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Environmentally Harmful Subsidies in the Transport Sector

This document discusses environmentally harmful subsidies in the transport sector, with the aim of helping policy-makers better understand the broad literature available on this issue.

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FOREWORD

This report discusses environmentally harmful subsidies in the transport sector, with the aim of helping policy-makers better understand the broad literature available on this issue. It was drafted by Michael Donohue, currently with Health Canada, while he worked in the OECD Environment Directorate in 2006/2007.

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ENVIRONMENTALLY HARMFUL SUBSIDIES IN THE TRANSPORTATION SECTOR

1. Overview and Discussion

1.1 Introduction

1. The removal of environmentally harmful subsidies has long been one of the objectives of environmental policy-makers, and a great deal of literature has been devoted to this topic. The OECD has had several workshops on this topic, and has released a number of reports. Environmentally harmful, or "perverse", subsidies have also been a focus of research in academia, government agencies, and environmental NGOs for some time. Despite the substantial body of work concerning environmentally harmful subsidies, the issues involved, and even the concept itself, still remain confused at best.

2. Nowhere is this more true than in the transportation sector. Due to the large infrastructure costs, relative to supply costs, and due to the "public good" aspects of the transport sector, the sector has always been one with very high levels of government support. The transport sector also happens to be one of the most significant sources of environmental damage from human activity. Environmental and transport policy workers have therefore taken a strong interest in reforming transport sector subsidies to produce environmental benefits. Despite their efforts, the key issues involved remain difficult to assess, and transport subsidies continue to be a major source of environmental damage.

3. Removing environmentally harmful transport subsidies is easier said than done. Before policymakers can set about removing such subsidies, they first need to know what exactly "environmentally harmful subsidies" are, and which of the existing subsidies *are* environmentally harmful. Answering this broad question involves answering a number of intermediary questions. Each of the following questions needs to be addressed by policy-makers, in order for them to determine how best to reduce environmentally harmful subsidies:

- What exactly *is* a subsidy? How does one define subsidies?
- How can, or should, subsidies be measured?
- What subsidies currently exist in the transport sector?
- What are the negative environmental impacts of the transport sector?
- Which of the transport sector subsidies can be considered *environmentally harmful*?
- How can these subsidies be reduced or removed?

4. Unfortunately, there is no clear answer to any of these questions. For each of the questions above, the available literature provides at least half a dozen different answers, none of which initially appear to be compatible with one another.

5. The purpose of this report is *not* to answer the above questions. Rather, the purpose of this report is to aid policy-makers in sorting through the many answers to these questions that already exist. This report will seek to put the issues above into context, and to demonstrate *why* there are so many different answers to the above questions. Hopefully, this may help policy-makers to better understand and interpret the available information. With the aid of this paper, policy-makers may be better able to choose for themselves the answers to the above questions that best suit their particular requirements.

6. This report will examine in turn the questions above, but it is not a thorough literature review. It does, however, attempt to provide a broad overview of the available literature, in order to demonstrate the range of approaches that are available. For each approach to answering the above questions, this report will both examine the theoretical basis for using different approaches and discuss the specific answers that have been provided by different sources.

7. The final section of this report does provide some recommendations and guidelines for policymakers to use to identify areas in which reforming transport sector support mechanisms may be useful. On the whole though, this report is primarily an overview of existing literature and theoretical approaches to subsidy reform.

1.2 Report Structure

8. Chapter 2 of this report examines some of the most important issues related to defining subsidies. Specifically, subsidies can be defined either in terms of support measures that are provided by *government*, or they can be defined in terms of support received from *society at large*. Also, subsidies can be defined in terms of the *total* subsidy received by an industry or transport mode, or they can be defined in terms of the *marginal* level of support received per passenger.

9. Chapter 3 examines in more detail the specific approaches that can be used to measure subsidies. Even subsidies that are defined in very similar manners, may end up being measured using very different techniques, resulting in different subsidy estimates.

