Appendix A: List of default values for price elasticities

This appendix provides a list of default price elasticities for a selection of countries.

TABLE **A.1**

Default values for price elasticities

Country	Price elasticity		Country	Price elasticity		Country	Price elasticity	
	ε_{gp}	ε_{dp}		ε_{gp}	ε_{dp}		ε_{gp}	ε_{dp}
Albania	−0.26	−0.13	**Georgia**	−0.26	−0.13	**Oman**	−0.52	−0.27
Algeria	−0.3	−0.22	**Germany**	−0.28	−0.38	**Pakistan**	−0.41	−0.22
Angola	−0.22	−0.22	**Ghana**	−0.26	−0.13	**Paraguay**	−0.22	−0.13
Argentina	−0.05	−0.22	**Greece**	−0.33	−0.44	**Peru**	−0.37	−0.43
Australia	−0.29	−0.65	**Guatemala**	−0.5	−0.22	**Philippines**	−0.35	−0.13
Austria	−0.54	−0.16	**Honduras**	−0.3	−0.13	**Poland**	−0.32	−0.13
Azerbaijan	−0.22	−0.22	**Hong Kong**	−0.12	−0.36	**Portugal**	−0.25	−0.29
Bahrain	−0.5	−0.19	**Hungary**	−0.32	−0.38	**Qatar**	−0.08	−0.15
Bangladesh	−0.09	−0.22	**Iceland**	−0.33	−0.38	**Romania**	−0.26	−0.13
Belarus	−0.26	−0.22	**India**	−0.36	−0.13	**Russia**	−0.1	−0.22
Belgium	−0.34	−0.38	**Indonesia**	−0.2	−0.38	**Saudi Arabia**	−0.09	−0.12
Benin	−0.26	−0.13	**Iran**	−0.2	−0.15	**Senegal**	−0.26	−0.13
Bolivia	−0.22	−0.22	**Iraq**	−0.09	−0.17	**Singapore**	−0.33	−0.12
Bosnia and Herzegovina	−0.26	−0.13	**Ireland**	−0.3	−0.38	**Slovakia**	−0.32	−0.38
Botswana	−0.26	−0.13	**Israel**	−0.23	−0.19	**Slovenia**	−0.33	−0.38
Brazil	−0.26	−0.32	**Italy**	−0.38	−0.24	**South Africa**	−0.26	−0.13
Brunei	−0.24	−0.27	**Japan**	−0.15	−0.26	**Spain**	−0.24	−0.38
Bulgaria	−0.26	−0.13	**Jordan**	−0.26	−0.22	**Sri Lanka**	−0.4	−0.17
Cambodia	−0.26	−0.13	**Kazakhstan**	−0.26	−0.22	**Sudan**	−0.26	−0.22

TABLE **A.1,** continued

Default values for price elasticities

Country	Price elasticity ε_{gp}	Price elasticity ε_{dp}	Country	Price elasticity ε_{gp}	Price elasticity ε_{dp}	Country	Price elasticity ε_{gp}	Price elasticity ε_{dp}
Cameroon	–0.26	–0.13	**Kenya**	–0.26	–0.13	**Sweden**	–0.32	–0.25
Canada	–0.48	–0.74	**Korea, South**	–0.6	–0.38	**Switzerland**	–0.37	–0.43
Chile	–0.25	–0.13	**Kuwait**	–0.09	–0.02	**Syria**	–0.22	–0.22
China	–0.26	–0.22	**Latvia**	–0.32	–0.13	**Taiwan**	–0.69	–0.28
Colombia	–0.04	–0.22	**Lebanon**	–0.26	–0.22	**Tanzania**	–0.26	–0.13
Congo, Republic of	–0.26	–0.13	**Libya**	–0.09	–0.22	**Thailand**	–0.16	–0.23
Costa Rica	–0.44	–0.13	**Lithuania**	–0.32	–0.13	**Togo**	–0.26	–0.13
Cote d'Ivoire	–0.09	–0.46	**Luxembourg**	–0.33	–0.38	**Trinidad and Tobago**	–0.22	–0.27
Croatia	–0.32	–0.13	**Macedonia, Former Yugoslav Republic of**	–0.26	–0.13	**Tunisia**	–0.22	–0.28
Cuba	–0.26	–0.13	**Malaysia**	–0.13	–0.22	**Turkey**	–0.19	–0.13
Cyprus	–0.33	–0.38	**Malta**	–0.32	–0.13	**Ukraine**	–0.14	–0.17
Czech Republic	–0.32	–0.38	**Mexico**	–0.31	–0.3	**United Arab Emirates**	–0.26	–0.13
Denmark	–0.4	–0.2	**Moldova**	–0.26	–0.13	**United Kingdom**	–0.33	–0.38
Dominican Republic	–0.29	–0.13	**Mongolia**	–0.26	–0.13	**United States of America**	–0.3	–0.07
Ecuador	–0.18	–0.17	**Mozambique**	–0.26	–0.13	**Uruguay**	–0.26	–0.13
Egypt	–0.21	–0.22	**Myanmar**	–0.22	–0.13	**Uzbekistan**	–0.26	–0.22
El Salvador	–0.26	–0.13	**Namibia**	–0.33	–0.38	**Venezuela**	–0.14	–0.17
Eritrea	–0.26	–0.13	**Nepal**	–0.26	–0.57	**Vietnam**	–0.26	–0.22
Estonia	–0.32	–0.38	**Netherlands**	–0.34	–0.01	**Yemen**	–0.22	–0.22
Ethiopia	–0.26	–0.22	**New Zealand**	–0.1	–0.38	**Zambia**	–0.26	–0.13
Finland	–0.33	–0.05	**Nicaragua**	–0.26	–0.22	**Zimbabwe**	–0.22	–0.22
France	–0.35	–0.24	**Nigeria**	–0.22	–0.22			
Gabon	–0.22	–0.22	**Norway**	–0.28	–0.07			

Source: Dahl (2012).

