for China will be around 94% higher than in 2015, but the growth for Beijing will be around 73%.

Figure 5.1. **Total population of cities over 300 000 inhabitants**

Million inhabitants



Source: United Nations (2014), *World Urbanization Prospects: The 2014 Revision.*

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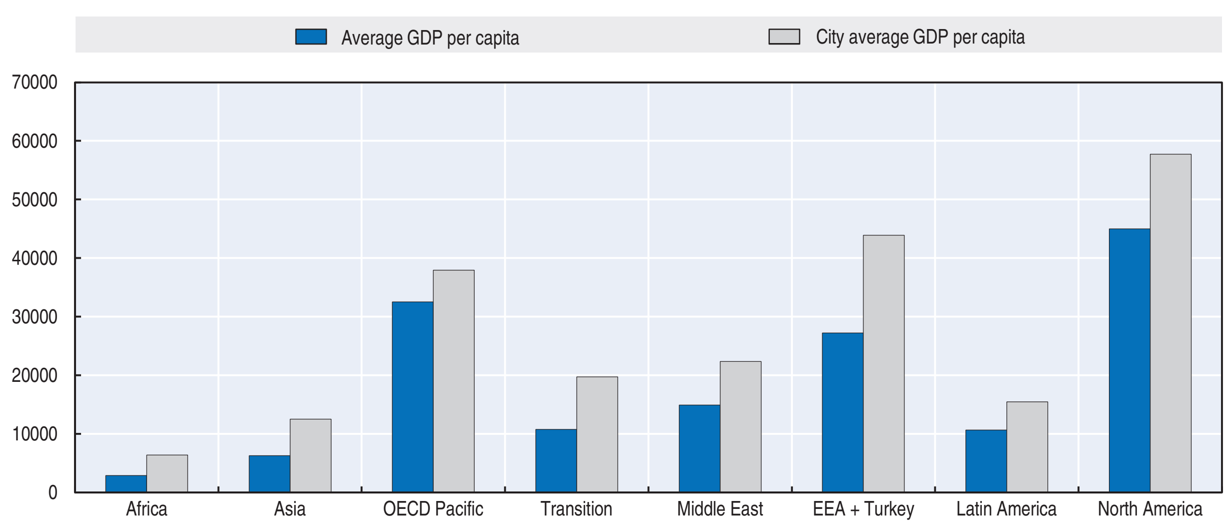
Figure 5.2. **GDP per capita in cities and countries by region**

2005 International USD



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Income growth generates transport demand and has, in particular, a positive impact on the ownership of passenger cars (see car ownership projections in Chapter 2). Income levels will grow highest in developing countries, especially in Asia. In Chinese and Indian cities, the average GDP per capita doubles between 2015 and 2030 and is projected to reach more than three times its 2015 level in 2050. Most changes in transport demand and mobility patterns are expected in these regions, which are the subject of a specific section at the end of this chapter.

Towards a global model for passenger transport demand in cities

Most urban passenger transport models apply at a local level. To explain travel behaviour for the population of a specific region or urban area, these models (e.g. Kitamura et al., 2000; Mandel et al., 1997) rely on highly disaggregated individual data and methods, which are unavailable at the global level. Passenger travel demand forecast in cities (e.g. Bowman and Ben-Akiva, 2001; Jovicic and Hansen, 2003; Vovsha et al., 2002) currently rely on detailed and interconnected modules requiring both large household travel surveys and ad hoc consumer preference surveys. These detailed models have the advantage of better capturing behavioural aspects but their findings are case specific with low transferability to other areas or regions.

Such methodologies are not replicable for a global level analysis. A commonly adopted approach for national or global level estimates of urban passenger travel demand, energy consumption and emissions would be to use vehicle stock to estimate total emissions by assuming average distance travelled per vehicle and fuel economy levels. This approach has been widely implemented in modelling different transport modes separately, especially in the private car sector (Daly and Ó Gallachóir, 2011; Meyer et al., 2012; Yan and Crookes, 2010). Comprehensive multi-modal analysis on a global scale is scarce. The Mobility Model (MoMo) developed by the IEA is one such model that estimates and projects the travel indicators, energy consumption, pollutant emissions and CO_2 emissions for all modes and regions of the world up to 2050 (IEA, 2015).

Being less complex and data-intensive, there are a number of caveats related to the validity of such long-term projections for transport demand. They do not take travel behaviour into account explicitly, as the projections are entirely based on vehicle stocks. A similar modelling approach has been implemented by other researchers for national and global regionalised projections (Cai and Xie, 2007; Meyer et al., 2007; Yan and Crookes, 2010). Some researchers have criticised these studies in that they extrapolate vehicle fleets based on growth rates independently for each transport mode, and are thus unable to account for the competition between transportation modes and potential mode shift (Schafer, 2012; Schafer and Victor, 1999).

Also working on a global scale are studies based on the concept of “travel time budget” and “time-money budget”, following an idea first expressed by Zahavi and Talvitie (1980). These studies (Meyer et al., 2012; Schafer, 1998; Schafer and Victor, 2000, 1999; Singh, 2006) work on the assumption that an average individual’s daily travel time and the share of travel expenditure in the individual’s overall budget are constant. As passenger kilometres travelled increase, due to income growth for example, travellers have to shift towards more flexible and faster transport modes to maintain their travel time budget constant. This can model the impact of pricing policies or of policies attempting to regulate vehicle use. However, it does not explore the use of non-motorised modes and only works at a very aggregate level. While travel expenditure appears to have some stability at the aggregate level, it gives widely different results at different times and locations (Mokhtarian and Chen, 2004).

The ITF model is a new tool developed to evaluate the impacts of transport, environment and technology substitution policies through projections of travel demand, CO_2 emissions and accessibility in cities up to 2050. Annex 5.B details the methodology of the model (see also Chen and Kauppila, 2017).

The model differs from existing models in two main areas. Firstly, it has a global perspective, extending the geographical reach of the 2015 edition of the ITF Transport Outlook. It considers each city above 300 000 inhabitants in 2014, and combines data from various sources to form one of the most extensive databases on mobility in cities (Box 5.1). It analyses five transport modes: private cars, public transport, motorcycles, walking and cycling. Secondly, it represents travel behaviour explicitly, modelling the aggregate behaviour for a segment of travellers as a function of the characteristics of the alternative modes and the socio-demographic attributes of the group (Koppelman and Bhat, 2006). The mode share module describes the interactions between the different modes, in a way that existing models, which analyse the evolution of each mode separately, are unable to do.

Box 5.1. **City Mobility database**

The database used for the modelling contains the 1 692 cities listed in the United Nations (2014) report, *World Urbanization Prospects: The 2014 Revision*. After merging cities belonging to the same urban agglomeration (for instance Pretoria and Johannesburg), 1 557 entries remain. The urban boundary for each selected city is provided by the Global Built-up Reference Layer (BUREF, 2010; Pesaresi and Carneiro Freire Sergio, 2014), complemented by the space-based land remote sensing data LANDSAT for the year 2010. Other GIS data sources, such as road and public transport supply, come from the intersection of this global urban boundary layer with the open-source OpenStreetMap layer.

The dataset contains the main socio-economic indicator for each city, such as GDP, population or area size. GDP at city level is estimated by redistributing the national GDP volume into the urban areas according to the GDP distribution map obtained from LANDSAT 2010, which provides GDP information for each cell of a grid with one square kilometre resolution. Future GDP in cities come from the application of an S-shaped curve to the growth of the national GDP projections, using the estimated relation between the concentration of population and the concentration of GDP shown by urban agglomerations in each country. When urban agglomerations are small, the elasticity between GDP and population concentration is low, which will then rise as population grows. Finally, when agglomerations become very large, the marginal benefit of increasing the concentration of population begins to decrease.

To enable the analysis of transport demand, demand related indicators are added for a large group of cities: transit fare, parking cost, average vehicle occupancy, mode share, average travel distance, trip rates, and so on. This information is collected through the analysis of multiple data sources, including individual city household surveys where available (see Table 5.A1.1 in Annex 5.A). The resulting dataset is an integrated cross-sectional dataset from multiple sources for the 1 557 urban agglomerations for the year 2010.

Transport policy scenarios

This *Outlook* assesses the impacts of combinations of policy measures with three alternative scenarios for future urban passenger transport: a baseline scenario, the Robust Governance scenario (ROG), and the Integrated Land Use and Transport Planning scenario

(LUT). The measures concern all areas of urban life and include land-use planning, public transport development, economic instruments and governmental regulations. Exogenous drivers, such as urbanisation, population and income growth, do not change between scenarios.

Baseline

In the baseline scenario, no additional measure aiming at influencing travel demand and reducing CO_2 emissions is implemented during the 2015-50 period. This scenario constitutes a business-as-usual reference for travel demand and CO_2 emissions in the urban transport sector against which to measure the efficiency of additional policies and compare alternative scenarios. It assumes that the future trends of car ownership, road supply, public transport supply, pricing structure and urban area growth will follow the trajectories of the past, as calibrated in each of the sub-models. For instance, public transport provision continues to grow with population and GDP per capita as observed in the historical data. For more details on these relationships, see Annex 5.B.

Advanced vehicle technology and alternative fuels penetrate the market at a relatively low rate, as in the latest 4°C Scenario (4DS) of the Mobility Model developed by the International Energy Agency (IEA). The 4°C Scenario (4DS) takes into account recent pledges by countries to limit emissions and improve energy efficiency, which help limit the long-term temperature increase to 4°C. In many respects the 4DS is already an ambitious scenario, requiring significant changes in policy and technologies. For example, this corresponds to a global average on-road fuel efficiency of passenger cars of 6.4 litres gasoline equivalent per 100 kilometres in 2050 compared to 10.3 litres gasoline equivalent per 100 kilometres in 2015.

ROG Scenario

The Robust Governance (ROG) scenario assumes that local governments play an active role and adopt pricing and regulatory policies to slow down the ownership and use of personal vehicles from 2020 onwards. Existing literature has proved the effectiveness of rigorous pricing strategies. For example, Meyer (1999) studied the effectiveness of various transportation demand management actions, and concludes that the actions which tend to increase the generalised cost of travel for personal vehicle use are most effective. A cross-country study by Greening (2004) indicates that fuel prices and strong government policies related to vehicle and fuel taxes play a significant role in shifting travel demand from private cars towards modes with lower carbon intensity. Studies on the demand for public transport show that playing on transit fares, parking pricing and car ownership is the most efficient way to encourage transit use (Litman, 2004; Paulley et al., 2006).

Following these findings, every city in the world implements pricing policies on fuel prices, fuel taxes, vehicle taxes and fees, parking fees, and transit fares in the ROG scenario. Each policy measure is specified as follows:

- The public transport pricing sub-model estimates the elasticity of the price of a single transit ticket with respect to GDP per capita for each country group. In this scenario, the price of a ticket grows according to the lowest regional elasticity.
- In 2030, fuel prices in each country correspond to a fictive oil price of USD 120 (real USD per barrel, 2005). Such prices can result from higher taxation, high oil prices, or a combination of both. The growth rates of oil prices between 2030 and 2050 are assumed to be the same as that in the baseline.

- Parking prices are 50% higher than in the baseline.
- Governments regulate car registration cost, purchase cost, operational cost, and so on at the national level, lowering overall car ownership levels, but without car restriction policies such as those implemented in some Chinese cities (see also the section on Asian cities). The elasticity of car ownership with respect to GDP per capita is lower than in the baseline.
- The size of urban areas and public transport provision (including mass transit) expands with the population and income as in the baseline.
- Road supply follows a need-based expansion strategy: more new roads are built to serve the new urban area. However, contrary to the baseline scenario, higher GDP growth levels do not trigger the expansion of the road network, which itself could lead to higher car ownership levels.
- Vehicle load factors, fuel efficiency standards and the market penetration of advanced vehicles and alternative fuels in this scenario reflect the assumptions made in the latest 2°C Scenario (2DS) of the Mobility Model developed by the International Energy Agency (IEA). The 2DS lays out an energy system deployment pathway and an emissions trajectory consistent with at least a 50% chance of limiting the average global temperature increase to 2°C. The world average on-road fuel efficiency of passenger cars becomes 4.4 litres gasoline equivalent per 100 kilometres in 2050, down from 6.4 litres in the baseline.

LUT Scenario

In addition to the policies introduced in the ROG scenario, the Integrated Land Use and Transport Planning (LUT) scenario assumes stronger prioritisation for sustainable urban transport development and a joint land-use policy. As land use and transport planning decisions interact, it is widely acknowledged that better co-ordination and integration are a prerequisite for sustainable development (Geerlings and Stead, 2003). In contrast to the ROG scenario, the LUT scenario anticipates higher supply of public transport, extensive deployment of mass transit and restrictions on urban sprawl in cities.

Better public transport options combined with more compact urban development are expected to directly contribute to increased public transport use and decreased trip distance. Many studies have found that the application of Transit-Oriented Development (TOD) has positive impacts on the sustainability of the cities. Cervero and Arrington (2008) surveyed several TOD cases in five United States metropolitan areas and found substantially lower trip rates by private cars for the dwellers in those areas. Wang et al. (2016) confirmed that concentrating population has the impact of raising the transit mode share, reducing car mode share, and decreasing the average trip distance.

TOD policies apply to neighbourhoods, so it is difficult to define such policies at city level. However, there is evidence that land-use factors, such as density, land use mix, transit access or parking restrictions, have cumulative and synergetic effects on travel behaviour (Litman, 2016; Litman and Burwell, 2006). While it matters which type of density is considered, it has been widely shown that densities are negatively correlated with per capita vehicle travel in cities. Research put forward by Newman and Kenworthy (2011) showed that the relationship between density and car travel is significant in 58 higher-income cities, with moderate increases in density leading to large reductions in vehicle travel. Proximity tends to reduce distances to destinations, and the necessity to use private cars (Banister, 2008). Chattopadhyay and Taylor (2012) found a 10% increase in a city's residential density, jobs per capita and public transit infrastructure, would lead to a 20% decrease in vehicle miles travelled per household in the urban areas in the United States. Higher densities also make the deployment of large-scale public transport systems more feasible, increase the share of public transport and encourage non-motorised travel (Holz-Rau et al., 2014).

The additional policies in the LUT scenario reflect this body of evidence and are represented in the model as follows:

- In all regions of the world, the expansion rate of public transport supply with population follows the path found in Europe, which is the highest of all.
- The thresholds in population density and GDP per capita needed for the development of a mass transit system is 20% lower than in the baseline scenario for every region.
- Urban area size remains constant from 2020 onwards. While the urban density is constant in the baseline, the 2015-50 growth in urban density in this scenario ranges from 20% to 83% depending on the region. The highest growth happens in Africa, where population growth is also highest.

Table 5.1. **Specification of the three policy scenarios for city passenger transport**

Variables	Baseline	Robust governance	Integrated land-use and transport planning
GDP	BAU	BAU	BAU
Population	BAU	BAU	BAU
Urbanisation	BAU	BAU	BAU
Car ownership	BAU	Low growth	Low growth
Road supply	BAU	Need-based expansion	Need-based expansion
PT stop supply	BAU	BAU	EU expansion pattern
Mass transit	BAU	BAU	Low thresholds of GDP per capita and population density
Fuel price	Current oil price + IEA-Momo-4DS	Current oil price + High taxation	Current oil price + High taxation
Parking price	BAU	50% higher in all countries	50% higher in all countries
PT ticket price	BAU	Low price elasticity to GDP per capita	Low price elasticity to GDP per capita
Urban sprawl	BAU	BAU	Constant urban area
Load factors	IEA-MoMo-4DS	IEA- MoMo-2DS	IEA-MoMo-2DS
Energy intensity	IEA- MoMo-4DS	IEA-MoMo-2DS	IEA-MoMo-2DS
Carbon intensity	IEA- MoMo-4DS	IEA-MoMo-2DS	IEA-MoMo-2DS
Local pollutant standards	ICCT – baseline	ICCT – baseline	ICCT – baseline

Passenger mobility in cities up to 2050

The alternative scenarios represent different ways to fulfil the mobility demand resulting from increasing population and income. The total passenger-kilometres are of the same order of magnitudes in all three scenarios, the common figure reflecting the need for transport of the population in cities. However, mode shares differ significantly between a baseline scenario where private mobility, especially by car, continues to increase and the LUT scenario where public transport becomes the dominant form of transportation in many regions. The following paragraphs discuss these elements in detail; the following section will examine the consequences of the scenarios in terms of emissions.

Mode shares

In the baseline scenario, the share of private vehicles continues to increase in all developing regions, but slightly decreases in developed economies. The share of public

Figure 5.3. **Car share in cities by region**

As a percentage of all trips, Baseline, Robust Governance (ROG) and Integrated Land-Use and Transport Planning (LUT) scenarios

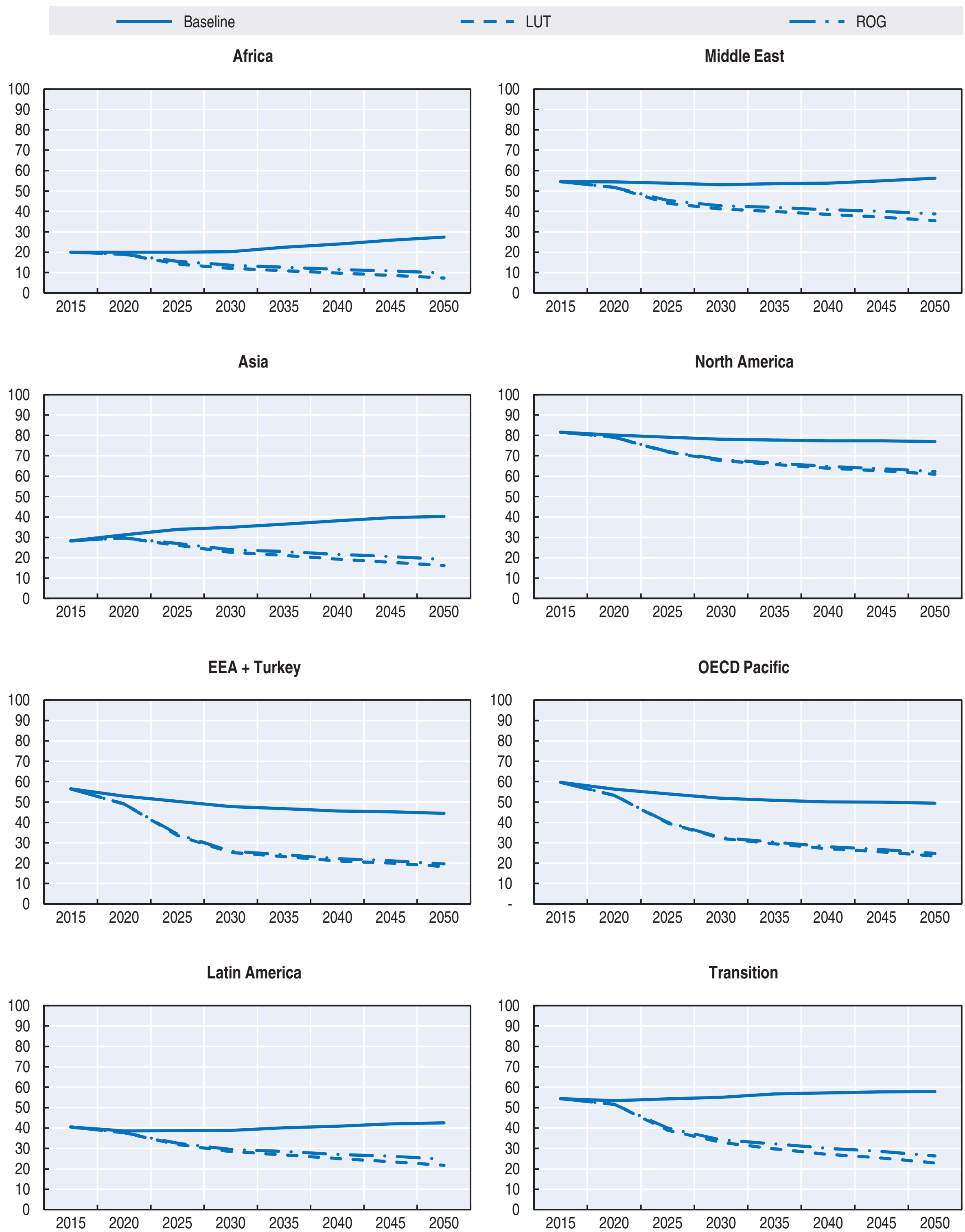

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Figure 5.4. Mobility by mode of transport, Asia and North America

Billion passenger-kilometres

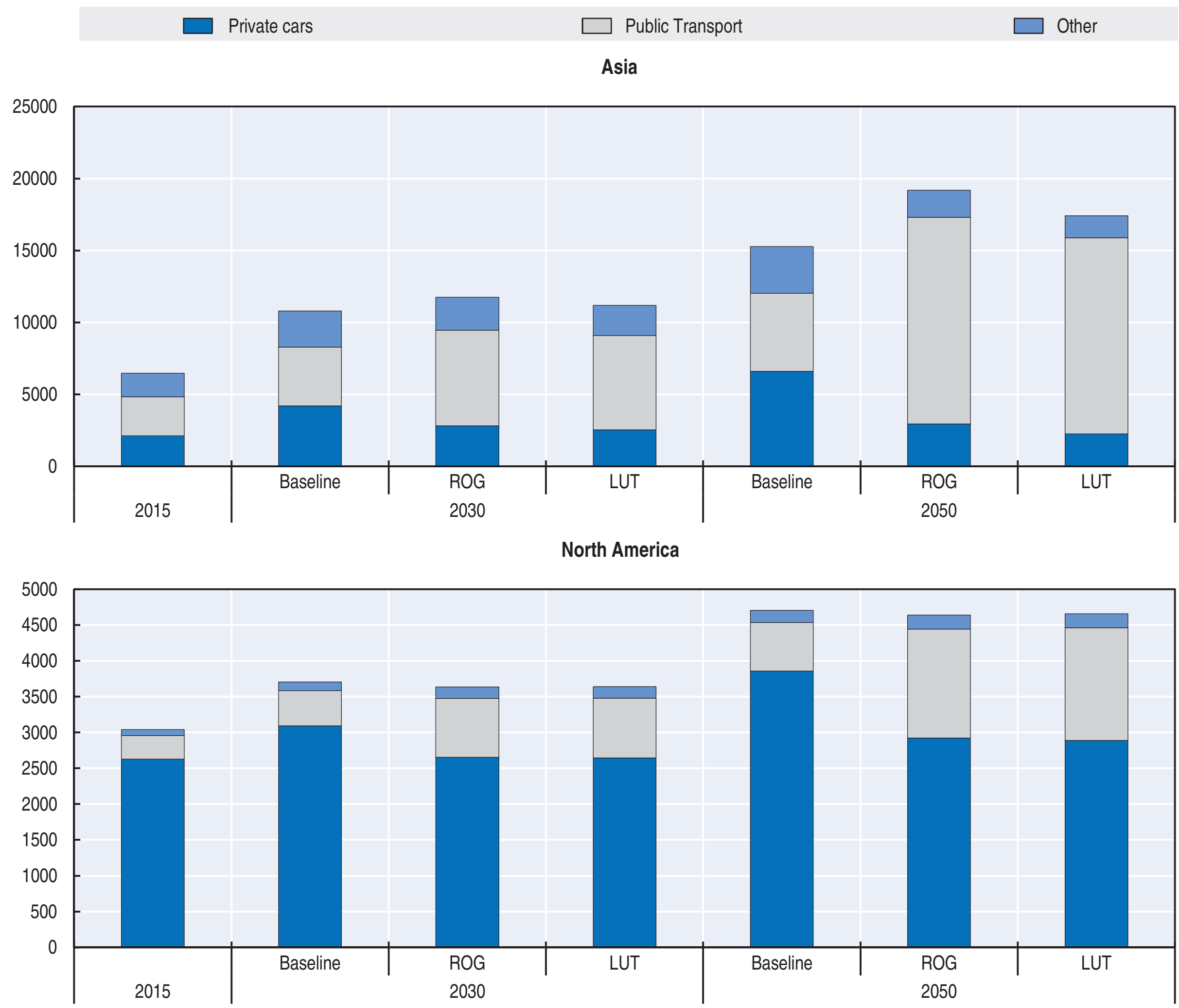

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Table 5.2. Share of car and public transport by region

As a percentage of all trips

	Private car				Public transport			
	2015	2050			2015	2050		
Regions		Baseline	ROG	LUT		Baseline	ROG	LUT
Africa	20.2	27.4	9.8	7.4	27.1	25.1	64.3	71.0
Asia	28.3	40.3	19.2	16.2	23.8	20.6	56.3	61.7
EEA + Turkey	56.4	44.4	19.7	18.4	19.4	24.9	49.9	52.7
Latin America	40.5	42.4	24.6	21.7	22.1	21.3	47.4	52.0
Middle East	54.6	56.3	38.8	35.5	15.9	15.9	37.8	42.4
North America	81.2	76.1	61.1	60.5	7.0	9.5	20.9	21.6
OECD Pacific	59.6	48.9	24.1	23.4	16.8	22.0	46.2	47.8
Transition	54.4	57.9	26.3	22.9	23.5	21.7	57.5	62.5

transport, motorcycles and non-motorised modes in developing countries are all projected to decrease until 2050, meaning that more residents of cities in developing regions will be shifting to private car use. At the end of the period, the private car is the dominant form of urban transport in all the regions of the world.

The highest growth in car share occurs in Asia where the average share of cars reaches 40%, or 1.5 times the 2015 level. China and India reach the highest value in the region. Following closely are other developing Asian countries, where the average car share grows from 30% in 2015 to 41% in 2050. In developed regions, we observe a natural reduction in car share. For instance, in Europe, the share of private cars decreases by 12 percentage points from 2015 to 2050. In North America, the reduction is 5 percentage points. Behavioural aspects win over purely exogenous growth factors. Former car users shift to public transport or non-motorised modes while the growth for transport demand remains low. This is in line with recent research showing that per capita daily travel demand has uncoupled from income in some high income countries, for instance the United Kingdom (Metz, 2012, 2010). In many large European cities with extensive public transport network, the pressure put on car usage has brought down the mode share of private cars (TfL, 2010, OMNIL, 2012).

In the ROG scenario, car use is lower in all regions because of the lower expansion rate of the road network and more stringent pricing policies increasing the fixed or variable costs of car ownership and car use. Reduction in the share of cars already happens in 2030, except in China and India, where the mode share of cars continues to increase due to rapid income growth. By 2050, public transport becomes the dominant urban transport mode in every region except North America, whose car share is still around 61%.

The share of motorcycles is on a downward trend in the ROG scenario in all developing regions, with travellers shifting to public transport. This is due to two reasons. The first is the result of per capita GDP growth, as high income travellers prefer safer and more convenient modes (Wen et al., 2012). The second reason is the stringent pricing policies in the ROG scenario, which make motorcycle and car use more expensive and public transport more affordable and attractive.

Another element explaining the growth in transit use is the shift of non-motorised trips to public transport, especially in developing regions, with two main underlying reasons. First, there is strong demand for faster mobility due to income growth. In 2015, the average travelled distance in OECD countries is three times the amount of non-OECD economies; it is only twice that amount in 2050. Second, the expansion of cities increases the length of trips for the urban residents, making walking and cycling less viable and encouraging a shift to motorised modes. Walking and cycling become an effective complement to public transport, meeting the requirements of short distance travel.

In the LUT scenario, the additional policies of land-use planning and TOD reinforce the use of public transport and further reduce car use, due to controlled urban sprawl, higher population density, higher transit network coverage and mass transit availability. Developing regions are more sensitive to the LUT policies than developed regions because cities in these regions are less mature. By 2050, the car share of developing Asian countries is 3 percentage point lower than in the ROG scenario. The figure is only 1.2 in North America and 1.3 in the European Economic Area (EEA) and Turkey region.

Table 5.3. **Total mobility by world region**

Billion passenger-kilometres

	2015	2030			2050		
Region		Baseline	ROG vs Baseline	LUT vs Baseline	Baseline	ROG vs Baseline	LUT vs Baseline
Africa	989.8	2 016.5	12.1%	0.0%	3 788.1	37.7%	6.5%
Asia	6 476.6	10 785.2	8.9%	3.8%	15 281.5	25.6%	13.9%
EEA + Turkey	1 699.5	2 047.4	5.4%	3.7%	2 484.1	13.2%	8.3%
Latin America	1 875.0	2 513.8	4.3%	-0.1%	3 397.8	17.5%	7.8%
Middle East	431.3	712.4	2.4%	-4.8%	1106.5	9.6%	-7.3%
North America	3 039.3	3 704.7	-1.9%	-1.8%	4 701.9	-1.3%	-1.0%
OECD Pacific	2 975.1	3 152.9	0.3%	0.7%	3 375.8	10.5%	11.8%
Transition	504.6	567.3	5.2%	4.8%	764.7	16.5%	7.4%
World	17 991.3	25 500.1	5.5%	1.7%	34 900.4	19.4%	9.1%

Transport demand

Under the baseline scenario, total motorised mobility (measured in passenger-kilometres) in cities rise by 42% in 2030 and 94% in 2050 compared with 2015, reaching 25 500 billion and 34 900 billion passenger-kilometres, respectively.

The policy measures of the ROG scenario do not impact the total mobility levels significantly. For developing countries, where mobility demand is growing fast, favouring transit use by improving public transport quantity and quality and reducing its cost significantly improves mobility levels. Public transport being more affordable, motorised mobility becomes available to a larger group of people. This is why total mobility levels in these regions are higher in the ROG scenario than in the baseline, where the reliance on cars limits the uptake of motorised mobility. On the contrary, in already highly motorised developed regions, public transport needs to compensate for the increased cost of car use (see Figure 5.4 for an illustration). If restrictions in car use are put in place without significant improvements to the public transport system, overall mobility levels will decrease.

In the LUT scenario, mobility demand is fulfilled through less carbon-intensive mobility options and reduced distance travelled. The overall passenger distance travelled figures are smaller under the LUT scenario than in the ROG scenario because the effective control on urban area size, which leads to lower urban sprawl, higher population density, and more transit-oriented development (TOD) patterns, contributes to a reduction in trip distances.

Emissions from mobility in cities up to 2050

Emissions from transport in cities have received a lot of attention because of the large impact local pollutants can have on health. The quality of the outdoor air is a more immediate concern to the inhabitants of cities than CO_2 emissions and has become the subject of much debate and policies. The policies range from direct and indirect restrictions in car usage to efficiency standards for new cars. However, the climate change impact of urban transport cannot be neglected. The total CO_2 emissions from all urban agglomerations in this study are 1 639 million tonnes (Mt) in the base year, amounting to slightly more than half of global surface passenger transport CO_2 emissions.

CO_2 emissions

In the baseline scenario, the level of total CO_2 emissions in large cities is 26% (419 Mt) higher in 2050 compared to 2015. Global emissions do not change between 2015 and 2030 due to the large fuel efficiency gains expected during the decade to come, and the low economic growth for the years up to 2020 (see also Chapter 1 for details on the short-term macroeconomic projections). However, emissions grow again from 2030 onwards based on the assumptions related to vehicle technology and fuel efficiency in the 4DS scenario of the IEA's Mobility Model. The world average fuel efficiency for on-road passenger light duty vehicles improves by 29% from 2015 to 2030 but only 14% from 2030 to 2050. This pace of technology improvement is not enough to offset the growing mobility demand between 2030 and 2050.

Policy interventions, especially rigorous car pricing policies, lower transit fares and higher vehicle technology improvements introduced in the ROG scenario could intensely mitigate CO_2 emissions from the urban passenger transportation sector. With solely the policy measures from ROG, the avoided CO_2 emission could reach 397 Mt in 2030 and 886 Mt in 2050 compared with the baseline. The additional policies introduced in LUT scenario would further reduce the CO_2 emissions by 48 Mt in 2030 and 104 Mt in 2050. Under the most effective policy scenario LUT, the global CO_2 emissions level from the urban transport sector would be 26% lower in 2030 and 35% lower in 2050 compared with 2015 levels.

Private cars are the main contributor of CO_2 emissions in cities, representing around 82% of all emissions in 2015 and around 75% in 2030 and 2050. With the implementation of the policy measures of the ROG and LUT scenario, the contribution of cars decreases to 40% in 2050.

Bus and motorcycle emissions represent 11% and 7% respectively of all emissions in cities in the base year, going up to 15% and 10% in 2030 and remaining stable until 2050, in the baseline scenario. In the ROG and LUT scenarios, the contribution of buses in total emissions increase both because of the additional public transport supply in these scenarios and because of the lower level of emissions from cars. Buses emit as much as cars in the ROG scenario in 2050; in the LUT scenario, buses even become the main contributor of CO_2 emissions in 2050. CO_2 emissions from urban rail are null in this model, as only tank-to-wheel CO_2 emissions are taken into account and urban rail is assumed to be fully electrical. A life-cycle analysis would increase the CO_2 emissions from urban rail, especially in India and Africa where the IEA projects that electricity production will remain carbon intensive through 2050.

The technology aspect of the ROG and LUT scenarios contribute most significantly to the CO_2 mitigation potential of these two scenarios. Figure 5.6 presents the avoided CO_2 emissions for the two scenarios, broken down by type of measure in 2030 and 2050. Technology improvements alone reduce global CO_2 emissions in cities by 15% in 2030 and 22% in 2050, compared to 2015.

Behavioural changes of the scale discussed in this *Outlook* have an impact on emissions (e.g. 11% less CO_2 emissions in the LUT scenario in 2050 compared to the base year) and they are essential in combatting congestion or health issues. However, emphasising behavioural changes in the fight against climate change does not take into account the surge in mobility which will result from the economic development of lower income countries. Even in the LUT scenario, despite the strict policies in place, car mobility increases in almost all developing regions. A complete decarbonisation of the transport sector in cities would require extreme changes in mobility patterns, on a scale out of proportion with the efforts currently deployed around the world. Such changes could take the form of much higher taxation of car mobility in cities or higher penetration of alternative fuels. The necessary penetration of electric

Figure 5.5. **CO_2 emissions in cities by mode of transport**

Million tonnes

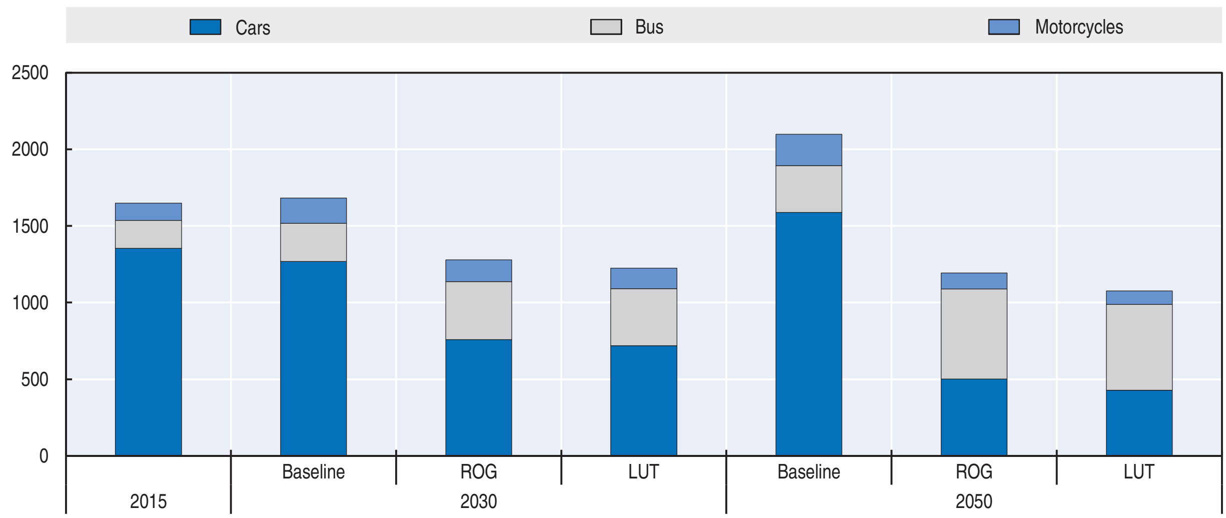

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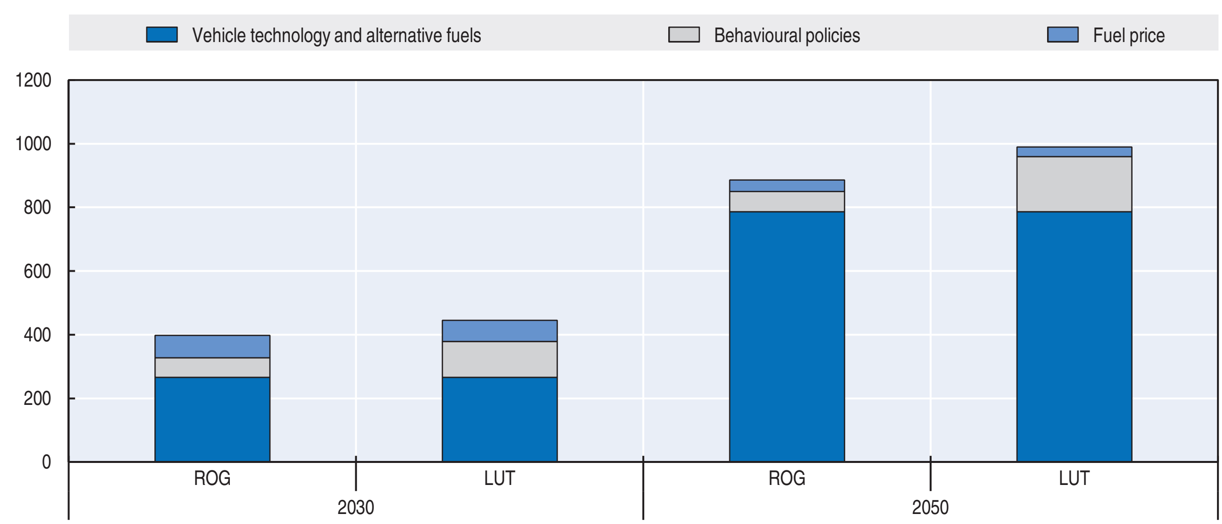
Figure 5.6. **Mitigation potential by type of measure**

Million tonnes of CO_2 avoided in cities



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vehicles in urban fleets in 2050 to bring emissions down to half their 2015 levels would be 65%, on top of all other policies already present in the ROG scenario, which is only likely to happen if all policies are aligned in favour of electric cars (see also Box 5.2).