10. Chapter 4 provides an overview of the definitions, measurement techniques, and subsidy estimates that have been used and produced in the available literature. The chapter is not a complete literature review, but an attempt to demonstrate the wide range of approaches that are routinely used. Each of the approaches used are discussed, with respect to the implications for policy.

11. Chapter 5 gives a general overview of the environmental impacts of transportation.

12. Chapter 6 presents some of the approaches and tools that have been developed which can be used to assist policy-makers in identifying *environmentally harmful* subsidies. Available approaches include cost-benefit analysis, and the OECD checklist approach. The theoretical basis, as well as key complications in identifying environmentally harmful subsidies, is also discussed.

13. Chapter 7 provides some recommendations regarding the approach that policy-makers may wish to take toward defining and measuring subsidies, and what the focus of transport sector reforms should be. Chapter 7 also provides some suggestions to help policy-makers focus their attention on the potentially most important areas for reform. Some examples of areas for where it may be beneficial to revise transport sector support measures are also suggested.

14. Chapter 8 provides a brief summary and conclusion of the main discussion points of this report.

2. Theoretical Approaches to Defining Subsidies

15. One of the first problems that policy-makers will encounter in efforts to reduce "environmentally harmful subsidies" is to determine what exactly a "subsidy" is. There is no one definition of subsidy that is common in the literature. In fact, there are literally dozens of different ways that subsidies can be defined and measured. Naturally, all these different approaches result in very different estimates of subsidy levels in the transport sector, with potentially wildly divergent policy implications.

2.1 Government Subsidies versus Social Subsidies

16. Within the literature on subsidies, both in the transport sector and in other sectors, there are numerous approaches to defining subsidies. Two general approaches stand out most strongly, however. Broadly speaking, subsidies can be seen in one of two ways: subsidies are given by governments or subsidies are given by society. Almost all subsidy definitions available in the literature could be seen as generally conforming to one of these perspectives on subsidies.

17. An economic approach might be to define subsidies as "transfers that distort the allocation of economic resources" which would be a society-wide approach to defining subsidies. A more government-oriented approach might be to define subsidies simply as financial payments from governments to firms or consumers. These are only two approaches, however. The distinction between subsidies derived from government action, versus social subsidies, is profound, and includes many possibilities for refinement. These two perspectives are discussed in greater detail below.

2.1.1 Subsidies are a form of support, through government action

18. Under this approach to a definition of subsidy, it is governments or regulatory bodies that provide firms, individuals, groups, or industries with a subsidy. Through some choice that the government makes, a group receives some form of benefit. This benefit need not be *financial*, so long as it provides some group with a benefit. Examples could include direct financial support, loan guarantees, market support or tax exceptions. The issue in this case is not so much what the government does, or does not do. The point is simply that the government chooses to take some action which either reduces government revenue, increases government spending, or otherwise reduces the amount of resources that government has available to devote to other purposes. When available government finances are reduced (or the financial security of the government is worsened) in order to provide a benefit to a particular group, then that group is said to be receiving a subsidy. Even in cases where government revenue impacts are minimal, there is still an implied cost to government. The "cost" to government of imposing an import tariff may be small, but it is non-negligible. So, long as industries, or individuals, are receiving some form of benefits, that can be traced back to government action (or inaction), then this could be qualified as a form of subsidy – a subsidy derived from government support.

2.1.2 Subsidies come from Society

19. An alternative interpretation of subsidies is that a subsidy is a benefit that a person or group receives from society as a whole, rather than simply from the government. When a particular sub group of society receives a benefit, for which the broader society pays the cost, then the activity of that sub group is being "subsidised" by society as a whole. This generally occurs when the activities of a group impose "costs" on society, for which the group is not held accountable. For example, the damages caused by air pollution are born by society at large, in the form of health and other negative impacts, but polluting individuals and firms are (most) often not required to compensate society for the damage inflicted. In such a case, society can be seen to be subsidising the polluting industry. In this example, the pollution is called an externality, because it is external to (does not impact) the market costs and prices faced by the polluting

firm, or by the consumers of that firm's products. Externalities are said to be "internalised" when they become part of the market in such a way that producers and/or consumers are forced to fully account for them in the market prices and production costs. While the definition of subsidies as being dependent on government actions is the more common definition of the term in general usage, many authors have argued that the failure of markets to internalize externalities is the more appropriate form of subsidy for public policy analysis.