Appendix B: List of literature on price elasticities

This appendix provides a list of the most relevant literature on price elasticities. References used in the methodology are listed in the References section.

TABLE **B.1**

Literature on price elasticities

Author	Title	Country	Data years	Own-price	Cross-price
APTA (2011)	*Potential Impact of Gasoline Price Increases on U.S. Public Transportation Ridership, 2011–2012*	USA	2000–2011		X
BITRE (2017)	Transport Elasticities Database	Global	Several	X	X
Dahl (2012)	Measuring global gasoline and diesel price and income elasticities	Global	1970–2010	X	
Davis and Kilian (2010)	*Estimating the effect of a gasoline tax on carbon emissions*	USA	2009	X	
GIZ (2013)	Transport Elasticities: Impacts on Travel Behaviour	Several	Several	X	X
Goodwin, Dargay and Hanly (2004)	Elasticities of road traffic and fuel consumption with respect to price and income: a review	USA, EU, Australia, Japan, OECD	1990–2003	X	
Hoessinger et al. (2014)	*Estimating the price elasticity of fuel demand with stated preferences derived from a situational approach*	Several	Several	X	
Litman (2013)	Understanding Price Elasticities and Cross-Elasticities	Several	Several	X	
Oum, Waters and Yong (1992)	*Concepts of price elasticities of transport demand and recent empirical estimates*	USA, Australia, UK	1970–1990	X	X
TRACE (1999)	Elasticity Handbook	EU	1998	X	X

Appendix C: Overview of pricing policies

This appendix provides an exhaustive overview of pricing policies in the transport sector, along with a summary of their impacts on vehicle travel and GHG emissions. Section 3.1 gives a condensed overview of pricing policies that are the focus of this methodology (in Table 3.1).

C.1 Reduction of fuel subsidies

Many jurisdictions subsidize vehicle fuel, either by charging less than international market prices for domestically produced fuel or by subsidizing fuel through taxes.[75] Many experts recommend reducing fuel subsidies as a way to reduce government cost burdens and the macroeconomic costs of importing petroleum, reduce pollution emissions, and allocate public resources more equitably (since fuel subsidies benefit higher-income households more than the poor).[76] Reducing fuel subsidies can significantly increase fuel prices.

Figure C.1 compares average gasoline prices around the world. Based on 2014 oil prices, gasoline was considered to have a high subsidy if it sold for less than $0.48 per litre (to cover petroleum production costs) and a moderate subsidy if it sold for $0.49–0.86 per litre (to cover petroleum and roadway production costs).

The four categories shown in this diagram are summarized as follows:

- **Country category 1 – high subsidies** (up to $0.48). The retail price of gasoline is below the price for crude oil on the world market.
- **Country category 2 – subsidies** ($0.49–0.85). The retail price of gasoline is at least as high as the price for crude oil on the world market and below the price in the United States.
- **Country category 3 – taxation** ($0.86–1.41). The retail price of gasoline is at least as high as the price in the United States and below the price in Poland. In November 2014, gasoline prices in Poland were the lowest in the European Union (EU). Prices in EU countries are subject to value-added tax (VAT), specific fuel taxes, and other country-specific duties and taxes. The EU sets minimum taxation rates for fossil fuels.
- **Country category 4 – high taxation** ($1.42 and higher). The retail price of gasoline is at least as high as the price in Poland. At these levels, countries are effectively using taxes to generate revenues and to encourage energy efficiency in the transport sector.

Vehicle travel and emissions impacts: Fuel subsidy reductions increase fuel prices. This tends to reduce vehicle travel, encourage more efficient driving, and encourage motorists to choose more fuel-efficient and alternative-fuel vehicles.

C.2 Fuel tax/levy

Many jurisdictions tax vehicle fuel. This can include general taxes that apply to many goods, and special taxes specific to vehicle fuel, sometimes dedicated (hypothecated) to roadway expenses. Fuel taxes can be increased, and indexed to inflation so that they increase automatically instead of requiring special action. Some studies suggest that the high fuel taxes in Europe, Japan and Korea are justified on economic efficiency grounds,[77] and are an efficient GHG emissions reduction strategy.[78]

Vehicle travel and emissions impacts: Fuel tax increases increase fuel prices (although a small portion of the tax increase may be absorbed by distributors), which tends to reduce vehicle travel, encourage more efficient driving, and encourage motorists to choose more fuel-efficient and alternative-fuel vehicles.

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[75] ADB (2014).