Despite the high growth in emissions expected in developing economies, their average CO_2 emissions per capita is still only one-third that of OECD countries in 2050. In the baseline scenario, city inhabitants of OECD countries emit on average 1.2 tonne of CO2 in 2050 for their transport activities, against 0.4 tonne for inhabitants of non-OECD economies. The average CO_2 intensity (emissions per kilometre travelled) is also lower in non-OECD countries, both in 2015 and in 2050, because of the more common use of non-motorised modes, and in particular walking.

Box 5.2. **IEA electric vehicle outlook**

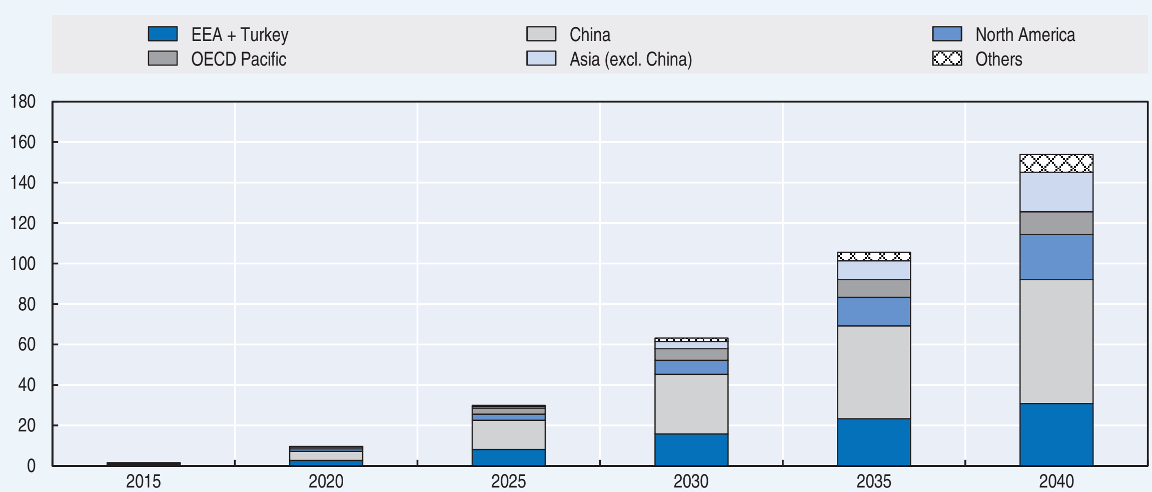
The global deployment of electric vehicles of all types is an integral part of the necessary actions to meet sustainability targets, alongside the optimisation of urban structures to reduce trip distances and a modal shift towards public transport. The Electric Vehicle Initiative 20 by 20 target calls for an electric car fleet of 20 million by 2020 globally. The Paris Declaration on Electro-Mobility and Climate Change and Call to Action sets a global deployment target of 100 million electric cars and 400 million electric 2- and 3-wheelers in 2030.

Current sales are still modest. In 2015, the global stock of electric cars went up to 1.3 million, a near-doubling over the stock of 2014 (IEA, 2016a). Although the share of electric cars in the global vehicle stock is still only 0.1%, this is a marked improvement from historic levels. The increase in sales has also been accompanied by a growth in electric vehicle supply equipment. The recent rise of electric cars has emerged both as a result of continuous technological improvements and because of mounting policy support.

According to the New Policies Scenario, a wider availability of electric car models and charging infrastructure will continue to drive electric car deployment: the stock rises by 50% per year to about 9 million by 2020 and 30 million by 2025; by 2040, the global stock of electric cars reaches more than 150 million, around two-thirds of which are plug-in hybrids (Figure 5.7). Yet, this growth of the global market for electric cars only has a minor impact on fuel consumption. Indeed, despite a significant decline in battery costs, electric cars might not become easily competitive with conventional cars, due to still higher payback times. The payback is quicker for commercial cars with high annual mileages, such as taxis, company fleets or car-shared vehicles. These vehicles having higher mileage, the CO_2 savings are also important for these types of vehicles, which should be prioritised by policies.

Figure 5.7. **Stock of electric cars by region, 2015 to 2040**

IEA New Policy Scenario, million vehicles



Source: IEA (2016), *World Energy Outlook.*

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Table 5.4 presents the regional breakdown of total urban CO_2 emissions. In the baseline scenario, the most dramatic increase in CO_2 emissions occurs in Africa, where emissions in 2050 is projected to be almost three times their 2015 levels. However, the highest growth in absolute value takes place in China and India. The combined emissions of these two countries grow by 297 Mt. CO_2 emissions in all regions significantly decrease in the ROG scenario. Regions with the greatest CO_2 mitigation potential are North America, because of the widespread use of private cars on the continent, and China and India, due to the high motorisation potential of these two countries.

Table 5.4. **Total CO_2 emissions in cities by region**

Million tonnes

	2015	2030				2050			
		Baseline	ROG	LUT	LUT vs ROG	Baseline	ROG	LUT	LUT vs ROG
Africa	41.9	75.3	60.3	52.8	-12.4%	155.7	76.5	59.9	-21.7%
Asia	323.4	510.1	401.7	376.9	-6.2%	760.3	437.2	385.8	-11.8%
EEA + Turkey	163.8	134.5	109.3	107.0	-2.1%	132.8	96.1	90.9	-5.3%
Latin America	133.5	161.3	133.7	126.9	-5.1%	216.4	141.5	126.6	-10.6%
Middle East	45.2	70.5	59.2	54.5	-7.9%	118.7	72.2	60.2	-16.7%
North America	592.6	469.8	344.1	343.5	-0.2%	457.1	238.1	237.7	-0.2%
OECD Pacific	303.8	202.2	129.2	128.9	-0.2%	168.2	88.5	88.2	-0.4%
Transition	34.9	35.3	24.1	23.5	-2.7%	49.5	22.5	19.7	-12.2%
World	1639.1	1659.0	1261.6	1214.0	-3.8%	2058.5	1172.5	1069.0	-8.8%

The additional urban policies in the LUT scenario have high impacts on the developing regions (e.g. an additional 22% in CO_2 reduction for Africa in 2050). In developed economies, the additional effect of the LUT policies is negligible. In Europe, Japan and Korea, the reason lies in the already (comparatively) high level of public transport infrastructure. In North America, Australia or New Zealand, the low CO_2 mitigation potential results from the low elasticity of mode choice to changes in pricing policies or public transport supply.

Local pollutants

In addition to its climate change impacts, urban transport is an important contributor to local air pollution, principally through the emission of NO_x, SO_4 and particulate matters (PM), which can contribute to severe health problems, including cardiovascular and respiratory diseases and numerous cancers. These problems are widespread: the World Health Organisation estimates that more than 90% of the world population lives in area where air pollution is above the limits for healthy living (WHO, 2016).

The effects of urban activity on CO_2 and local air pollutants are not always correlated. While emissions of CO_2 are strictly proportional to fuel consumption, the quantity of local pollutants per litre of fuel in exhaust fumes can vary greatly. Regulation has historically focused on limits on tailpipe emissions, because it was assumed that consumer pressure would result in fuel efficiency gains, and thus in less CO_2 emissions. While there is a controversy regarding differences in the level of emissions of local pollutants between test and on-road conditions (Franco et al., 2014), the strengthening of emission standards means that, in the European Union, new passenger cars in 2014 emit 100 times less PM than new cars in 1996. It is estimated that the most advanced emission controls could effectively eliminate over 99 percent of local air pollutants from engines (Chambliss et al., 2013).

To estimate the emissions of local pollutants resulting from the urban mobility levels of the three scenarios, this Outlook uses emission factors from the Roadmap model of the International Council on Clean Transportation (ICCT, 2014). The Roadmap includes expected improvements in vehicle efficiency standards, and their probable penetration in vehicle fleets until 2030.

Figure 5.8. **NO_x, SO_4 and $PM_{2.5}$ emissions by region**

Thousand tonnes

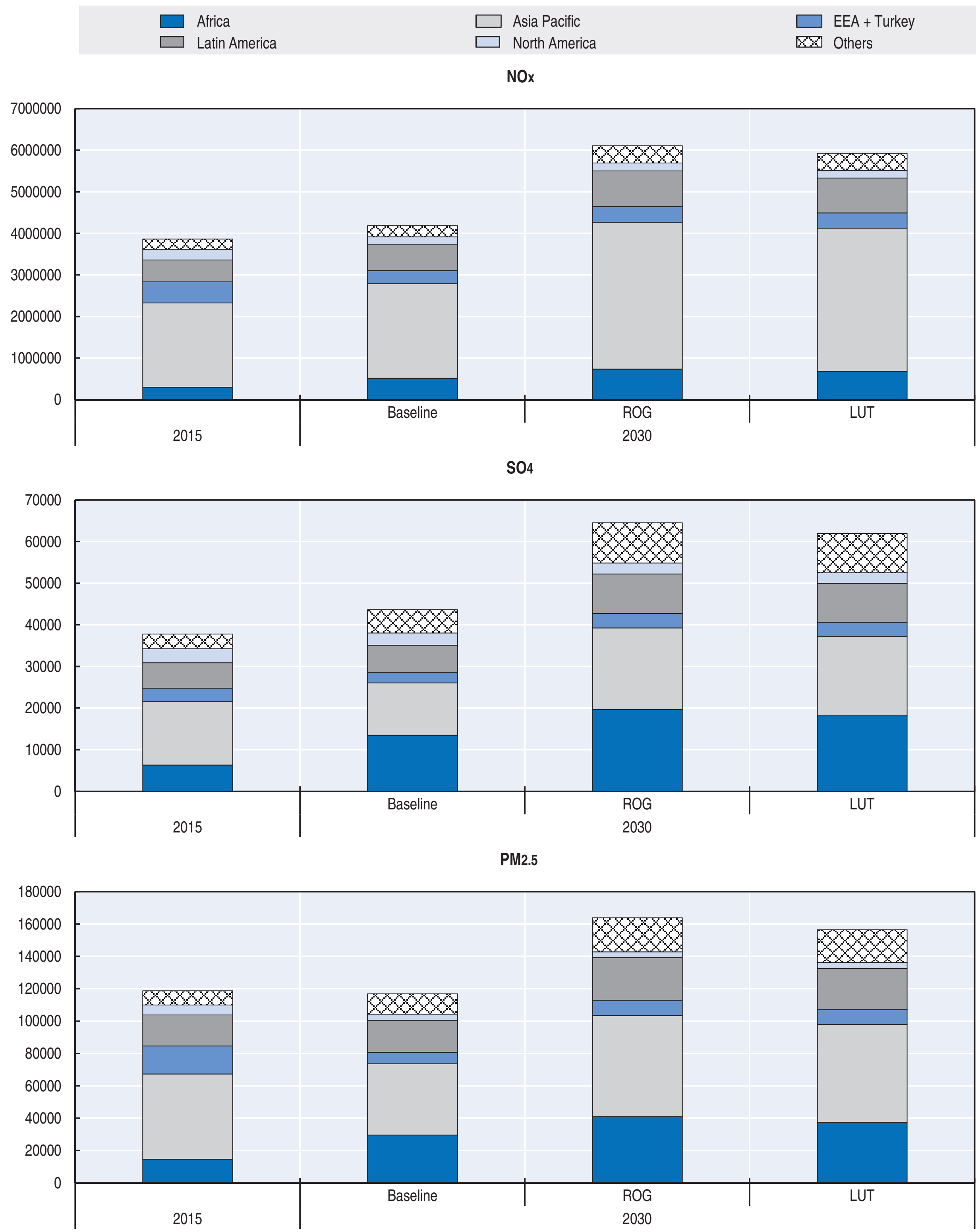

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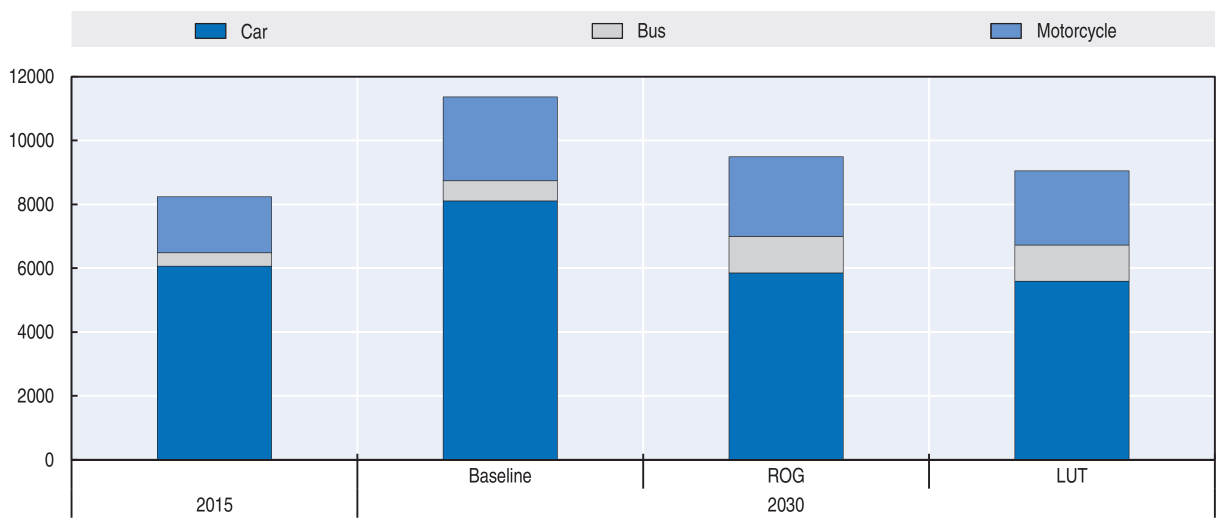
Figure 5.8 shows the evolution of the emissions of local pollutants between 2015 and 2030 by region. In the baseline scenario, emissions of SO_4 and NO_x moderately increase, and those of $PM_{2.5}$ even decrease. Car mobility, which increases most in this scenario, becomes much cleaner. In the more public transport-oriented scenarios, all local pollutants grow more because of the development of bus travel necessary to replace car mobility (Figure 5.9). Diesel buses, which form most of the bus fleet in many countries, have higher emission factors than cars and will not become much cleaner, especially in developing countries. For instance, diesel buses in China emit on average 7.7 g of NO_x per kilometre in 2015 and 5.7 g in 2030 when emissions from gasoline cars go down from 0.1 g per kilometre in 2015 to 0.03 g in 2030.

Figure 5.9. **Vehicle activity by mode**

Billion vehicle-kilometres



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It is difficult to predict the health impacts of these scenarios, as transport is only one contributor of local pollutants. Several other factors, such as the topography and climate of cities, as well as the presence of industry, also enter the equation. In regions with heavily polluting industries, such as coal plants, its share can be as low as one-third (Beijing Municipal Environmental Protection Bureau, 2014). However, our projections show that most of the increase will take place in developing countries, where many cities are already choking on local pollution. Any additional emission is likely to bring significant health issues. Extra effort will be required to develop clean public transportation systems, especially in medium cities where rail investment is not an option, for instance through the phasing in of buses powered by alternative fuels or through the development of coherent planning policies. In the LUT scenario, the decrease in the average distance travel causes some reduction in the emissions of local pollutants.

Accessibility

Policy packages that are well co-ordinated and address externalities from increasing motorised mobility in cities make a significant difference for sustainable urban futures. The policy scenarios introduced earlier in this chapter (Robust Governance and Land-Use Transport Planning) do not merely influence mobility patterns in cities. They also affect the way in which people, jobs and other urban functions can be accessed in cities.

Accessibility, however, is only to some extent about mobility. Designing urban transport policies has traditionally focused on travel time savings and congestion relief. According to this vision, transport planning aims at maximising the distance that infrastructure users can travel within their time and money budgets. However, there is growing consensus that this is not recognising the actual purpose of transport, which is providing accessibility to opportunities such as employment, goods or services. Taking this shift of emphasis seriously requires rethinking the governance and finance models for connecting transport and land use policy and planning.

Improving accessibility, not merely mobility, will be decisive for sustainable and inclusive cities. In a meta-study reviewing the effects of the built environment on travel behaviour, Ewing and Cervero (2010) highlight the importance of accessibility to valued destinations. Improving the level of accessibility in cities is an important dimension of social inclusion (Viegas and Martinez, 2016).

Measuring accessibility in cities

Ways of measuring accessibility abound and remain subject to wide discussion (Bhat et al., 2005; Geurs and Wee, 2004; Handy and Niemeier, 1997; Murray et al., 1998). There is a broad consensus about understanding accessibility as the ease or potential for reaching valued locations, "where services, goods or opportunities are available" (Paez, 2016; see also Hansen, 1959; Owen and Levinson, 2014). However, research differs according to the dimensions of accessibility emphasised, such as transport, land-use factors, time constraints or individual characteristics (Geurs and Wee, 2004). Similarly, different perspectives of measurement persist, varying from relatively simple infrastructure-based and proximity measures (i.e. the walking distance to a transport stop) to more complex ones, taking into account individual utility functions (ibid.). Location-based metrics, focusing on the accessible mass of opportunities at different locations, strike a good balance between theoretical soundness, data and computing requirements on the one hand, and policy relevance on the other (for a comprehensive discussion of accessibility measures see Geurs and Wee, 2004).

When it comes to comparative studies of accessibility in cities beyond the case study format, the objectives of accessibility measures are usually more modest and often based on the concept of proximity. This has been largely due to limited availability of data and computing power. As a recent example of applied research, the European Commission measured accessibility to public transport in European cities (Poelman and Dijkstra, 2015). The study calculates the share of the population living within walking distance of public transport facilities and assesses the level of service frequency at stops and stations. This metric allows for comparison of the population share covered by the public transport network and the quality of service, as measured through frequency. The advantage of such proximity-based metrics is the relative ease of computation, moderate data requirements and the clarity for policy messaging. However, the policy implications might be limited as the distribution of actually valued destinations, and hence the constraints to reach them are not sufficiently taken into account (Peralta, 2015).

The arrival of new standardised sources and tools for computation and measurement make it possible to go beyond accessibility metrics that are limited to single case studies and proximity-based measures. Innovative research by the Accessibility Observatory located at the University of Minnesota estimated in a series of reports the potential accessibility to jobs in more than 40 US metropolitan areas by car, public transport and walking for 1990, 2000 and 2010 (Owen and Levinson, 2015; 2014; Levinson, 2013). Combining disaggregated census population data, job locations and detailed information of the urban transport network, timetables and travel speeds, this research estimates the number of jobs an average city dweller can reach in ten minute time bands up to one hour. Valuing job locations with shorter travel times higher than with longer ones, this location-based metric adds an element of gravity.

In a similar vein, the World Bank calculates average accessibility to jobs by different modes of transport for a number of cities in Latin America, Africa and Asia. The metric computes the average accessibility to jobs by mode within an assumed maximum commuting threshold of one hour. Working on a case-by-case basis this approach uses detailed and locally specific data, taking into account travel and land use patterns allowing the assessment of different accessibility scenarios, comparison between modes and different points in time (Peralta and Mehndiratta, 2015). The drawback of this approach is that it remains case-study based and dependent on locally available data, notably job locations, which are difficult to obtain or unavailable on a broader scale.

The Outlook accessibility index

This *Outlook* analyses accessibility in cities for both road and public transport. We define a common accessibility indicator for both modes, following these two principles:

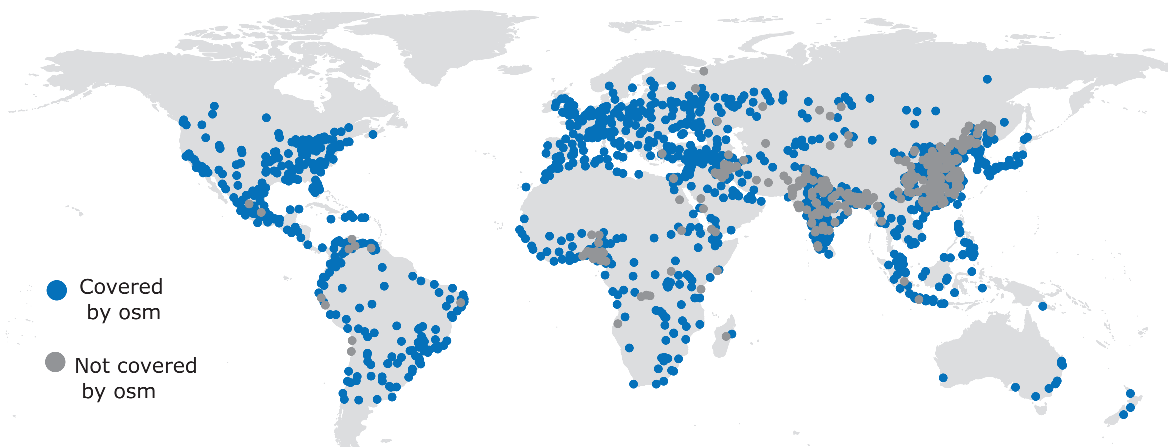
- *Conceptual simplicity.* While the state of the art in accessibility research has been moving towards more complex models of accessibility (Geurs et al., 2012), a conceptually simple approach allows overcoming the challenge of extensive data and computing requirements. Contour-based metrics calculating the number of opportunities within a time threshold are best suited to bridge data availability, theoretical complexity and comparison between cities and regions.
- *Global data availability, or of global reach.* As the derived value of global metrics is to compare, situate and benchmark cities across the world, data need to be standardised across countries and widely available. As a consequence, only globally standardised datasets are used for this (see Annex 5.A on data sources).

The accessibility index in this *Outlook* is defined as the average number of inhabitants that can be reached within a 30 minute threshold by private car or public transport. The spatial distribution of the population in cities is used as a proxy for opportunities. While population does not represent actual opportunities, there is some empirical evidence that population density correlates with opportunities such as jobs and services. For instance, Kaufman et al. (2016) showed that the distribution of services, offices and commercial spaces within cities is highly correlated to the one of population. Such a proxy is very useful in the case of a global study; detailed analysis of specific cities should however rely on the actual location of opportunities.

Additionally, to analyse mobility in cities by means of public transport, we also consider the notion of public transport coverage, corresponding to the share of the population which has access to public transport by walk and represents the number of potential users of the public transport network. This metric is similar to the People near Transit (PnT) metrics developed by the Institute for Transportation and Development Policy (ITDP, 2016).

Accessibility by car is calculated for 1 390 cities among the 1 557 urban agglomerations used in the previous section of this chapter; public transport coverage for 1 014 cities. These two indicators are built using OpenStreetMap data. Some cities are excluded because of data quality (see Figure 5.10 for the cities sufficiently covered by OpenStreetMap). Accessibility by public transport is computed for a sample of 23 cities, with GTFS data. The General Transit Feed Specification (GTFS) format is increasingly recognised as a global standard for public transport schedules, but only a small sample of cities was used due to incomplete data coverage.

Figure 5.10. **Coverage of cities by OpenStreetMap (OSM)**



Accessibility in cities today

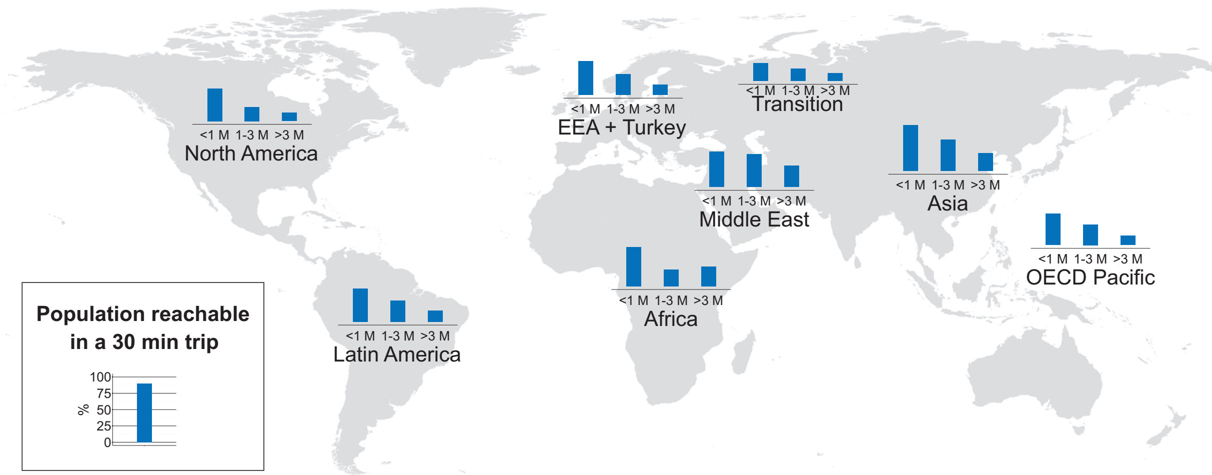
Road accessibility

In large and dense cities like Beijing, inhabitants can, on average, reach 3 million inhabitants in a 30 minute car ride, or 13% of the total population. In a sprawled city like Buenos Aires, this number goes down to 0.8 million inhabitants, or 5% of the total population. Figure 5.11 shows the average road accessibility by world region. Clear geographical patterns, correlated with density patterns, appear: Asian and Middle East cities offer the highest level of accessibility, regardless the size of the urban agglomeration considered. Northern American cities as well as cities from the transition economies are characterised by low accessibility albeit for different reasons. Northern American cities are sprawled but provide an efficient and relatively uncongested road network. Although the density observed in transition economies is equivalent to European cities, they lack high capacity trunk roads and thus suffer from low speeds and high congestion.

Overall, the differences in road accessibility are explained by three factors: population density, free-flow speed and congestion. Population density impacts the distance people need to travel to reach a given number of inhabitants. Free-flow (uncongested) speeds vary from city to city depending on the provision of fast and high-capacity road infrastructure. The level of congestion, defined as the relative travel time loss at peak hour, is the last major driver of accessibility. Together these three factors explain 75% of the difference between the cities. The elasticity of road accessibility with respect to density is 0.7, according to which increasing population density by 10% would lead to a 7% increase in road accessibility.

These three factors provide a categorisation of the policies to enhance accessibility. Improving the road network to increase free-flow speeds and alleviating road congestion are the first two levers. Historically it has been the preferred option as accessibility is more

Figure 5.11. **Road accessibility in cities by region and city size**



sensitive to speed and congestion than density. The elasticity with respect to actual speed is indeed higher, with a value at 1.6.

Policy instruments for increasing density, such as land-use planning and zoning, tend to be more efficient. Accessibility is globally higher in dense cities, even those with low-quality road infrastructure, because the variability of density between cities is much higher than that of speed. The ratio between Northern American cities and African cities ranges between 1:4 and 1:8 for density, depending on city size, when it is only 2:1 for speed.

Increasing road provision has little effect on free flow speeds and congestion. According to our model of congestion (Box 5.5), increasing the density of trunk roads (in km of roads by km^2) by 10% induces a 1% increase in free flow speeds. The relationship between congestion and road supply is more complex. A large supply of trunk roads implies high capacities and thus low congestion. However, vehicle-kilometres increase at a similar pace than road capacity: higher speeds lead to a higher demand for road transport which, in turn, calls for more infrastructure building. Statistical analysis (Box 5.5) shows that road congestion first decreases sharply with GDP per capita but quickly stabilises at around 40%. This result extends the well-known rule that, in congested cities, providing more capacity usually does not resolve the problem of congestion.

Public transport coverage

Before looking at the accessibility index for public transport, we first focus on public transport coverage. Indeed, accessibility in cities depends on the number of people who live within walking distance from transit stops. Public transport coverage, or People near Transit (PnT), measures the number of residents in a city who live within a walking distance from public transport stops. PnT can also be considered as a proxy for the integration of transport and land-use in cities (ITDP, 2016).

Based on the available data on public transport stops, public transport coverage is calculated for 1 014 cities. The proximity to stops is evaluated for bus and for mass transit, with a maximum walking distance of one kilometre, which is equivalent to approximately 12-15 minute walk. Public transport coverage is calculated as the percentage of residents of a city living within that distance from at least one public transport stop. Figure 5.13 illustrates this indicator on a set of cities.

Box 5.5. **A global model of congestion in cities**

The TomTom congestion index (TomTom, 2016) estimates the time lost by drivers of a city during the morning peak hour: a congestion index of 50% indicates that, on average, the morning congestion increases driving times by 50% on average. To analyse the influence of some characteristics of cities on congestion levels, the following model is built:

$$\text{Congestion} = A.\left(\frac{\text{VKM}}{\text{Trunk}^{*}\text{Capacity}}\right)^{\beta}$$

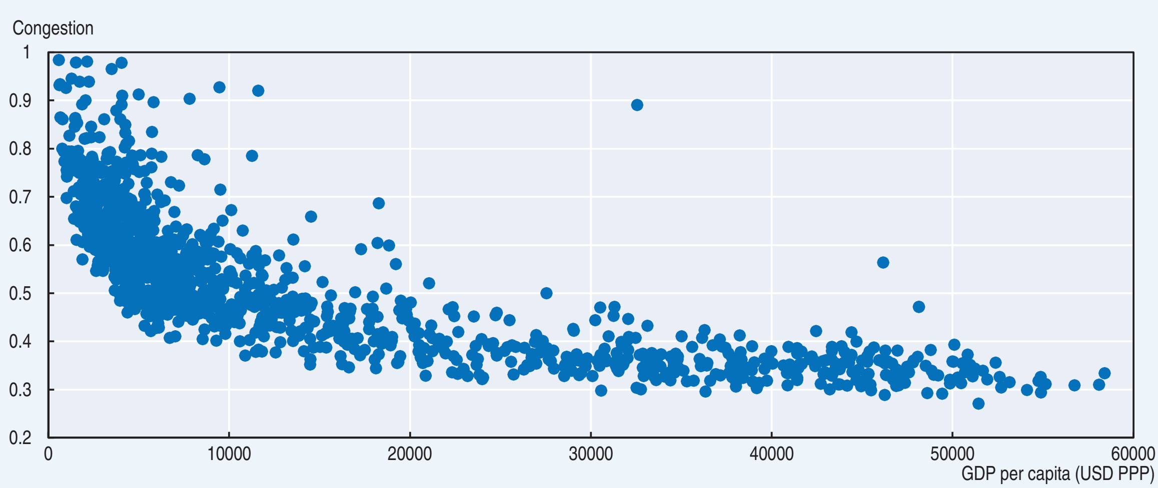
VKM is the total number of vehicle-kilometres in the city, Trunk the length of fast and high capacity roads, and Capacity the average unit capacity (in VKM/hour). The quantities VKM and Trunk are known from the urban passenger model. Road capacity is difficult to assess globally as it varies according to the number of lanes, road geometries, intersection design, speed limitations, etc. It is assumed that Capacity can be written as $\text{Capacity} = B.(\text{GDP per capita})^{\gamma}$.

The results of the estimation are in Table 5.5. Congestion first sharply decreases with GDP before stabilising at an index between 40% and 50%. The stabilising reflects the inter-relation between road capacity and vehicle use. From a certain level of GDP onwards, vehicle-kilometres and the total length of trunk roads grow at the same pace, leaving the ratio between the two, congestion, unchanged. This result recalls, on a global level, the classical work by Downs (1962, 2004) sometimes known as "fundamental law of peak hour congestion". It states that on urban commuter expressways, road will be as congested as before after any new investment in road capacity.

Table 5.5. **Results of the estimation of the congestion model**

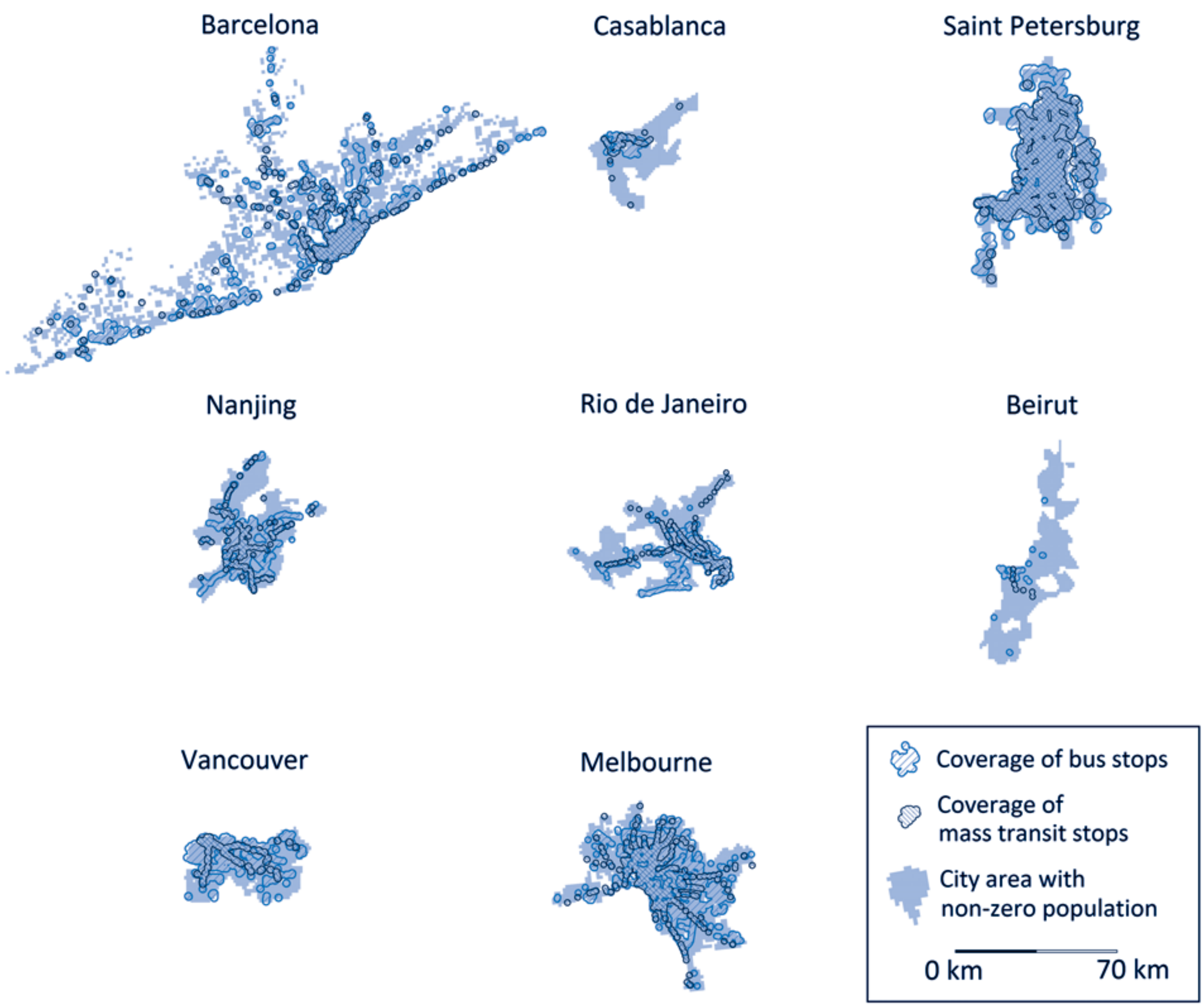
Variable	Elasticity
log(VKM/Trunk)	0.12
log(GDP per capita	-0.22

Figure 5.12. **Congestion in cities as a function of GDP per capita**



StatLink http://dx.doi.org/10.1787/888933442821

Figure 5.13. **Public transport coverage in selected cities**

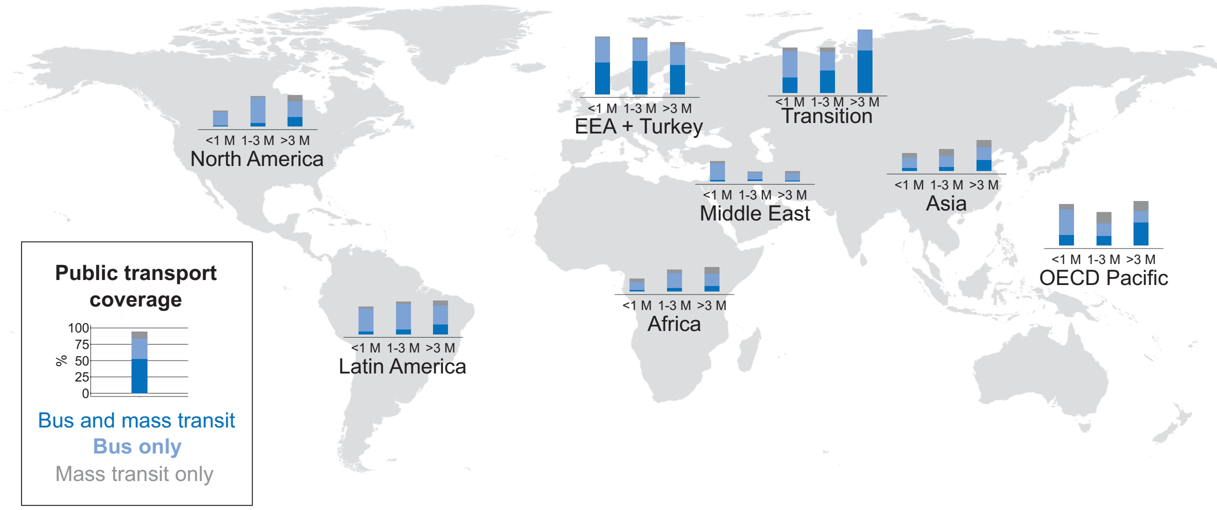


When coverage is computed, the values are likely to be low estimates of the public transport coverage, because of possible OSM data incompleteness. However, it is likely that the cities for which no data was available are also the cities with the lowest public transport supply, thus skewing the results in the other direction.

On average, around 53% of the residents of the considered cities live in proximity to a public transport stop, with 28% of all the residents covered by mass transit. Cities from Europe and transition economies have the best coverage, with an average of 85% and 80% of the population correspondingly and relatively high shares of mass transit: 51% for Europe and 47% for transition countries (Figure 5.14). OECD Pacific, North America and Asia have lower public transport coverage rates but fairly large shares of mass transit. The rest of the world regions tend to have lower coverage with bus prevailing over mass transit modes.