2.1.3 Discussion

20. Both approaches to defining a subsidy can be further subdivided in a variety of ways. These possible subdivisions will be discussed in more detail later in this chapter.

21. It is crucial, however, to understand the fundamental difference between these two basic approaches to subsidies. Depending on which approach is used, radically different conclusions can be reached regarding the level of subsidy that exists in different industries.

22. Consider for example the case of road subsidies. In most EU countries, road tolls, vehicle licensing and registration fees, and fuel taxes, more than make up the cost of infrastructure spending. In other words, government revenue from roads is larger than government spending on roads. So, from the perspective of government intervention, road transportation does not receive any subsidisation at all. On the other hand, from a social perspective, road transportation is heavily subsidised in many EU (and other) countries, because of the external costs of transportation that are born by society as a whole. Road transportation is a major source of air pollution, global warming, and noise. The effects of air pollution, global warming, and noise, are born by all members of society, not merely road users. From a social perspective, the "costs" of road transportation include not only the infrastructure costs, which are paid by government (or occasionally private firms), but also these external costs, that are paid for by all members of society. While the expenditures of road users (on road tolls, licensing fees, fuel taxes, etc.) are generally sufficient to reimburse the government (or private firm) expenditure on infrastructure, they fall well short in many cases of covering the additional external costs to society of air pollution, noise, and global warming.

23. Beyond changing the analysis of whether a particular industry receives a subsidy, the choice of subsidy definition can also alter the relative level of subsidy between industries. The rail industry provides a contrast to the road transportation sector. In most countries, governments spend far more on developing rail infrastructure and providing financial support (direct or indirect) to the rail sector than they receive in revenue from that sector. So, from the government perspective, rail is heavily subsidised. From a social perspective, though, the external costs of rail operations are usually much lower than in the road transportation industry. Air pollution, greenhouse gas (GHG) emissions and noise from rail are much less than from road traffic. The full social costs of rail operations to society, including both external costs and net of government subsidies, may be lower in many countries than the full social cost of road use. So, from a social perspective, road use is actually more heavily subsidised than railways, while from the government perspective, the opposite is true.

24. As these examples may help to demonstrate, the key to determining what constitutes a subsidy, is to determine what sort of "costs" need to be considered. If the amount that users pay is enough to cover the costs of a transportation mode, then there is no subsidy. If however, users pay less than the cost of what they receive, then they are being subsidised. If "costs" is limited to "cost to government", then road transportation is not subsidised in most EU countries. If "cost" is expanded to include "social costs", then road transportation can be seen as highly subsidised in many countries. From the perspective of government cost, rail travel is much more heavily subsidised than rail. Thus, the choice of how to define a

subsidy, and in particular, what to include as "costs" of use, are critical for policy-analysis in determining which industries are receiving subsidies; and which more so than others.

2.2 Marginal versus Average Costs

25. As discussed above, measuring the level of subsidies that transportation users (or modes) receive, requires that we know what the costs of using that mode of transport are. If the amount that users pay covers the cost of their activity, then they are not being subsidised. If the amount users pay falls short of the cost of their activity (be it from a government financing or a social perspective), then their use of the transportation system is being subsidised. There are a number of different ways to measure the "cost" of using the transportation system, however. As discussed above, one factor is whether costs are measured from a social perspective or a government financing perspective. Another crucial consideration, though, is whether cost of use should refer to total/average cost, or to marginal cost.

26. The *total cost* of use of a transportation mode, is simply the sum total of all costs in supplying that transportation mode. Average cost is just total cost divided by the number of users. So if each user pays the average cost of supplying the transportation system, then users as a whole will cover the total cost of the system.