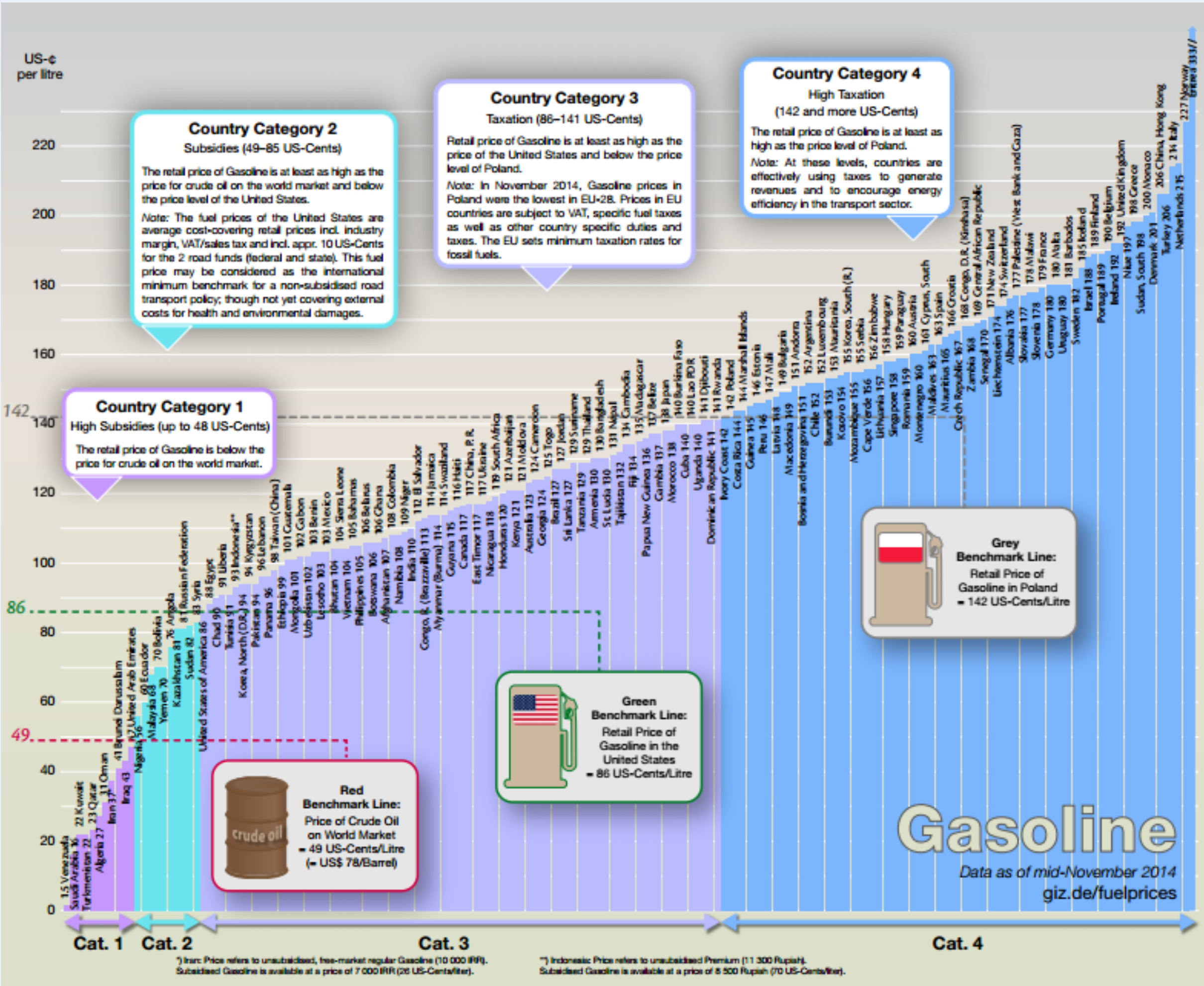
[76] Coady et al. (2010); GSI (2010); IEA (2013).

[77] Parry and Small (2004); Swiss ARE (2005); van Essen et al. (2007); Clarke and Prentice (2009).

[78] Sterner (2006).

FIGURE **C.1**

International gasoline prices



Source: GIZ (2015b).

C.3 Carbon tax (fuel taxes based on a fuel's carbon content)

Carbon taxes are taxes based on fossil fuel carbon content, and are therefore a tax on CO_2 emissions. They differ from fuel excise taxes, which are applied primarily to motor vehicle fuels as a way to finance highways and other transportation services. Because carbon taxes are intended primarily to internalize the environmental costs of fuel consumption and encourage energy conservation, there is no particular requirement for how their revenues should be used. Revenues can be used to reduce taxes, provide rebates or finance new public services, including energy conservation programmes.

If most revenues are returned to residents and businesses, resulting in no significant increase in total government income, the taxes are considered revenue neutral, called a "tax shift". Many economists advocate tax shifting to help achieve strategic policy objectives: raise taxes on "bads", such as pollution emissions, and reduce taxes on "goods", such as labour and investments.[79]

[79] Clarke and Prentice (2009).

Vehicle travel and emissions impacts: Carbon taxes increase fuel prices. The higher the carbon intensity of a fuel, the more prices per litre increase (i.e. larger relative price increases for diesel than for gasoline, and smaller increases for electricity; see the United States Environmental Protection Agency Greenhouse Gas Equivalencies Calculator[80]). This tends to reduce vehicle travel, encourage more efficient driving, and encourage motorists to choose more fuel-efficient and alternative-fuel vehicles.