Vast coverage by public transport is a prerequisite for good accessibility. However, public transport coverage does not provide sufficient information for policy implications. Even if residents live in proximity to public transport stops, variations of the quality of service of the available public transport modes may affect the mobility patterns significantly.

Figure 5.14. **Public transport coverage in cities by region**



Moreover, access to a public transport stop does not imply easy access to the desired opportunities. The next section describes the accessibility index, which solves some of these issues.

Public transport accessibility for a sample of 23 cities

Computing the accessibility index for public transport was only possible for a limited set of city due to limited data availability on public transport services. Figure 5.15 illustrates the computed indicator for the 23 cities in our dataset.

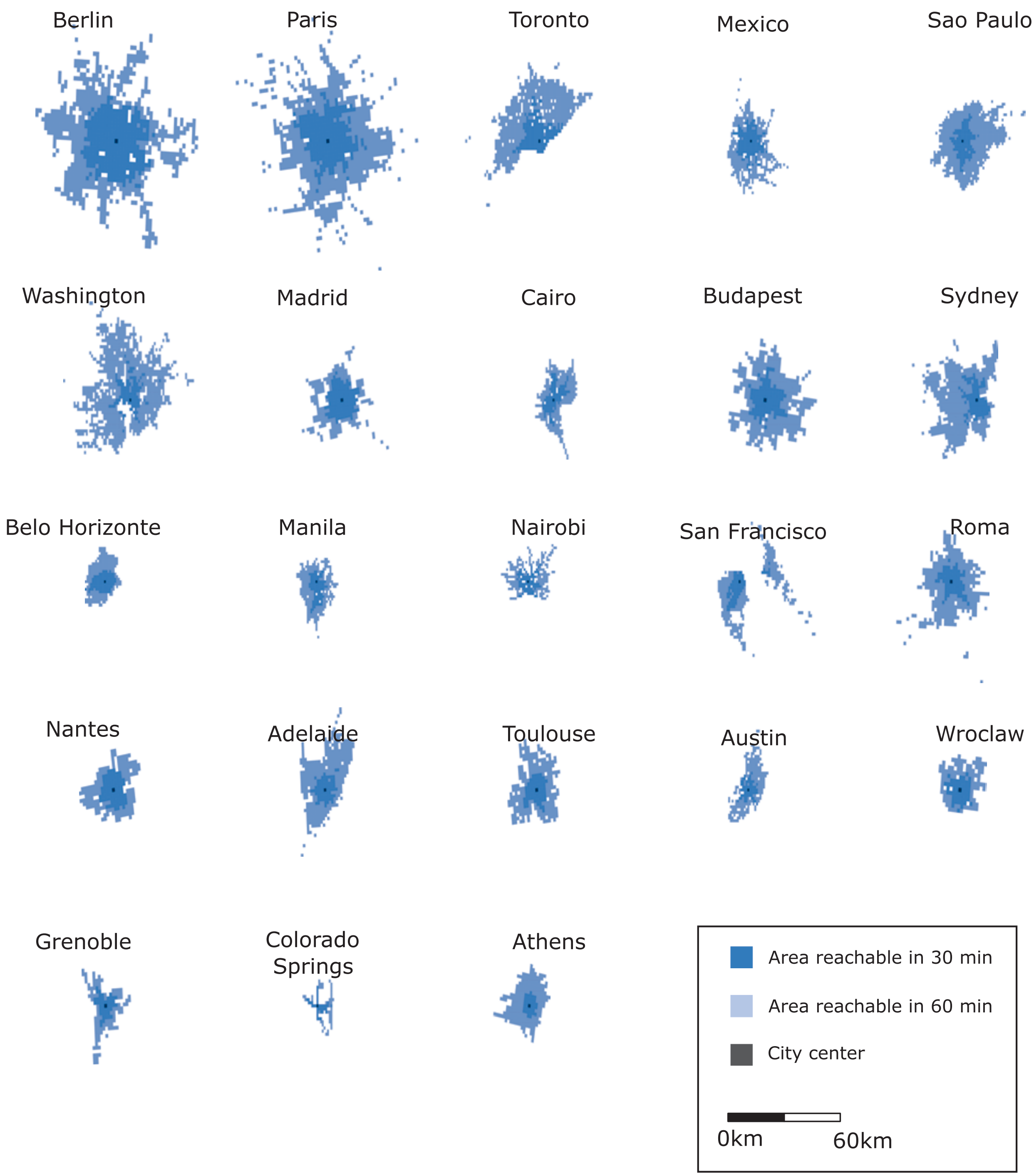
Accessibility by public transport varies greatly by city, with European cities generally offering higher accessibility than developing cities. Around 12% of the 10 million inhabitants of Paris urban area can be reached in 30 minutes by public transport against less than 4% of Cairo's 17 million inhabitants. Although Cairo is nearly twice as dense as Paris, its public transport system is only half as fast, with less extensive coverage, leading to lower accessibility. Here, the speed of the public transport network needs to be understood as the average speed over all trips, assuming that the geographical distribution of trip ends is similar to that of density; it is not the average commercial speed of the lines composing the network.

Compared to public transport coverage, the accessibility index provides more meaningful insights on public transport efficiency. Figure 5.16 depicts that no relationship exists between the two indicators. In well-covered cities, accessibility varies from a few per cent to 30%. Conversely, in cities with low accessibility, coverage varies from 100% to 30%. Low frequencies and station density, as well as inadequate networks, can result in very low average speed even when the coverage is very good.

As in the case of roads, public transport accessibility is driven by population density and speed. Those two variables explain 80% of the variability between cities. Accessibility is much more sensitive to speed than density: the elasticities are 2.9 and 1, respectively. Because public transport tends to connect dense areas, a small increase in speed has a great effect on the number of inhabitants people can reach in 30 minutes. This highlights the interest of mass transit as a lever for enhancing accessibility, especially when coordinated with land use.

Figure 5.15. **Accessibility by public transport in 23 cities**

30 and 60-minute isochrones



The accessibility gap in favour of European cities relates to an unequal distribution of public transport speeds. The average speed for cities ranges from 5 to 15 km. Most of the cities with no or little mass transit achieve a speed between 5 and 8 km/hour, one notable exception being the transport network of Nairobi which, with nearly no rail transport, offers a speed of 8.8 km/h thanks to a large and rather efficient informal transport system.

The so-called Matatus are mini-coaches operating on a network of 2 000 stops with a peak frequency of nearly 30 buses per hour. The average speed can go up to 15 km/h for cities with significant mass transit provision.

Reducing the accessibility gap between cities requires significant investment in infrastructure and improved services. The high variation in average speed has to do with the unequal provision of public transport services. Yet, quantifying the quality of a transport network is challenging. Common indicators, such as station density or the total length of public transport lines, focus only on the spatial extent of the network and are more easily related to public transport coverage. They fail to grab much of the differences in accessibility between cities of similar coverage (Figure 5.16).

Figure 5.16. **Public transport accessibility in cities**

Public transport coverage and average accessibility by public transport

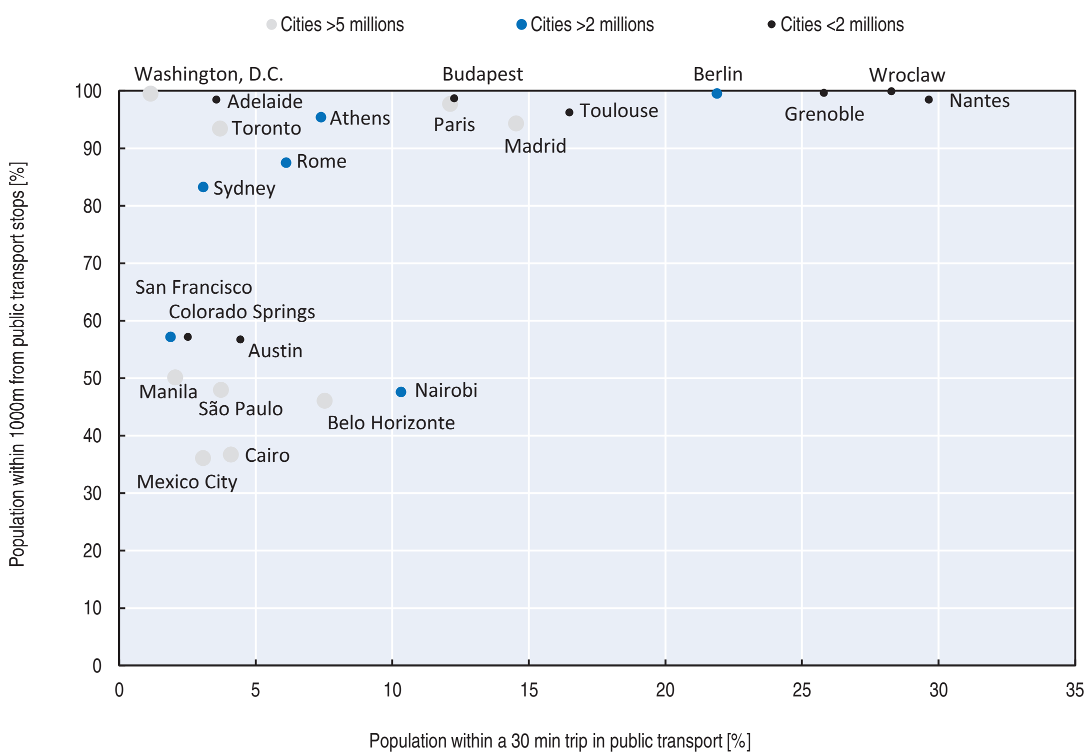


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Table 5.C2 in Annex 5.C presents two simple measures that overcome this difficulty for the 23 cities of our sample. These are the number of buses and mass transit stations, multiplied by the average frequency at peak hour, measuring the total number of vehicle calls at stations per hour. These two indicators explain more than 55% of the speed differences between public transport networks and thus appear to be good measures of network quality. In particular, it appears that increasing mass transit provision of 1% increases the average speed by 0.14%.

Policy implications

Accessibility, as measured in this *Outlook*, is higher for cars than for public transport, except for some large western metropolises, because of the flexibility offered by this mode. Contrary to public transport, which does not cover all inhabitants of a city, cars can, in theory go between any two places. However, promoting accessibility by car raises many issues, not least because of congestion (see also the Outlook section below). The road infrastructure required to accommodate a car-oriented accessibility can be very difficult to build and maintain, especially in dense cities.

Public transport, on the other hand, can deliver accessibility to the greatest number. Investment in transport infrastructure needs to be coupled with wider policy packages, including travel demand management, land-use planning and promotion of active modes. Innovative mobility solutions, such as car-sharing or demand-responsive buses, can also be promoted to form part of the transport options for travellers. Indeed, a recent study by ITF (2016) shows that these two mobility options, if implemented together with adequate mass transit, can provide high levels of accessibility at a reasonable cost and bring additional benefits, such as reduced public parking space and emission reductions (Box 5.6).

Currently, accessibility by public transport is especially low in developing cities, where the motorisation rate is also the lowest. Many inhabitants are thus excluded from fast access to opportunities in these cities. This raises a major equity issue that also applies, to a lesser extent, to North American cities. As investing in public transport infrastructure is costly, there is also a significant policy challenge here: how to develop a mass transit network while

Box 5.6. **The ITF Shared Mobility Model**

The advent of shared mobility on a large scale could change travel patterns in cities and improve accessibility significantly. The ITF Shared Mobility simulation model (ITF 2016), developed for Lisbon, Portugal, shows that the car fleet needed for daily commuting can be reduced to 3% of today's fleet if all trips are made using a comprehensive shared mobility platform.

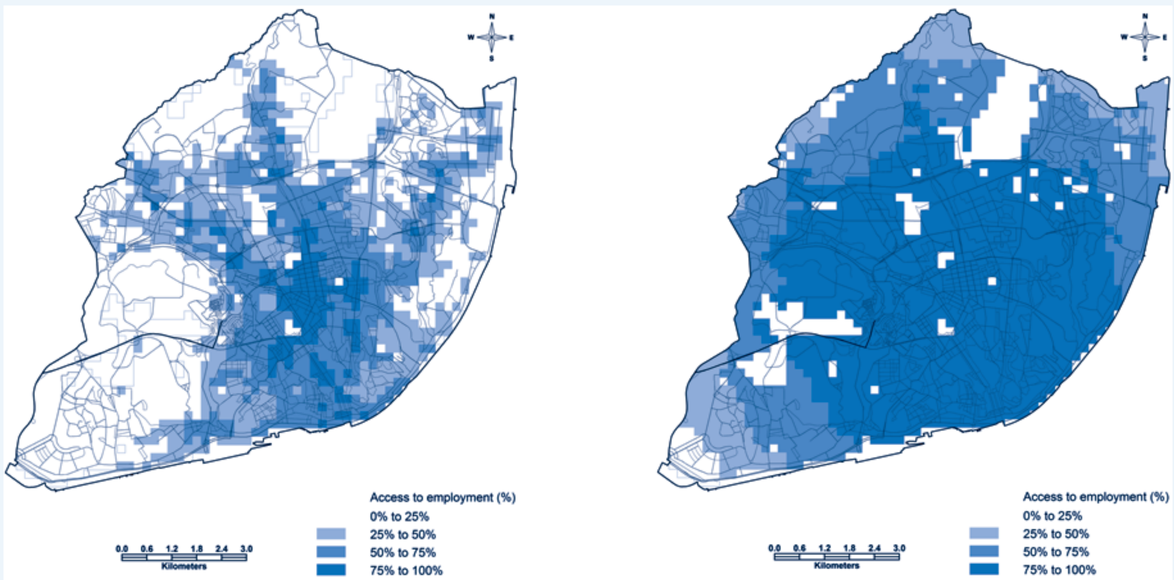
The Shared Mobility model simulates the current situation as a baseline and assesses the possible large-scale deployment of a shared vehicle fleet that provides on-demand transport in different scenarios, while keeping the same level of mobility. The shared alternatives in the model are designed to provide high level of acceptance by current car drivers and include on-demand door-to-door rides by "Shared Taxis" and pre-booked transfer-free rides at pop-up stops by "Taxi-Buses". While rail and subway services continue to operate as today in the shared-mobility scenarios, all other motorised modes, including taxis and buses, are replaced with shared alternatives.

The main findings of the study, besides the drastic car fleet reduction, include a decrease in congestion, emissions reduced by one-third, and 95% less space needed for public parking. The total vehicle-kilometres travelled is 37% less during the peak hours compared to today, while each car is running almost ten times more kilometres than currently. The induced shorter vehicle lifetimes lead to more frequent fleet renewal, which enables a quicker fleet turnover and a faster penetration of fuel-efficient or alternative fuel technologies. The shared mobility scenarios also result in cheaper trips due to more efficient use of capacity. Other benefits include the decrease in the number of transfers and better accessibility. Figure 5.16 shows the comparison of accessibility to jobs in the baseline and the shared mobility scenarios. With shared mobility, the majority of grid cells have at least 75% of the jobs in the city reachable within 30 minutes.

The challenges for policy makers lie in the creation of the right market conditions and operational frameworks. While a sudden change to a complete shared mobility system is not conceivable, a gradual installation is plausible and may already yield large benefits. In one of the scenarios, individual cars are allowed to drive in the city two working days per week, while other days the shared mobility system must be used. This results in significant reductions of congestion and emissions, and could be an opportunity for car owners to shift to the shared mobility service gradually.

Box 5.6. **The ITF Shared Mobility Model** *(cont.)*

Figure 5.17. **Accessibility to jobs in Lisbon before (left) and after (right) the introduction of shared mobility solutions**



Source: ITF (2016), *Shared Mobility: Innovations for Liveable Cities.*

maintaining affordability? Indeed, in many developing cities, low-income urban residents are already too poor to afford public transport. For instance, in Sao Paolo, Mexico City and Manila public transport is beyond the reach of the 20% at the bottom of the income pyramid (Carruthers et al., 2005). Financing an inclusive, yet efficient, transport system requires innovative mechanisms, such as taxes to capture land value increases in areas served by public transport systems or contributions of private vehicle users through road infrastructure and parking charges.

Outlook for accessibility

This section analyses the consequences, in terms of accessibility of the different policy scenarios used for our transport demand and CO_2 emission projections.

Despite their slow transport networks, cities from the developing world offer reasonable accessibility by car and public transport because of a high population density. This could change if these cities follow the same urbanisation pathway as in Europe and North America. During the post-war years, large shares of the population began to move outwards, from the city centres to suburbs, in developed countries (e.g., Mills, 1972). This resulted in urban sprawling and in a decrease of population density. This trend is still ongoing. In Europe, between 1990 and 2000, the urbanised area increased by 18.4%, while population density fell by 9% (Oueslati et al., 2014).

The determinants of urban sprawl are known. The monocentric city model (Alonso 1964; Mills, 1981) identifies income and commuting costs as essential drivers of sprawl. When inhabitants of a city have access to cheap and efficient transport means, they tend to relocate in the periphery of cities to increase the size of their dwellings. The empirical relevance of the monocentric model has been tested several times in developed countries (Brueckner and Fansler (1983), McGrath (2005)). In a developing country context, Shanzi et al. (2009) investigated the determinants of the spatial scale of Chinese cities and demonstrated the crucial role that income growth has played in China's urban expansion.

The analysis of the ITF city database shows that the two main drivers of urban extent are population and GDP per capita. Urban extent increases at a slower pace than population, thus bigger cities tend to be denser. However, richer cities tend to be more sprawled. For this reason, the average density of cities decreases in the baseline scenario. This is true for all regions of the world, although to different degrees. The density decrease is particularly sharp in Asia, where the GDP per capita will be a significant driver of urban expansion.

The growth in infrastructure in the baseline scenario is not sufficient to maintain accessibility levels. As density decreases, maintaining accessibility constant requires an increase in the speed of transport networks, both road and public. Although trunk road length increases with population and wealth, a wider city also requires a larger network to serve suburban dwellers. Moreover, the combined effects of urban extension, population and income growth will result in a surge in road traffic, and thus call for more road capacity to limit congestion.

The situation is particularly dramatic for Asian cities. The drop in density is sharp, -19% between 2010 and 2050, while road traffic rises up to +532%. Although the trunk road length is projected to grow by 137%, this will not be enough to alleviate congestion. Maintaining road accessibility constant would require multiplying the trunk road network by six, a growth that is not financially and environmentally sustainable. To a lower extent, similar trends are observed in transition economies and Latin America. Road accessibility is thus expected to deteriorate between 2010 and 2050 in most cities of the developed world, unless strict policy packages are put in place.

The loss in road accessibility can be compensated by infrastructure investment in the public transport system. In the baseline scenario, the number of cities with mass transit more than triples in developing countries. In cities with mass transit, public transport accessibility will not drop on average. However, significant shares of the urban population will have to rely on car for travel purposes, as providing efficient public transport services for low density suburbs is difficult.

Table 5.6. **Changes in some city characteristics between 2015 and 2050 in the baseline scenario**

	Density %	VKM %	Trunk road provision %	Trunk road need %	Cities with mass transit(1) %	
Africa	-8	325	180	158	460	(5 to 28)
Asia	-19	532	137	295	295	(37 to 146)
EEA + Turkey	-7	40	46	39	6	(77 to 82)
Latin America	-8	152	49	92	51	(37 to 56)
Middle East	-2	228	99	98	175	(4 to 11)
North America	-1	68	39	36	9	(35 to 38)
OECD Pacific	-8	12	11	24	16	(19 to 22)
Transition	-15	147	57	120	347	(17 to 76)

In the LUT scenario, where urban extent is assumed to be fixed, density grows at the same rate as population. This implies a major increase in density for regions where rapid urbanisation is still ongoing. In Africa, population density in cities will triple to an average of 24 000 inhabitants per km^2. Although high, these numbers are still plausible: in the two densest cities in the world, Dhaka (Bangladesh) and Hyderabad (Pakistan), there are 40 thousand inhabitants per km^2. Vehicle-kilometres also rise at a much lower pace and more cities implement mass transit systems, reducing both congestion and improving the share of the population which has access to public transport.

Table 5.7. **Changes in some city characteristics between 2015 and 2050 in the LUT scenario**

	Density %	VKM %	Cities with mass transit %	
Africa	195	48	920	(5 to 51)
Asia	140	181	627	(37 to 269)
EEA + Turkey	41	-30	12	(77 to 86)
Latin America	72	27	81	(37 to 67)
Middle East	127	177	325	(4 to 17)
North America	54	68	11	(35 to 39)
OECD Pacific	24	-37	37	(19 to 26)
Transition	61	-27	124	(17 to 38)

This emphasises the crucial importance of land use policies in maintaining accessibility to opportunities in the developing countries. Without strict land use control, urban sprawl will increase the need for infrastructure to a point that is not sustainable. On the contrary, density decreases the need for private car, reduces distances to destinations and makes the implementation of mass transit systems more feasible.

Passenger transport in Asian cities

According to the results of the ITF model for mobility in cities, 43% of the world's transport demand in passenger-kilometres will be in Asia by 2050. This is a region that is projected to grow significantly and rapidly in population, economic development, urbanisation rate, and motorisation level. Although increases in motorisation will bring positive benefits and contribute to economic growth, high levels of congestion, energy consumption, local air pollution, and CO_2 emissions will often follow. This section focuses on urban transport trends and projections in cities in China, India and Southeast Asia.

Motorisation trends in Asian cities

In 2010, China surpassed the United States to be the largest automobile market in the world (CAAM, 2016). More than 20 million vehicles were sold in China in 2014, resulting in a total number of 92 million cars in the same year (CAAM, 2010, 2014). Despite its low vehicle ownership rate, at 58 vehicles per 1 000 persons, compared to 804 vehicles per 1 000 persons in the United States (Wang et al., 2011), it is already the world's largest CO_2 emitter and has recently become the top global crude oil importer. The level of CO_2 emissions from the transport sector in China has more than doubled from 2000 to 2010 (CAIT, 2015); China's demand for oil and subsequent CO_2 emissions will only increase as its transport sector grows, unless a comprehensive range of policies and measures is implemented to alter the course of development.

In India, raising automobile sales, household income, urban population, and urbanisation are all leading to higher transport demand. Urban population has increased from 60 million in 1951 to 410 million in 2015 (United Nations, 2014). The number and size of cities have also increased, which will ultimately increase travel demand and total distance travelled. The number of cars has grown from 16 million in 1990 to almost 40 million in 2000, reaching a total number of 131 million in 2014 (IEA, 2015). Most of these vehicles are motorcycles and only 21 million of them are passenger cars. Compared to China, India has a much smaller car market but the transport sector is still a leading contributor to Indian cities' CO_2 emissions mainly because of motorcycles. India's passenger vehicle market is heavily dominated by motorcycles, which are the fastest growing type of vehicle in India, with an average annual growth rate that is higher than all other types of motor vehicles. Hence, in addition to CO_2 emissions, local air pollution is a major problem in Indian cities.

Local air pollution from transport activities, along with traffic congestion, are pressing challenges in many Southeast Asian countries. Transport demand in Southeast Asia has been steadily increasing over the past three decades and has not shown any signs of slowing down. Recent statistics from the IEA (2015) show that the number of motorcycles has grown by 177% in Vietnam between 2000 and 2013. The increase in cars was 600% in the same period. In Malaysia, the growth in cars is 148%, while the Philippines saw a relatively lower percentage at 44% over the same period of time. Indonesia has also experienced high vehicle growth rates for both motorcycles and cars, with an over 600% and 280% increase respectively. Most cars have also become single occupancy vehicles most of the time, leading to greater time delays in urban cities. It is not surprising that due to its affordability and practicality, motorcycles are the leading transport mode choice in many Southeast Asian cities. In Vietnam, 95% of all vehicles are motorcycles. These increases in motorcycles could be a reflection of the lack of an adequate public transport system and the general appeal of personal mobility over public transport. Transport challenges exist in smaller Southeast Asian countries too. Traffic congestion costs Cambodia around USD 6 million per month as a result of lower economic efficiency and the loss of working time and fuel (Sotheary and Kunthear, 2015). In Kuala Lumpur, the World Bank estimated the costs of traffic congestion to be 1.1% to 1.2% of the national GDP in 2014 (Sander et al., 2015).

Although the transport priorities in most Asian cities are traffic congestion and local air pollution, their transport sectors have increasingly become a bigger contributor of CO_2 emissions. The high motorisation rate in Vietnam led to a 190% increase in its CO_2 emissions from the transport sector between 2000 and 2010, which is higher than China (160%) and India (100%) over the same period (CAIT, 2015). Indonesia, Cambodia and Malaysia also recorded significant increases of transport-induced emissions. The Philippines was the only country selected in this study not to witness a growth in its transport emissions. As carbon emissions become a pressing concern in the region, there is now a greater sense of urgency for Asian cities to adopt more sustainable transport development policies and measures.

In order to successfully reduce carbon emissions, it is important to first identify measures that will also provide climate co-benefits through the development of energy efficient and low carbon transport systems in Asia. Policies and measures that support the adoption of advanced vehicle technology and alternative fuel will reduce CO_2 emission by improving energy intensity. However, as a result of the increasing number of vehicles in Asia, advancing vehicle and fuel technology will not be enough to reduce CO_2 emissions, as the growth of vehicle ownership and use surpass technological improvements. A range of policies and measures that include land use planning, public transport development, economic instruments, and governmental regulations need to be considered.

The development of public transport in areas with high urban population density and user demand is a way to reduce congestion and emissions. In general and especially so in developing cities, public transport provides services at a lower cost to the user than driving but travel time can be longer for transit than driving and accessibility can also decrease (see section on Accessibility). Increase in public transport efficiency and ridership can also lead to economic benefits through high economic rates of return in dense cities (Cambridge Systematics Inc. and Apogee Research, 1996).

Selected cities

The selected cities for this chapter include five Chinese, five Indian and five Southeast Asian cities that reflect a wide range of population size, motorisation rates and existing transport policies and services (Table 5.8). Some cities offer more transit services than others. For example, out of the 15 cities selected in this study, only four cities offer bus rapid transit (BRT) systems, regular bus and metro rail transit services. Many of the Southeast Asian cities also offer several informal public transport options, either in the form of three-wheelers or mini buses. The 15 cities exhibit different levels of motorisation rates, both for cars and motorcycles. On the other hand, the selected cities are all experiencing high levels of local air pollution and congestion.

Table 5.8. **Transport characteristics of selected Asian cities in 2010**

City	Population (Million)	Cars (Million)	Two-wheelers (Million)	Car ownership rate	Two-wheeler ownership rate	Vehicle Restriction (Year)	Transit Services
China							
Beijing	15	4.81	0.35	321	23	Yes (2011)	Bus, BRT, Metro
Shanghai	19.55	1.46	1.29	75	66	Yes (1994)	Bus, Metro
Guangzhou	10.49	1.36	0.54	130	51	Yes (2012)	Bus, BRT, Metro
Tianjin	8.54	1.38	0.15	161	18	Yes (2014)	Bus, Metro
Xi'an	4.85	0.74	0.26	153	53	N/A	Bus, Metro
India							
Mumbai	19.42	0.43	0.77	22	40	N/A	Bus, Metro
Delhi	21.94	1.61	3.25	74	148	N/A	Bus, Metro
Bangalore	8.28	0.51	1.95	62	235	N/A	Bus, Metro
Ahmedabad	6.21	0.21	1.05	33	169	N/A	Bus, BRT
Jaipur	3.02	0.19	0.92	62	304	N/A	Bus, BRT, Metro
Southeast Asia							
Manila	11.89	1.13	6.67	95	561	N/A	Bus, Metro
Kuala Lumpur	5.81	2.86	1.34	493	232	N/A	Bus, BRT, Metro
Jakarta	9.63	2.00	8.76	207	910	N/A	Bus, BRT
Phnom Penh	1.51	0.18	0.73	123	486	N/A	Bus
Hanoi	2.81	0.80	2.20	284	782	N/A	Bus

Note: Ownership rates are per 1 000 inhabitants.
Source: Chinese Cities Statistical Yearbooks for population, cars and motorcycles data in Chinese cities. TERI data for population, cars and motorcycles data in Indian cities. Southeast Asian cities data obtained from the Philippines Ministry of Transport, Malaysian Ministry of Transport, Regional Statistics of DKI of Jakarta Province, JICA, Vietnam Department of Transport, and DKI Transport statistic.

Policy scenarios

This study applies the same set of policy scenarios as in the global urban model, presented earlier in this chapter, tailoring each measure or assumption to individual cities (see Tables in Annex 5.D). Although each scenario contains a different set of policy assumptions, the framework for estimating transport demand and CO_2 emissions is similar across all scenarios. The scenario outcomes are not predictions, but different possible futures based on the assumptions applied in each scenario.

The projection of transport demand in Chinese and Indian cities were estimated differently from the Southeast Asian cities due to data availability, which is a wider challenge in the region (Box 5.7).

Box 5.7. **Transport data in Asia and the Pacific: Challenges and opportunities**

"If you cannot measure it, you cannot improve it", goes the quote popularly attributed to Lord Kelvin (William Thomson). The need for reliable, robust data sets is felt particularly by those working towards sustainable transport in the developing world. Better data provides direction for informed action: for example, the Cities Air, Climate, Transport database (*www.citiesact.org*) covering nearly 500 cities across Asia shows that 97% of these cities are not meeting air pollution targets. Identifying what modes of transport generate the air pollution would be a critical point of action.

The Asian Development Bank, together with its partners, is currently undertaking a regional project to improve the quality of transportation data in Asia and the Pacific, and widen the access to this data. The project – "Better Transport Data for Sustainable Transport Policies and Investment Planning" – intends to collect, collate and generate insights from currently available transport data in forty (40) of ADB's developing member countries (DMCs). The data will be shared through a publicly accessible portal, and used as inputs to a transportation model to assess the potential impacts of future transport scenarios in these countries.

A key challenge towards benchmarking across countries in Asia is the non-availability of standardized definitions. A notable example relates to road vehicles. Each country is using its own set of vehicle categories, most often derived from the usage of the vehicles, which does not follow internationally-recognized classifications. Simple steps can be taken to harmonise, such as using publications like the "Illustrated Glossary for Transport Statistics" (ITF et al., 2009); these guidelines could be further enriched by feedback from users in Asia and the Pacific.

The non-collection of key transport data is also a challenge in the region. Average vehicle-kilometres driven by different vehicle sub-segments, for example, are not commonly collected by developing and middle-income countries. The non-availability of such information prevents generation of other important indicators for transport. Moreover, access to readily-available disaggregated data is often limited. Solutions need not be complicated: collection of data for additional indicators, such as vehicle-kilometres driven, can easily be incorporated into the vehicle registration and renewal processes.

City-level transport data in the region most often comes from ad hoc initiatives, supported by external parties, and is limited to the main cities in developing and middle-income countries. Inconsistencies can sometimes be found between datasets for the same parameter generated by different government agencies from the same country. Increasing the vertical integration between relevant stakeholders through discussions and workshops on transport data collection can accelerate the generation of quality data in the region. Local governments can be better capacitated in transport data collection and tapped to contribute to an integrated database.

Box 5.7. Transport data in Asia and the Pacific: Challenges and opportunities *(cont.)*

The "Better Transport Data" initiative underlines the importance of accounting for local contexts, priorities, resources, and capacities when looking into transport data. At the same time, countries in the region can benefit from mutual sharing of experiences and methods, as well as in having standard guidelines for defining, and collecting transport data. The availability of openly accessible and curated data – through a web portal and possible crowd-sourcing tools – is also envisioned to generate interest, both from state and non-state actors, in improving transport data and research in the region.

Travel demand projections for the Chinese and Indian cities were developed using the ASIF (Activity, Structure, Intensity, Fuel type) approach (Schipper et al., 2000), where their motorisation rates were modelled based on South Korea and Japan's historical motorisation rates for cars and motorcycles, while projections for bus and passenger rail transportation demand follow population density growth (ITF, 2015). For the five Southeast Asian cities, household travel survey data that included individual trip data such as mode choice, travel distance, travel time, and socioeconomic variables were obtained from the Japan International Cooperation Agency (JICA). These data supported the construction of five mode choice models (multinomial logit), which enabled the projections of 2050 travel demand and CO_2 emissions using parameters derived from the choice models.

Baseline

In the baseline scenario, no major new public transport development, economic instruments, or governmental regulations will be implemented in the selected cities, apart from those that have already been introduced. For example, existing restrictions on vehicle registration in Chinese cities will continue but not spread to other cities that currently do not have such regulations. Motor vehicle ownership and use will continue to increase for cities without any restrictions on vehicle growth. These cities include all five Indian cities and one Chinese city, i.e. Xi'an. There is no substantial effort to improve public transport services, in terms of reducing bus and rail travel time or developing BRT systems in cities where such systems are currently unavailable. Similar assumptions were made for Southeast Asian cities. Advanced vehicle technology and alternative vehicle fuel use will continue to penetrate the market but at a relatively low rate, especially for Indian cities. There will also be no significant improvement in fuel efficiency standards, which coincides with the IEA 4DS (IEA, 2015).

ROG Scenario

In the ROG scenario, city governments play a larger role in regulating vehicle use and ownership. Governmental regulations and standards refer to non-market based policies, such as restrictions on annual vehicle ownership growth and fuel economy standards. A cap on vehicle growth rate through tight vehicle quota control regulations will ensure reductions in congestion, local air pollution and global carbon emissions. Auctions or lottery schemes that distribute the limited number of license plates available will accompany such regulations, as currently implemented in cities such as Singapore, Shanghai and Beijing. In this scenario, restrictions on vehicle registration will exist in all Chinese cities and their quotas will gradually decrease between 2030 and 2050. Fuel efficiency standards in this scenario follow the assumptions made in the IEA 2DS (IEA, 2015), which are more stringent than in the baseline scenario. Such standards are usually implemented on a national level but complement local measures.

In addition to changes in vehicle registration and fuel efficiency standards by 2050, other economic instruments will also be implemented. In this scenario, fuel taxes, road tolls and parking pricing will be widely implemented in all Chinese, Indian and Southeast Asian cities, leading to a general increase of 64% in the cost of driving in 2030 and 99% in 2050. There will also be an increase in bus and rail subsidies, which will lower the cost of public transport to users by 30% in 2030 and 50% in 2050.

LUT Scenario

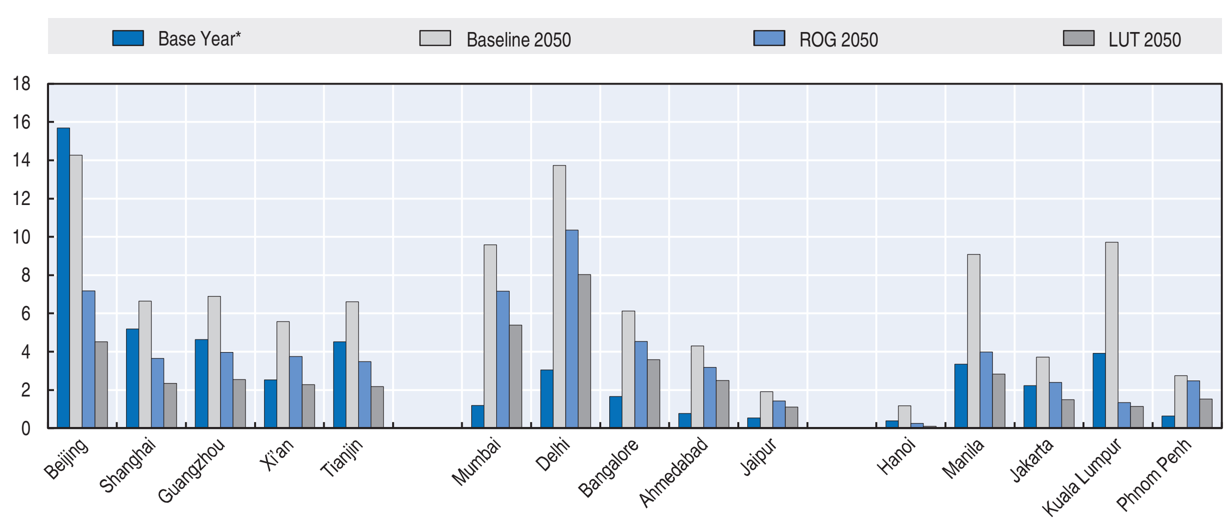
In the LUT scenario, there is a greater urge for sustainable urban transport development in the cities. Therefore, all the measures of the ROG scenario will be implemented together with appropriate urban planning measures that will reduce travel distance and urban sprawl through an increase in population density. Population density will be 15% and 25% higher in 2030 and 2050 respectively in this scenario compared to the Baseline and ROG scenarios for the Chinese and Indian cities, and distance travelled will not increase beyond 2010 levels for Southeast Asian cities. This could be achieved by the development of more mixed use transit corridors. In this scenario, public transport will also be greatly improved through the decrease of bus and rail travel time by 30% in 2030 and 60% in 2050. BRT services are available in all cities in this scenario, which will further decrease transit travel time, yet increase accessibility.

Scenario results

Emission trends vary by city (Figures 5.18). The significant decreases in emissions in Chinese cities are due to the vehicle ownership regulations that will become more stringent over time, as well as reductions in vehicle use due to the assumptions made in the ROG and LUT scenarios. Xi'an, which is the only Chinese city in this study that does not have a limitation on vehicle ownership, will continue to have increasing emission levels in

Figure 5.18. **Total CO_2 emissions in the selected Asian cities**

Million tonnes



Note: The base year is 2010 for the Chinese and Indian cities, 2015 for the other Southeast Asian cities.

StatLink http://dx.doi.org/10.1787/888933442845

the Baseline and ROG scenarios. CO_2 emissions will only decrease in Xi'an when a wider range of policies and measures are implemented as assumed in the LUT scenario.

Emission projections in Indian cities differ from those in the five selected Chinese cities and will follow a much more linear trend over the next few decades. Nevertheless, the rate of growth could decrease, as shown in the ROG and LUT scenarios, if cities implement appropriate transport policies to change travel demand and behaviour, and if the pace of technological progress is quicker.