C.4 Vehicle tax/levy

Most countries impose various taxes and fees on motor vehicle purchases and ownership. These can be structured in many ways that can affect vehicle travel and fuel consumption:

- Some cities use high fees to ration vehicle ownership. For example, Singapore auctions a limited number of Certificates of Entitlement, and some Chinese cities are applying similar systems.[81]
- Some countries have very high import duties on vehicles, which can reduce vehicle ownership, particularly if the country lacks domestic vehicle production.
- Many countries have vehicle taxes and fees that increase with vehicle weight or engine size, or fuel intensity.
- Some jurisdictions have vehicle taxes and fees that vary by fuel type.
- Some jurisdictions subsidize the purchase of low-carbon-fuel vehicles, including LPG and electricity.

Vehicle travel and emissions impacts: Very high vehicle ownership fees may reduce total vehicle ownership and use. High duties on imported vehicles may encourage motorists to retain older, often less efficient and less safe vehicles, or circumvent the rules by smuggling. Vehicle taxes and fees that vary by vehicle weight, engine size or fuel intensity can encourage motorists to purchase smaller and more fuel-efficient vehicles. Vehicle taxes and fees that vary by fuel type, or that subsidize low-carbon-fuel vehicles, can encourage motorists to choose lower-carbon-fuelled vehicles.

C.5 Road pricing (road tolls and congestion pricing)

"Road pricing" means that motorists pay directly for driving on a particular roadway or in a particular area. Road pricing has two general objectives: revenue generation (road tolls and distance-based vehicle fees that do not vary by time and location) and congestion management (congestion pricing, which applies higher prices for driving under congested conditions). Table C.1 compares these objectives.

TABLE **C.1**

Comparison of road pricing objectives

Revenue generation (road tolls and distance-based fees)	Congestion management (congestion pricing)
• Generates funds • Rates set to maximize revenue or recover specific costs • Revenue often dedicated to roadway projects • Shifts to other routes and modes not desired (because this reduces revenues[82])	• Reduced peak-period vehicle traffic • Is a travel demand management strategy • Revenue not dedicated to roadway projects • Requires variable rates (higher during congested periods) • Travel shifts to other modes and times considered desirable

[80] Available at: www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

[81] Feng and Li (2013).

[82] Spears, Boarnet and Handy (2010).

Road tolls are widely used to finance highways and bridges, and some cities have implemented various types of congestion pricing.[83] Road pricing is sometimes criticized as unfair to lower-income commuters, but, on most urban corridors, only a small portion of motorists are in the low-income category, and road tolls are generally less regressive than other roadway funding options such as general taxes.[84]

Vehicle travel and emissions impacts: Revenue-generating tolls tend to reduce vehicle travel on affected roadways. Congestion pricing tends to reduce vehicle travel under congested conditions; by reducing congestion, it can provide additional energy conservation and emissions reductions. In most cases, these prices only apply to a minor portion of total vehicle travel, such as major new highways and bridges, or urban peak vehicle travel. As a result, although they may significantly reduce affected vehicles' travel and emissions, their total impacts are modest.

C.6 More efficient parking pricing (charging motorists for parking, and "cash out" parking so non-drivers receive comparable benefits)

"Parking pricing" means that motorists pay directly for using parking facilities.[85] It may be implemented to recover parking facility costs, as a parking management strategy (to reduce parking problems), as a travel demand management, management strategy, strategy (to reduce vehicle traffic), or downtown improvement district[86]), or for a combination of these objectives.[87] It can focus on various types of parking, such as on-street parking[88] or commuter parking.[89]

In most communities, the majority of parking is unpriced. Where users do pay, prices are often low or non-marginal – for example, with discounted annual or monthly rates. Many experts recommend more efficient pricing, with rates that increase with demand.[90]

Vehicle travel and emissions impacts: Parking pricing can have various travel and emissions impacts, depending on conditions:[91]

- High residential parking prices, with restrictions on on-street parking, may reduce vehicle ownership.
- Worksite parking pricing may cause some commuters to shift from driving to walking, cycling, ride sharing or public transit.
- Parking prices in a commercial district may cause some travellers to shift destinations, such as shopping at a mall rather than downtown.
- Parking prices at a particular location may cause some motorists to park elsewhere, if cheaper or free parking is available nearby.
- Some motorists may try to avoid parking prices by parking illegally.

Because parking facilities are costly (many parking spaces are worth more than most vehicles that occupy them), parking pricing can have large price effects and travel impacts.[92] In many situations, cost-recovery parking pricing would more than double the variable cost of driving. For example, cost-recovery prices for a typical commuter parking space would total $5–10 per day, which generally exceeds fuel costs for an average commute. As a result, parking pricing can be an effective strategy to reduce vehicle travel and emissions.

C.7 Distance-based vehicle insurance and registration fees

"Distance-based pricing" (also called "pay-as-you-drive" and "per-mile pricing") means that vehicle charges are based on the amount a vehicle is driven during a time period. Such fees tend to be more economically efficient and fair than existing pricing practices. Converting fixed costs into distance-based

[83] Eliasson (2014); Van Amelsfort and Swedish (2015).

[84] Schweitzer and Taylor (2008).

[85] Shoup (2005).

[86] In a downtown improvement district, vehicle owners pay an ad valorem tax (tax at the value of the property) for using parking spaces in a specific geographical area. This is an analogous concept to a business improvement district.

[87] Weinberger, Kaehny and Rufo (2009).

[88] SFPark (2012).

[89] Rye and Ison (2005).

[90] Barter (2010); FHWA (2012).

[91] Vaca and Kuzmyak (2005); Litman (2010).

[92] Hess (2001); Spears, Boarnet and Handy (2010).

charges (called "variabilization") gives motorists a new opportunity to save money when they reduce their annual travel. Below are examples of distance-based pricing:

- **Pay-as-you-drive vehicle insurance.** Insurance is one of the largest costs of owning a car, averaging about $750 per vehicle per year. Insurance premiums are generally considered a fixed cost, although the chances of having a crash increase with annual vehicle kilometres. A simple and effective way to make vehicle insurance distance based is to prorate existing premiums by vehicle kilometres, incorporating all existing rating factors.[93] With this system, a $375 annual insurance premium becomes a $0.03 per mile fee, and a $1,250 annual premium becomes a $0.10 per mile fee. This provides several benefits: more accurate insurance pricing; increased insurance affordability; a 10% reduction in total vehicle kilometres; a 12–15% reduction in vehicle crashes and insurance claims (it is particularly effective in reducing crashes because it gives the highest-risk motorists the greatest incentive to reduce annual vehicle kilometres); consumer cost savings (motorists are predicted to save an average of $50–100 annually in net insurance costs); and significant reductions in traffic congestion, road and parking facility costs, and pollution.

- **Distance-based registration fees.** This means that vehicle licensing and registration fees are prorated by vehicle kilometres, so a $60 annual licence fee becomes a $0.005 per mile charge, and a $240 annual licence fee becomes a $0.02 per mile charge. Similarly, other purchase and ownership fees, such as Singapore's vehicle quota charges, can be converted into variable fees.[94]

- **Distance-based vehicle purchase taxes.** Purchase taxes average about $1,200 per vehicle. These could be converted to distance-based taxes, which average about $0.01 per mile if paid over an average vehicle lifetime, or $0.03 per mile if paid over the first four years of a vehicle's operating life.[95] However, this may require monitoring of distances travelled per vehicle, which may not be feasible.

- **Distance-based vehicle lease fees.** Vehicle leases (which account for approximately 30% of new vehicle acquisitions in the United States) and rentals can be restructured to be more distance based. Although most leases and rentals include additional fees for "excessive driving", these are usually set at a high level and so only affect a minority of leased vehicle travel. Yet, analysis of the vehicle resale market indicates that virtually all kilometres driven increase vehicle depreciation, typically by $0.05–0.15 per additional vehicle mile. It makes sense that vehicle dealers reward their customers who minimize their vehicle travel on leased and rented cars with discounts.[96]

- **Weight–distance fees.** Weight–distance fees are a distance-based road use charge that increases with vehicle weight. The charge would range from about $0.035 per mile for automobiles up to $0.20 per mile for combination trucks. This is a more equitable way to fund roads than fuel taxes because it can more accurately represent the roadway costs imposed by individual vehicles.[97]

- **Distance-based emission fees.** Distance-based emission fees that reflect each vehicle's emission rate would give motorists with higher-polluting vehicles a greater incentive to reduce their vehicle travel, and, conversely, give motorists who must drive high annual kilometres an incentive to choose less polluting vehicles.[98] For example, in a particular area, an older vehicle that lacks current emission control equipment might pay $0.05 per mile, while a current vehicle might pay $0.02 per mile, and an ultra-low-emission vehicle might pay just $0.01 per mile. However, this may require monitoring of distances travelled per vehicle, which may not be feasible.

Vehicle travel and emissions impacts: The vehicle travel and emissions impacts of distance-based pricing can vary significantly depending on the strategy and the conditions under which it is

93 Litman (1997); Ferreira and Minikel (2010); Greenberg (2013).

94 Greenberg (2000); Barter (2010).

95 Greenberg (2000).

96 Greenberg (2000).

97 Haldenbilen and Ceylan (2005).

98 Sevigny (1998).

implemented. Since vehicle insurance, registration fees, purchase taxes and lease fees are relatively large, converting them to distance-based pricing can have large impacts on affected vehicles' travel and emissions (more than 10%, in some cases). If distance-based insurance is optional, it would probably affect a small portion of total vehicle travel, but if mandated could affect most or all private vehicles. Distance-based emission fees could provide proportionately larger reductions in emissions than in mileage, since vehicles with the highest emissions rates would be charged the highest per-kilometre fees, and so have the greatest incentive to reduce travel.

C.8 Public transit fare reforms (reduced and more convenient fares)

Public transit fare reforms can include reduced fares, free transfers, universal transit passes (e.g. all students at a university or all employees at a worksite receive transit passes), and more convenient payment systems (e.g. passes, electronic payment cards, mobile telephone payment systems).

Vehicle travel and emissions impacts: Although most transit travel has relatively low price elasticities, some pricing reforms can have relatively large impacts on travel.[99] For example, universal transit passes can significantly increase affected travellers' transit travel.