As for the Southeast Asian cities, the policy scenarios trigger the largest decrease in CO_2 emissions from the baseline to the LUT scenario in 2050 for Hanoi (90%) and Kuala Lumpur (88%). These decreases largely result from the shift from cars to public transport options. The difference in CO_2 emission reduction between the LUT and ROG scenarios is the smallest for Kuala Lumpur (18%) and largest for Hanoi (124%), which shows that the impact of the same combination of policy measures will vary depending on a city's existing transport mode choice, preferences, alternatives, and policies.

Policy options for sustainable transport in Asian cities

Achieving low-carbon mobility in Asian cities requires targeted policies, which differ according to the varying transport preferences, constraints and needs found in different cities. The same set of policies and measures can trigger different outcomes. Cities are diverse in terms of the modes available and existing transport services, which leads to different policy impacts, even within the same country or region. This calls for special attention to be paid to the local context when examining the policy options of a city. The following paragraphs conclude by bringing forward some common elements for sustainable transport in Asia cities.

Government regulations are complementary to economic instruments in reducing car use and CO_2 emissions. Xi'an, the only Chinese city selected in this study without an existing regulation on vehicle registration restriction, had the lowest number of cars in 2010 in China. However, without governmental regulation, its total number of vehicles increases by 82% in 2050 (baseline scenario). In the five Indian cities selected for this study, the increase in cars can be as high as 96% for the same time horizon, as is the case in Mumbai. These outcomes can be avoided by a mix of government regulation and economic instruments, in the form of fuel taxes, road pricing, parking fee, or transit subsidies, which provide incentives to drive less and use public transport more.

To be fully efficient, economic instruments need be coupled with integrated land-use and transport planning. Land-use and transport planning strategies can change the density of urban cities and diversity of activities in neighbourhoods. It reduces the average distance travelled, transport demand and CO_2 emissions subsequently. Given their high population density, Chinese and Indian cities are well suited for the development of efficient public transport systems. The effect of the policies in the LUT scenario is particularly high in reducing CO_2. Emphasising public transport services using high capacity vehicles also reduces congestion and emissions.

Since the share of motorised two-wheelers is high in most developing Asian cities, especially in Southeast Asia, economic instruments need also apply to them. These include road tolls and parking policies that will serve as transport demand management tools for both types of vehicle. In addition, the high shares of motorcycles often hide an issue with public transport provision. The regulation of motorcycles can only go hand in hand with an improvement of public transport, or cities face the risk of significant loss of accessibility.

The low modal shares for public transport in some Southeast Asian cities can also be explained by the existence of informal public transport services. Such services provide more flexible route and often at a lower cost than structured public transport. Since the cost of public transport is relatively low in Chinese, Indian and Southeast Asian cities, the provision of further transit subsidies may not be effective in encouraging greater public transport use. Another way to increase its appeal is to improve the quality of the services, for example, by decreasing travel time. This implies the development of faster travel modes. Speed can be further enhanced by using dedicated roadways or introducing BRT systems, and enabling smoother transfers between vehicles and other transport modes.

The LUT scenario reflects the improvement of bus and passenger rail travel time and the availability of BRT systems in all 15 cities. Compared to the baseline scenario, bus ridership will increase by 28 to 117% in Chinese cities and by 36 to 138% in Indian cities in 2030. Bus ridership in the ROG scenario, which only includes transit subsidies as a policy to increase ridership, increases on a much smaller scale. A similar trend is observed for passenger rail ridership. The improvement of the quality of the public transport network appears much more efficient in encouraging mode shift than pure economic instruments.

Finally, the results highlight the importance of timing in policy implementation. Cities should act now to reduce transport CO_2 emissions. In 2010, Beijing had the highest passenger light duty vehicle demand in China, most certainly because it only started regulating the growth in private cars in 2011, whereas Shanghai proposed its vehicle ownership policy 25 years earlier in 1986 and implemented it in 1994. Despite having a larger population and higher GDP level, Shanghai has managed to keep its vehicle ownership rate low, not just because it implemented a vehicle restriction policy, but also because it started early while its vehicle ownership rate was still relatively low.

Since most of the rapidly growing cities are still at the beginning of their motorisation growth projections, cities have to act now to avoid greater levels of traffic congestion, local air pollution and CO_2 emissions. The rate of vehicle ownership need not follow population and GDP increases as proven by cities such as Shanghai, Hong Kong and Singapore. At the same time, higher travel demand, measured in passenger kilometre, need not imply higher emission levels, as more energy efficient transport modes could be chosen for the same distance travelled. The integration of land-use and transport planning policies will continue to maintain a desirable level of accessibility and prevent significant urban sprawl, which will then reduce total distance travelled over time. Together with adequate infrastructure investment, robust pricing policies, improved transport services, and higher market penetration rates of energy efficient vehicles and fuel, cities will be able to achieve sustainable transport.

References

Alonso, W. (1964), *Location and Land Use. Towards a Theory of Land Rent*, Harvard University Press, Cambridge (Massachusetts).

Banister, D. (2008), "The sustainable mobility paradigm", *Transport Policy, New Developments in Urban Transportation Planning* 15, 73-80, *http://dx.doi.org/10.1016/j.tranpol.2007.10.005*.

Beijing Environmental Protection Bureau (2014), *The sources of local pollution in Beijing*.

Bhat, C.R. et al. (2005), *Measuring Access to Public Transportation Services: Review of Customer Oriented Transit Performance Measures and Methods of Transit Submarket Identification*, Centre for Transportation Research University of Texas, *www.utexas.edu/research/ctr/pdf_reports/0_5178_1.pdf*.

BMCC and BTRC (2004), *The Outline of Beijing Transport Development*, Beijing Municipal Committee of Communication and Beijing Transport Research Center, Beijing.

Bowman, J.L., Ben-Akiva and M.E. (2001), *Activity-based disaggregate travel demand model system with activity schedules. Transportation Research Part A: Policy and Practice* 35, 1-28, *http://dx.doi.org/10.1016/S0965-8564(99)00043-9*.

Brueckner and Fansler (1983), "The economics of urban sprawl: Theory and evidence on the spatial sizes of cities", *Review of Economics and Statistics*, Vol. 65, No. 3, pp. 479-482.

CAAM (2010), "Automotives Statistics", *2010 China Vehicle Sales*, China Association of Automobile Manufacturers, Beijing, *www.caam.org.cn*, assessed March 12, 2016.

CAAM (2014), "Automotives Statistics", *2014 China Vehicle Sales*, China Association of Automobile Manufacturers, Beijing, *www.caam.org.cn*, assessed March 12, 2016.

Cai, H. and S. Xie (2007), "Estimation of vehicular emission inventories in China from 1980 to 2005", *Atmospheric Environment*, Vol. 41, pp. 8963-8979.

CAIT (2015), *CAIT Climate Data Explorer*, World Resources Institute, Washington, DC, *www.cait.wri.org*, assessed July 3, 2016.

Cambridge Systematics Inc. and Apogee Research (1996), "Measuring and Valuing Transit Benefits and Disbenefits: Summary," *Transit Cooperative Research Program Report 20*, Transport Research Board, National Academy Press.

Carruthers, R. et al. (2005), "Affordability of Public Transport in Developing Countries", *Transport Papers*, TP-3, January 2005, The World Bank Group, Washington, DC.

Cervero, R. and G. Arrington (2008), "Vehicle Trip Reduction Impacts of Transit-Oriented Housing", *Journal of Public Transportation*, Vol. 11.

Chambliss, S. et al. (2013), *The Impact of Stringent Fuel and Vehicle Standards on Premature Mortality and Emissions*, The International Council on Clean Transportation. *www.theicct.org/global-health-roadmap*.

Chattopadhyay, S. and E. Taylor (2012), "Do Smart Growth Strategies Have a Role in Curbing Vehicle Miles Traveled? A Further Assessment Using Household Level Survey Data", *The B.E. Journal of Economic Analysis and Policy*, Vol. 12.

Chen, G. and J. Kauppila (2017), "Global Urban Passenger Travel Demand and CO_2 Emissions to 2050: A New Model", presented at the 96th TRB Annual Meeting.

Daly, H. and B.P. Ó Gallachóir (2011), "Modelling private car energy demand using a technological car stock model", *Transportation Research Part D: Transport and Environment*, Vol. 16, pp. 93-101.

Downs, A. (2004), *Stuck in Traffic. Coping with Peak-Hour Traffic Congestion*, Brookings Institution Press, Washington, DC.

Downs, A. (1962), "The Law of Peak-Hour Expressway Congestion", *Traffic Quarterly*, Vol. 16/3, pp. 393-409.

Ewing, R. and R. Cervero (2010), "Travel and the built environment: a meta-analysis", *Journal of American Planning*, Vol. 76/3, pp. 265-294.

Franco et al. (2014), "Real-world exhaust emissions from modern diesel cars, a meta-analysis of PEMs emissions data from EU (EURO 6) and US (TIER 2 BIN 5/ULEV II) diesel passenger cars", *ICCT White Paper*.

Geerlings, H. and D. Stead (2003), "The integration of land use planning, transport and environment in European policy and research", *Transport Policy, Urban Transport Policy Instruments*, Vol. 10, pp. 187-196.

Geurs, K.T. et al. (2012), *Accessibility Analysis and Transport Planning. Challenges for Europe and North America*, Edward Elgar, Cheltenham, *www.elgaronline.com/view/9781781000106.xml*.

Geurs, K.T and B. van Wee (2004), "Accessibility evaluation of land-use and transport strategies: Review and research directions", *Journal of Transport Geography*, Vol. 12, 2004, pp. 127-140.

Greening, L.A. (2004), "Effects of human behavior on aggregate carbon intensity of personal transportation: comparison of 10 OECD countries for the period 1970-1993", *Energy Economics*, Vol. 26, pp. 1-30.

Handy, S.L. and D.A. Niemeier (1997), "Measuring Accessibility: An Exploration into Issues and Alternatives *Environment and Planning*, Vol. 29/7, pp. 1175-1194.

Hansen, W.G. (1959), "How accessibility shapes land use", *Journal of the American Institute of Planners*, Vol. 25, pp. 73-76.

He, D., H. Liu, K. He, F. Meng, Y. Jiang, M. Wang, J. Zhou, P. Calthorpe, J. Guo, Z. Yao, and Q. Wang (2013), "Energy Use of, and CO_2 Emissions from China's Urban Passenger Transport Sector – Carbon Mitigation Scenarios Upon the Transport Mode Choices", *Transport Research Part A*, Vol. 53, pp. 53-67.

Holz-Rau, C., J. Scheiner and K. Sicks (2014), "Travel Distances in Daily Travel and Long-Distance Travel: What Role is Played by Urban Form?" *Environment and Planning A*, Vol. 46, pp. 488-507.

IEA (2015), *Energy Technology Perspectives 2015*. OECD Publishing, Paris, *http://dx.doi.org/10.1787/energy_tech-2015-en*.

IEA (2016), *World Energy Outlook 2016*. IEA, Paris, *http://dx.doi.org/10.1787/weo-2016-en*.

ICCT (2014), *Global Transportation Roadmap Model*, *www.theicct.org/global-transportation-roadmap-model*.

ITDP (2016), *People Near Transit: Improving Accessibility and Rapid Transit Coverage in Large Cities*, New York.

ITF (2016), "Shared Mobility: Innovation for Liveable Cities", *International Transport Forum Policy Papers*, No. 21, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5jlwvz8bd4mx-en*.

ITF (2015), *Low-Carbon Mobility for Mega Cities: What Different Policies Mean for Urban Transport Emissions in China and India*. OECD, International Transport Forum, *www.itf-oecd.org/sites/default/files/docs/2016-01-19_report_china_india_bd.pdf*.

ITF, Eurostat and UNECE (2009), *Illustrated Glossary for Transport Statistics*.

Jovicic, G. and C.O. Hansen (2003), "A passenger travel demand model for Copenhagen", *Transportation Research Part A: Policy and Practice*, Vol. 37, pp. 333-349.

Kaufmann, T., L. Radaelli and E. Shmueli (2016), "Quantitative Land Use Planning: Deploying Data-Driven Methods in The Practice of City Planning", submitted for publication to the *Proceedings of the National Academy of Sciences of the United States of America*.

Kitamura, R., C. Chen, R.M. Pendyala and R. Narayanan (2000), "Micro-simulation of daily activity-travel patterns for travel demand forecasting", *Transportation*, Vol. 27, pp. 25-51.

Koppelman, F.S. and C. Bhat (2006), *A Self Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models*, US Department of Transportation, Federal Transit Administration 31.

Levinson, D. (2013), "Access Across America", *Center for Transportation Studies*, University of Minnesota, *http://access.umn.edu/research/america/auto/2013/*.

Litman, T. (2016), *Land-Use Impacts on Transport How Land Use Factors Affect Travel Behavior*, Victoria Transport Policy Institute, Canada.

Litman, T. (2004), "Transit price elasticities and cross-elasticities", *Journal of Public Transportation*, Vol. 7/3.

Litman, T. and D. Burwell (2006), "Issues in sustainable transportation", *International Journal of Global Environmental Issues*, Vol. 6, pp. 331-347.

Mandel, B., M. Gaudry and W. Rothengatter (1997), "A disaggregate Box-Cox Logit mode choice model of intercity passenger travel in Germany and its implications for high-speed rail demand forecasts", *Ann Reg Sci*, Vol. 31, pp. 99-120.

McGrath, D.T. (2005), "More evidence on the spatial scale of cities", *Journal of Urban Economics*, Vol. 58/1, pp. 1-10.

Metz, D. (2012), "Demographic determinants of daily travel demand", *Transport Policy*, Vol. 21, pp. 20-25.

Metz, D. (2010), "Saturation of Demand for Daily Travel", *Transport Reviews*, Vol. 30, pp. 659-674.

Meyer, I., S. Kaniovski and J. Scheffran (2012), "Scenarios for regional passenger car fleets and their CO_2 emissions", *Energy Policy, Modeling Transport (Energy) Demand and Policies*, Vol. 41, pp. 66-74.

Meyer, I., M. Leimbach and C.C. Jaeger (2007), "International passenger transport and climate change: A sector analysis in car demand and associated emissions from 2000 to 2050", *Energy Policy*, Vol. 35, pp. 6332-6345.

Meyer, M.D. (1999), "Demand management as an element of transportation policy: using carrots and sticks to influence travel behavior", *Transportation Research Part A: Policy and Practice*, Vol. 33, pp. 575-599.

Mills, D.E. (1981), "Growth, speculation and sprawl in a monocentric city", *Journal of Urban Economics*, Vol. 10/2, pp. 201-226.

Mokhtarian, P.L. and C. Chen (2004), "TTB or not TTB, that is the question: a review and analysis of the empirical literature on travel time (and money) budgets", *Transportation Research Part A: Policy and Practice*, Vol. 38, pp. 643-675.

Murray, A.T. et al. (1998), "Public Transportation Access", *Transport Research Part D: Transport and Environment*, Vol. 3/5, pp. 319-328.

Newman, P. and J. Kenworthy (2011), "Peak Car Use: Understanding the Demise of Automobile Dependence", *Journal of World Transport Policy and Practice*, Vol. 127, pp. 31-42.

OMNIL (2012), *Enquête Globale Transport, La mobilité en Ile-de-France*, Cahier Numéro 1.

Oueslati, W. et al. (2014), "Determinants of urban sprawl in European cities", *Urban Studies*, Vol. 52/9, pp. 1594-1614.

Owen, A. and D. Levinson (2015), "Access Across America: Walking 2014", *Center for Transportation Studies*, University of Minnesota, *http://access.umn.edu/research/america/walking/2014/documents/CTS15-03.pdf*.

Owen, A. and D. Levinson (2014), "Access Across America: Transit 2014", *Center for Transportation Studies*, University of Minnesota, *http://access.umn.edu/research/america/transit/2014/*.

Paez, A. (2016), "Access and social complexity: identifying and managing access requirements across social groups and across the world", in Sclar, C. et al., *Improving urban access. New approaches to funding transport investment*, Earthscan, London and New York, pp. 190-217.

Paulley, N., R. Balcombe, R. Mackett, H. Titheridge, J. Preston, M. Wardman, J. Shires and P. White (2006), "The demand for public transport: The effects of fares, quality of service, income and car ownership", *Transport Policy, Innovation and Integration in Urban Transport Policy*, Vol. 13, pp. 295-306.

Peralta, T. (2015), "Mobility for all: Getting the right urban indicator. Shifting from the proximity of transport to the accessibility of opportunities", *Connections*, Note 25, November 2015, The World Bank, *www.worldbank.org/en/topic/transport/brief/connections-note-25*.

Peralta, T. and S.R. Mehndiratta (2015), "Accessibility analysis of growth patterns in Buenos Aires. Density, employment and spatial form", *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 2512.

Pesaresi, M. and M. Carneiro Freire Sergio (2014), *Buref – producing a global reference layer of built-up by integrating population and remote sensing data*.

Poelman, H. and L. Dijkstra (2015), "Measuring access to public transport in European cities", *Regional Working Paper*, 01/2015, European Commission, *http://ec.europa.eu/regional_policy/sources/docgener/work/2015_01_publ_transp.pdf*.

Sander, G. et al. (2015), *Malaysia economic monitor: transforming urban transport*, Washington, DC, World Bank Group.

Shanzi, K. et al. (2009), "Determinants of urban spatial scale: Chinese cities in transition", *Urban Studies*, Vol. 46/13, pp. 1-19.

Schafer, A. (2012), "Introducing behavioral change in transportation into energy/economy/environment models", *Policy Research Working Paper Series*, No. 6234, The World Bank.

Schafer, A. (1998) "The global demand for motorized mobility", *Transportation Research Part A: Policy and Practice*, Vol. 32, pp. 455-477.

Schafer, A. and D.G. Victor (2000), "The future mobility of the world population", *Transportation Research Part A: Policy and Practice*, Vol. 34, pp. 171-205.

Schafer, A. and D.G. Victor (1999), "Global passenger travel: implications for carbon dioxide emissions", *Energy*, Vol. 24, pp. 657-679.

Schipper, L, C. Marie-Lilliu and R. Gorham, (2000), *Flexing the Link between Transport and Greenhouse Gas Emissions: A Path for the World Bank*, Washington, DC, World Bank.

Singh, S.K. (2006), "Future mobility in India: Implications for energy demand and CO_2 emission", *Transport Policy*, Vol. 13, pp. 398-412.

Sotheary, P. and M. Kunthear (2015), "Congestion costing $6 million a month", *The Phnom Penh Post*, *www.phnompenhpost.com/national/congestion-costing-6-million-month*, accessed 19 October 2016.

TERI (2015), *Unpublished Transport Data for Indian Cities*, The Energy and Resources Institute, New Delhi.

TfL (2010), *Travel in London Report 2*, Transport for London.

TomTom (2016), *TomTom Traffic Index. Measuring congestion worldwide*, *www.tomtom.com/fr_fr/trafficindex/*.

United Nations (2014), “World urbanization prospects: The 2014 Revision”, United Nations Publications, New York.

Viegas, J. and L. Martinez (2016), “Practical approaches to measuring access and social inclusion. Lessons from Lisbon”, in Sclar, C. et al., *Improving urban access. New approaches to funding transport investment*, Earthscan, London and New York, pp. 170-189.

Vovsha, P., E. Petersen and R. Donnelly (2002), “Microsimulation in Travel Demand Modeling: Lessons Learned from the New York Best Practice Model”, *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 1805, pp. 68-77.

Wang, Y., T.F. Welch, B. Wu, X. Ye and F.W. Ducca (2016), “Impact of transit-oriented development policy scenarios on travel demand measures of mode share, trip distance and highway usage in Maryland”, *KSCE J Civ Eng*, Vol. 20, pp. 1006-1016.

Wang, Y., J. Teter, and D. Sperling (2011), “China’s Soaring Vehicle Population: Even Greater Than Forecasted?” *Energy Policy*, Vol. 39, No. 6, pp. 3296-3306.

Wen, C.-H., Y.-C. Chiou and W.-L. Huang (2012), “A dynamic analysis of motorcycle ownership and usage: A panel data modeling approach”, *Accident Analysis & Prevention, PTW + Cognitive impairment and Driving Safet*y, Vol. 49, pp. 193-202.

WHO (2016), *Ambient air pollution: A global assessment of exposure and burden of disease*, World Health Organisation, Geneva.

Yan, X. and R.J. Crookes (2010), “Energy demand and emissions from road transportation vehicles in China”, *Progress in Energy and Combustion Science*, Vol. 36, pp. 651-676.

Zahavi, Y. and A. Talvitie (1980), “Regularities in Travel Time and Money Expenditures”, *Transportation Research Record: Journal of the Transportation Research Board*, pp.13-19.

ANNEX 5.A1

Data sources

Table 5.A1.1. **Data Sources**

Name	Description	Source
City List		
	Full list of cities with population above 300k by 2014	UN Habitat, WUP2014
Mode Shares		
	Percentage of trips (all purposes) by different type of modes	Various sources
	Main Source	The EPOMM Modal Split Tool - *www.epomm.eu/tems/result_cities.phtml?more=1*
	Other miscellaneous sources	National Household Travel Survey
		Statistic year books
		Reports from local transport authorities
		Reports from different research institutes and organizations
		Union Internationale des Transports Publics (UITP), Mobility in Cities Database
Transport Supply		
	Global road network	OpenStreetMap, *www.openstreetmap.org/*
	Global public transport network	OpenStreetMap, *www.openstreetmap.org/*
	Mobility in Cities Database	UITP
	World metro database	*http://mic-ro.com/metro/table.html*
	Rapid transit database	ITDP
	Public transport network and timetables	Various public transport operators and agencies based on the General Transit Feed Specification format (GTFS), *www.transitwiki.org/TransitWiki/index.php?title=General_Transit_Feed_Specification*
	Travel speeds	TomTom Traffic Index, *www.tomtom.com/en_gb/trafficindex/*
Urban Built-up Areas		
	BUREF – Global Built-up Reference Layer (BUREF2010) is a spatial raster dataset containing an estimation of the distribution and density of built-up areas using publicly available global spatial data related to the year 2010	European Commission, Joint Research Centre, *http://publications.jrc.ec.europa.eu/repository/handle/JRC90459*
	LANDSAT – Landsat represents the world's longest continuously acquired collection of space-based moderate-resolution land remote sensing data.	A joint initiative between the U.S. Geological Survey (USGS) and NASA, *http://landsat.usgs.gov//about_project_descriptions.php*
Population		
	Total population, urban population by country, cities with population above 300K	UN Habitat, WUP2014
	Worldpop population raster grid at continental scales for Africa, Asia, and Latin America and the Caribbean (spatial resolution of approx. 1km; year 2010).	Worldpop, *www.worldpop.org.uk/*
	National population raster grid for Australia (spatial resolution of approx. 1km; year 2011)	Australian Bureau of Statistics, *www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.0072011?OpenDocument*

Table 5.A1.1. **Data Sources** *(cont.)*

Name	Description	Source
	Geostat vector population grid for Europe (spatial resolution of approx. 1km; year 2011)	Eurostat and EFGS, *http://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/population-distribution-demography*
	National population vector grid for New Zealand (spatial resolution of approx. 1km; year 2011)	LINZ and Statistics New Zealand, *https://koordinates.com/layer/8707-nz-1km-pop-grid/*
	American Community Survey population layer at Census Block Group level for the United States of America (Census Block group level; year 2014)	American Community Survey, *www.census.gov/programs-surveys/acs/*
	Gridded Population of the World dataset (GPW version 4) to complement the above mentioned data sources for the following countries (Armenia, Azerbaijan, Bahrain, Canada, Cuba, Georgia, Iran, Iraq, Israel, Jordan, Kazakhstan, Kuweit, Kyrgizstan, Lebanon, Oman, Qatar, Republic of Moldova, Russia, Saudi Arabia, Serbia, State of Palestine, Syrian Arab Republic, Tajikistan, Turkey, Turkmenistan, Ukraine, United Arab Emirates, Uzbekistan, White Russia, Yemen).	GPW version 4, SEDAC, *http://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-count*
GDP		
	GDP, GDP per capita projection by country	OECD ECO department
	GDP by cell grid in 2010	LANDSAT
Car Ownership		
	Passenger Cars per 1000 inhabitant by country	IRF World Road Statistics 50th Anniversary (Data 2000-11)
Transport Prices		
	Transportation prices by city, e.g. gasoline per litre, monthly pass, one-way transit ticket, taxi per hour etc.	NUMBEO, open source, *www.numbeo.com/cost-of-living/prices_by_city.jsp*

ANNEX 5.A2

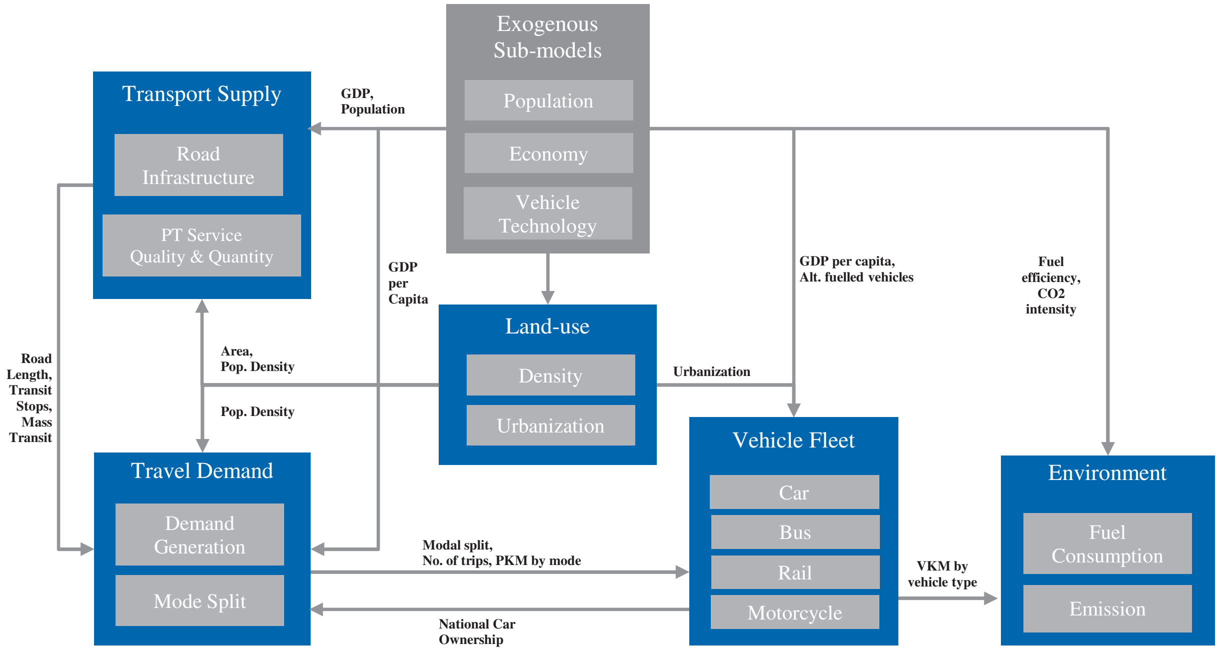
Methodology for the global urban passenger model

The scope of this study is all the urban agglomerations with population above 300 thousand, following the definition of UN World Population Prospects (2014 Revision). The full city list contains 1692 cities. The general model structure comprises six sub-models. The transport system is composed by three highly interrelated sub-models: Travel Demand, Transport Supply and Vehicle Fleet. The dynamics among the sub-models play a fundamental role in the quantitative analysis. The interaction between land-use and transport system is represented as Land-use sub-model influencing the mode choice and vehicle ownership and in turn being affected by the transport supply level. The Exogenous Sub-model contains the inputs of population, economy and vehicle technology providing exogenous drivers to the transport system. The outcomes of Vehicle Fleet sub-model feed into the Environment sub-model to compute the CO_2 emissions. The sub-models are structured as the following:

- Replicating the UN Habitat approach to project the urban population from 2030 to 2050;
- A sigmoid curve to forecast the GDP growth rates for the cities. The relationship between the national share of urban population concentration and the national share of urban GDP concentration follows an S-shaped curve;
- Regression models for urban transport supply, including road provision and public transport supply;
- Discrete choice model to estimate the modal split of each city;
- A sigmoid curve to forecast the passenger car ownership and assumptions to infer the share of other type of vehicles;
- CO_2 intensities and technological pathways by mode for converting vehicle activities into CO_2 emission (IEA, Mobility Model).

The urban boundary for each selected city is provided by the Global Built-up Reference Layer (BUREF2010) (Pesaresi and Carneiro Freire Sergio, 2014) and complimented by the space-based land remote sensing data LANDSAT of year 2010. This global urban boundary layer is used to intersect other GIS-based transport data layers to get the transport supply indicators for each urban area, such as the road and public transport supply within each urban boundary. The GDP at city level in the base year is estimated by redistributing the national GDP volume from the OECD Environment Directorate into the urban areas according to the GDP distribution map obtained from LANDSAT 2010, which provides GDP raster that measures the GDP density for each cell grid (1 square km resolution).

Figure 5.A2.1. **Modelling framework for the ITF global model for mobility in cities**



Transport Supply

The main source for road network and public transport network data is OpenStreetMap (*www.openstreetmap.org*). OpenStreetMap is an open data source and a collaborative project created with crowdsource approach, which encourages the volunteers worldwide to contribute through the collection of geographic data. Due to the nature of crowdsourcing approach, there are discrepancies in data quality across regions, countries and cities. To reduce the risk of data discrepancy, only five levels of main roads are considered, namely motorway, trunk, primary, secondary and tertiary. And some cities with poor public transport supply coverage are eliminated for the regression analysis.

The equations for the estimation of the total road network length and total number of public transport stops (bus, metro, tram, BRT, etc.) are the following,

$$rdLen_i = a_1 * pop_i^{\beta_1} * area_i^{\beta_2} * gcap_i^{\beta_3}$$

$$ptStops_i = a_2 * pop_i^{\beta_4} * area_i^{\beta_5} * gcap_i^{\beta_6}$$

Where, $rdLen_i$, $ptStops_i$, pop_i, $area_i$, $gcap_i$ are total road length, total number of public transport stops, urban area size and GDP per capita of city i, respectively. β is the estimated coefficient for each variable.

National car ownership

The historical car ownership (passenger car per 1000 inhabitant by country) data is collected from IRF with a time span from 2000 to 2011 that includes 169 countries of the world. The conceptualisation of the passenger car ownership model follows the study by Dargay et al. (Dargay et al., 2007). We build a passenger car ownership model that explicitly models the car saturation level as a function of observable urbanisation rate of each country. The elasticity of passenger car ownership with respect to per capita GDP follows an S-shaped curve, with car ownership rising slowly with income while income remains low, accelerating while income goes through medium levels, and slowing down again as incomes reach high levels.

$$carOwn_i = \frac{b_n + exp(u^*uRate_i)}{1 + exp(-gr_j^*(gcap_i - m_j))}$$

Where, *i* is the country, *n* is the continent, *j* is the income group, *uRate* is the urbanisation rate, *gcap* is the GDP per capita, b_n denotes the constant term of the saturation level, *u* is the coefficient for urbanisation rate, *gr* is the growth rate, and *m* is the midpoint of the curve.

Car ownership is modelled as the dependent variable in the first instance, based on urbanisation rate and per capita income. The predicted car ownership is then treated as an independent variable in the development of mode share models.

Transport costs

Fuel price (gasoline price per litre) at city level is mainly from an open source database Numbeo (*www.numbeo.com/*), and complemented by the national level data (pump prices of the most widely sold grade of gasoline) collected from World Bank. A city without fuel price data collected is assumed to have the same price as its closest city in the same country which has fuel price observed. If no such city was found, the fuel price level is assumed to be equal to the national average price collected from the World Bank. The fuel price growth rates by different country groups are taken from IEA's MoMo model to forecast the future fuel prices from 2010 to 2050.

Transit ticket price per trip is also collected from the same data source. A regression model is estimated to predict the transit ticket price in the future. The formulation is,

$$ptFare_i = c_j^*gcap_i^{\beta_7}$$

Where, c_j is the constant term of country group *j*, β_7 is the estimated coefficient of GDP per capita.

Parking price is collected from the a parking rate survey carried out by Colliers International in 2011 (Moore, 2011). Daily parking cost $parking_i$ is a function of car density (cars per square kilometre) $carDens_i$ and public transport stop density (number of public transport stops per square kilometre) $ptDens_i$.

$$parking_i = d^*carDens_i^{\beta_8}{}^*ptDens_i^{\beta_9}$$

Mode choice

Existing studies show that the aggregated mode share for each city is a function of urban development status, including urban scale, geography, economy, land use, personal behaviour and public policy (He et al., 2013, 2011; Norley, 2015). It aims to answer the questions on what are the impacts of urban development policies related to socio-economic development, car ownership, urban structure, road supply, public transport provision and pricing indicators on the aggregated modal split of a city. Mode shares are the parameters which are sensitive to the urban development policies. It is an alternative to the usual individual-based or trip-based behavioural logit models used in travel demand modelling. A standard multinomial logit model is applied.

$$P_{ni} = \frac{e^{U_{ni}}}{\sum_j e^{Unj}}$$

$$U_{C_i} = ASC_C + \beta_{cown}{}^*carOwn_i + \beta_{fpx}{}^*fPrice_i + \beta_{pk}{}^*pPark_i + \beta_{rds}{}^*rDens_i$$

$$U_{PT_i} = ASC_{PT} + \beta_{ptds}{}^{*}ptDens_i + \beta_{mast}{}^{*}mass_i + \beta_{tpx}{}^{*}\mathrm{ptFare}_i + \beta_{\mathrm{pds}_{PT}}{}^{*}\mathrm{popDens}_i$$

$$U_{W_i} = ASC_W + \beta_{pds_W}{}^{*}popDens_i + \beta_{gcap_W}{}^{*}gcap_i$$

$$U_{B_i} = ASC_B + \beta_{pds_B}{}^{*}popDens_i + \beta_{gcap_B}{}^{*}gcap_i$$

$$U_{M_i} = ASC_M + \beta_{pds_M}{}^{*}popDens_i + \beta_{gcap_M}{}^{*}gcap_i$$

Where, ASC is alternative specific constant, β is estimated coefficients, fPrice is fuel price, *pPark* is parking cost, ptFare is transit ticket price (single trip), rDens is road density, ptDens is density of public transport stops, mass is the availability of mass transit mode, gcap is GDP per capita, and C, PT, W, B, M are car, public transport, walk, bicycle, motorcycle, respectively.

The data set contained 247 observations, with an average weighted mode share in value of 42% for car, 30% for public transport, 18% for walk, 6% for bike and 3% for motorcycle. The calibrated model has $\rho^2 = 0.279$, showing a satisfactory explanatory power of the mode choice, and all the variables are statistically significant.

The values for the calibrated parameters, such as the preference factors, are plausible and in line with other studies that suggest higher preference for personal car as compared to public transport and bicycle to be the least preferred mode. All the coefficients are statistically significant. The calibrated coefficients indicate that car ownership and road density have positive impacts on the car use. Positive impacts of transit stop density and the availability of mass transit are found on the use of public transport. The pricing variables, namely, fuel price, parking cost and transit fare are found to have negative impacts on the use of corresponding mode. We find urban density to contribute positively to the ridership of public transport and the use of non-motorised modes and the values of the coefficients are higher in for the public transport, followd by walking and cycling. GDP per capita uses as proxy for income level is found to have negative impacts on the use of motorcycle and non-motorised modes. This finding is in line with the existing studies that the increasing income leads to the growing demand for faster and more convenient transport modes.

Trip rates and distances

Average trip rate in this study means number of trips per day per person considering all trip purposes. In trip generation analysis, the approach involves setting up model to represent the relationship between trip rates and the socio-economic characteristics. In this study, we used a simple regression analysis to find the relationship between the observed average trip rates from the household travel surveys and the GDP per capita.

Average travel distance is defined as the single trip distance regardless of trip purpose. We used the observed sample trip distances to establish a relationship between average distance by private vehicle and the urban area size. We also obtained average differences in travel distance between different modes, such as average travel distances by public transport is 45% longer than car, distance of a bike trip is usually around 32% of a car trip distance. Based on available data, we made such a simplified average value for all cities over our study time period. If more and better data are collected in the future, the trip rates and trip distance estimations will be enhanced. The methodology will be further improved by including more explanatory variables on travel distances by mode, such as land-use mix, population density, and possibility evolve over time as well.

Vehicle technology and CO_2 emission

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 IEA's MoMo model and the Energy Technologies Perspectives. The scenario used for the baseline is the four degree scenario (4DS) in the World Energy Outlook, 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.

ANNEX 5.A3

Detailed results for transport speed and densities

The following two tables give regional results for the main indicators used to examine the accessibility by car (Table 5.C1) and by public transport (Table 5.C2).

Table 5.A3.1. **Road speeds and density in cities**

		Density (thousand inhab./km^2)	Free flow speed (km/h)	Congested speed (km/h)	Speed loss due to congestion %
Cities > 3 millions	Transition	5.8	21.3	14.1	51
	North America	1.8	29.3	21.3	37
	Africa[1]	14.7	17.9	10.8	67
	OECD Pacific	1.8	33.6	24.3	38
	EEA + Turkey	3.4	26.7	19.1	40
	Latin America	8.4	19.9	13.2	50
	Asia	8.6	24.6	15.8	56
	Middle East	5.6	27.8	18.4	50
Cities > 1 million	Transition	2.8	19.7	12.6	57
	North America	1.6	26.7	19.7	35
	Africa[1]	7.0	17.2	10.4	65
	OECD Pacific	1.8	28.4	20.7	37
	EEA + Turkey	2.3	24.1	17.4	38
	Latin America	8.5	19.5	12.8	52
	Asia	7.5	21.2	13.3	60
	Middle East	6.3	24.8	16.3	52
Smaller cities	Transition	2.4	18.6	11.3	64
	North America	1.6	24.7	18.4	34
	Africa[1]	5.6	17.6	11.0	60
	OECD Pacific	1.4	25.8	19.1	35
	EEA + Turkey	2.1	22.5	16.1	39
	Latin America	4.5	17.6	11.7	51
	Asia	6.3	19.4	12.1	61
	Middle East	3.6	21.2	13.7	55

1. Density from African cities have been computed using a methodology that does not guarantee completely accurate and comparable results. It is most likely overestimated.