C.9 Company car tax reforms (reduced tax structures that encourage employers to subsidize employees' car travel)

A significant portion of vehicle travel is by company cars – that is, vehicles purchased by companies for employees' use. Many employees consider a high-value company car a substitute for wages, resulting in less fuel-efficient vehicles that are driven greater distances than motorists would choose if they purchased vehicles and fuel themselves.[100] Since a significant proportion of the second-hand car market consists of ex-company cars, these policies tend to leverage long-term increases in fuel consumption. A European Commission study[101] found that most EU countries under-tax company cars, resulting in direct revenue losses that may approach 0.5% of EU GDP (€54 billion). As well, welfare losses from distortions of consumer choice are substantial, perhaps equal to 0.1–0.3% of GDP (€12–37 billion).

To encourage energy efficiency, in 2002, the United Kingdom (UK) implemented a new company car tax system in which the tax was based on the level of CO_2 emissions the cars produce.[102] Business mileage discounts were removed to eliminate the financial incentive, which existed under the old system, for some company car drivers to do unnecessary business miles. An evaluation study estimated that this reform has led to a reduction in business miles being travelled in company cars in the UK in 2002/03 of 300–400 million miles and that this will continue in subsequent years. This represents a reduction in CO_2 emissions equivalent to about 0.1% of all CO_2 emissions from road transport in the UK. However, a review of the UK tax reform[103] found that it significantly increased diesel car purchases. Since company cars represent 55% of new car sales, this has led to a major shift towards diesel in the UK car stock as a whole, which is considered environmentally harmful. In 2010, a modification to the company car taxation system was introduced, which provided a step change incentive for drivers of low- and ultra-low-carbon vehicles. This change provides a financial advantage for hybrid and electric vehicles, which makes them the dominant clean vehicle technology.

Vehicle travel and emissions impacts: In countries where company cars are a significant portion of new vehicles and are more energy-intensive than motorists would choose for privately purchased vehicles, company car tax reforms can reduce total vehicle travel and emissions. However, such policies must be carefully structured to avoid undesirable consequences, such as the purchase of diesel vehicles.

C.10 Smart Growth pricing reforms

Smart Growth pricing reforms charge higher fees for sprawled development, reflecting the higher costs of providing public infrastructure and services to

99 McCollom and Pratt (2004).

100 Rivers et al. (2005).

101 Næss-Schmidt and Winiarczyk (2009).

102 HMRC (2004).

103 Potter and Atchulo (2012).

more dispersed locations. Sprawled development increases many environmental, social and economic costs, including per capita costs to governments of providing public infrastructure and services (e.g. water, sewage, roads, emergency services, school transportation); direct costs to consumers from increased motor vehicle travel; and increased external traffic costs, including congestion, accidents and pollution emissions.[104] Residents of more compact, infill development typically drive significantly less and produce fewer transport emissions than similar households located in automobile-dependent urban fringe areas.[105]

Experts find that development policies in most jurisdictions underprice sprawl – for example, by failing to charge residents for the higher costs of public infrastructure and services.[106] Several studies have calculated the additional fees that should be charged for sprawled, automobile-dependent development.[107]

Vehicle travel and emissions impacts: Smart Growth pricing reforms, which charge lower development fees and utility charges for buildings located in more compact areas, and implement effective traffic, parking and stormwater management systems that reduce infrastructure burdens, can result in significantly more accessible, multi-modal communities where residents drive less (often 40–60% less) and consume less energy than they would in more automobile-dependent urban fringe locations.

104 Ewing and Hamidi (2014); Litman (2014); Libertun de Duren and Compeán (2015).

105 Ewing and Cervero (2010); Boarnet and Handy (2014); Mehaffy (2015).

106 Blais (2010).

107 Stantec Consulting (2013); SGA (2015); City of Calgary (2016).

Appendix D: Overview of revenue impacts of pricing policies

Table D.1 provides an overview of the potential revenue impacts of pricing policies. Impacts of revenue use are discussed in Sections 3.1 and 6.1.

TABLE **D.1**

Potential revenue impacts of pricing policies

Pricing policy	Possible revenue uses	Travel and emissions impacts	Other impacts
Reduced fuel subsidies	Frees up public funds to reduce taxes or invest in other services.	Varies	Varies. By reducing vehicle travel, it provides traffic reduction benefits.
Carbon taxes	Can be used to reduce other taxes (revenue neutral) or invested in other services, including energy conservation programmes.	Can provide particularly large emissions reductions if a portion of revenues is invested in emissions reductions programmes.	Varies. By reducing vehicle travel, it provides traffic reduction benefits.
Increased fuel taxes	Can contribute to general funds, or be invested in roads or other transport modes.	If invested in roadway expansion, may increase total vehicle travel and emissions. If invested to improve other modes, can reduce vehicle travel and emissions.	If invested to improve other modes, can significantly reduce traffic problems and improve mobility for non-drivers.
Increased vehicle taxes	Can contribute to general funds, or be invested in roads or other transport modes.	If invested in roadway expansion, may increase total vehicle travel and emissions. If invested to improve other modes, can reduce vehicle travel and emissions.	If invested to improve other modes, can significantly reduce traffic problems and improve mobility for non-drivers.
Efficient road pricing	Can be invested in roads or other transport modes.	If invested in roadway expansion, may increase total vehicle travel and emissions. If invested to improve other modes, can reduce vehicle travel and emissions.	If invested to improve other modes, can significantly reduce traffic problems and improve mobility for non-drivers.
Efficient parking pricing	Can be invested in parking facilities, invested in other transport modes, or help finance other local government services.	If invested to improve other modes, can reduce vehicle travel and emissions.	If invested to improve other modes, can significantly reduce traffic problems and improve mobility for non-drivers.

TABLE D.1, continued

Potential revenue impacts of pricing policies

Pricing policy	Possible revenue uses	Travel and emissions impacts	Other impacts
Distance-based pricing	Generally, revenue neutral. Savings to motorists who drive less than average are offset by higher fees paid by those who drive more than average.	Reduces vehicle travel and emissions.	Can reduce traffic problems and provide savings to people who drive less than average annual kilometres.
Public transit fare reforms	Often requires subsidies.	Increases transit travel and reduces automobile travel.	Can reduce traffic problems and improve mobility for non-drivers.
Company car policy reforms	Mixed	Generally reduces total vehicle travel.	Can reduce car ownership and use.
Smart Growth reforms	Mixed. May increase revenues from sprawled-location residents.	Reduces local vehicle travel.	Reduces sprawl costs and improves accessibility for non-drivers.

Appendix E: ASIF terminology

The ASIF framework describes the four components that determine the transport sector's GHG emissions. ASIF stands for "activity" (trips, in km per mode), "structure" (modal share), "intensity" (energy intensity by mode, in MJ/km) and "fuel" (carbon intensity of the fuel, in $kgCO_2/MJ$). It was developed to provide an easily understandable framework for bottom-up methodologies in the transport sector.

Table E.1 provides the key indicators for transport MRV using the ASIF framework.

TABLE **E.1**

Key indicators for transport MRV using the ASIF framework

Data type	A-S-I-F	Category of data	General Indicators	Options for further differentiation
Top-down	Emission factors for fuels **(F)**	Carbon content	• NCV of fuel ($kgCO_2/MJ$) for each fuel type • Grid emission factors for electricity	• Correction factors for indirect emissions (based on life cycle assessment) • Fuel quality (e.g. sulfur content)
Bottom-up	Activity **(A)** and modal shift **(S)**	Fleet composition	• Number of vehicles by vehicle type (e.g. car, truck, motorcycle)	• Vehicle class or engine size • Vehicle age or technology
		Distance travelled	• Vehicle kilometre by vehicle type (in VKT) • Passenger kilometre (PKM) • Tonne kilometre (TKM)	• Mode • Vehicle class or engine size • Vehicle age or technology
		Trips	• Number of trips • Tonnes transported • Trip length	• By mode • By trip purpose (e.g. work, leisure)
		Load factor	• Occupancy (in persons/vehicle) • Load of goods vehicles (in %)	• Mode • Vehicle class or engine size
	Intensity **(I)**	Fuel consumption	• Fuel consumption (in L/km or kWh/km) by vehicle type	• Vehicle class (size is usually related to weight) • Vehicle age and engine technology (e.g. European standards) • Speed and/or congestion on the road (level of service) • Load (for trucks • Gradient (for trucks) • Aerodynamic design and rolling resistance of tyres

Source: Adapted from GIZ (2016), Section 2, p. 17, Table 2.

Appendix F: Method for estimating global default cross-price elasticities for approach C

In contrast to approaches A and B, approach C separately quantifies the GHG impacts from mode shifts through cross-price elasticities of gasoline. The availability of alternatives greatly amplifies the impacts of pricing policies.

The steps below give detailed information on how the global default cross-price elasticity values were estimated:

Step 1: Literature analysis

The authors of this methodology conducted an extensive literature search for suitable studies on mode shift and cross-price elasticities (see Appendix B for a list of further reading). No complete and comprehensive data set of cross-price elasticities is currently accessible. As a baseline for setting up a model defining global default values, the authors decided to use the cross-price elasticities for bus and rail described in a study by the American Public Transport Association.[108] The cross-price elasticities for rail had to be averaged over several (United States [US]–specific) rail transport categories.

However, there is specific literature on cross-price elasticities for selected countries. Where this is the case, countries are advised to use the country-specific values.

Step 2: Choose suitable descriptive parameters

The cross-price elasticity values assumed for the US are not applicable globally and need to be adjusted for applicability in other countries according to suitable descriptive parameters. Such parameters are defined in a paper on gasoline and diesel own-price elasticities:[109] (1) **fuel price** and (2) **average per capita income**. The authors assumed that these parameters could also be used to estimate cross-price elasticities.

[108] APTA (2011).

[109] Dahl (2012).

Step 3: Adjust the US-specific cross-price elasticity values for global applicability

The basis for the adjustment of the US-specific cross-price elasticity values is the table on own-price gasoline elasticities adapted from Dahl (2012) (see Table 8.4). The authors assumed that the influence of gasoline price and per capita income on the cross-price elasticity is exactly the same as for the own-price elasticity.[110] Box F.1 illustrates how this was done.

[110] According to Dahl (2012).

BOX **F.1**

Adjusting the US-specific cross-price elasticity value to another country (example)

The objective is to adjust the US-specific cross-price elasticity value to country C. The average gasoline price and per capita income are known for both countries.