Table 5.A3.2. **Public transport speeds and provision in cities**

Urban area	Country	Area (km^2)	Density (thous. inhab./km^2)	Speed (km/h)	Bus provision (in number of bus calls/hour)	Mass transit provision (in number of vehicle calls/hour)
Baltimore and Washington, D.C.	USA	3 833	1.8	9.0	103 868	3 557
São Paulo	Brazil	2 488	7.9	9.2	759 835	5 467
Manila	Philippines	1 216	9.8	7.2	451 095	810
Ciudad de México (Mexico City)	Mexico	2 219	9.1	10.6	49 150	8 934
Al-Qahirah (Cairo)	Egypt	1 173	14.4	7.1	130 171	3 252
Toronto	Canada	1 827	3.4	10.4	16 5374	18 196
Vale do Aço and Belo Horizonte	Brazil	696	8.5	7.8	265 348	408
Madrid	Spain	3 242	1.8	11.3	321 996	9 021
Paris	France	3 144	3.3	15.2	302 693	184 881
San Jose and San Francisco	USA	1 924	2.6	7.9	28 532	1 279
Sydney	Australia	1 639	2.7	9.6	171 500	3 558
Roma (Rome)	Italy	2 370	1.7	8.4	604 54	5 533
Athínai (Athens)	Greece	550	5.6	6.8	21 499	2 882
Nairobi	Kenya	539	6.0	8.8	64 496	0
Berlin	Germany	1 336	2.6	16.4	210 507	62 169
Colorado Springs	USA	402	1.4	5.7	360	0
Adelaide	Australia	792	1.5	8.1	50 047	3 211
Austin	USA	702	2.0	7.8	11 661	236
Budapest	Hungary	1 374	1.3	9.8	25 310	12 308
Toulouse	France	596	1.5	8.0	16 271	2 003
Grenoble	France	322	1.5	7.6	4 866	3 039
Nantes	France	305	1.9	9.1	21 550	5 560
Wroclaw	Poland	163	3.9	7.7	10 875	3 633

ANNEX 5.A4

Scenario assumptions for Asian cities

The following three tables provide the declination at the city level of the assumptions of the three policy scenarios of the ITF model for mobility in cities.

Table 5.A4.1. **Chinese cities**

Scenario	Baseline		Robust Governance (ROG)		Integrated Land Use and Transport Planning (LUT)	
	2030	2050	2030	2050	2030	2050
Population Density	UN World Population Prospects	UN World Population Prospects	UN World Population Prospects	UN World Population Prospects	15% increase UN World Population Prospects	25% increase UN World Population Prospects
Public Transport Development						
Average Travel Time per Commute Trip (min)	53-58	53-58	53-58	53-58	37-41	21-23
BRT availability	Beijing and Guangzhou	Beijing and Guangzhou	Beijing and Guangzhou	Beijing and Guangzhou	All Cities	All Cities
Economic Instruments						
Fuel Tax Increase (%)	N/A	N/A	33 (similar to Korea)	63 (similar to Japan)	33 (similar to Korea)	63 (similar to Japan)
Parking Pricing (USD/hr)	0.78-2.35	0.78-2.35	1.40-4.23	2.03-6.11	1.40-4.23	2.03-6.11
Road Tolls	0.78	0.78	1.17	1.56	1.17	1.56
Bus Subsidy Increase (%)	N/A	N/A	30	50	30	50
Rail Subsidy Increase (%)	N/A	N/A	30	50	30	50
Governmental Regulations						
Annual Vehicle Registration Restriction						
Beijing	211 200	151 200	144 270	48 090	144 270	48 090
Shanghai	100 000	100 000	146 440	73 220	146 440	73 220
Guangzhou	120 000	120 000	136 482	68 241	136 482	68 241
Xi'an	N/A	N/A	100 000	73 904	100 000	73 904
Tianjin	100 000	90 000	90 000	68 820	90 000	68 820
Fuel Economy Standards						
All Cities	IEA 4DS	IEA 4DS	IEA 2DS	IEA 2DS	IEA 2DS	IEA 2DS

Table 5.A4.2. **Indian Cities**

Scenario	Baseline		Robust Governance (ROG)		Integrated Land Use and Transport Planning (LUT)	
	2030	2050	2030	2050	2030	2050
Population Density	UN World Population Prospects	UN World Population Prospects	UN World Population Prospects	UN World Population Prospects	15% increase UN World Population Prospects	25% increase UN World Population Prospects
Public Transport Development						
Average Travel Time per Commute Trip (min)	45-60	45-60	45-60	45-60	32-42	18-24
BRT availability	Delhi, Ahmedabad, Jaipur, and Indore	Delhi, Ahmedabad, Jaipur, and Indore	Delhi, Ahmedabad, Jaipur, and Indore	Delhi, Ahmedabad, Jaipur, and Indore	All Cities	All Cities
Economic Instruments						
Fuel Tax Increase (%)	N/A	N/A	63 (similar to Japan)	63 (Similar to Japan)	63 (similar to Japan)	63 (Similar to Japan)
Parking Pricing (USD/hr)	0.60-0.91	0.60-0.91	1.08-1.64	1.56-2.37	1.08-1.64	1.56-2.37
Road Tolls	0.61	0.61	0.92	1.22	0.92	1.22
Bus Subsidy Increase (%)	N/A	N/A	30	50	30	50
Rail Subsidy Increase (%)	N/A	N/A	30	50	30	50
Governmental Regulations						
Fuel Economy Standards						
All Cities	IEA 4DS	IEA 4DS	IEA 2DS	IEA 2DS	IEA 2DS	IEA 2DS

Table 5.A4.3. **Southeast Asian Cities**

Scenario	Baseline		Robust Governance (ROG)		Integrated Land Use and Transport Planning (LUT)	
	2030	2050	2030	2050	2030	2050
Public Transport Development						
Average Travel Time[1] Decrease (%)	N/A	N/A	N/A	N/A	30	60
Economic Instruments						
Fuel Tax Increase (%)	N/A	N/A	33 (similar to Korea)	63 (similar to Japan)	33 (similar to Korea)	63 (similar to Japan)
Parking Pricing Increase (%)	N/A	N/A	80	160	80	160
Road Tolls	N/A	N/A	USD 1.02	USD 1.36	USD 1.02	USD 1.36
Bus Subsidy Increase (%)	N/A	N/A	30	50	30	50
Rail Subsidy Increase (%)	N/A	N/A	30	50	30	50
Governmental Regulations						
Fuel Economy Standards						
All Cities	IEA 4DS	IEA 4DS	IEA 2DS	IEA 2DS	IEA 2DS	IEA 2DS

1. Based on household travel survey data from each city. In the Baseline and ROG scenarios, the travel time for all modes used in the mode choice and emission models were all from the household travel survey data. In the LUT scenario, travel time for bus and train would decrease by 30% in 2030 and by 60% in 2050.

Statistical annex

Rail freight transport

Million tonne-kilometres

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	52	46	66	50	25	23	40	23
Armenia	705 e	718 e	743 e	816 e	867 e	851 e	786	640
Australia	218 684	237 163	258 624	261 420 e	290 570 e	..	..	372 580
Austria	21 915	17 767	19 833	20 345	19 499	19 320	20 494	20 266
Azerbaijan	10 021	7 592	8 250	7 845	8 212	7 958	..	..
Belarus	48 994	42 274	46 224	47 384 e	48 475 e	43 143 e	..	..
Belgium	8 469	5 947	6 264 e	6 698 e	..	..	..	..
Bosnia-Herzegovina	1 242	992	877	1 018	1 150	1 243	..	..
Bulgaria	4 693	3 145	3 064	3 291	2 908	3 246	3 439	3 650
Canada	236 842	216 287	240 292	248 468	256 622	258 617	277 402	282 780 p
China	2 510 628	2 523 917	2 764 413	2 946 579	2 918 709	2 917 390	2 753 020	..
Croatia	3 312	2 641	2 618	2 438	2 332	2 086	2 119	2 183
Czech Republic	15 437	12 791	13 770	14 316	14 266	13 965	14 574	15 261
Denmark	1 863	1 696	2 240	2 614	2 278	2 448	2 453	..
Estonia	5 943	5 934	6 638	6 271	5 129	4 722	3 256	..
Finland	10 777	8 872	9 750	9 395	9 275	9 470	9 596	8 468
France	40 436	32 129	29 965	34 202	32 539	32 010	32 217	..
FYROM[1]	743	497	525	479	423	421	411	278
Georgia	6 515	5 417	6 228	6 055	5 976	5 526	4 988	4 261
Germany	115 652	95 834	107 317	113 317	110 065	112 613	112 629	116 632
Greece	786	537	601	352	283 e	238 e	343 e	294
Hungary	9 874	7 673	8 809	9 118	9 230	9 722	10 158	10 010
Iceland	x	x	x	x	x	x	x	x
India	551 448	600 546	625 723	667 607	649 645	665 810	681 698	685 925
Ireland	103	79	92	105	91	99	100	96
Italy	21 981	17 791 |	18 616	19 787	20 244	19 037	20 072	17 984 e
Japan	22 256	20 562	20 398	19 998	20 471	21 071	21 029	..
Korea	11 566	9 273	9 452	9 997	10 271	10 459	9 564	..
Latvia	19 581	18 725	17 179	21 410	21 867	19 532	19 441	18 906
Liechtenstein	17	10	11	10	10	9	..	..
Lithuania	14 748	11 888	13 431	15 088	14 172	13 344	14 307	14 036
Luxembourg	280	200	309	270	231	218	208	207
Malta	x	x	x	x	x	x	x	x
Mexico	74 582	69 185	78 771	79 729	79 353	77 717	..	..
Moldova, Republic of	2 873	1 058	959	1 196	960	1 227	1 182	963
Montenegro, Republic of	184	101	151	136	73	105	94	..
Netherlands	6 984	5 578	5 925	6 378	6 142	6 077	6 170	6 472
New Zealand	4 556	3 962	3 919	4 178	4 581	4 547	4 492	4 450
Norway	3 629	3 506	3 498	3 574	3 489	3 383	3 539	3 498
Poland	52 043	43 554	48 795	53 746	48 903	50 881	50 073	50 603
Portugal	2 549	2 174	2 313	2 322	2 421	2 290	2 438	2 661
Romania	15 236	11 088	12 375	14 719	13 472	12 941	12 264	..
Russian Federation	2 116 240	1 865 305	2 011 308	2 127 835	2 222 389	2 196 217	2 300 532	2 305 945
Serbia, Republic of	4 339	2 967	3 522	3 611	2 769	3 022	2 988	3 248
Slovak Republic	9 299	6 964	8 105	7 960	7 591	8 494	8 829	8 439
Slovenia	3 520	2 668	3 421	3 752	3 470	3 799	4 110	4 175
Spain	10 287	7 391	7 872	8 018	7 477	7 394	7 603	..
Sweden	22 924	20 389 |	23 464	22 864	22 043	20 970	21 296	20 583
Switzerland	12 265	10 565	11 074	11 526	11 061	11 812	12 313	12 431
Turkey	10 739	10 326	11 462	11 677	11 670	11 177	11 992	10 474
Ukraine	257 007	196 188	218 091	243 866	237 722	224 434 e	..	..
United Kingdom	21 077	19 171	18 576	20 974	21 467	22 401	22 143	19 342
United States	2 525 364	2 309 811	2 491 450	2 524 667	2 500 300	2 541 355	2 702 743	..

.. Not available; | Break in series; e Estimated value; x Not applicable; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ba8d.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Road freight transport

Million tonne-kilometres

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	4 098 e	4 445 e	4 626 e	3 805 e	3 223 e	3 497 e	..	..
Armenia	1 034 e	182	236	287	401	484	544	479
Australia	187 585	179 266	184 330	188 434	193 035	199 344	205 735	212 010
Austria	18 160	16 276	16 539	16 997	16 143	15 524	16 605	17 161
Azerbaijan	10 317	11 021	11 728	12 776	13 744	14 575	..	..
Belarus	22 767	..	..	..	..	..	..	..
Belgium	38 356	36 174	35 001	33 107	32 105	32 795	31 808	31 729
Bosnia-Herzegovina	1 873	1 711	..	1 718	2 310	2 658	..	..
Bulgaria	15 321	17 741	19 454	21 212	24 387	27 237	27 922	32 350
Canada	129 380	118 903	135 294	136 393	143 043	143 921	166 580	..
China	3 286 819 |	3 718 882	4 338 967	5 137 474	5 953 486	5 573 810	6 101 660	..
Croatia	11 042	9 429	8 780	8 927	8 649	9 133	9 381	10 439
Czech Republic	50 877	44 954	51 833	54 830	51 228	54 893	54 092	58 714
Denmark	10 718	10 002	10 573	12 025	12 292	12 222	12 950	..
Estonia	7 026	5 249	5 611	5 913	5 793	5 987	6 308	..
Finland	31 035	27 657	30 337	26 917	25 458	24 429	23 401	24 485
France	195 515	166 052	174 409	177 993	165 808	165 315	159 530	..
FYROM[1]	3 978	4 035	4 235	8 933 |	8 965	7 466	10 622	10 192
Georgia	600	611	620	628	637	646	655	664
Germany	341 550	307 575	313 097	323 848	307 106	305 781	310 142	..
Greece	16 960 e	16 940 e	20 146 e	20 426	20 416	19 203 p	19 223	19 763
Hungary	35 744	35 373	33 720	34 529	33 735	35 817	37 517	38 352
Iceland	805 e	813 e	806 e	777 e	786 e	808 e	850 e	911 e
India	920 000	1 015 000	1 128 000	1 212 000	1 266 302 e	1 333 163 e	1 409 953 e	1 495 678 e
Ireland	17 290	12 068	10 924	9 941	9 895	9 138	9 772	9 844
Italy	165 385	156 341	162 509	135 148	118 100	120 161	110 411	..
Japan	346 420	334 667	246 175 |	233 956	209 956	214 092	210 008	..
Korea	101 437	99 089	102 808	104 476	108 365	118 582	124 650	..
Latvia	12 344	8 115	10 590	12 131	12 178	12 816	13 670	14 690
Liechtenstein	330	264	305	312	281	318	..	..
Lithuania	20 419	17 757	19 398	21 512	23 449	26 338	28 067	26 485
Luxembourg	9 566 e	8 400	8 657	8 837	6 550	7 214	7 912	7 095
Malta	..	..	..	..	..	..	..	..
Mexico	227 290	211 600	220 285 |	226 900	233 464	235 427	..	..
Moldova, Republic of	2 966	2 707	3 057	3 583	3 922	5 238	5 152	5 091
Montenegro, Republic of	137	179	167	102	76	67	122	..
Netherlands	37 092	36 333	30 114	30 344	28 718	31 845	32 033	32 237
New Zealand	20 898	17 613	20 050	20 534	20 944	21 286	23 301	..
Norway	17 763	16 245	17 334	17 167	18 087	19 712	20 297	..
Poland	174 223	191 484	214 204	218 888	233 310	259 708	262 860 |	273 107
Portugal	38 950	35 356	34 640	37 472	32 274	39 624	36 336	34 524
Romania	56 377	34 265	25 883	26 347	29 662	34 026	35 135	..
Russian Federation	216 276	180 136	199 341	222 823	248 862	250 054	246 784	232 549
Serbia, Republic of	1 112	1 185	1 689	1 907	2 474	2 824	2 959	2 973
Slovak Republic	29 094	27 484	27 411	29 045	29 504	30 005	31 304	33 525
Slovenia	2 635	2 276	2 289	2 176	1 849	1 889	2 062	2 069
Spain	242 978	211 891	210 064	206 840	199 205	192 594	195 763	209 387
Sweden	37 933	32 118	32 738	33 417	37 305 |	38 629	38 808	38 102
Switzerland	17 130	16 775	16 906	17 372	17 109	17 241	17 541	..
Turkey	181 935	176 455	190 365	203 072	216 123	224 048	234 492	244 329
Ukraine	19 800	33 193	34 391	38 596	38 951	..	..	..
United Kingdom	161 600	140 854	153 829	155 043 |	160 423 |	148 626 |	144 935 |	160 893
United States	4 018 805	3 576 215	3 668 077	3 859 535	..	..	..	..

.. Not available; | Break in series; e Estimated value; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ba8d.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Inland waterway freight transport

Million tonne-kilometres

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	x	x	x	x	x	x	x	x
Armenia	x	x	x	x	x	x	x	x
Australia	x	x	x	x	x	x	x	x
Austria	2 359	2 003	2 375	2 123	2 191	2 353	2 177	1 806
Azerbaijan	x	x	x	x	x	x	x	x
Belarus	132	..	..	..	..	..	..	..
Belgium	8 746	7 086	8 210	9 251 e	10 420	10 365	10 451	10 426
Bosnia-Herzegovina	x	x	x	x	x	x	x	x
Bulgaria	1 936	1 794	1 813	1 422	1 397	1 196	971	1 081
Canada	22 800	21 059	23 934	25 000 e	26 300 e	26 600 e	..	..
China	1 741 170	1 803 267	2 242 853	2 606 884	2 829 548	3 073 028	3 683 960	..
Croatia	843 |	727	941	692	772	771	716	879
Czech Republic	863	641	679	695	669	693	656	585
Denmark	x	x	x	x	x	x	x	x
Estonia	..	..	..	..	..	..	..	..
Finland	80	61	76	90	124	121	136	130
France	7 504	7 423	8 060	7 864	7 830	7 912	7 752	..
FYROM[1]	x	x	x	x	x	x	x	x
Georgia	x	x	x	x	x	x	x	x
Germany	64 061	55 497	62 278	55 027	58 488	60 070	59 093	55 315
Greece	x	x	x	x	x	x	x	x
Hungary	2 250	1 831	2 393	1 840	1 982	1 924	1 811	1 824
Iceland	x	x	x	x	x	x	x	x
India	2 950	3 710	4 030	3 800	3 063	2 418	2 829	..
Ireland	x	x	x	x	x	x	x	x
Italy	64	76	135	144	81	89	64	..
Japan	x	x	x	x	x	x	x	x
Korea	x	x	x	x	x	x	x	x
Latvia	0	0	0	0	0	0	0	0
Liechtenstein	x	x	x	x	x	x	x	x
Lithuania	13	4	4	4	2	1	1	1
Luxembourg	366	279	359	305	290	315	285	235
Malta	x	x	x	x	x	x	x	x
Mexico	x	x	x	x	x	x	x	x
Moldova, Republic of	1	1	0	1	1	1	1	0
Montenegro, Republic of	x	x	x	x	x	x	x	x
Netherlands	44 446	35 638	46 592	47 303	47 520	48 600	48 535	49 425
New Zealand	x	x	x	x	x	x	x	x
Norway	x	x	x	x	x	x	x	x
Poland	1 274	1 020	1 030	909	815	768	779	2 187
Portugal	..	..	..	..	..	..	..	..
Romania	8 687	11 765 |	14 317	11 409	12 520	12 242	11 760	..
Russian Federation	63 705	52 686	53 955	59 144	80 762 |	80 101	72 317	63 625
Serbia, Republic of	1 369	1 114	875	963	605	701	759	859
Slovak Republic	1 101	899	1 189	931	986	1 006	905	741
Slovenia	x	x	x	x	x	x	x	x
Spain	x	x	x	x	x	x	x	x
Sweden	x	x	x	x	x	x	x	x
Switzerland	..	..	..	..	..	..	..	..
Turkey	x	x	x	x	x	x	x	x
Ukraine	4 498	2 745	3 837	2 218	1 748	..	..	..
United Kingdom	160	133	125	143	157	211	169	..
United States	454 376	406 608	450 529	464 667	461 927	438 253	482 977	..

.. Not available; | Break in series; e Estimated value; x Not applicable

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ba8d.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Oil pipeline transport

Million tonne-kilometres

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	4	6	2	x	x	x	x	x
Armenia	1 958 e	1 688 e	2 103 e	2 470 e	2 876 e	2 750 e	2 837	2 624
Australia	x	x	x	x	x	x	x	x
Austria	7 521	7 304	7 000	7 228	7 146	8 392	8 259	8 475
Azerbaijan	62 434	73 195	72 931	65 850	63 172	63 734	..	..
Belarus	x	x	x	x	x	x	x	x
Belgium	1 450 e	1 450	1 450	1 450	..	..	..	..
Bosnia-Herzegovina	x	x	x	x	x	x	x	x
Bulgaria	420	436	415	481	573	633	583	661
Canada	124 000	123 200	124 300	151 200	165 000	175 400	192 400	213 600
China	194 403	202 242	219 719	288 544	321 100	349 600	432 800	..
Croatia	1 677	1 797	1 703	1 477	1 216	1 485	1 447	1 740
Czech Republic	2 315	2 156	2 191	1 954	1 907	1 933	2 063	2 023
Denmark	4 209	3 895	3 547	3 265	3 078	2 739	2 409	..
Estonia	x	x	x	x	x	x	x	x
Finland	x	x	x	x	x	x	x	x
France	20 918	19 481	17 607	17 207	15 151	11 521	11 115	..
FYROM[1]	164	144	123	98	37	..	6 |	6
Georgia	..	..	..	..	..	..	..	..
Germany	15 670	15 950	16 259	15 623	16 207	18 180	17 541	17 714
Greece	x	x	x	x	x	x	x	x
Hungary	5 637	5 262	5 623	5 581	5 802	5 694	5 801	5 305
Iceland	x	x	x	x	x	x	x	x
India	107 230	120 360	123 060	134 800	141 660	..	..	..
Ireland	x	x	x	x	x	x	x	x
Italy	11 266	10 497	10 400	9 954	10 066	10 024	9 555	9 667 e
Japan	x	x	x	x	x	x	x	x
Korea	x	x	x	x	x	x	x	x
Latvia	2 097	1 573	2 350	2 439	2 631	2 279	2 376	1 965
Liechtenstein	x	x	x	x	x	x	x	x
Lithuania	527	410	579	591	632	563	567	496
Luxembourg	x	x	x	x	x	x	x	x
Malta	x	x	x	x	x	x	x	x
Mexico	..	..	..	..	..	..	..	..
Moldova, Republic of	x	x	x	x	x	x	x	x
Montenegro, Republic of	x	x	x	x	x	x	x	x
Netherlands	5 967	5 622	5 647	5 502	5 572	5 405	5 837	6 044
New Zealand	x	x	x	x	x	x	x	x
Norway	3 827	3 854	3 440	3 065	2 721	2 724	2 845	..
Poland	21 247	22 908	24 157	23 461	22 325	20 112	20 543	21 843
Portugal	450	413	383	364	360	350	371	391
Romania	1 720	1 243	996	879	785	829	984	..
Russian Federation	1 112 852	1 122 802	1 122 964	1 120 140	1 187 627	1 223 931	1 220 442	1 268 535
Serbia, Republic of	462	402	381	311	295	381	355	923
Slovak Republic	..	..	..	..	..	..	..	..
Slovenia	x	x	x	x	x	x	x	x
Spain	9 141	8 232	8 182	8 601	8 900	8 691	8 967	10 115
Sweden	x	x	x	x	x	x	x	x
Switzerland	248	233	218	203	183	228	234	113 |
Turkey	36 402	45 111	39 636	44 690	37 362	26 714	15 331	52 514
Ukraine	32 120	28 256	18 688	14 292	10 607	..	..	..
United Kingdom	10 180	10 185	10 309	10 024	9 914	..	..	..
United States	884 305	829 848	831 308	881 385	..	..	..	..

.. Not available; | Break in series; e Estimated value; x Not applicable

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ba8d.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Total inland freight transport

Million tonne-kilometres

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	4 154	4 497	4 694	3 855	3 248	3 520	..	..
Armenia	3 697 e	2 588 e	3 082 e	3 573 e	4 144 e	4 085 e	4 167	3 743
Australia	391 045	416 429	442 954	449 854 e	483 605 e	..	..	584 590
Austria	49 955	43 350	45 747	46 693	44 979	45 589	47 535	47 708
Azerbaijan	82 772	91 808	92 909	86 471	85 128	86 267	..	..
Belarus	71 893	..	..	..	..	..	..	..
Belgium	57 021 e	50 657	50 925 e	50 506 e	..	..	..	..
Bosnia-Herzegovina	3 115	2 703	..	2 736	3 460	3 901	..	..
Bulgaria	22 370	23 116	24 746	26 406	29 265	32 312	32 915	37 742
Canada	513 022	479 449	523 820	561 061	590 965	604 538	..	..
China	7 733 020 |	8 248 308	9 565 952	10 979 481	12 022 843	11 913 828	12 971 440	..
Croatia	16 874 |	14 594	14 042	13 534	12 969	13 475	13 663	15 241
Czech Republic	69 492	60 542	68 473	71 795	68 070	71 484	71 385	76 582
Denmark	16 790	15 593	16 360	17 904	17 648	17 409	17 812	..
Estonia	12 969	11 183	12 249	12 184	10 922	10 709	9 564	..
Finland	41 892	36 590	40 163	36 402	34 857	34 020	33 133	33 083
France	264 373	225 085	230 041	237 266	221 328	216 757	210 613	..
FYROM[1]	4 885	4 676	4 883	9 510 |	9 425	7 887	11 039	10 476
Georgia	..	..	..	..	..	..	..	..
Germany	536 933	474 856	498 951	507 815	491 866	496 644	499 405	..
Greece	17 746 e	17 477 e	20 747 e	20 778 e	20 699 e	19 441 p	19 566 e	20 057
Hungary	53 505	50 139	50 545	51 068	50 749	53 157	55 287	55 490
Iceland	805 e	813 e	806 e	777 e	786 e	808 e	850 e	911 e
India	1 581 630	1 739 618	1 881 090	2 018 600	2 056 723	..	..	..
Ireland	17 393	12 147	11 016	10 046	9 986	9 237	9 872	9 940
Italy	198 696	184 705 |	191 660	165 033	148 491	149 311	140 102	..
Japan	368 676	355 229	266 573 |	253 954	230 427	235 163	231 037	..
Korea	113 003	108 362	112 260	114 473	118 636	129 041	134 214	..
Latvia	34 022	28 413	30 119	35 980	36 676	34 627	35 487	35 561
Liechtenstein	347	274	316	322	291	327	..	..
Lithuania	35 707	30 059	33 412	37 195	38 255	40 246	42 942	41 018
Luxembourg	10 212 e	8 879 e	9 325 e	9 412 e	7 071 e	7 747 e	8 405	7 537
Malta	..	..	..	..	..	..	..	..
Mexico	301 872	280 785	299 056 |	306 629	312 817	313 144	..	..
Moldova, Republic of	5 840	3 766	4 016	4 780	4 883	6 466	6 335	6 054
Montenegro, Republic of	321	280	318	238	149	172	216	..
Netherlands	94 489	83 171	88 278	89 527	87 952	91 927	92 575	94 178
New Zealand	25 454	21 575	23 969	24 712	25 525	25 833	27 793	..
Norway	25 219	23 605	24 272	23 806	24 297	25 819	26 681	..
Poland	248 787	258 966	288 186	297 004	305 353	331 469	334 255 |	347 740
Portugal	41 949	37 943	37 336	40 158	35 055	42 264	39 145	37 576
Romania	82 020	58 361 |	53 571	53 354	56 439	60 038	60 143	..
Russian Federation	3 509 073	3 220 929	3 387 568	3 529 942	3 739 640 |	3 750 303	3 840 075	3 870 654
Serbia, Republic of	7 282	5 668	6 467	6 792	6 143	6 928	7 061	8 003
Slovak Republic	39 494	35 347	36 705	37 936	38 081	39 505	41 038	42 705
Slovenia	6 155	4 944	5 710	5 928	5 319	5 688	6 172	6 244
Spain	262 406	227 514	226 118	223 459	215 582	208 679	212 333	..
Sweden	60 857	52 507 |	56 202	56 281	59 348 |	59 599	60 104	58 685
Switzerland	29 643	27 573	28 198	29 101	28 353	29 281	30 088	..
Turkey	229 076	231 892	241 463	259 439	265 155	261 939	261 815	307 317
Ukraine	313 425	260 382	275 007	298 972	289 028	..	..	..
United Kingdom	193 017	170 343	182 839	186 183 e	191 961	..	..	..
United States	7 882 850	7 122 482	7 441 364	7 730 254	..	..	..	..

.. Not available; | Break in series; e Estimated value; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ba8d.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Coastal shipping

National transport

Million tonne-kilometres

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	..	..	..	..	..	..	..	..
Armenia	x	x	x	x	x	x	x	x
Australia	121 916	109 622	116 208	113 357	102 577	104 462	105 404	..
Austria	x	x	x	x	x	x	x	x
Azerbaijan	6 076	6 173	4 859	5 186	5 062	4 632	..	..
Belarus	x	x	x	x	x	x	x	x
Belgium	..	..	..	..	..	..	..	..
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	..	..	..	..	..	..	..	..
Canada	27 852	26 678	29 547	31 735	..	..	..	..
China	3 285 100	3 952 400	4 599 900	4 935 500	5 341 200	4 870 500	..	..
Croatia	248	214	210	217	222	211	205	217
Czech Republic	x	x	x	x	x	x	x	x
Denmark	..	..	..	..	..	..	..	..
Estonia	..	..	..	..	..	..	..	..
Finland	2 937	2 513	3 621	3 966	2 840	1 900	2 010	2 180
France	..	..	..	..	..	..	..	..
FYROM[1]	x	x	x	x	x	x	x	x
Georgia	..	..	..	..	..	..	..	..
Germany	..	..	..	..	..	..	..	..
Greece	x	x	x	x	x	x	x	x
Hungary	x	x	x	x	x	x	x	x
Iceland	48	57	47	43	12	32	13	..
India	..	..	..	..	..	..	..	..
Ireland	..	..	..	..	..	..	..	..
Italy	47 017 e	49 173 e	53 156 e	53 708 e	50 287 e	49 112 e	52 961 e	54 519 e
Japan	187 859	167 135	179 898	174 900	177 791	184 860	183 120	180 381
Korea	29 590	25 249	23 281	27 220	25 804	30 476	29 848	..
Latvia	..	..	..	..	..	..	..	..
Liechtenstein	x	x	x	x	x	x	x	x
Lithuania	x	x	x	x	x	x	x	x
Luxembourg	x	x	x	x	x	x	x	x
Malta	..	..	..	..	..	..	..	..
Mexico	..	..	..	..	..	..	..	..
Moldova, Republic of	x	x	x	x	x	x	x	x
Montenegro, Republic of	x	x	x	x	x	x	x	x
Netherlands	..	..	..	..	..	..	..	..
New Zealand	..	..	..	..	..	..	..	..
Norway	22 860	22 141	18 703	19 717	18 432	20 663	21 058	..
Poland	..	..	..	..	..	..	..	..
Portugal	..	..	..	..	..	..	..	..
Romania	..	..	..	..	..	..	..	..
Russian Federation	12 450	12 042	12 640	13 239	12 138 |	12 133	13 126	14 956
Serbia, Republic of	x	x	x	x	x	x	x	x
Slovak Republic	x	x	x	x	x	x	x	x
Slovenia	x	x	x	x	x	x	x	x
Spain	45 396	40 040	41 666	42 811	41 761	40 773	41 848	44 977 p
Sweden	8 255	6 504	7 851	7 794 |	6 892	6 764	6 637	6 923
Switzerland	x	x	x	x	x	x	x	x
Turkey	11 114	11 397	12 569	15 961	17 158	19 725	18 553	19 189
Ukraine	..	..	..	2 747	1 702	..	..	..
United Kingdom	48 400	47 600	40 800	41 600	34 000	28 000	26 000	..
United States	303 495	286 578	280 822	263 105	229 349	239 158	251 801	..

.. Not available; | Break in series; e Estimated value; x Not applicable; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ba8d.

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1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Rail container transport

Twenty-foot equivalent unit (TEU)

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	..	..	..	..	..	..	..	..
Armenia	..	..	..	..	..	..	15 735	..
Australia	..	..	..	..	..	..	..	..
Austria	1 358 667	1 104 894	1 310 989	1 356 994	1 278 267	1 148 801	1 169 566	1 156 260
Azerbaijan	13 553	13 851	13 582	16 797	19 264	17 396	..	..
Belarus	..	..	..	..	..	..	..	..
Belgium	864 031	749 417	..	..	..	..	..	..
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	102 211	109 818	57 297	51 387	53 272	63 725	35 419	37 807
Canada	3 205 834	2 952 584	3 235 761	3 315 391	3 559 595	3 686 321	3 897 973	4 071 322
China	..	..	..	..	..	..	..	..
Croatia	96 577	64 786	69 583	44 214	37 744	41 299	40 792	34 115
Czech Republic	997 974	876 747	1 051 439	1 111 464	1 157 228	1 274 125	1 336 973	1 476 907
Denmark	210 925	161 827	197 945	198 763	157 306	166 870	137 144	..
Estonia	21 190	17 355	22 484	34 967	48 863	62 014	72 019	..
Finland	133 644	89 318	70 204	60 174	43 105	42 211	41 137	33 434
France	..	..	..	..	..	..	..	..
FYROM[1]	..	..	..	..	..	..	..	..
Georgia	40 117	30 727	45 923	43 856	55 798	48 083	49 339	44 022
Germany	6 023 299	5 078 291	5 614 553	5 921 037	6 228 484	6 456 060	6 272 430	5 979 000
Greece	88 473	56 550	51 009	65 175	..	..	..	..
Hungary	447 944	452 273	568 685	520 752	386 746	519 480	448 166	651 093
Iceland	x	x	x	x	x	x	x	x
India	2 308 000	2 421 000	2 562 000	2 604 000	2 586 000	2 869 000	3 111 000	2 920 000
Ireland	4 896	4 340	13 472	14 280	13 776	14 784	15 330	14 910
Italy	1 291 673	864 525	649 259	563 196	752 433	767 503	789 217	710 969
Japan	..	..	..	..	..	..	..	..
Korea	..	..	..	..	..	..	..	..
Latvia	52 759	71 142	98 223	101 099	111 117	97 710	97 028	69 813
Liechtenstein	x	x	x	x	x	x	x	x
Lithuania	101 711	70 247	78 188	102 297	104 171	103 952	90 745	69 964
Luxembourg	26 967	33 892	..	..	..	..	..	..
Malta	x	x	x	x	x	x	x	x
Mexico	..	..	..	..	..	..	..	..
Moldova, Republic of	3 525	1 922	1 914	1 774	1 463	2 015	1 883	365
Montenegro, Republic of	..	..	..	..	..	..	..	..
Netherlands	1 077 777	1 026 295	921 108	939 808	1 539 810	1 300 000	1 406 000	1 441 000
New Zealand	..	..	..	..	..	..	..	..
Norway	552 003	519 954	493 386	412 043	386 620	332 653	324 653	475 909
Poland	706 804	426 619	569 759	783 338	1 026 181	1 091 888	1 072 627	1 098 698
Portugal	82 664	88 032	171 146	185 456	191 895	183 583	262 337	367 905
Romania	230 829	145 065	196 328	125 372	91 465	61 474	54 995	..
Russian Federation	..	..	..	..	..	..	..	..
Serbia, Republic of	..	..	..	..	..	..	..	..
Slovak Republic	374 672	314 700	449 429	585 669	526 643	593 281	636 652	621 315
Slovenia	256 449	222 740	325 556	385 194	395 945	390 507	398 621	458 449
Spain	..	..	..	..	..	..	..	..
Sweden	416 973	533 876 |	536 934	486 271	450 303	433 918	430 588	411 664
Switzerland	..	..	..	..	..	..	..	..
Turkey	319 583	439 936	451 710	659 004	707 989	814 981	891 605	713 504
Ukraine	255 014	109 217	167 535	214 634	262 455	..	..	..
United Kingdom	..	..	..	..	..	..	..	..
United States	..	..	..	..	..	..	..	..

.. Not available; | Break in series; x Not applicable

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ba8d.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Maritime container transport

Twenty-foot equivalent unit (TEU)

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	46 798	68 622	71 614	80 744	87 909	109 054	99 350	104 060
Armenia	x	x	x	x	x	x	x	x
Australia	6 312 647	6 102 990	6 329 135	6 788 836	7 060 177	7 164 877	7 404 823 p	7 902 122 p
Austria	x	x	x	x	x	x	x	x
Azerbaijan	3 025	3 768	13 306	9 712	4 459	2 276	..	..
Belarus	x	x	x	x	x	x	x	x
Belgium	10 478 990	9 185 866	10 431 840	10 253 280	9 915 814	9 886 286	9 725 574	9 928 293
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	200 863	168 339	170 835	179 167	212 369	218 999	236 944	242 865
Canada	4 447 910	3 924 200	4 520 000	4 557 000	4 935 000	..	..	..
China	..	..	..	..	..	..	..	..
Croatia	210 729	151 926	144 649	154 451	144 041	130 236	138 278	181 912
Czech Republic	x	x	x	x	x	x	x	x
Denmark	747 000	637 000	734 000	782 000	763 000	747 000	743 000	..
Estonia	182 065	131 278	152 060	198 193	228 032	253 900	261 069	..
Finland	1 594 686	1 104 755	1 219 575	1 398 630	1 449 596	1 472 143	1 440 462	1 413 654
France	3 940 558	3 719 061	3 921 094	3 890 854	4 073 475	4 284 491	4 436 507	..
FYROM[1]	x	x	x	x	x	x	x	x
Georgia	253 811	181 613	226 115	299 461	357 654	403 447	446 972	379 816
Germany	15 667 000	11 915 000	13 096 000	15 271 000	15 325 000	15 552 000	15 905 000	..
Greece	1 036 980	1 025 729	1 187 487	2 054 064	3 220 371	3 620 126	3 928 785	3 744 380
Hungary	x	x	x	x	x	x	x	x
Iceland	..	..	..	..	..	..	..	..
India	6 578 000	6 863 000	7 561 000	7 651 000	7 714 000	7 453 000	7 960 000	8 198 000
Ireland	1 043 809	823 218	772 548	744 056	732 316	726 019	796 620	876 848
Italy	7 896 531	6 605 651	8 644 600	8 645 200	9 398 353	9 491 151	10 104 971	..
Japan	20 705 861	18 015 533	20 533 734	21 135 704	21 225 537	21 490 748	21 717 563	..
Korea	17 926 748	16 341 378	19 368 960	21 610 502	22 550 275	23 469 251	24 798 210	..
Latvia	167 491	145 415	208 508	246 590	366 824	385 665	391 218	359 756
Liechtenstein	x	x	x	x	x	x	x	x
Lithuania	373 263	247 995	295 226	382 194	381 371	402 733	450 183	350 393
Luxembourg	x	x	x	x	x	x	x	x
Malta	..	..	..	..	..	..	..	..
Mexico	3 316 087	2 884 487	3 691 374 |	4 223 631	4 878 097	4 875 281	..	..
Moldova, Republic of	x	x	x	x	x	x	x	x
Montenegro, Republic of	x	x	x	x	x	x	x	x
Netherlands	11 206 050	9 955 769	11 242 400	11 446 796	11 522 747	11 133 970	11 756 188	11 719 281
New Zealand	..	..	..	..	2 424 902	2 524 754	2 686 756	2 792 132
Norway	624 762	585 647	656 244	691 172	714 565	729 947	761 332	770 447
Poland	635 387	660 594	1 041 690	1 330 746	1 648 886	1 979 703	2 256 061	1 793 407
Portugal	1 548 388	1 508 678	1 690 073	1 791 644	1 994 327	2 418 743	2 706 975	2 752 614
Romania	1 405 333	607 483	548 094	653 306	675 414	659 375	663 271	..
Russian Federation	2 486 233	1 786 509	2 454 838	3 028 264	3 371 039	3 501 985	3 617 159	2 906 126
Serbia, Republic of	x	x	x	x	x	x	x	x
Slovak Republic	x	x	x	x	x	x	x	x
Slovenia	353 880	334 316 |	480 981	586 915	556 392	596 429	676 381	802 696
Spain	13 314 317	11 719 125	12 505 803	13 849 935	13 999 337	13 709 523	14 066 730	14 149 470
Sweden	1 081 549	996 444	1 071 238	1 165 087	1 150 775	1 147 065	1 155 418	1 150 691
Switzerland	x	x	x	x	x	x	x	x
Turkey	5 091 621	4 404 442	5 743 455	6 523 506	7 192 396	7 899 933	8 351 122	8 146 398
Ukraine	..	516 712	659 690	729 523	693 210	..	..	..
United Kingdom	8 764 000	7 415 000	8 254 000	8 176 000	8 013 000	8 273 000	9 540 000	9 799 000
United States	32 006 944	28 467 280	31 507 445	32 745 592	33 236 967	34 484 687	35 867 974	..

.. Not available; | Break in series; x Not applicable; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ba8d.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Passenger transport by rail

Million passenger-kilometres

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	41	32	19	18	16	12	8	7
Armenia	24 e	35 e	50 e	49 e	53 e	55 e	52	44
Australia	14 031	14 767	14 750	14 974	15 256	15 222	15 239	15 675
Austria	10 837	10 653	10 737	10 899	11 323	11 915	12 092	12 208
Azerbaijan	1 049	1 024	917	660	591	457	..	..
Belarus	8 188	7 401	7 578	7 941 e	8 977 e	8 998 e	..	..
Belgium	10 406	10 427	10 403	11 003	..	10 595	..	..
Bosnia-Herzegovina	78	61	59	100	54	40	..	..
Bulgaria	2 335	2 144	2 100	2 068	1 876	1 826	1 702	1 552
Canada	1 574	1 413	1 404	1 404	1 376	1 365	1 327	1 341 p
China	777 860	787 889	876 218	961 229	981 233	1 059 560	1 160 480	..
Croatia	1 810	1 835	1 742	1 486	1 104	948	927	951
Czech Republic	6 803	6 503	6 591	6 714	7 265	7 601	7 797	8 298
Denmark	6 475	6 367	6 577	6 890	7 020	7 076	7 098	..
Estonia	274	249	248	241	236	225	282	..
Finland	4 052	3 876	3 959	3 882	4 035	4 053	3 874	4 113 |
France	86 339	85 612	85 602	88 732	88 003	87 397	86 726	..
FYROM[1]	148	154	155	145	99	80	80	178
Georgia	674	626	654	641	625	585	550	465
Germany	82 539	82 253	83 886	85 414	88 796	89 615	90 976	..
Greece	1 657	1 414	1 337	958	832 e	755 e	1 072	1 263
Hungary	8 293	8 073	7 692	7 806	7 806	7 843	7 738	7 609
Iceland	x	x	x	x	x	x	x	x
India	838 032	903 465	978 508	1 046 522	1 098 103	1 140 412	1 147 190	1 135 718 e
Ireland	1 976	1 683	1 678	1 638	1 578	1 569	1 695	1 917
Italy	49 524	48 124	47 172	46 845	46 759	48 739	49 957	51 158 e
Japan	404 585	393 765	393 466	395 067	404 396	414 387	413 970	..
Korea	56 766	55 489	58 381	63 044	70 079	66 353	67 860	..
Latvia	951	756	749	741	725	729	649	591
Liechtenstein	x	x	x	x	x	x	x	x
Lithuania	398	357	373	389	403	391	373	361
Luxembourg	345	333	347	349	373	394	409	383
Malta	x	x	x	x	x	x	x	x
Mexico	178 |	449	844 |	891	970	1 036	..	..
Moldova, Republic of	486	423	399	363	347	330	257	181
Montenegro, Republic of	125	99	91	65	62	73	76	..
Netherlands	15 313	15 400	15 400	16 808	17 098	17 018	17 018	17 700 e
New Zealand	..	..	..	..	..	..	..	..
Norway	3 107	3 080	3 134	3 076	3 092	3 260	3 440	3 555
Poland	20 195	18 637	17 921	18 177	17 826	16 797	16 015	17 367
Portugal	4 213	4 152	4 111	4 143	3 803	3 649	3 852	3 957
Romania	6 958 |	6 128	5 438	5 073	4 571	4 411	4 976	..
Russian Federation	175 872	151 467	138 885	139 742	144 612	138 517	130 027	120 644
Serbia, Republic of	583	522	522	541	540	612	453	509
Slovak Republic	2 296	2 264	2 309	2 431	2 459	2 485	2 583	3 411
Slovenia	834	840	813	773	742	760	697	709
Spain	23 969	23 137	22 456	22 795	22 476	23 788	25 072	26 142
Sweden	11 146	11 321	11 155	11 378	11 792	11 842	12 121	12 373 p
Switzerland	17 776	18 571	19 177	19 471	19 262	19 447	20 010	..
Turkey	5 097	5 374	5 491	5 882	4 598	3 777	4 393	4 828
Ukraine	53 056	48 327	50 248	50 593	49 329	48 881 e	..	..
United Kingdom	50 626	50 439	53 320	55 914	58 127	59 145	61 768	63 363
United States	9 943	9 518	10 332	10 570	10 949	10 959	10 742	10 519

.. Not available; | Break in series; e Estimated value; x Not applicable; p Provisional data
Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/9319.
Disclaimer: http://oe.cd/disclaimer
1. FYROM: the Former Yugoslav Republic of Macedonia
Source: ITF Transport statistics

Passenger transport by private car

Million passenger-kilometres

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	5 647 e	6 068 e	5 535 e	6 726	6 654	7 587	..	..
Armenia	2 426 e	2 356	2 344	2 380	2 450	2 457	2 537	2 396
Australia	262 063	260 946	262 517	265 181	267 609	269 617	271 591	274 997
Austria	..	..	..	..	..	..	..	..
Azerbaijan	..	..	..	..	..	..	..	..
Belarus	..	..	..	..	..	..	..	..
Belgium	113 010	113 430	109 388	109 970	110 141	109 828	..	..
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	..	..	..	..	..	..	..	..
Canada	477 000	493 000	..	..	..	..	..	..
China	1 247 611	1 351 144	1 502 081	1 676 025	1 846 755	1 125 090	1 208 410	..
Croatia	..	..	..	..	..	..	..	..
Czech Republic	72 380 e	72 290 e	63 570 |	65 490 e	64 260 e	64 650 e	66 260 e	69 705 e
Denmark	61 009	60 455	59 759	59 759	60 190	60 854	60 064	..
Estonia	..	..	..	..	..	..	..	..
Finland	63 400	64 330	64 745	65 490	65 270	65 115	65 520	66 295
France	799 988	802 887	810 793	812 656	814 994	819 442	829 636	..
FYROM[1]	4 215 e	4 244 e	4 683 e	5 322 e	5 116 e	5 964 e	6 769 e	6 987 e
Georgia	5 568	5 724	5 885	6 049	6 219	6 393	6 572	6 756
Germany	871 300	881 100	884 800	894 400	896 300	903 100	920 800	..
Greece	35 895 e	..	..	..	..	..	..	..
Hungary	54 005	54 396	52 595	52 251	51 793	51 823	52 722 e	54 603 e
Iceland	4 950 e	5 003 e	4 958 e	4 777 e	4 832 e	4 971 e	5 226 e	5 605 e
India	5 196 000	5 556 000	5 940 000	6 351 000	6 777 787 e	7 314 588 e	7 946 568 e	8 671 295 e
Ireland	..	..	..	..	..	..	..	..
Italy	676 359	719 912	698 390	665 328	578 668	620 368	642 920	679 427
Japan	822 076	817 360	..	..	..	..	..	..
Korea	210 310	216 378	264 281	248 111	248 362	250 425	258 220	..
Latvia	..	..	..	..	..	..	..	..
Liechtenstein	..	..	..	..	..	..	..	..
Lithuania	37 991	36 055	32 569	29 908	34 191	33 325	24 366	24 865
Luxembourg	..	..	..	..	..	..	..	..
Malta	..	..	..	..	..	..	..	..
Mexico	..	..	..	..	..	..	..	..
Moldova, Republic of	..	..	..	..	..	..	..	..
Montenegro, Republic of	..	..	..	..	..	..	..	..
Netherlands	147 044 e	..	144 200	144 400	139 700	145 400	144 969	139 320
New Zealand	..	..	..	..	..	..	..	..
Norway	55 956	56 536	57 037	58 029	58 701	59 407	61 288	..
Poland	172 620 e	182 758 e	188 810 e	197 835 e	208 501 e	213 120 e	218 941 e	..
Portugal	85 819 e	..	..	..	..	..	..	..
Romania	..	..	..	..	..	..	..	..
Russian Federation	123	109	295	283	338	337	263	352
Serbia, Republic of	..	..	..	..	..	..	..	..
Slovak Republic	26 395	26 420	26 879	26 887	26 935 e	27 155 e	27 251 e	27 531
Slovenia	24 878	25 775	25 636	..	..	..	..	..
Spain	342 611	350 401	341 629	334 021	321 045	316 539	308 704	317 553
Sweden	108 200	108 300	108 000	109 200	109 600	107 600	114 900	117 000 p
Switzerland	80 689	82 459	83 775	84 889	86 651	88 255	89 674	..
Turkey	..	..	..	..	..	..	..	..
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	666 024	661 194	644 023	641 620	645 123	640 587	654 234 p	..
United States	5 147 478	4 507 134	4 529 562	4 575 485	4 612 480	4 638 407	4 633 149	..

.. Not available; | Break in series; e Estimated value; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/9319.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Passenger transport by bus and coach

Million passenger-kilometres

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	790 e	1 302 e	2 370 e	1 254 e	983 e	1 063 e	..	..
Armenia	95 e	..	..	..	..	..	..	..
Australia	18 839	19 176	19 501	19 918	20 422	20 745	21 078	21 204
Austria	..	..	..	..	..	..	..	..
Azerbaijan	14 041	15 291	16 633	18 264	20 034	21 880	..	..
Belarus	8 220	..	..	..	..	..	..	..
Belgium	17 610	17 630	17 385	17 670	17 905	21 520	..	..
Bosnia-Herzegovina	2 113	1 951	..	1 454	1 926	1 764	..	..
Bulgaria	12 305	10 073	9 924	9 766	9 233	8 916	10 145	10 231
Canada	15 471 e	..	..	..	..	..	..	..
China	..	..	..	..	..	..	..	..
Croatia	4 093	3 438	3 284	3 145	3 249	3 507	3 648	3 377
Czech Republic	9 369	9 494	10 816	9 267	9 015	9 026	10 010	9 996
Denmark	6 782	6 781	6 853	6 853	6 849	6 697	6 491	..
Estonia	2 676	2 336	2 266	2 260	2 490	2 619	2 569	..
Finland	7 540	7 540	7 540	7 540	7 540	7 540	7 540	7 540
France	50 551	49 562	50 626	52 000	52 201	53 165	54 174	..
FYROM[1]	1 785	1 765	1 984	2 208	1 994	1 980	2 474	2 276
Georgia	..	..	..	..	..	..	..	..
Germany	79 582	78 594	78 092	77 957	76 019	77 146	78 790	..
Greece	6 287 e	..	..	..	..	..	..	..
Hungary	16 979	16 081	16 250	16 259	16 868	16 965	17 441	17 618
Iceland	637 e	644 e	638 e	615 e	622 e	640 e	673 e	721 e
India	..	..	..	..	..	..	..	..
Ireland	..	..	..	..	..	..	..	..
Italy	102 438	101 706	102 219	102 440	101 516	101 768	102 815	103 053
Japan	83 831	81 360	77 750 |	73 988	75 668	74 571	72 579	..
Korea	96 350	94 409	114 582	115 207	106 838	109 503	110 296	..
Latvia	2 517	2 143	2 311	2 412	2 358	2 325	2 330	2 314
Liechtenstein	..	..	..	..	..	..	..	..
Lithuania	2 952	2 382	2 348	2 400	2 387	2 521	2 672	2 457
Luxembourg	..	..	..	..	..	..	..	..
Malta	..	..	..	..	..	..	..	..
Mexico	463 865	436 900	452 033 |	465 600	480 690	484 776	..	..
Moldova, Republic of	2 599	2 300	2 417	2 733	2 835	3 124	2 874	2 922
Montenegro, Republic of	123	102	80	80	111	109	108	..
Netherlands	16 192 e	..	..	..	..	..	..	..
New Zealand	..	..	..	..	..	..	..	..
Norway	6 147	6 208	5 631 |	5 672	5 791	5 844	5 985	6 414
Poland	47 723 e	43 903 e	41 651 e	40 126 e	39 419 e	37 781 e	39 158 e	37 580
Portugal	10 937 e	..	..	5 850	5 850	6 023	5 657	6 047 |
Romania	13 881 |	12 805	11 955	11 773	12 584	12 923	14 061	..
Russian Federation	151 774	141 191	140 333	138 284	132 968	126 042	127 090	126 271
Serbia, Republic of	4 719	4 582	4 653	4 652	4 640	4 612	4 223	4 601
Slovak Republic	6 567	5 295	5 142	5 338	5 300	5 166	5 281	5 268
Slovenia	3 146	3 196	3 183	..	..	..	..	..
Spain	60 864	57 043	50 902	55 742	54 531	53 836	39 469	46 389
Sweden	9 049	9 046	9 109	9 345	9 228	9 274	9 250	9 386 p
Switzerland	6 230	6 352	6 486	6 677	6 837	6 895	7 016	..
Turkey	..	..	..	..	..	..	..	..
Ukraine	60 671	54 631	51 463	50 881	49 704	..	..	..
United Kingdom	43 200	44 200	44 700	42 600	42 200	40 400	39 600 p	..
United States	505 782	490 873	469 790	471 080	504 300	517 466	545 852	..

.. Not available; | Break in series; e Estimated value; p Provisional data
Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/9319.
Disclaimer: http://oe.cd/disclaimer
1. FYROM: the Former Yugoslav Republic of Macedonia
Source: ITF Transport statistics

Total passenger transport by road

Million passenger-kilometres

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	6 437 e	7 370 e	7 905 e	7 980 e	7 637 e	8 650 e	..	..
Armenia	2 521 e	2 356	2 344	2 380	2 450	2 457	2 537	2 396
Australia	280 902	280 122	282 018	285 099	288 031	290 362	292 670	296 202
Austria	..	..	..	..	..	..	..	..
Azerbaijan	14 041	15 291	16 633	18 264	20 034	21 880	..	..
Belarus	8 220	..	..	..	..	..	..	..
Belgium	130 620	131 060	126 773	127 640	128 046	131 348	..	..
Bosnia-Herzegovina	2 113	1 951	..	1 454	1 926	1 764	..	..
Bulgaria	12 305	10 073	9 924	9 766	9 233	8 916	10 145	10 231
Canada	492 471 e	493 000	..	..	..	..	..	..
China	1 247 611	1 351 144	1 502 081	1 676 025	1 846 755	1 125 090	1 208 410	..
Croatia	4 093	3 438	3 284	3 145	3 249	3 507	3 648	3 377
Czech Republic	81 749	81 784	74 386 |	74 757	73 275	73 676	76 270	79 701
Denmark	67 791	67 236	66 612	66 612	67 039	67 551	66 554	..
Estonia	2 676	2 336	2 266	2 260	2 490	2 619	2 569	..
Finland	70 940	71 870	72 285	73 030	72 810	72 655	73 060	73 835
France	850 539	852 450	861 419	864 656	867 195	872 607	883 810	..
FYROM[1]	6 000 e	6 009 e	6 667 e	7 530 e	7 110 e	7 944 e	9 243 e	9 263 e
Georgia	5 568	5 724	5 885	6 049	6 219	6 393	6 572	6 756
Germany	950 882	959 694	962 892	972 357	972 319	980 246	999 590	..
Greece	42 182 e	..	..	..	..	..	..	..
Hungary	70 984	70 477	68 845	68 510	68 661	68 788	70 163 e	72 221
Iceland	5 587 e	5 647 e	5 596 e	5 392 e	5 454 e	5 611 e	5 899 e	6 326 e
India	5 196 000	5 556 000	5 940 000	6 351 000	6 777 787 e	7 314 588 e	7 946 568 e	8 671 295 e
Ireland	..	..	..	..	..	..	..	..
Italy	778 797	821 618	800 609	767 768	680 184	722 136	745 735	782 480
Japan	905 907	898 720	..	..	..	..	..	..
Korea	306 660	310 787	378 863	363 318	355 200	359 928	368 516	..
Latvia	2 517	2 143	2 311	2 412	2 358	2 325	2 330	2 314
Liechtenstein	..	..	..	..	..	..	..	..
Lithuania	40 943	38 437	34 917	32 308	36 578	35 846	27 038	27 322
Luxembourg	..	..	..	..	..	..	..	..
Malta	..	..	..	..	..	..	..	..
Mexico	463 865	436 900	452 033	465 600	480 690	484 776	..	..
Moldova, Republic of	2 599	2 300	2 417	2 733	2 835	3 124	2 874	2 922
Montenegro, Republic of	123	102	81	80	111	109	108	..
Netherlands	163 236 e	..	..	..	..	..	..	..
New Zealand	..	..	..	..	..	..	..	..
Norway	62 103	62 744	62 668 |	63 701	64 492	65 251	67 273	..
Poland	220 343 e	226 661 e	230 461 e	237 961 e	247 920 e	250 901 e	258 099 e	..
Portugal	96 756 e	..	..	..	..	..	..	..
Romania	13 881 |	12 805	11 955	11 773	12 584	12 923	14 061	..
Russian Federation	151 897	141 300	140 628	138 567	133 306	126 379	127 353	126 623
Serbia, Republic of	..	..	..	..	..	..	..	..
Slovak Republic	32 962	31 715	32 021	32 225	32 235	32 321	32 532	32 799
Slovenia	28 024	28 971	28 819	..	..	..	..	..
Spain	403 475	407 444	392 531	389 763	375 576	370 375	348 173	363 942
Sweden	117 249	117 346	117 109	118 545	118 828	116 874	124 150	126 386 p
Switzerland	86 919	88 811	90 261	91 566	93 488	95 150	96 690	..
Turkey	206 098	212 464	226 913	242 265	258 874	268 178	276 073	290 734
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	709 224	705 394	688 723	684 220	687 323	680 987	693 834 p	..
United States	5 653 260	4 998 007	4 999 352	5 046 565	5 116 780	5 155 873	5 179 001	..

.. Not available; | Break in series; e Estimated value; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/9319.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Total inland passenger transport

Million passenger-kilometres

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	6 478	7 402	7 924	7 998	7 653	8 662	..	..
Armenia	2 545 e	2 391 e	2 394 e	2 429 e	2 503 e	2 512 e	2 589 e	2 440
Australia	294 933	294 889	296 768	300 073	303 287	305 584	307 908	311 876
Austria	..	..	..	..	..	..	..	..
Azerbaijan	15 090	16 315	17 550	18 924	20 625	22 337	..	..
Belarus	16 408	..	..	..	..	..	..	..
Belgium	141 026	141 487	137 176	..	..	141 943	..	..
Bosnia-Herzegovina	2 191	2 012	..	1 554	1 980	1 804	..	..
Bulgaria	14 640	12 217	12 024	11 834	11 109	10 742	11 847	11 783
Canada	494 045 e	494 413	..	..	..	..	..	..
China	2 025 471	2 139 033	2 378 299	2 637 254	2 827 988	2 184 650	2 368 890	..
Croatia	5 903	5 273	5 026	4 631	4 353	4 455	4 575	4 328
Czech Republic	88 552	88 287	80 977 |	81 471	80 540	81 277	84 067	87 999
Denmark	74 266	73 603	73 189	73 502	74 059	74 627	73 652	..
Estonia	2 950	2 585	2 514	2 501	2 726	2 844	2 851	..
Finland	74 992	75 746	76 244	76 912	76 845	76 708	76 934	77 948
France	936 878	938 062	947 021	953 388	955 198	960 004	970 536	..
FYROM[1]	6 148 e	6 163 e	6 822 e	7 675 e	7 209 e	8 024 e	9 323 e	9 441 e
Georgia	6 242	6 350	6 539	6 690	6 844	6 978	7 122	7 221
Germany	1 033 421	1 041 947	1 046 778	1 057 771	1 061 115	1 069 861	1 090 566	..
Greece	43 839 e	..	..	..	..	..	..	..
Hungary	79 277	78 550	76 537	76 316	76 467	76 631	77 901 e	79 830 e
Iceland	5 587	5 647	5 596	5 392	5 454	5 611	5 899	6 326
India	6 034 030	6 459 460	6 918 510	7 397 520	7 923 000 e	8 434 000 e	9 010 000 e	9 807 013
Ireland	..	..	..	..	..	..	..	..
Italy	828 321	869 742	847 781	814 613	726 943	770 875	795 692	833 638
Japan	1 310 492	1 292 485	..	..	..	..	..	..
Korea	363 426	366 276	437 244	426 362	425 279	426 281	436 376	..
Latvia	3 468	2 899	3 060	3 153	3 083	3 054	2 979	2 905
Liechtenstein	..	..	..	..	..	..	..	..
Lithuania	41 341	38 794	35 290	32 697	36 981	36 237	27 411	27 683
Luxembourg	..	..	..	..	..	..	..	..
Malta	..	..	..	..	..	..	..	..
Mexico	464 043 |	437 349	452 877	466 491	481 660	485 812	..	..
Moldova, Republic of	3 085	2 723	2 816	3 096	3 182	3 454	3 131	3 103
Montenegro, Republic of	248	201	172	145	173	182	184	..
Netherlands	178 549 e	..	..	..	..	..	..	..
New Zealand	..	..	..	..	..	..	..	..
Norway	65 210	65 824	65 802 |	66 777	67 584	68 511	70 713	..
Poland	240 538 e	245 298 e	248 382 e	256 138 e	265 746 e	267 698 e	274 114 e	..
Portugal	100 969 e	..	..	..	..	..	..	..
Romania	20 839	18 933	17 393	16 846	17 155	17 334	19 037	..
Russian Federation	327 769	292 767	279 513	278 309	277 918	264 896	257 380	247 267
Serbia, Republic of	..	..	..	..	..	..	..	..
Slovak Republic	35 258	33 979	34 330	34 656	34 694	34 806	35 115	36 210
Slovenia	28 858	29 811	29 632	..	..	..	..	..
Spain	427 444	430 581	414 987	412 558	398 052	394 163	373 245	390 084
Sweden	128 395	128 667	128 264	129 923	130 620	128 716	136 271	138 759 p
Switzerland	104 695	107 382	109 438	111 037	112 750	114 597	116 700	..
Turkey	211 195	217 838	232 404	248 147	263 472	271 955	280 466	295 562
Ukraine	113 727	102 958	101 711	101 474	99 033	..	..	..
United Kingdom	759 850	755 833	742 043	740 134	745 450	740 132	755 602	..
United States	5 663 203	5 007 525	5 009 684	5 057 135	5 127 729	5 166 832	5 189 743	..

.. Not available; | Break in series; e Estimated value; p Provisional data
Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/9319.
Disclaimer: http://oe.cd/disclaimer
1. FYROM: the Former Yugoslav Republic of Macedonia
Source: ITF Transport statistics

Road traffic injury accidents

Number of accidents

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	1 208	1 465	1 564	1 876	1 870	2 075	1 914	1 992
Armenia	2 202	2 002	1 974 e	2 319 e	2 602 e	2 824 e	3 156	3 399
Australia	..	..	..	..	..	..	..	..
Austria	39 173	37 925	35 348	35 129	40 831 |	38 502	37 957	37 960
Azerbaijan	2 970	2 792	2 721	2 890	2 892	2 846	..	..
Belarus	7 238	6 739	..	..	..	..	..	..
Belgium	48 827	47 798	45 918	47 945	44 234	41 279	41 481	40 303
Bosnia-Herzegovina	40 859	40 237	..	37 928	34 884	35 725	..	..
Bulgaria	8 045	7 068	6 609	6 639	6 717	7 015	7 018	7 225
Canada	129 764	125 456	125 636	124 199	124 500	122 101	112 167 p	..
China	265 204	238 351	219 521	210 812	..	..	..	..
Croatia	16 283	15 730	13 272	13 228	11 773	11 225	10 607	11 038
Czech Republic	22 481	21 706	19 676	20 487	20 504	20 342	21 054	21 561
Denmark	5 020	4 174	3 498	3 525	3 124	2 984	..	..
Estonia	1 869	1 505	1 347	1 492	1 383	1 385	1 435	..
Finland	6 881	6 414	6 072	6 408	5 725	5 334	5 324	5 164
France	74 487	72 315	67 288	65 024	60 437	56 812	58 191	..
FYROM[1]	4 403	4 353	4 223	4 462	4 108	4 230	3 852	3 854
Georgia	6 015	5 482	5 099	4 486	5 359	5 510	5 992	6 432
Germany	320 614	310 806	288 297	306 266	299 637	291 105	302 435	305 659
Greece	15 083	14 789	15 032	13 849	12 398	12 109	11 690	11 565 p
Hungary	19 174	17 864	16 308	15 827	15 174	15 691	15 847	16 331
Iceland	1 085	893	883	849	742	822	808	912
India	484 704	486 384	499 628	497 686	490 383	486 476	489 400	501 423
Ireland	5 580	6 615	5 780	5 230	5 376	4 976 p	5 412 p	..
Italy	218 963	215 405	212 997	205 638	188 228	181 660	177 031	..
Japan	766 394	737 637	725 924	692 084	665 157	629 033	573 842	536 899
Korea	215 822	231 990	226 878	221 711	223 656	215 354	223 552	232 053
Latvia	4 196	3 160	3 193	3 386	3 358	3 489	3 728	3 689
Liechtenstein	402	358	366	327	403	468	465	445
Lithuania	4 796	3 805	3 530	3 266	3 391	3 391	3 256	3 161
Luxembourg	927	869	876	962	1 019	949	908	983
Malta	15 007	14 877	13 727	14 624	14 546	14 070	14 473	15 504
Mexico	30 379	16 011 |	14 581	11 473	12 888	..	..	..
Moldova, Republic of	2 869	2 729	2 921	2 825	2 713	2 603	2 564	2 535
Montenegro, Republic of	1 760	1 718	1 520	1 451	1 217 |	1 266	1 334	..
Netherlands	8 897	6 927	3 853 e	..	..	..	..	..
New Zealand	11 647	11 125	10 886	9 804	9 604	9 347	8 880	9 737
Norway	7 726	6 922	6 434	6 079	6 154	5 241	4 972	4 563
Poland	49 054	44 196	38 832	40 065	37 062	35 847	34 970	32 967
Portugal	33 613	35 484	35 426	32 541	29 867	30 339	30 604	31 953
Romania	29 861	28 612	25 996	26 648	26 928	24 827	25 355	..
Russian Federation	218 322	203 618 |	199 431	199 868	203 597	204 068	199 723	184 000
Serbia, Republic of	16 651	15 807	14 179	14 119	13 333	13 522	13 043	13 638
Slovak Republic	8 343	6 465	6 570	5 775	5 370	5 113	5 391	5 502
Slovenia	8 938	8 589	7 560	7 218	6 864	6 542	6 264	6 585
Spain	93 161	88 251	85 503	83 027	83 115	89 519	91 570	97 756
Sweden	18 462	17 858	16 500 |	16 119	16 458	14 815	12 926	14 672
Switzerland	20 736	20 506	19 609	18 990	18 148	17 473	17 803	17 736
Turkey	104 212	111 121	116 804	131 845	153 552	161 306	168 512	183 011
Ukraine	51 279	37 049	31 914	31 281	30 699	..	..	..
United Kingdom	176 814	169 805	160 080	157 068	151 346	144 426	152 407	146 203
United States	1 664 000 e	1 548 000 e	1 572 000 e	1 530 000 e	1 634 000 e	1 621 000 e	1 648 000 e	..

.. Not available; | Break in series; e Estimated value; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/225f.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Road traffic casualties (injuries plus fatalities)

Number

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	1 554	1 833	2 069	2 472	2 569	2 798	2 617	2 692
Armenia	3 532 e	3 078 e	2 964 e	3 681 e	4 050 e	4 310 e	4 776	5 084
Australia	34 961	35 183	34 128	35 359	35 391	24 246	..	..
Austria	51 200	49 791	46 410	45 548	51 426 |	48 499	48 100	47 845
Azerbaijan	4 284	3 974	3 796	4 047	4 165	4 112	..	..
Belarus	9 058 e	8 605 e	..	..	..	..	..	..
Belgium	65 381	63 663	61 204	63 723	58 533	54 691	53 975	52 571
Bosnia-Herzegovina	12 318	11 434	..	10 395	9 478	10 052	..	..
Bulgaria	11 013	9 575	8 854	8 958	8 794	9 376	9 299	9 679
Canada	178 825	172 986	174 319	169 764	168 558	166 444	151 734 p	..
China	378 403	342 884	319 299	299 808	284 324	272 040	..	..
Croatia	23 059	22 471	18 759	18 483	16 403	15 642	14 530	15 372
Czech Republic	29 577	28 145	25 186	26 322	26 257	25 942	27 046	27 704
Denmark	6 329	5 250	4 408	4 259	3 778	3 585	..	..
Estonia	2 530	2 031	1 799	1 980	1 794	1 814	1 824	..
Finland	8 857	8 336	7 945	8 223	7 343	6 939	6 934	6 651
France	98 073	95 207	88 453	85 214	79 504	73 875	76 432	..
FYROM[1]	6 886	6 891	6 357	7 025	6 281	6 682	6 186	6 061
Georgia	9 930	8 999	8 245	7 164	8 339	8 559	9 047	9 789
Germany	413 524	401 823	374 818	396 374	387 978	377 481	392 912	396 891
Greece	20 563	20 097	20 366	18 400	16 628	16 054	15 359	14 838 p
Hungary	26 365	24 096	21 657	20 810	19 584	20 681	20 750	21 543
Iceland	1 585	1 299	1 261	1 217	1 044	1 232	1 172	1 324
India	643 053	641 118	662 025	653 897	647 925	632 465	633 145	646 412
Ireland	8 200	9 980	8 482	7 421	7 759	7 068 p	7 622 p	..
Italy	315 470	311 495	308 834	295 879	270 617	261 494	254 528	..
Japan	950 912	916 194	901 245	859 304	829 830	785 880	715 487	670 140
Korea	344 832	367 713	357 963	346 620	349 957	333 803	342 259	355 021
Latvia	5 724	4 184	4 241	4 403	4 356	4 517	4 815	4 753
Liechtenstein	110	112	114	107	109	113	101	113
Lithuania	6 317	4 796	4 529	4 215	4 253	4 263	4 054	4 018
Luxembourg	1 274	1 204	1 217	1 341	1 412	1 297	1 261	1 384
Malta	1 172	1 069	1 079	1 577	1 599	1 582	1 796	1 711
Mexico	38 148	36 525	33 649	30 451	29 275	..	..	..
Moldova, Republic of	3 994	3 288	4 187	3 976	3 952	3 516	3 404	3 634
Montenegro, Republic of	2 585	2 578	2 194	2 133	1 768	1 886	1 900	..
Netherlands	9 500 e	7 676 e	4 291 e	..	2 980	..	..	..
New Zealand	15 540	14 925	14 406	12 858	12 430	12 034	11 512	12 589
Norway	11 123	10 056	9 338	8 531	8 340	7 029	6 438	5 804
Poland	67 534	60 618	52 859	53 690	49 369	47 416	45 747	42 716
Portugal	44 709	47 151	47 302	42 851	38 823	39 390	39 653	41 549
Romania	39 996	38 320	34 791	35 509	36 251	33 325	34 152	..
Russian Federation	300 819	283 143	277 202	279 801	286 609	285 462	278 751	254 311
Serbia, Republic of	23 172	22 320	19 982	20 040	19 090	19 118	18 529	19 909
Slovak Republic	11 646	8 918	8 503	7 382	6 790	6 562	6 912	7 059
Slovenia	12 623	12 285	10 454	9 814	9 278	8 867	8 328	8 830
Spain	134 047	127 680	122 823	117 687	117 793	126 400	128 320	136 144
Sweden	26 645	25 639	23 571 |	22 679	23 110	20 522	17 795	19 902
Switzerland	25 913	25 479	24 564	23 562	22 557	21 648	21 764	21 791
Turkey	188 704	205 704	215 541	241 909	271 829	278 514	288 583	311 951
Ukraine	70 972	51 023	43 850	43 086	42 650	..	..	..
United Kingdom	240 456	231 913	217 605	212 710	204 733	192 693	203 865	195 926
United States	2 383 000 e	2 251 000 e	2 272 000 e	2 249 000 e	2 396 000 e	2 346 000 e	2 371 000 e	..

.. Not available; | Break in series; e Estimated value; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/225f.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Road traffic injuries

Number

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	1 251	1 455	1 716	2 150	2 235	2 503	2 353	2 422
Armenia	3 125 e	2 753 e	2 670 e	3 354 e	3 739 e	3 994 e	4 479	4 738
Australia	33 524	33 692	32 775	34 082	34 091	23 059	..	..
Austria	50 521	49 158	45 858	45 025	50 895 |	48 044	47 670	47 366
Azerbaijan	3 232	3 044	2 871	3 031	2 997	2 948	..	..
Belarus	7 494 e	7 283 e	..	..	..	..	..	..
Belgium	64 437	62 720	60 363	62 861	57 763	53 967	53 248	51 839
Bosnia-Herzegovina	11 884	11 052	..	10 039	9 175	9 718	..	..
Bulgaria	9 952	8 674	8 078	8 301	8 193	8 775	8 639	8 971
Canada	176 394	170 770	172 081	167 741	166 479	164 493	149 900 p	..
China	304 919	275 125	254 074	237 421	224 327	213 724	..	..
Croatia	22 395	21 923	18 333	18 065	16 010	15 274	14 222	15 024
Czech Republic	28 501	27 244	24 384	25 549	25 515	25 288	26 358	26 966
Denmark	5 923	4 947	4 153	4 039	3 611	3 394	..	..
Estonia	2 398	1 931	1 720	1 879	1 707	1 733	1 746	..
Finland	8 513	8 057	7 673	7 931	7 088	6 681	6 705	6 385
France	93 798	90 934	84 461	81 251	75 851	70 607	73 048	..
FYROM[1]	6 724	6 731	6 195	6 853	6 149	6 484	6 056	5 913
Georgia	9 063	8 261	7 560	6 638	7 734	8 045	8 536	9 187
Germany	409 047	397 671	371 170	392 365	384 378	374 142	389 535	393 432
Greece	19 010	18 641	19 108	17 259	15 640	15 175	14 564	14 033 p
Hungary	25 369	23 274	20 917	20 172	18 979	20 090	20 124	20 899
Iceland	1 573	1 282	1 253	1 205	1 035	1 217	1 168	1 308
India	523 193	515 458	527 512	511 412	509 667	494 893	493 474	500 279
Ireland	7 921	9 742	8 270	7 235	7 597	6 880 p	7 429 p	..
Italy	310 745	307 258	304 720	292 019	266 864	258 093	251 147	..
Japan	944 833	910 354	895 417	853 769	824 569	780 715	710 649	665 281
Korea	338 962	361 875	352 458	341 391	344 565	328 711	337 497	350 400
Latvia	5 408	3 930	4 023	4 224	4 179	4 338	4 603	4 566
Liechtenstein	109	111	114	105	108	111	98	111
Lithuania	5 818	4 426	4 230	3 919	3 951	4 007	3 787	3 777
Luxembourg	1 239	1 156	1 185	1 308	1 378	1 252	1 226	1 348
Malta	1 157	1 048	1 064	1 560	1 590	1 564	1 786	1 700
Mexico	32 769	31 656	28 617	26 045	24 736	..	..	..
Moldova, Republic of	3 494	2 801	3 735	3 543	3 510	3 221	3 080	3 334
Montenegro, Republic of	2 473	2 478	2 099	2 075	1 722	1 812	1 835	..
Netherlands	8 750 e	6 956 e	3 651 e	..	..	..	..	..
New Zealand	15 174	14 540	14 031	12 574	12 122	11 781	11 219	12 270
Norway	10 868	9 844	9 130	8 363	8 195	6 842	6 291	5 687
Poland	62 097	56 046	48 952	49 501	45 792	44 059	42 545	39 778
Portugal	43 824	46 414	46 365	41 960	38 105	38 753	39 015	40 956
Romania	36 931	35 523	32 414	33 491	34 209	31 464	32 334	..
Russian Federation	270 883	255 484	250 635	251 848	258 618	258 437	251 793	231 197
Serbia, Republic of	22 275	21 512	19 326	19 312	18 406	18 472	17 993	19 308
Slovak Republic	11 040	8 534	8 150	7 057	6 438	6 311	6 617	6 749
Slovenia	12 409	12 114	10 316	9 673	9 148	8 742	8 220	8 710
Spain	130 947	124 966	120 345	115 627	115 890	124 720	126 632	134 455
Sweden	26 248	25 281	23 305 |	22 360	22 825	20 262	17 525	19 643
Switzerland	25 556	25 130	24 237	23 242	22 218	21 379	21 521	21 538
Turkey	184 468	201 380	211 496	238 074	268 079	274 829	285 059	304 421
Ukraine	63 254	45 675	38 975	38 178	37 519	..	..	..
United Kingdom	237 811	229 576	215 700	210 750	202 931	190 923	202 011	194 122
United States	2 346 000 e	2 217 000 e	2 239 000 e	2 217 000 e	2 362 000 e	2 313 000 e	2 338 000 e	..