Parameters	United States	Country C
Gasoline price ($ per litre)	0.60	0.25
Income ($ per capita)	30,000	15,000
Gasoline own-price elasticity (according to Table 8.4)	–0.22	–0.11
Percentage difference	+50%	–50%

The table above shows that, corresponding with the parameters gasoline price and per capita income, country C has an own-price elasticity that is 50% lower than the equivalent value for the US. We now assume that the same ratio applies to cross-price elasticities. The US has the following fuel cross-price elasticities:[111]

- cross-price elasticity towards bus systems – **0.14**
- cross-price elasticity towards rail systems – **0.22**

By applying the ratio from above (–50%) to the US-specific cross-price elasticities, we get the cross-price elasticities we need for country C:

- cross-price elasticity towards bus transport = 0.14 × 0.5 = **0.07**
- cross-price elasticity towards rail transport = 0.223 × 0.5 = **0.11**

The example can be reproduced in Table 8.5 in Section 8.1.4. The values in grey represent the cross-price elasticities for the US.[112] The values in yellow represent the cross-price elasticities for country C. The cross-price elasticity values for any other country (with a specific gasoline price and per capita income) have been estimated according to the method described above.

TABLE **F.1**

Adjusting the US-specific cross-price elasticity value to another country (example)

Gasoline price (2016 $ per litre)	Income per capita (2016 $/population)		
	<12,000	12,000–24,000	>24,000
<0.30	Bus 0.09	Bus 0.07	Bus 0.14
	Rail 0.15	Rail 0.11	Rail 0.22
0.30–0.80	Bus 0.14	Bus 0.15	Bus 0.14
	Rail 0.22	Rail 0.24	Rail 0.22
>0.80	Bus 0.16	Bus 0.20	Bus 0.21
	Rail 0.25	Rail 0.31	Rail 0.32

111 APTA (2011).

112 APTA (2011).

Appendix G: Stakeholder participation during the assessment process

This appendix provides an overview of the ways that stakeholder participation can enhance the process for assessment of GHG impacts of transport policies. Table G.1 provides a summary of the steps in the assessment process where stakeholder participation is recommended and why it is important, noting where relevant guidance can be found in the ICAT *Stakeholder Participation Guide*.

TABLE **G.1**

List of steps where stakeholder participation is recommended in the impact assessment

Chapter/step in this document	Why stakeholder participation is important at this step	Relevant chapters in *Stakeholder Participation Guide*
Chapter 2 – Objectives of assessing the GHG impacts or pricing policies	• Ensure that the objectives of the assessment respond to the needs and interests of stakeholders	Chapter 5 – Identifying and understanding stakeholders
Chapter 3 – Overview of transport pricing policies	• Identify the full range of stakeholder groups affected by, or with influence over, the policy • Enhance coordination of the assessment by considering different stakeholder perspectives and knowledge	Chapter 5 – Identifying and understanding stakeholders Chapter 6 – Establishing multi-stakeholder bodies
Chapter 4 – Using the methodology • Section 4.2.5 – Planning stakeholder participation	• Build understanding, participation and support for the policy among stakeholders • Ensure conformity with national and international laws and norms, as well as donor requirements relating to stakeholder participation • Identify and plan how to engage stakeholder groups who may be affected or may influence the policy • Coordinate participation at multiple steps for this assessment with participation in other stages of the policy design and implementation cycle, and other assessments	Chapter 4 – Planning effective stakeholder participation Chapter 5 – Identifying and understanding stakeholders Chapter 6 – Establishing multi-stakeholder bodies Chapter 9 – Establishing grievance redress mechanisms
Chapter 6 – Identifying impacts: how pricing policies reduce GHG emissions	• Improve and validate causal chain with stakeholder insights on cause–effect relationships between the policy, behaviour change and expected impacts	Chapter 8 – Designing and conducting consultations
Chapter 7 – Estimating the baseline scenario and emissions	• Inform assumptions on expected effects of existing and planned policies	Chapter 8 – Designing and conducting consultations

TABLE **G.1**, continued

List of steps where stakeholder participation is recommended in the impact assessment

Chapter/step in this document	Why stakeholder participation is important at this step	Relevant chapters in *Stakeholder Participation Guide*
Chapter 10 – Estimating GHG impacts for vehicle purchase incentives and road pricing	• Improve and validate causal chain with stakeholder insights on cause–effect relationships between the policy, behaviour change and expected impacts	Chapter 8 – Designing and conducting consultations
Chapter 11 – Monitoring performance over time	• Ensure that monitoring frequency addresses the needs of decision makers and other stakeholders	Chapter 8 – Designing and conducting consultations
Chapter 12 – Reporting	• Raise awareness of benefits and other impacts to build support for the policy • Inform decision makers and other stakeholders about impacts to facilitate adaptive management • Increase accountability and transparency, and thereby credibility and acceptance of the assessment	Chapter 7 – Providing information to stakeholders

Appendix H: Selecting the scope of the methodology

The scope of this methodology was selected using a set of criteria developed with the TWG:

- demand from countries
- potential for strong mitigation impact/large-scale transformation
- availability of international default data
- ability to strengthen national-level transport MRV systems
- potential for successful development of low-complexity methodology
- lack of existing methodology.