.. Not available; | Break in series; e Estimated value; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/225f.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Road traffic fatalities

Number

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	303	378	353	322	334	295	264	270
Armenia	407	325	294 e	327 e	311 e	316 e	297	346
Australia	1 437	1 491	1 353	1 277	1 300	1 187	1 150	1 205
Austria	679	633	552	523	531 |	455	430	479
Azerbaijan	1 052	930	925	1 016	1 168	1 164	..	..
Belarus	1 564	1 322	..	..	..	..	..	..
Belgium	944	943	841	862	770	724	727	732
Bosnia-Herzegovina	434	382	..	356	303	334	..	..
Bulgaria	1 061	901	776	657	601	601	660	708
Canada	2 431	2 216	2 238	2 023	2 079	1 951	1 834 p	..
China	73 484	67 759	65 225	62 387	59 997	58 316	..	..
Croatia	664	548	426	418	393	368	308	348
Czech Republic	1 076	901	802	773	742	654	688	738
Denmark	406	303	255	220	167	191	..	..
Estonia	132	100	79	101	87	81	78	..
Finland	344	279	272	292	255	258	229	266
France	4 275	4 273	3 992	3 963	3 653	3 268	3 384	..
FYROM[1]	162	160	162	172	132	198	130	148
Georgia	867	738	685	526	605	514	511	602
Germany	4 477	4 152	3 648	4 009	3 600	3 339	3 377	3 459
Greece	1 553	1 456	1 258	1 141	988	879	795	805 p
Hungary	996	822	740	638	605	591	626	644
Iceland	12	17	8	12	9	15	4	16
India	119 860	125 660	134 513	142 485	138 258	137 572	139 671	146 133
Ireland	279	238	212	186	162	188 p	193 p	166
Italy	4 725	4 237	4 114	3 860	3 753	3 401	3 381	..
Japan	6 079	5 840	5 828	5 535	5 261	5 165	4 838	4 859
Korea	5 870	5 838	5 505	5 229	5 392	5 092	4 762	4 621
Latvia	316	254	218	179	177	179	212	187
Liechtenstein	1	1	0	2	1	2	3	2
Lithuania	499	370	299	296	302	256	267	241
Luxembourg	35	48	32	33	34	45	35	36
Malta	15	21	15	17	9	18	10	11
Mexico	5 379	4 869	5 032	4 406	4 539	..	..	..
Moldova, Republic of	500	487	452	433	442	295	324	300
Montenegro, Republic of	112	100	95	58	46	74	65	..
Netherlands	750	720	640	661	650	570	570	621
New Zealand	366	385	375	284	308	253	293	319
Norway	255	212	208	168	145	187	147	117
Poland	5 437	4 572	3 907	4 189	3 577	3 357	3 202	2 938
Portugal	885	737	937	891	718	637	638	593
Romania	3 065	2 797	2 377	2 018	2 042	1 861	1 818	..
Russian Federation	29 936	27 659 |	26 567	27 953	27 991	27 025	26 958	23 114
Serbia, Republic of	897	808	656	728	684	646	536	601
Slovak Republic	606	384	353	325	352	251	295	310
Slovenia	214	171	138	141	130	125	108	120
Spain	3 100	2 714	2 478	2 060	1 903	1 680	1 688	1 689
Sweden	397	358	266 |	319	285	260	270	259
Switzerland	357	349	327	320	339	269	243	253
Turkey	4 236	4 324	4 045	3 835	3 750	3 685	3 524	7 530 |
Ukraine	7 718	5 348	4 875	4 908	5 131	4 824 p	..	..
United Kingdom	2 645	2 337	1 905	1 960	1 802	1 770	1 854	1 804
United States	37 423	33 883	32 999	32 479	33 561	32 719	32 675	35 200 e

.. Not available; | Break in series; e Estimated value; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/225f.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Road traffic fatalities, per million inhabitants

Number

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	103	129	121	111	115	102	91	93
Armenia	137	110	99	110	104	106	99	115
Australia	68	69	61	57	57	51	49	51
Austria	82	76	66	62	63	54	50	56
Azerbaijan	120	104	102	111	126	124	..	..
Belarus	164	139	..	..	..	..	..	..
Belgium	88	87	77	78	69	65	65	65
Bosnia-Herzegovina	113	100	..	93	79	87	..	..
Bulgaria	142	121	105	89	82	83	91	99
Canada	73	66	66	59	60	56	52	..
China	55	51	49	46	44	43	..	..
Croatia	150	124	96	98	92	86	73	82
Czech Republic	104	86	77	74	71	62	65	70
Denmark	74	55	46	39	30	34	..	..
Estonia	99	75	59	76	66	61	59	..
Finland	65	52	51	54	47	47	42	49
France	66	66	61	61	56	50	51	..
FYROM[1]	79	78	79	83	64	96	63	71
Georgia	215	186	174	136	158	136	137	164
Germany	55	51	45	49	45	41	42	42
Greece	140	131	113	103	89	80	73	74
Hungary	99	82	74	64	61	60	63	65
Iceland	38	53	25	38	28	46	12	48
India	100	103	109	114	109	108	108	111
Ireland	62	52	46	41	35	41	42	36
Italy	80	72	69	65	63	56	56	..
Japan	47	46	46	43	41	41	38	38
Korea	120	119	111	105	108	101	94	91
Latvia	145	119	104	87	87	89	106	95
Liechtenstein	..	..	..	..	..	..	..	..
Lithuania	156	117	97	98	101	87	91	83
Luxembourg	72	96	63	64	64	83	63	63
Malta	37	51	36	41	21	43	23	26
Mexico	47	42	42	37	37	..	..	..
Moldova, Republic of	140	137	127	122	124	83	91	84
Montenegro, Republic of	182	162	153	94	74	119	105	..
Netherlands	46	44	39	40	39	34	34	37
New Zealand	86	89	86	65	70	57	65	69
Norway	53	44	43	34	29	37	29	23
Poland	143	120	103	110	94	88	84	77
Portugal	84	70	89	84	68	61	61	57
Romania	149	137	117	100	102	93	91	..
Russian Federation	210	194	186	196	195	188	187	160
Serbia, Republic of	122	110	90	101	95	90	75	85
Slovak Republic	113	71	65	60	65	46	54	57
Slovenia	106	84	67	69	63	61	52	58
Spain	67	59	53	44	41	36	36	36
Sweden	43	39	28	34	30	27	28	26
Switzerland	47	45	42	40	42	33	30	31
Turkey	60	61	56	52	50	48	45	96
Ukraine	167	116	106	107	113	106	..	..
United Kingdom	43	38	30	31	28	28	29	28
United States	123	110	107	104	107	103	102	110

.. Not available
Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/68d5.
Disclaimer: http://oe.cd/disclaimer
1. FYROM: the Former Yugoslav Republic of Macedonia
Source: ITF Transport statistics

Road traffic fatalities, per million motor vehicles

Number

	2008	2009	2010	2011	2012	2013	2014	2015
Albania	..	..	..	..	..	..	..	..
Armenia	..	..	..	..	..	..	..	..
Australia	94	95	84	78	78	69	65	67
Austria	117	108	92	86	86	72	67	74
Azerbaijan	..	..	..	..	..	..	..	..
Belarus	..	..	..	..	..	..	..	..
Belgium	146	143	126	126	111	104	103	102
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	375	301	249	203	178	172	181	..
Canada	115	104	102	91	93	85	78	..
China	..	..	..	..	..	..	..	..
Croatia	370	309	243	239	237	221	182	..
Czech Republic	186	150	133	127	120	103	108	114
Denmark	141	105	88	76	57	65	..	..
Estonia	201	154	120	148	121	108	..	..
Finland	102	75	71	73	62	61	53	60
France	108	107	99	98	86	77	80	..
FYROM[1]	..	..	..	..	..	..	..	..
Georgia	..	..	..	..	..	..	..	..
Germany	87	80	70	76	67	61	61	62
Greece	168	154	133	120	104	93	84	85
Hungary	275	226	203	177	168	163	166	..
Iceland	45	65	31	46	34	56	15	56
India	..	..	..	..	..	..	..	..
Ireland	112	96	88	77	67	76	77	..
Italy	92	83	80	75	73	66	66	..
Japan	67	64	64	61	58	57	53	53
Korea	293	286	264	244	246	227	208	195
Latvia	283	236	296	251	245	241	276	..
Liechtenstein	..	..	..	..	..	..	..	..
Lithuania	237	173	139	136	135	112	179	156
Luxembourg	88	118	78	79	79	102	81	81
Malta	51	71	50	55	29	56	30	..
Mexico	..	..	..	..	..	..	..	..
Moldova, Republic of	..	..	..	..	..	..	..	..
Montenegro, Republic of	..	..	..	..	..	..	..	..
Netherlands	79	74	65	66	64	56	56	..
New Zealand	113	120	116	88	95	77	86	91
Norway	76	62	60	47	39	50	37	..
Poland	255	216	177	181	150	137	127	112
Portugal	155	128	162	..	124	111	112	..
Romania	637	553	463	389	380	331	308	..
Russian Federation	..	..	..	..	..	..	..	..
Serbia, Republic of	..	..	..	..	..	..	..	..
Slovak Republic	320	198	174	153	159	110	125	..
Slovenia	176	135	107	109	99	95	81	89
Spain	93	82	74	62	57	51	51	51
Sweden	71	63	47	57	50	45	46	43
Switzerland	66	64	59	57	59	46	41	..
Turkey	360	351	309	274	251	233	211	..
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	76	67	54	56	51	49	51	48
United States	144	131	128	123	126	122	119	..

.. Not available

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/68d5.

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1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Investment in rail transport infrastructure

Million euros

	2007	2008	2009	2010	2011	2012	2013	2014
Albania	1.0	1.0	0.0	0.0	1.0	0.0	1.0	1.0
Armenia	..	..	..	..	..	..	..	..
Australia	1 962.0	1 727.0	2 285.0	3 612.0	5 498.0	6 601.0	4 973.0	4 321.0
Austria	1 505.0	1 683.0	2 062.0	1 936.0	2 143.0	1 688.0	1 648.0	1 567.0
Azerbaijan	3.0	11.0	3.0	3.0	3.0	3.0	4.0	4.0
Belarus	..	..	..	..	..	..	..	..
Belgium	1 009.0	1 223.0	1 223.0	1 078.0	1 076.0	1 178.0	1 091.0	1 073.0
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	44.0	72.0	50.0	130.0	90.0	114.0	124.0	65.0
Canada	646.0	617.0	493.0	698.0	869.0	1 045.0	1 011.0	934.0 p
China	..	..	..	..	..	..	..	..
Croatia	92.0	126.0	98.0	83.0	81.0	62.0	183.0	131.0
Czech Republic	612.0	1 218.0	741.0	563.0	447.0	381.0	335.0	454.0
Denmark	232.0	373.0	357.0	396.0	863.0	916.0	996.0	1 159.0
Estonia	30.0	23.0	37.0	35.0	94.0	94.0	94.0	..
Finland	211.0	327.0	361.0	388.0	355.0	450.0	605.0	643.0
France	4 505.0	5 119.0	5 047.0	4 915.0	7 004.0	8 100.0	10 546.0	9 610.0
FYROM[1]	1.0	2.0	4.0	2.0	0.0	..	..	..
Georgia	212.0	48.0	80.0	77.0	249.0	255.0	82.0	67.0
Germany	3 836.0	3 816.0	3 412.0	3 807.0	4 086.0	3 930.0	4 210.0	4 420.0
Greece	324.0	340.0	467.0	212.0	185.0	177.0	96.0	..
Hungary	376.0	298.0	318.0	272.0 |	349.0	473.0	623.0	689.0
Iceland	x	x	x	x	x	x	x	x
India	3 927.0	4 663.0	4 724.0	5 150.0	4 836.0	5 412.0	5 289.0	..
Ireland	244.0	..	..	..	..	..	..	..
Italy	7 702.0	7 109.0	5 687.0	4 773.0	4 466.0	4 238.0	4 103.0	..
Japan	6 883.0	7 367.0	9 602.0	11 308.0	10 222.0	11 969.0	9 192.0	..
Korea	3 458.0	2 417.0	2 704.0	2 745.0	2 877.0	3 517.0	4 224.0	..
Latvia	36.0	63.0	63.0	73.0	53.0	102.0	77.0	136.0
Liechtenstein	x	x	x	x	x	x	x	x
Lithuania	76.0	85.0	67.0	107.0	116.0	140.0	139.0	264.0
Luxembourg	138.0	149.0	172.0	157.0	150.0	125.0	146.0	191.0
Malta	x	x	x	x	x	x	x	x
Mexico	563.0	498.0	438.0	435.0	649.0	621.0	735.0	..
Moldova, Republic of	10.0	25.0	8.0	7.0	7.0	10.0	13.0	5.0
Montenegro, Republic of	..	..	..	..	..	..	..	..
Netherlands	845.0	820.0	778.0	1 097.0	1 136.0	..	..	..
New Zealand	..	..	..	..	..	..	..	..
Norway	310.0	288.0	359.0	479.0	561.0	676.0	839.0	..
Poland	647.0	904.0	650.0	690.0	925.0	431.0	263.0	..
Portugal	329.0	392.0 |	360.0	403.0	333.0	86.0	71.0	120.0
Romania	311.0	316.0	177.0	169.0	161.0	118.0	209.0	278.0
Russian Federation	5 434.0	9 480.0	6 577.0	9 052.0	9 872.0	11 194.0	9 787.0	..
Serbia, Republic of	2.0	2.0	6.0	12.0	7.0	3.0	9.0	12.0
Slovak Republic	287.0	215.0	175.0 |	273.0	289.0	216.0	324.0	276.0
Slovenia	62.0	96.0	72.0	131.0	106.0	72.0	140.0	297.0
Spain	8 345.0	8 981.0	8 772.0	7 669.0	7 553.0	5 350.0	2 710.0	3 042.0 p
Sweden	1 253.0	1 319.0	1 319.0	1 434.0	1 400.0	1 330.0	1 104.0	1 187.0
Switzerland	2 329.0	2 622.0	2 888.0	3 036.0	3 414.0	3 464.0	3 665.0	3 550.0
Turkey	499.0	672.0	756.0	1 493.0	1 470.0	1 485.0	2 247.0	1 354.0
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	7 733.0	7 644.0	6 408.0	6 390.0	6 110.0	6 251.0	5 722.0	7 890.0
United States	6 682.0	6 949.0	7 133.0	7 370.0	8 334.0	10 485.0	9 857.0	11 350.0

.. Not available; | Break in series; x Not applicable; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ccbe.

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1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Investment in road transport infrastructure

Million euros

	2007	2008	2009	2010	2011	2012	2013	2014
Albania	253.0	500.0	487.0	242.0	210.0	181.0	234.0	193.0
Armenia	..	..	..	..	..	..	..	..
Australia	8 026.0	9 263.0	9 196.0	11 201.0	13 806.0	15 898.0	12 991.0	11 128.0
Austria	870.0	875.0	665.0	390.0	303.0	327.0	363.0	453.0
Azerbaijan	374.0	1 327.0	1 272.0	1 546.0	1 562.0	1 484.0	1 914.0	1 411.0
Belarus	..	..	..	..	..	..	..	..
Belgium	166.0	156.0	175.0	348.0 |	248.0	553.0	587.0	417.0
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	134.0	169.0	101.0	281.0	344.0	388.0	359.0	253.0
Canada	7 810.0	8 751.0	10 891.0	15 394.0	15 061.0	14 763.0	13 086.0	..
China	..	..	..	..	..	..	..	..
Croatia	1 066.0	1 101.0	909.0	515.0	466.0	479.0	424.0	280.0
Czech Republic	1 493.0	2 043.0	1 987.0	1 720.0	1 293.0	876.0	648.0	604.0
Denmark	1 029.0	936.0	714.0	937.0	1 052.0	1 324.0	1 047.0	1 102.0
Estonia	126.0	142.0	119.0	137.0	158.0	158.0	158.0	..
Finland	802.0	973.0	922.0	890.0	973.0	1 128.0	1 148.0	1 132.0
France	12 489.0	12 623.0	12 648.0	11 942.0	11 876.0	12 006.0	12 093.0	10 735.0
FYROM[1]	39.0	45.0	43.0	32.0	38.0	..	..	..
Georgia	122.0	124.0	219.0	232.0	216.0	178.0	237.0	224.0
Germany	10 845.0	11 410.0	12 620.0	11 240.0	11 340.0	11 530.0	11 730.0	11 780.0
Greece	1 516.0	1 760.0	1 791.0	1 394.0	1 310.0	1 088.0	2 181.0	..
Hungary	646.0	979.0	1 566.0	840.0	298.0	153.0	401.0	164.0
Iceland	187.0	216.0	121.0	79.0	39.0	38.0	42.0	..
India	4 384.0	4 722.0	4 807.0	6 360.0	5 617.0	6 208.0	7 729.0	8 605.0
Ireland	1 462.0	1 361.0	1 214.0	1 188.0	850.0	776.0	561.0	..
Italy	13 664.0	13 051.0	5 641.0	3 389.0	4 129.0	3 107.0	2 841.0	..
Japan	31 561.0	31 862.0	37 206.0	35 774.0	35 858.0	37 290.0	..	..
Korea	5 918.0	4 983.0	5 290.0	5 051.0	4 676.0	5 231.0	6 144.0	..
Latvia	231.0	272.0	132.0	131.0	222.0	190.0	199.0	188.0
Liechtenstein	..	..	..	..	..	..	..	..
Lithuania	312.0	437.0	448.0	422.0	343.0	243.0	253.0	224.0
Luxembourg	157.0	137.0	149.0	183.0	222.0	213.0	220.0	205.0
Malta	26.0	16.0	4.0	13.0	17.0	27.0	11.0	39.0
Mexico	2 164.0	2 545.0	3 023.0	3 938.0	3 913.0	3 990.0	4 346.0	..
Moldova, Republic of	28.0	26.0	13.0	14.0	8.0	40.0	36.0	39.0
Montenegro, Republic of	51.0	11.0	23.0	18.0	15.0	18.0	20.0	9.0
Netherlands	1 680.0	2 194.0	2 363.0	2 300.0	2 287.0	..	..	..
New Zealand	487.0	511.0 |	579.0	732.0	842.0	668.0	765.0	952.0
Norway	1 735.0	2 137.0	2 489.0	2 675.0	2 812.0	3 301.0	3 843.0	..
Poland	3 443.0	4 508.0	5 340.0	6 510.0	8 319.0	4 382.0	2 465.0	..
Portugal	1 453.0	1 366.0	951.0 |	1 511.0	..	274.0 p	211.0 p	..
Romania	2 806.0	3 891.0	3 105.0	2 850.0	3 283.0	3 092.0	2 729.0	2 493.0
Russian Federation	7 297.0	9 872.0	6 242.0	6 201.0	8 424.0	9 281.0	9 836.0	..
Serbia, Republic of	406.0	379.0	252.0	229.0	339.0	257.0	279.0	337.0
Slovak Republic	520.0	567.0	662.0	342.0	432.0	311.0	360.0	550.0
Slovenia	666.0	694.0	406.0	221.0	112.0	102.0	104.0	139.0
Spain	8 077.0	8 522.0	9 422.0	7 851.0	5 966.0	5 316.0	4 646.0	4 266.0 p
Sweden	1 423.0	1 604.0	1 574.0	1 668.0	1 911.0	2 213.0	2 013.0	1 864.0
Switzerland	2 674.0	2 840.0	2 997.0	3 423.0	3 827.0	3 880.0	..	..
Turkey	1 947.0	2 234.0	2 918.0	5 419.0	5 181.0	4 799.0	4 880.0	4 803.0
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	6 202.0	6 038.0	6 568.0	6 486.0	5 566.0	5 560.0	6 030.0	7 726.0
United States	56 257.0	55 208.0	59 292.0	63 589.0	60 417.0	64 524.0	62 194.0	64 283.0

.. Not available; | Break in series; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ccbe.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Investment in inland waterway transport infrastructure

Million euros

	2007	2008	2009	2010	2011	2012	2013	2014
Albania	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Armenia	x	x	x	x	x	x	x	x
Australia	x	x	x	x	x	x	x	x
Austria	4.0	3.0	5.0	11.0	2.0	3.0	11.0	10.0
Azerbaijan	..	..	..	..	..	119.0	424.0	260.0
Belarus	..	..	..	..	..	..	..	..
Belgium	178.0	188.0	188.0	154.0 |	152.0	152.0	167.0	103.0
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	405.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Canada	..	..	..	..	..	..	..	..
China	..	..	..	..	..	..	..	..
Croatia	2.0	2.0	4.0	3.0	3.0	3.0	2.0	..
Czech Republic	14.0	22.0	59.0	58.0	22.0	17.0	7.0	10.0
Denmark	x	x	x	x	x	x	x	x
Estonia	x	x	x	x	x	x	x	x
Finland	5.0	2.0	2.0	2.0	1.0	2.0	3.0	2.0
France	226.0	189.0	245.0	253.0	264.0	236.0	224.0	180.0
FYROM[1]	x	x	x	x	x	x	x	x
Georgia	x	x	x	x	x	x	x	x
Germany	820.0	905.0	1 170.0	1 100.0	1 040.0	870.0	840.0	905.0
Greece	x	x	x	x	x	x	x	x
Hungary	4.0	0.0	3.0	1.0	0.0	0.0	0.0	..
Iceland	x	x	x	x	x	x	x	x
India	..	..	..	..	..	..	..	..
Ireland	x	x	x	x	x	x	x	x
Italy	29.0	34.0	27.0	42.0	36.0	52.0	136.0	..
Japan	x	x	x	x	x	x	x	x
Korea	x	x	x	x	x	x	x	x
Latvia	x	x	x	x	x	x	x	x
Liechtenstein	x	x	x	x	x	x	x	x
Lithuania	3.0	4.0	1.0	1.0	2.0	0.0	1.0	3.0
Luxembourg	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0
Malta	x	x	x	x	x	x	x	x
Mexico	x	x	x	x	x	x	x	x
Moldova, Republic of	0.0	0.0	0.0	0.0	1.0	0.0	0.0	..
Montenegro, Republic of	x	x	x	x	x	x	x	x
Netherlands	263.0	270.0	361.0	252.0	263.0	..	..	..
New Zealand	x	x	x	x	x	x	x	x
Norway	x	x	x	x	x	x	x	x
Poland	13.0	21.0	25.0	25.0	29.0	0.0	0.0	..
Portugal	10.0	7.0	5.0	1.0	1.0	3.0	0.0	..
Romania	359.0	490.0	536.0	423.0	519.0	279.0	268.0	314.0
Russian Federation	58.0	102.0	59.0	68.0	302.0	230.0	107.0	..
Serbia, Republic of	24.0	36.0	19.0	21.0	26.0	25.0	15.0	18.0
Slovak Republic	0.0	1.0	2.0	3.0	1.0	1.0	1.0	0.0
Slovenia	x	x	x	x	x	x	x	x
Spain	x	x	x	x	x	x	x	x
Sweden	x	x	x	x	x	x	x	x
Switzerland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turkey	x	x	x	x	x	x	x	x
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	..	..	..	..	..	..	..	..
United States	..	..	..	..	..	..	..	..

.. Not available; | Break in series; x Not applicable

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ccbe.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Total investment in inland transport infrastructure

Million euros

	2007	2008	2009	2010	2011	2012	2013	2014
Albania	254.0	501.0	487.0	242.0	211.0	181.0	235.0	193.0
Armenia	..	..	..	..	..	..	..	..
Australia	9 987.0	10 991.0	11 481.0	14 812.0	19 304.0	22 499.0	17 964.0	15 449.0
Austria	2 379.0	2 560.0	2 731.0	2 337.0	2 448.0	2 018.0	2 022.0	2 030.0
Azerbaijan	378.0	1 338.0	1 275.0	1 548.0	1 565.0	1 606.0	2 342.0	1 675.0
Belarus	..	..	..	..	..	..	..	..
Belgium	1 354.0	1 567.0	1 586.0	1 580.0 |	1 475.0	1 883.0	1 845.0	1 593.0
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	584.0	240.0	151.0	411.0	434.0	502.0	483.0	318.0
Canada	8 456.0	9 368.0	11 385.0	16 093.0	15 930.0	15 808.0	14 097.0	..
China	..	..	..	..	..	..	..	..
Croatia	1 160.0	1 229.0	1 011.0	601.0	550.0	544.0	609.0	..
Czech Republic	2 120.0	3 282.0	2 787.0	2 341.0	1 762.0	1 275.0	990.0	1 068.0
Denmark	1 261.0	1 309.0	1 070.0	1 333.0	1 915.0	2 239.0	2 043.0	2 261.0
Estonia	156.0	165.0	156.0	172.0	252.0	252.0	252.0	..
Finland	1 018.0	1 302.0	1 285.0	1 280.0	1 329.0	1 580.0	1 756.0	1 777.0
France	17 220.0	17 931.0	17 940.0	17 110.0	19 144.0	20 342.0	22 863.0	20 525.0
FYROM[1]	40.0	47.0	46.0	34.0	39.0	..	..	..
Georgia	334.0	173.0	299.0	310.0	465.0	433.0	319.0	291.0
Germany	15 501.0	16 131.0	17 202.0	16 147.0	16 466.0	16 330.0	16 780.0	17 105.0
Greece	1 840.0	2 100.0	2 258.0	1 606.0	1 495.0	1 265.0	2 276.0	..
Hungary	1 026.0	1 278.0	1 887.0	1 112.0 |	647.0	625.0	1 024.0	..
Iceland	187.0	216.0	121.0	79.0	39.0	38.0	42.0	..
India	8 311.0	9 385.0	9 531.0	11 509.0	10 452.0	11 620.0	13 018.0	..
Ireland	1 706.0	..	..	..	..	..	..	..
Italy	21 395.0	20 194.0	11 355.0	8 204.0	8 631.0	7 397.0	7 080.0	..
Japan	38 444.0	39 229.0	46 808.0	47 082.0	46 079.0	49 259.0	..	..
Korea	9 376.0	7 400.0	7 994.0	7 796.0	7 553.0	8 748.0	10 368.0	..
Latvia	267.0	335.0	195.0	204.0	275.0	292.0	276.0	324.0
Liechtenstein	..	..	..	..	..	..	..	..
Lithuania	391.0	527.0	516.0	530.0	462.0	383.0	393.0	491.0
Luxembourg	296.0	287.0	321.0	340.0	374.0	339.0	366.0	397.0
Malta	26.0	16.0	4.0	13.0	17.0	27.0	11.0	39.0
Mexico	2 727.0	3 043.0	3 461.0	4 373.0	4 562.0	4 611.0	5 081.0	..
Moldova, Republic of	38.0	51.0	22.0	21.0	16.0	51.0	49.0	43.0
Montenegro, Republic of	51.0	11.0	23.0	18.0	15.0	18.0	20.0	9.0
Netherlands	2 788.0	3 284.0	3 502.0	3 649.0	3 686.0	..	..	..
New Zealand	487.0	511.0 |	579.0	732.0	842.0	668.0	765.0	952.0
Norway	2 045.0	2 425.0	2 847.0	3 154.0	3 373.0	3 977.0	4 682.0	..
Poland	4 103.0	5 434.0	6 016.0	7 225.0	9 273.0	4 813.0	2 728.0	..
Portugal	1 792.0	1 765.0 |	1 316.0 |	1 915.0	..	363.0 p	282.0 p	..
Romania	3 476.0	4 698.0	3 818.0	3 442.0	3 964.0	3 489.0	3 206.0	3 085.0
Russian Federation	12 789.0	19 454.0	12 878.0	15 321.0	18 598.0	20 706.0	19 729.0	..
Serbia, Republic of	432.0	417.0	276.0	262.0	372.0	284.0	304.0	366.0
Slovak Republic	808.0	782.0	839.0 |	618.0	722.0	528.0	685.0	826.0
Slovenia	728.0	790.0	478.0	352.0	218.0	174.0	244.0	436.0
Spain	16 422.0	17 503.0	18 194.0	15 520.0	13 519.0	10 666.0	7 356.0	7 308.0 p
Sweden	2 677.0	2 924.0	2 892.0	3 101.0	3 311.0	3 543.0	3 117.0	3 052.0
Switzerland	5 003.0	5 462.0	5 885.0	6 459.0	7 241.0	7 344.0	..	..
Turkey	2 446.0	2 905.0	3 674.0	6 913.0	6 651.0	6 284.0	7 127.0	6 156.0
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	13 935.0	13 682.0	12 976.0	12 876.0	11 676.0	11 812.0	11 752.0	15 616.0
United States	..	..	..	..	..	..	..	..

.. Not available; | Break in series; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ccbe.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Investment in sea port infrastructure

Million euros

	2007	2008	2009	2010	2011	2012	2013	2014
Albania	1.0	3.0	3.0	4.0	10.0	9.0	1.0	2.0
Armenia	x	x	x	x	x	x	x	x
Australia	702.0	1 057.0	1 171.0	1 813.0	3 329.0	5 400.0	4 595.0	3 201.0
Austria	x	x	x	x	x	x	x	x
Azerbaijan	..	..	..	..	59.0	49.0	420.0	260.0
Belarus	x	x	x	x	x	x	x	x
Belgium	159.0	203.0	219.0	230.0 |	241.0	236.0	197.0	150.0
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	46.0	7.0	8.0	5.0	5.0	3.0	3.0	15.0
Canada	175.0	184.0	299.0	320.0	249.0	411.0 |	630.0	..
China	..	..	..	..	..	..	..	..
Croatia	17.0	52.0	77.0	51.0	63.0	96.0	74.0	70.0
Czech Republic	x	x	x	x	x	x	x	x
Denmark	67.0	71.0	66.0	49.0	62.0	58.0	164.0	..
Estonia	57.0	41.0	75.0	39.0	18.0	..	..	..
Finland	221.0	238.0	100.0	69.0	76.0	56.0	39.0	44.0
France	226.0 |	436.0	532.0	328.0	299.0	313.0	446.0	460.0
FYROM[1]	x	x	x	x	x	x	x	x
Georgia	4.0	30.0 |	24.0	24.0	13.0	8.0	12.0	3.0
Germany	640.0	630.0	685.0	965.0	925.0	890.0	780.0	450.0
Greece	64.0	112.0	107.0	73.0	25.0	24.0	33.0	..
Hungary	x	x	x	x	x	x	x	x
Iceland	37.0	21.0	20.0	14.0	17.0	15.0	13.0	..
India	66.0	55.0	65.0	72.0	61.0	62.0	44.0	64.0
Ireland	..	..	..	..	..	..	..	..
Italy	1 179.0	940.0	1 278.0	1 345.0	1 268.0	1 343.0	1 126.0	..
Japan	2 506.0	2 849.0	4 656.0	2 169.0	2 290.0	3 280.0	2 291.0	..
Korea	2 347.0	185.0	..	..	..	..	..	..
Latvia	142.0	269.0	..	..	..	..	..	..
Liechtenstein	x	x	x	x	x	x	x	x
Lithuania	26.0	42.0	16.0	21.0	27.0	28.0	83.0	22.0
Luxembourg	x	x	x	x	x	x	x	x
Malta	8.0 e	6.0 e	13.0 e	3.0	6.0	8.0	4.0	5.0
Mexico	438.0	579.0	383.0	487.0	543.0	667.0	649.0	..
Moldova, Republic of	..	5.0	3.0	5.0	4.0	..	..	4.0
Montenegro, Republic of	2.0	3.0	2.0	3.0	3.0	1.0	25.0	19.0
Netherlands	..	..	..	..	..	..	..	..
New Zealand	..	..	..	..	..	..	..	..
Norway	123.0	9.0	81.0	19.0	8.0	11.0	29.0	..
Poland	17.0	30.0	4.0	27.0	64.0	154.0	94.0	..
Portugal	157.0	128.0	100.0	112.0	83.0	62.0	34.0	..
Romania	..	..	..	..	..	..	..	..
Russian Federation	197.0	410.0	181.0	116.0	325.0	86.0	147.0	..
Serbia, Republic of	x	x	x	x	x	x	x	x
Slovak Republic	x	x	x	x	x	x	x	x
Slovenia	7.0	10.0	54.0	13.0	6.0	5.0	8.0	23.0
Spain	2 573.0	2 871.0	2 508.0	2 247.0	1 789.0	1 245.0	830.0	873.0 p
Sweden	81.0	60.0	72.0	107.0	88.0	69.0	101.0	..
Switzerland	x	x	x	x	x	x	x	x
Turkey	23.0	30.0	20.0	16.0	34.0	72.0	43.0	9.0
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	..	..	..	..	..	..	..	..
United States	..	..	..	..	..	..	..	..

.. Not available; | Break in series; e Estimated value; x Not applicable; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ccbe.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Investment in airport infrastructure

Million euros

	2007	2008	2009	2010	2011	2012	2013	2014
Albania	1.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Armenia	..	..	..	..	..	..	..	..
Australia	..	..	..	..	..	..	..	..
Austria	187.0	306.0	221.0	174.0	..	..	..	..
Azerbaijan	70.6	82.7	28.6	200.9	163.8	278.2	270.6	78.7
Belarus	..	..	..	..	..	..	..	..
Belgium	135.0	116.0	116.0	30.0 |	34.0	74.0	93.0	107.0
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	3.0	4.0	1.0	2.0	2.0	10.0	5.0	..
Canada	741.0	810.0	731.0	608.0	701.0	953.0	1 155.0	1 033.0
China	..	..	..	..	..	..	..	..
Croatia	19.9	20.6	27.9	28.1	18.6	15.6	16.1	77.9
Czech Republic	77.0	325.0	92.0	81.0	40.0	47.0	56.0	36.0
Denmark	64.0	20.0	92.0	48.0	31.0	31.0	80.0	..
Estonia	31.0	56.0	19.0	3.0	6.0	..	..	..
Finland	74.0	108.0	76.0	45.0	44.0	45.0	35.0	86.0
France	1 052.0	820.0	718.0	759.0	896.0	932.0	757.0	700.0
FYROM[1]	0.0	1.0	0.0	0.0	102.0	..	..	..
Georgia	27.5	0.0	0.0	0.4	0.9	38.6	12.7	6.8
Germany	1 620.0	1 140.0	1 510.0	1 480.0	1 815.0	1 390.0	930.0	770.0
Greece	37.0	45.0	51.0	38.0	49.0	60.0	49.0	..
Hungary	2.5	..	10.7	50.3	38.8	26.6	16.7	9.3
Iceland	5.0	10.0	5.0	2.0	2.0	2.0	1.0	..
India	17.0	21.0	133.0	208.0	189.0	876.0	783.0	811.0
Ireland	271.0	403.0	509.0	243.0	83.0	..	..	..
Italy	124.0	126.0	117.0	634.0	184.0	98.0	87.0	..
Japan	2 278.0	2 265.0	2 538.0	2 362.0	1 330.0	1 359.0	1 131.0	..
Korea	262.0	92.0	..	..	..	..	..	..
Latvia	16.0	19.0	3.0	3.0	6.0	9.0	38.0	50.0
Liechtenstein	x	x	x	x	x	x	x	..
Lithuania	53.0	11.0	29.0	8.0	14.0	3.0	7.0	6.0
Luxembourg	64.0	47.0	19.0	7.0	12.0	11.0	0.0	2.0
Malta	..	..	..	..	..	..	..	..
Mexico	191.0	326.0	179.0	271.0	226.0	202.0	187.0	..
Moldova, Republic of	4.0	12.0	4.0	0.0	2.0	..	0.0	0.0
Montenegro, Republic of	4.0	0.0	2.0	28.0	4.0	2.0	..	..
Netherlands	..	..	..	..	..	..	..	..
New Zealand	..	..	..	..	..	..	..	..
Norway	238.0	206.0	252.0	203.0	158.0	476.0	485.0	..
Poland	85.0	79.0	63.0	132.0	206.0	146.0	153.0	..
Portugal	82.0	135.0	151.0	127.0 |	102.0	64.0	53.0	..
Romania	42.0	9.0	6.0	1.0	2.0	21.0	19.0	29.0
Russian Federation	434.0	438.0	267.0	472.0	433.0	660.0	778.0	..
Serbia, Republic of	0.0	0.0	1.0	1.0	0.0	0.0	3.0	1.0
Slovak Republic	16.0	30.0	56.0	70.0	33.0	31.0	4.0	5.0
Slovenia	24.0	5.0	13.0	7.0	3.0	4.0	4.0	1.0
Spain	2 164.0	2 132.0	1 773.0	1 744.0	1 235.0	943.0	585.0	363.0 p
Sweden	118.0	108.0	87.0	79.0	126.0	404.0	289.0	115.0
Switzerland	..	..	169.0	211.0	328.0	265.0	294.0	294.0
Turkey	175.0	138.0	569.0	520.0	426.0	376.0	610.0	127.0
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	..	..	..	..	..	..	..	..
United States	..	..	..	..	..	..	..	..

.. Not available; | Break in series; x Not applicable; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ccbe.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Rail infrastructure maintenance expenditure

Million euros

	2007	2008	2009	2010	2011	2012	2013	2014
Albania	..	..	..	..	..	..	..	..
Armenia	..	..	..	..	..	..	..	..
Australia	..	..	..	..	..	..	..	..
Austria	325.0	356.0	348.0	344.0	451.0	480.0	497.0	504.0
Azerbaijan	12.0	21.0	29.0	23.0	19.0	..	..	..
Belarus	..	..	..	..	..	..	..	..
Belgium	..	..	..	295.0	312.0	311.0	329.0	333.0
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	30.0	58.0	38.0	36.0	33.0	37.0	42.0	50.0
Canada	528.0	532.0	500.0	643.0	705.0	755.0	739.0	850.0 p
China	..	..	..	..	..	..	..	..
Croatia	112.0	106.0	76.0	90.0	87.0	102.0	102.0	106.0
Czech Republic	253.0	353.0	372.0	359.0	364.0	353.0	378.0	424.0
Denmark	..	..	..	..	..	..	..	..
Estonia	..	..	..	..	..	..	..	..
Finland	167.0	180.0	196.0	195.0	197.0	181.0	201.0	194.0
France	3 377.0	3 672.0	3 730.0	3 770.0	3 804.0	3 983.0	3 884.0	3 115.0
FYROM[1]	0.0	5.0	3.0	2.0	2.0	..	..	..
Georgia	133.0	133.0	132.0	138.0	23.0	42.0	48.0	46.0
Germany	..	..	..	..	..	..	..	..
Greece	..	..	..	..	..	..	..	..
Hungary	1 288.0	458.0	399.0	440.0	435.0	435.0	418.0	400.0
Iceland	x	x	x	x	x	x	x	x
India	9 706.0	11 396.0	12 444.0	14 916.0	15 327.0	16 389.0	16 900.0	..
Ireland	144.0	..	..	..	..	..	..	..
Italy	8 282.0	8 036.0	7 832.0	7 829.0	7 675.0	7 477.0	7 205.0	..
Japan	..	..	..	..	..	..	..	..
Korea	1 470.0	..	..	..	..	..	..	..
Latvia	85.0	129.0	133.0	98.0	109.0	112.0	110.0	119.0
Liechtenstein	x	x	x	x	x	x	x	x
Lithuania	115.0 |	166.0	132.0	143.0	151.0	156.0	153.0	155.0
Luxembourg	108.0	115.0	126.0	120.0	124.0	132.0	139.0	143.0
Malta	x	x	x	x	x	x	x	x
Mexico	..	..	..	..	..	..	..	..
Moldova, Republic of	..	..	..	..	..	..	..	..
Montenegro, Republic of	..	..	..	..	..	..	..	..
Netherlands	1 367.0	1 175.0	1 410.0	1 690.0	1 798.0	1 798.0	1 798.0	..
New Zealand	..	..	..	..	..	..	..	..
Norway	422.0	449.0	542.0	678.0	730.0	757.0	713.0	801.0
Poland	100.0	36.0	157.0	213.0	239.0	307.0	387.0	..
Portugal	122.0	122.0	127.0	135.0	..	..	..	..
Romania	96.0	..	..	..	..	..	..	..
Russian Federation	..	..	..	..	..	..	..	..
Serbia, Republic of	20.0	21.0	16.0	13.0	17.0	16.0	9.0	9.0
Slovak Republic	15.0	14.0	15.0 |	12.0	6.0	9.0	7.0	8.0
Slovenia	70.0	112.0	102.0	68.0	81.0	87.0	71.0	69.0
Spain	..	..	..	..	..	..	..	..
Sweden	540.0	598.0	590.0	724.0	750.0	851.0	924.0	976.0
Switzerland	847.0	475.0	534.0	588.0	668.0	728.0	729.0	708.0
Turkey	191.0	207.0	178.0	223.0	195.0	193.0	172.0	171.0
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	..	..	..	..	..	..	..	..
United States	..	..	..	..	..	..	..	..

.. Not available; | Break in series; x Not applicable; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ccbe.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Road infrastructure maintenance expenditure

Million euros

	2007	2008	2009	2010	2011	2012	2013	2014
Albania	6.0	8.0	9.0	7.0	8.0	7.0	9.0	15.0
Armenia	..	..	..	..	..	..	..	..
Australia	873.0	900.0	1 056.0	1 327.0 |	1 553.0	1 817.0	1 855.0	1 931.0
Austria	486.0	467.0	516.0	559.0	494.0	517.0	559.0	667.0
Azerbaijan	31.0	35.0	25.0	23.0	26.0	..	..	..
Belarus	..	..	..	..	..	..	..	..
Belgium	94.0	102.0	111.0	184.0	156.0	145.0	147.0	..
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	215.0	203.0	69.0	100.0	71.0	103.0	96.0	93.0
Canada	6 879.0	6 948.0	6 551.0	8 703.0	5 816.0	6 233.0	3 943.0 |	..
China	..	..	..	..	..	..	..	..
Croatia	158.0	168.0	144.0	195.0	212.0	187.0	209.0	257.0
Czech Republic	590.0	612.0	579.0	670.0	570.0	571.0	513.0	587.0
Denmark	729.0	716.0	866.0	1 058.0	881.0	945.0	..	..
Estonia	32.0	38.0	39.0	38.0	39.0	..	..	..
Finland	611.0	673.0	684.0	667.0	658.0	525.0	511.0	506.0
France	2 294.0	2 286.0	2 601.0	2 431.0	2 746.0	2 851.0	2 904.0	2 760.0
FYROM[1]	14.0	14.0	12.0	16.0	15.0	..	..	..
Georgia	11.0	12.0	11.0	9.0	13.0	15.0	14.0	16.0
Germany	..	..	..	..	..	..	..	..
Greece	..	..	..	..	..	..	..	..
Hungary	1 367.0	445.0	454.0	328.0 e	256.0	296.0	370.0	357.0
Iceland	36.0	47.0	30.0	29.0	29.0	30.0	28.0	..
India	5 382.0	5 296.0	6 255.0	9 380.0	9 299.0	7 764.0	7 041.0	6 894.0
Ireland	56.0	56.0	46.0	164.0	161.0	139.0	129.0	..
Italy	9 764.0	10 756.0	6 008.0	6 437.0	6 220.0	7 196.0	9 134.0	..
Japan	11 373.0	10 876.0	13 529.0	13 966.0	15 701.0	17 606.0	..	..
Korea	1 526.0	..	..	..	..	..	..	..
Latvia	202.0	231.0	131.0	113.0	125.0	120.0	133.0	154.0
Liechtenstein	..	..	..	..	..	..	..	..
Lithuania	125.0	134.0	125.0	160.0	153.0	123.0	127.0	143.0
Luxembourg	23.0	27.0	30.0	34.0	37.0	34.0	41.0	41.0
Malta	13.0	1.0	25.0	25.0	27.0	24.0	25.0	17.0
Mexico	465.0	690.0 |	672.0	802.0	821.0	825.0	1 097.0	..
Moldova, Republic of	11.0	18.0	17.0	37.0	36.0	55.0	64.0	72.0
Montenegro, Republic of	..	..	..	..	..	..	..	..
Netherlands	1 091.0	1 231.0	827.0	1 209.0	323.0	..	..	..
New Zealand	616.0	579.0 |	607.0	720.0	789.0	948.0	885.0	969.0
Norway	1 109.0	1 149.0	1 221.0	1 361.0	1 615.0	1 747.0	1 841.0	1 998.0
Poland	1 515.0	2 006.0	2 341.0	2 636.0	2 678.0	428.0	438.0	..
Portugal	192.0	141.0	124.0 |	102.0	..	165.0	174.0	..
Romania	1 337.0	..	..	..	..	..	..	..
Russian Federation	..	..	..	..	..	..	..	..
Serbia, Republic of	300.0	331.0	259.0	229.0	205.0	209.0	129.0	143.0
Slovak Republic	156.0	161.0	192.0	175.0	160.0	193.0	204.0	181.0
Slovenia	139.0	148.0	151.0	137.0	122.0	120.0	123.0	118.0
Spain	..	..	..	..	..	..	..	..
Sweden	836.0	859.0	787.0	875.0	856.0	959.0	1 044.0	1 017.0
Switzerland	1 410.0	1 611.0	1 817.0	2 001.0	2 238.0	2 414.0	..	..
Turkey	278.0	309.0	411.0	360.0	674.0	600.0	630.0	582.0
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	5 639.0	5 009.0	4 337.0	3 919.0	3 462.0	3 470.0	3 160.0	3 229.0
United States	22 513.0	22 642.0	23 088.0	29 810.0	29 886.0	33 994.0	..	..

.. Not available; | Break in series; e Estimated value

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ccbe.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Inland waterway infrastructure maintenance expenditure

Million euros

	2007	2008	2009	2010	2011	2012	2013	2014
Albania	..	..	..	..	..	..	..	..
Armenia	x	x	x	x	x	x	x	x
Australia	x	x	x	x	x	x	x	x
Austria	..	..	..	..	11.0	12.0	17.0	19.0
Azerbaijan	..	..	..	..	..	..	..	..
Belarus	..	..	..	..	..	..	..	..
Belgium	76.0	87.0	131.0	65.0	58.0	71.0	66.0	27.0
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	788.0	2.0	1.0	1.0	2.0	1.0	1.0	1.0
Canada	..	..	..	..	..	..	..	..
China	..	..	..	..	..	..	..	..
Croatia	2.0	3.0	1.0	1.0	1.0	1.0	1.0	..
Czech Republic	3.0	2.0	2.0	2.0	2.0	3.0	5.0	5.0
Denmark	x	x	x	x	x	x	x	x
Estonia	x	x	x	x	x	x	x	x
Finland	16.0	17.0	26.0	17.0	20.0	15.0	15.0	17.0
France	58.0	60.0	61.0	60.0	61.0	61.0 e	61.0 e	60.0 e
FYROM[1]	x	x	x	x	x	x	x	x
Georgia	x	x	x	x	x	x	x	x
Germany	..	..	..	..	..	..	..	..
Greece	x	x	x	x	x	x	x	x
Hungary	33.0	2.0	1.0	3.0 e	2.0	1.0	1.0	1.0
Iceland	x	x	x	x	x	x	x	x
India	..	..	..	..	..	..	..	..
Ireland	x	x	x	x	x	x	x	x
Italy	98.0	83.0	82.0	81.0	78.0	77.0	113.0	..
Japan	x	x	x	x	x	x	x	x
Korea	x	x	x	x	x	x	x	x
Latvia	x	x	x	x	x	x	x	x
Liechtenstein	x	x	x	x	x	x	x	x
Lithuania	2.0	3.0	1.0	1.0	1.0	2.0	2.0	2.0
Luxembourg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malta	x	x	x	x	x	x	x	x
Mexico	x	x	x	x	x	x	x	x
Moldova, Republic of	0.0	4.0	1.0	0.0	..	..	..	..
Montenegro, Republic of	x	x	x	x	x	x	x	x
Netherlands	492.0	583.0	693.0	544.0	343.0	..	..	..
New Zealand	x	x	x	x	x	x	x	x
Norway	x	x	x	x	x	x	x	x
Poland	2.0	2.0	3.0	8.0	17.0	8.0	21.0	..
Portugal	..	..	..	..	0.0	1.0	1.0	..
Romania	28.0	..	..	..	..	..	..	..
Russian Federation	..	..	..	..	..	..	..	..
Serbia, Republic of	11.0	13.0	11.0	13.0	23.0	18.0	17.0	17.0
Slovak Republic	1.0	4.0	2.0	2.0	2.0	3.0	4.0	9.0
Slovenia	x	x	x	x	x	x	x	x
Spain	x	x	x	x	x	x	x	x
Sweden	x	x	x	x	x	x	x	x
Switzerland	..	..	..	..	..	..	..	..
Turkey	x	x	x	x	x	x	x	x
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	..	..	..	..	..	..	..	..
United States	..	..	..	..	..	..	..	..

.. Not available; e Estimated value; x Not applicable
Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ccbe.
Disclaimer: http://oe.cd/disclaimer
1. FYROM: the Former Yugoslav Republic of Macedonia
Source: ITF Transport statistics

Sea port infrastructure maintenance expenditure

Million euros

	2007	2008	2009	2010	2011	2012	2013	2014
Albania	..	..	..	..	..	..	..	..
Armenia	x	x	x	x	x	x	x	x
Australia	..	..	..	..	..	..	..	..
Austria	x	x	x	x	x	x	x	x
Azerbaijan	..	..	..	..	..	..	..	..
Belarus	x	x	x	x	x	x	x	x
Belgium	130.0	130.0	135.0	..	..	..	..	..
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	27.0	0.0	5.0	1.0	1.0	1.0	1.0	2.0
Canada	114.0	128.0	138.0	151.0	264.0 |	251.0	219.0	..
China	..	..	..	..	..	..	..	..
Croatia	8.0	5.0	4.0	3.0	3.0	4.0	4.0	3.0
Czech Republic	x	x	x	x	x	x	x	x
Denmark	..	..	..	..	..	..	..	..
Estonia	..	..	..	..	..	..	..	..
Finland	89.0	82.0	107.0	106.0	122.0	101.0	112.0	101.0
France	44.0	48.0	48.0	53.0	53.0	53.0 e	53.0 e	53.0 e
FYROM[1]	x	x	x	x	x	x	x	x
Georgia	..	0.0	0.0	0.0	2.0	0.0	0.0	0.0
Germany	..	..	..	..	..	..	..	..
Greece	..	..	..	..	..	..	..	..
Hungary	x	x	x	x	x	x	x	x
Iceland	..	..	..	..	..	..	..	..
India	171.0	158.0	132.0	192.0	148.0	131.0	178.0	193.0
Ireland	..	..	..	..	..	..	..	..
Italy	1 394.0	1 163.0	1 287.0	1 098.0	1 447.0	1 628.0	1 263.0	..
Japan	..	..	..	..	..	..	..	..
Korea	273.0	..	..	..	..	..	..	..
Latvia	52.0	60.0	..	..	..	..	..	..
Liechtenstein	x	x	x	x	x	x	x	x
Lithuania	4.0	6.0	2.0	7.0	2.0	3.0	3.0	4.0
Luxembourg	x	x	x	x	x	x	x	x
Malta	..	..	..	1.0	1.0	1.0	0.0	2.0
Mexico	..	..	..	..	..	..	..	..
Moldova, Republic of	..	..	..	..	..	..	..	..
Montenegro, Republic of	..	..	..	..	..	..	..	..
Netherlands	..	..	..	..	..	..	..	..
New Zealand	..	..	..	..	..	..	..	..
Norway	..	..	..	..	..	..	..	..
Poland	6.0	6.0	10.0	10.0	15.0	15.0	20.0	..
Portugal	1.0	1.0	1.0	1.0	4.0	3.0	3.0	..
Romania	..	..	..	..	..	..	..	..
Russian Federation	..	..	..	..	..	..	..	..
Serbia, Republic of	x	x	x	x	x	x	x	x
Slovak Republic	x	x	x	x	x	x	x	x
Slovenia	1.0	1.0	2.0	2.0	3.0	3.0	2.0	3.0
Spain	..	..	..	..	..	..	..	..
Sweden	28.0	1.0	23.0	27.0	27.0	20.0	20.0	..
Switzerland	x	x	x	x	x	x	x	x
Turkey	x	x	x	x	x	x	x	x
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	..	..	..	..	..	..	..	..
United States	..	..	..	..	..	..	..	..

.. Not available; | Break in series; e Estimated value; x Not applicable

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ccbe.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Airport infrastructure maintenance expenditure

Million euros

	2007	2008	2009	2010	2011	2012	2013	2014
Albania	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Armenia	..	..	..	..	..	..	..	..
Australia	..	..	..	..	..	..	..	..
Austria	..	..	..	..	..	..	..	..
Azerbaijan	10.2	7.4	10.7	3.8	7.3	..	..	..
Belarus	..	..	..	..	..	..	..	..
Belgium	..	..	..	..	..	..	..	..
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	3.0	0.0	1.0	2.0	2.0	0.0	2.0	..
Canada	630.0	630.0	600.0	707.0	699.0	756.0 |	741.0	721.0
China	..	..	..	..	..	..	..	..
Croatia	1.9	1.8	3.4	2.3	3.5	3.5	4.5	4.5
Czech Republic	13.0	12.0	13.0	14.0	7.0	9.0	15.0	9.0
Denmark	..	..	..	..	..	..	..	..
Estonia	..	..	..	..	..	..	..	..
Finland	218.0	232.0	230.0	240.0	267.0	268.0	251.0	233.0
France	..	..	..	..	..	..	..	..
FYROM[1]	..	..	..	..	..	..	..	..
Georgia	0.0	1.4	0.4	0.4	0.4	0.9	0.5	0.0
Germany	..	..	..	..	..	..	..	..
Greece	..	..	..	..	..	..	..	..
Hungary	658.8	..	..	6.0	0.1	0.1	0.0	0.1
Iceland	..	..	..	..	..	..	..	..
India	211.0	117.0	168.0	220.0	144.0	167.0	130.0	122.0
Ireland	37.0	37.0	33.0	34.0	29.0	..	..	..
Italy	113.0	98.0	100.0	102.0	95.0	115.0	109.0	..
Japan	..	..	..	..	..	..	..	..
Korea	28.0	..	..	..	..	..	..	..
Latvia	..	..	..	..	..	..	..	..
Liechtenstein	x	x	x	x	x	x	x	..
Lithuania	4.0	12.0	2.0	1.0	1.0	1.0	2.0	2.0
Luxembourg	4.0	3.0	5.0	8.0	7.0	10.0	10.0	9.0
Malta	..	..	..	..	..	..	..	..
Mexico	..	..	..	..	..	..	..	..
Moldova, Republic of	..	..	..	..	..	..	0.0	0.0
Montenegro, Republic of	..	..	..	..	..	..	..	..
Netherlands	..	..	..	..	..	..	..	..
New Zealand	..	..	..	..	..	..	..	..
Norway	..	..	..	..	..	..	..	..
Poland	6.0	20.0	4.0	5.0	21.0	64.0	34.0	..
Portugal	5.0	18.0	14.0	9.0 |	16.0	..	..	..
Romania	2.0	..	..	..	..	..	..	..
Russian Federation	..	..	..	..	..	..	..	..
Serbia, Republic of	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
Slovak Republic	2.0	2.0	3.0	5.0	2.0	3.0	1.0	1.0
Slovenia	..	..	..	..	..	..	..	..
Spain	..	..	..	..	..	..	..	..
Sweden	32.0	34.0	31.0	26.0 |	17.0	18.0	16.0	12.0
Switzerland	..	..	..	..	..	..	..	..
Turkey	2.0	3.0	5.0	7.0	3.0	45.0	32.0	10.0
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	..	..	..	..	..	..	..	..
United States	..	..	..	..	..	..	..	..

.. Not available; | Break in series; x Not applicable

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ccbe.

Disclaimer: http://oe.cd/disclaimer

1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Total spending on road infrastructure investment and maintenance

Million euros

	2007	2008	2009	2010	2011	2012	2013	2014
Albania	259.0	508.0	496.0	249.0	218.0	187.0	243.0	208.0
Armenia	..	..	..	..	..	..	..	..
Australia	8 899.0	10 163.0	10 252.0	12 527.0 |	15 359.0	17 715.0	14 846.0	13 059.0
Austria	1 356.0	1 342.0	1 181.0	949.0	797.0	844.0	922.0	1 120.0
Azerbaijan	406.0	1 362.0	1 297.0	1 569.0	1 588.0	..	..	..
Belarus	..	..	..	..	..	..	..	..
Belgium	261.0	258.0	286.0	532.0 |	404.0	698.0	734.0	..
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	349.0	372.0	170.0	381.0	415.0	490.0	455.0	345.0
Canada	14 690.0	15 699.0	17 443.0	24 097.0	20 877.0	20 996.0	17 029.0 |	..
China	..	..	..	..	..	..	..	..
Croatia	1 224.0	1 270.0	1 053.0	710.0	678.0	665.0	633.0	537.0
Czech Republic	2 083.0	2 654.0	2 566.0	2 390.0	1 863.0	1 447.0	1 161.0	1 191.0
Denmark	1 757.0	1 651.0	1 580.0	1 995.0	1 933.0	2 268.0	..	..
Estonia	158.0	180.0	158.0	175.0	197.0	..	..	..
Finland	1 413.0	1 646.0	1 606.0	1 557.0	1 631.0	1 653.0	1 659.0	1 638.0
France	14 783.0	14 909.0	15 249.0	14 373.0	14 622.0	14 857.0	14 997.0	13 495.0
FYROM[1]	53.0	59.0	55.0	47.0	53.0	..	..	..
Georgia	134.0	136.0	230.0	242.0	229.0	193.0	251.0	240.0
Germany	..	..	..	..	..	..	..	..
Greece	..	..	..	..	..	..	..	..
Hungary	2 013.0	1 423.0	2 021.0	1 168.0 e	554.0	449.0	771.0	521.0
Iceland	222.0	263.0	151.0	108.0	68.0	68.0	70.0	..
India	9 766.0	10 018.0	11 062.0	15 740.0	14 916.0	13 972.0	14 770.0	15 500.0
Ireland	1 518.0	1 417.0	1 260.0	1 352.0	1 011.0	915.0	690.0	..
Italy	23 428.0	23 807.0	11 649.0	9 826.0	10 349.0	10 303.0	11 975.0	..
Japan	42 934.0	42 737.0	50 735.0	49 740.0	51 559.0	54 896.0	..	..
Korea	..	..	..	..	..	..	..	..
Latvia	434.0	503.0	263.0	244.0	346.0	310.0	332.0	342.0
Liechtenstein	..	..	..	..	..	..	..	..
Lithuania	437.0	571.0	573.0	582.0	496.0	366.0	380.0	367.0
Luxembourg	180.0	164.0	178.0	216.0	259.0	247.0	261.0	246.0
Malta	38.0	17.0	29.0	37.0	44.0	51.0	36.0	56.0
Mexico	2 629.0	3 235.0 |	3 695.0	4 740.0	4 733.0	4 815.0	5 443.0	..
Moldova, Republic of	39.0	44.0	31.0	51.0	45.0	95.0	100.0	111.0
Montenegro, Republic of	..	..	..	..	..	..	..	..
Netherlands	2 771.0	3 425.0	3 190.0	3 509.0	2 610.0	..	..	..
New Zealand	1 104.0	1 091.0 |	1 186.0	1 452.0	1 630.0	1 615.0	1 650.0	1 921.0
Norway	2 844.0	3 286.0	3 709.0	4 036.0	4 427.0	5 048.0	5 684.0	..
Poland	4 959.0	6 514.0	7 681.0	9 147.0	10 998.0	4 810.0	2 903.0	..
Portugal	1 645.0	1 507.0	1 075.0 |	1 613.0	..	439.0 p	385.0 p	..
Romania	4 143.0	..	..	..	..	..	..	..
Russian Federation	..	..	..	..	..	..	..	..
Serbia, Republic of	706.0	710.0	510.0	458.0	544.0	465.0	408.0	480.0
Slovak Republic	676.0	728.0	854.0	517.0	592.0	504.0	564.0	731.0
Slovenia	805.0	842.0	557.0	358.0	234.0	222.0	227.0	257.0
Spain	..	..	..	..	..	..	..	..
Sweden	2 259.0	2 463.0	2 360.0	2 542.0	2 768.0	3 172.0	3 056.0	2 882.0
Switzerland	4 084.0	4 451.0	4 814.0	5 424.0	6 064.0	6 295.0	..	..
Turkey	2 226.0	2 542.0	3 329.0	5 780.0	5 854.0	5 398.0	5 510.0	5 385.0
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	11 841.0	11 047.0	10 905.0	10 406.0	9 029.0	9 031.0	9 190.0	10 955.0
United States	78 770.0	77 850.0	82 380.0	93 399.0	90 302.0	98 517.0	..	..

.. Not available; | Break in series; e Estimated value; p Provisional data

Note: Detailed metadata at: http://metalinks.oecd.org/transport/20161124/ccbe.

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1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Total inland transport infrastructure investment as a percentage of GDP

Percentage

	2007	2008	2009	2010	2011	2012	2013	2014
Albania	3.2	5.7	5.6	2.7	2.3	1.9	2.4	1.9
Armenia	..	..	..	..	..	..	..	..
Australia	1.5	1.6	1.6	1.6	1.8	1.9	1.6	1.4
Austria	0.8	0.9	1.0	0.8	0.8	0.6	0.6	0.6
Azerbaijan	1.6	4.0	4.0	3.9	3.3	3.0	4.2	3.0
Belarus	..	..	..	..	..	..	..	..
Belgium	0.4	0.4	0.5	0.4 |	0.4	0.5	0.5	0.4
Bosnia-Herzegovina	..	..	..	..	..	..	..	..
Bulgaria	1.8	0.6	0.4	1.1	1.1	1.2	1.2	0.7
Canada	0.8	0.9	1.2	1.3	1.2	1.1	1.0	1.0 p
China	..	..	..	..	..	..	..	..
Croatia	2.6	2.6	2.2	1.3	1.2	1.2	1.4	1.0
Czech Republic	1.5	2.0	1.9	1.5	1.1	0.8	0.6	0.7
Denmark	0.5	0.5	0.5	0.6	0.8	0.9	0.8	0.9
Estonia	1.0	1.0	1.1	1.2	1.5	1.4	1.3	1.3
Finland	0.5	0.7	0.7	0.7	0.7	0.8	0.9	0.9
France	0.9	0.9	0.9	0.9	0.9	1.0	1.1	1.0
FYROM[1]	0.7	0.7	0.7	0.5	0.5	0.5	0.5	0.5
Georgia	4.5	2.0	3.9	3.5	4.5	3.5	2.6	2.3
Germany	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.6
Greece	0.8	0.9	1.0	0.7	0.7	0.7	1.3	1.3
Hungary	1.0	1.2	2.0	1.1 |	0.6	0.6	1.0	0.8
Iceland	1.2	2.0	1.3	0.8	0.4	0.3	0.4	0.3
India	0.9	1.1	1.0	0.9	0.8	0.8	0.9	0.9
Ireland	0.9	0.8	0.8	0.8	0.6	0.5	0.4	0.3
Italy	1.3	1.2	0.7	0.5	0.5	0.5	0.4	0.4
Japan	1.2	1.2	1.3	1.1	1.1	1.1	1.0	1.0
Korea	1.1	1.1	1.2	0.9	0.9	0.9	1.1	1.0
Latvia	1.2	1.4	1.0	1.1	1.4	1.3	1.2	1.4
Liechtenstein	..	..	..	..	..	..	..	..
Lithuania	1.3	1.6	1.9	1.9	1.5	1.2	1.1	1.3
Luxembourg	0.8	0.8	0.9	0.9	0.9	0.8	0.8	0.8
Malta	0.5	0.3	0.1	0.2	0.3	0.4	0.2	..
Mexico	0.4	0.4	0.5	0.6	0.5	0.5	0.5	0.5
Moldova, Republic of	1.2	1.2	0.6	0.5	0.3	0.9	0.8	..
Montenegro, Republic of	1.9	0.4	0.8	0.6	0.5	0.6	0.6	0.3
Netherlands	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
New Zealand	0.5	0.6 |	0.7	0.7	0.7	0.5	0.5	0.6
Norway	0.7	0.8	1.0	1.0	0.9	1.0	1.2	1.2
Poland	1.3	1.5	1.9	2.0	2.4	1.2	0.7	0.7
Portugal	1.0	1.0 |	0.8 |	1.1	0.9	0.2 p	0.2 p	..
Romania	2.8	3.3	3.2	2.7	3.0	2.6	2.2	2.1
Russian Federation	1.3	1.7	1.5	1.3	1.4	1.3	1.3	1.2
Serbia, Republic of	1.5	1.2	0.9	0.9	1.1	0.9	0.9	1.1
Slovak Republic	1.3	1.1	1.3 |	0.9	1.0	0.7	0.9	1.1
Slovenia	2.1	2.1	1.3	1.0	0.6	0.5	0.7	1.2
Spain	1.5	1.6	1.7	1.4	1.3	1.0	0.7	0.7 p
Sweden	0.8	0.8	0.9	0.8	0.8	0.8	0.7	0.7
Switzerland	1.4	1.5	1.5	1.5	1.4	1.4	1.4	..
Turkey	0.5	0.6	0.8	1.3	1.2	1.0	1.2	1.0
Ukraine	..	..	..	..	..	..	..	..
United Kingdom	0.6	0.7	0.8	0.7	0.6	0.6	0.6	0.7
United States	0.6	0.6	0.7	0.7	0.6	0.6	0.6	0.6

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1. FYROM: the Former Yugoslav Republic of Macedonia

Source: ITF Transport statistics

Glossary

2DS scenario: The 2DS scenario of the International Energy Agency (IEA) lays out an energy system deployment pathway and an emissions trajectory consistent with at least a 50% chance of limiting the average global temperature increase to 2°C. For instance, the world average on-road fuel efficiency of passenger cars is 4.4 litres gasoline equivalent per 100 kilometres in 2050, down from 6.4 litres in the baseline.

4DS scenario: The 4°C Scenario (4DS) of the International Energy Agency (IEA) takes into account recent pledges by countries to limit emissions and improve energy efficiency, which help limit the long-term temperature increase to 4°C. In many respects the 4DS is already an ambitious scenario, requiring significant changes in policy and technologies. For example, this corresponds to a global average for on-road fuel efficiency of passenger cars of 6.4 litres gasoline equivalent per 100 kilometres in 2050 compared to 10.3 litres gasoline equivalent per 100 kilometres in 2015.

Accessibility: Accessibility is defined as the ease of reaching valued destinations or opportunities, such as people, jobs, markets, and other services. *Accessibility by air* measures the travel time from any city of at least 300,000 inhabitants to an alpha-city, representing a global centre of economic activity. *Accessibility in cities* computes the share of the population that can be reached within 30min by car and public transport respectively in a given city.

Air service agreement: Agreement between two parties, usually countries, with respect to the furniture of air services. Such agreements can have provisions on the maximum allowed frequency, seat capacity, on the airports of operations, on fares or on the nationality of carriers operating between the two countries.

Asia: All Asian countries excluding Japan and South-Korea, which are part of OECD-Pacific.

Biofuel: Fuels that are directly or indirectly produced from organic material, i.e. biomass, such as plant materials or animal waste. Biofuel in this publication here refers to liquid biofuels, such as ethanol or biodiesel.

Bus Rapid Transit (BRT): Buses running in lanes separated from the general traffic, with high standards of quality of service, in particular regarding frequency and reliability.

Bulk ship (bulkers): Ships transporting goods in unpackaged bulk, such as grains, coal, ore or cement.

Car: A road motor vehicle, other than a moped or a motorcycle, primarily designed to carry one or more persons. This includes SUVs and is equivalent in the text to Passenger Light Duty Vehicle (PLDV).

City: Used as a generic term to designate all urban agglomerations having more than 300 000 inhabitants. The boundaries of the city in the Outlook tend to go beyond administrative boundaries (see *Urban agglomeration*).

Congestion: The relative travel time loss at peak hour on the road network, due slower travel speeds as a consequence of high travel demand.

Container ship: A ship fitted throughout with fixed or portable cell guides for the exclusive carriage of containers.

Domestic non-urban transport: All transport activity within a country, passenger and freight, excluding transport in cities.

EEA + Turkey: The twenty-eight members of the EU plus Switzerland, Norway, Iceland and Turkey.

Free-flow speed: Average speed a vehicle can travel according to the road type, excluding congestion or other constraints (traffic lights, weather conditions etc.).

Herfindahl–Hirschman Index (h-index): Index measuring competition (in this Outlook, for the aviation market), defined as the sum of the squared market-shares of each individual firm (in our case, airlines). The h-index varies between 0 and 1, with 0 corresponding to atomistic competition and 1 to a monopolistic situation.

Liquefied natural gas (LNG): Natural gas consists mainly of methane occurring naturally in underground deposits, associated with crude oil or gas recovered from coal mines (colliery gas). To facilitate its transportation, natural gas may be converted to liquid form by reducing its temperature to160°C under atmospheric pressure. It then becomes liquefied natural gas (LNG).

Local pollutants: Elements of ambient air pollution, including emissions of mono-nitrogen oxides (NO_x), sulphate (SO4) and fine particulate matter ($PM_{2.5}$).

Low-cost carrier (LCC): Air carrier which offers lower fares in exchange for lower comfort. Extras, such as food on board, checked-in luggage or seat placement usually generate additional fees. Low-cost carriers share some cost-cutting practices, such as having a single type of aircraft or maximising aircraft usage by flying only short distances.

Mass transit: Bus Rapid Transit (BRT) or urban rail (metro included).

Mega-ship: Very large container ship with a capacity larger than 13 000 TEU.

Middle East: Middle East including Israel.

Mode: Contrasting types of transport service relevant to the comparison being made: e.g. road, rail, waterway, air or private car, powered two-wheelers, bus, metro, urban rail.

Mode split/mode share: Percentage of total passenger-kilometres accounted for by a single mode of transport; percentage of total freight tonne-kilometres or tonnes lifted accounted for by a single mode.

MoMo model: The IEA Mobility Model is global transport spreadsheet model containing detailed by-mode, by-fuel and by-region historical data and projections to 2050 for the transport sector, related energy use and greenhouse gas emissions.

Motorcycle: Powered two-wheeled vehicles, motorcycles and scooters, equivalent in this text to two-wheelers.

New Policy Scenario: The New Policies Scenario serves as the IEA baseline scenario. It takes account of broad policy commitments and plans that have been announced by countries, including national pledges to reduce greenhouse-gas emissions and plans to phase out fossil-energy subsidies, even if the measures to implement these commitments have yet to be identified or announced.

Non-motorised modes: Walking and biking.

North America: United States and Canada. Mexico is part of Latin-America in this report.

OECD Pacific: Australia, Japan, New Zealand and South Korea.

Passenger-kilometre (pkm): Unit of measurement for passenger transport activity representing the transport of one passenger over a distance of one kilometre.

Revenue Passenger Kilometre: Measure of passenger traffic: number of paying passengers multiplied by the kilometres flown

Shared mobility: Large-scale deployment of shared vehicle fleets providing on-demand transport.

Urban agglomeration: The city and its surrounding areas based on contiguous built-up land.

Tankers: Ships transporting liquid cargo, especially oil and oil products.

TEU (Twenty-foot Equivalent Unit): A statistical unit based on an ISO container of 20 foot length (6.10 m) to provide a standardised measure of containers of various capacities and for describing the capacity of container ships or terminals. One 20 Foot ISO container equals 1 TEU.

Three-wheeler: Powered three-wheeled vehicles, such as auto-rickshaws in India.

Tonne-kilometre (tkm): Unit of measurement of goods transport which represents the transport of one tonne of goods over a distance of one kilometre.

Transition economies: Former Soviet Union countries and Non-EU South-Eastern Europe.

Transit-oriented development: A dense development with access to public transport in walking distance and characterised by a mix of residential, employment, commercial and other uses.

Two-wheelers: Powered two-wheeled vehicles, motorcycles and scooters. Equivalent in this text to motorcycles.

Vehicle-kilometre: A unit of measurement for transport demand, freight and passenger, representing any movement of a vehicle over a distance of one kilometre.

List of acronyms

ACI	Airport Council International
ADB	Asian Development Bank
BAU	Business as usual
BRT	Bus Rapid Transit
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
ECLAC	Economic Commission for Latin America
EEA	European Economic Area
EFTA	European Free Trade Area
FIA	Fédération International de l'Automobile (International Automobile Federation)
GDP	Gross Domestic Product
GIS	Geographical Information Systems
GTFS	General Transit Feed Specification
HSR	High-speed rail
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ICCT	International Council for Clean Transportation
IEA	International Energy Agency
IMF	International Monetary Fund
IMO	International Maritime Organisation
IRF	International Road Federation
IRTAD	International Traffic Safety Data and Analysis Group
ITDP	Institute for Transportation and Development Policy
ITF	International Transport Forum
JICA	Japan International Cooperation Agency
LCC	Low-cost carrier
LNG	Liquefied natural gas
LUT	Integrated Land Use and Transport Planning (scenario for Chapter 5)
MBM	Market-based measure
MTEU	Million Twenty Foot Equivalent Unit
OSM	OpenStreetMap
PLDV	Passenger Light Duty Vehicle
PnT	People near Transit
PPP	Purchasing power parity
ROG	Robust Governance (scenario for Chapter 5)
SDG	Sustainable Development Goals
TEU	Twenty Foot Equivalent Unit
TOD	Transit-Oriented Development
UITP	International Association of Public Transport

UNCTAD	United Nations Committee for Trade and Development
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
VKM	Vehicle-kilometre
WBCSD	World Business Council on Sustainable Development
WTO	World Trade Organisation

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where governments work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

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OECD Publishing disseminates widely the results of the Organisation's statistics gathering and research on economic, social and environmental issues, as well as the conventions, guidelines and standards agreed by its members.

THE INTERNATIONAL TRANSPORT FORUM

The International Transport Forum is an intergovernmental organisation with 57 member countries. It acts as a think tank for transport policy and organises the Annual Summit of transport ministers. ITF is the only global body that covers all transport modes. The ITF is politically autonomous and administratively integrated with the OECD.

The ITF works for transport policies that improve peoples' lives. Our mission is to foster a deeper understanding of the role of transport in economic growth, environmental sustainability and social inclusion and to raise the public profile of transport policy.

The ITF organises global dialogue for better transport. We act as a platform for discussion and pre-negotiation of policy issues across all transport modes. We analyse trends, share knowledge and promote exchange among transport decision-makers and civil society. The ITF's Annual Summit is the world's largest gathering of transport ministers and the leading global platform for dialogue on transport policy.

The Members of the Forum are: Albania, Armenia, Argentina, Australia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Chile, China (People's Republic of), Croatia, Czech Republic, Denmark, Estonia, Finland, France, Former Yugoslav Republic of Macedonia, Georgia, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Korea, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Mexico, Republic of Moldova, Montenegro, Morocco, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Kingdom and the United States.

OECD PUBLISHING, 2, rue André-Pascal, 75775 PARIS CEDEX 16
(74 2017 01 1 P) ISBN 978-92-82-10799-7 – 2017

ITF Transport Outlook 2017

The *ITF Transport Outlook* provides an overview of recent trends and near-term prospects for the transport sector at a global level. It also presents long-term projections for transport demand to 2050 for freight (maritime, air and surface) and passenger transport (car, rail and air) as well as related CO_2 emissions, under different policy scenarios.

This edition specifically looks at how the main policy, economic and technological changes since 2015, along with other international developments such as the UN Sustainable Development Goals, are shaping the future of mobility. A special focus on accessibility in cities highlights the role of policies in shaping sustainable transport systems which provide equal access to all.

Contents

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ISBN 978-92-82-10799-7
74 2017 01 1 P