27. On the other hand, *marginal cost* measure how much it would cost to add one additional unit of transportation. For instance, how much additional cost, on top of existing costs, is associated with one more car on the roads, one more train on the tracks or one more passenger on a bus. Using a marginal cost perspective, the question is not whether total costs are covered by users, but whether each individual user pays enough to cover the additional cost of that one user's activity.

28. This distinction may be clarified by an example. Suppose that the annual cost to government of building, maintaining, and operating a system of roads is 10 million euros. Assume that one million cars drive along the roads every year. And suppose that, given the current level of usage of one million cars, the additional cost to government of allowing one more car onto the road would be five euros per year. In this simplistic example, the average cost per user is the total cost of 10 million euros, divided by the number of users, one million, so the average cost of operating the system is 10 euros per driver. On the other hand, the marginal cost per driver, is the same as the cost of adding one more driver, at current usage levels; in this case, 5 euros. So in this example, average cost, is twice as high as the marginal cost of one additional driver.

29. The example above uses a government financing perspective, but the distinction between marginal and average costs is equally valid from a social cost perspective. In such a case, the question would be whether a subsidy involves the failure of an individual user to pay the average social cost of their activities, or the marginal social cost of their activities.

30. When an operating system has very high capital costs, but low costs for each additional user (such as a rail system), then the marginal costs are generally much lower than average costs. In some cases though, marginal cost may actually be higher. This could, for instance, be the case in a highly congested system. If motorways are already strained and near capacity, then each additional user will incur more costs, both on his fellow users, and on system operations, than the last user did. In this case, the marginal cost will increase for each additional user of the system. It may even happen that marginal costs increase to the point where they exceed average cost (at least in the short run).

31. Regardless of whether one takes a social perspective or a government finance perspective, determination of whether transport users are being subsidised depends on whether they are expected to pay

their marginal costs of use, or the average cost of their use. Both approaches have certain advantages and disadvantages, which are discussed below.

2.2.1 Marginal Cost

32. A marginal cost approach is particularly useful when considering issues of economic (socioeconomic) efficiency. Suppose, for example, that the government decides to charge public transport users the average cost of building and operating the public transport system. This will almost surely be higher than the marginal cost of a passenger. Suppose that the average cost of public transport is \$2, but that the marginal cost is \$1. If the operators charge \$2, then there will be a group of people who would be willing to use the system at a cost of \$1, but not at the current price of \$2. This creates inefficiency. The government could provide these people with transport for the cost of only \$1. And these people would be quite happy to pay the \$1. The fact that this does not happen, results in a socially inefficient level of transport use.

33. The reason that operators choose not to let these people use the system for only \$1, is that they would then lose 50% of the revenue from all the people who are already using the system at a cost of \$2. While this argument may seem rational from a cost-recovery point of view, it is not socially efficient. I.e., it does not produce the largest possible net benefit for all concerned. The transfer of money between existing users and system operators is just that, a pure *money transfer*. Money simply changing hands does not impact overall social "welfare". On the other hand, providing people with a service, when the cost of providing it is less than their willingness to pay for it, creates gains in net social welfare.

34. Pure economic theory states that the net wellbeing of all concerned is maximised when the price that users pay, is equal to the long run marginal cost of their use. This is equally true whether a government finance or social perspective is taken. From the perspective of government financing, user benefits less government expenditures are maximised when users pay the marginal cost of financing the system. From a social perspective, social welfare is maximised when everyone pays back to society the marginal social cost (damages) that their activities create. Paying the marginal – rather than average – costs provides the right price signals for environmental costs to be reduced to the optimal level.

2.2.2 Average Costs

35. While the marginal cost approach is more efficient in terms of economic theory and wealth/welfare maximisation, average cost pricing allows for cost recovery, and may be more politically acceptable in some circumstances.

36. The discussion above supposes that an extra dollar in the hands of transport users, or an extra dollar in government revenue, each have the same effect on net social wealth, and hence on social wellbeing. In practice, though, governments have limited budgets and spending in one area must be offset by less spending in other areas, or higher taxation.

37. While charging users their marginal costs is the most efficient form of user charging/taxing, all other things being equal, other things are rarely equal in practice. If marginal costs are lower than average costs, charging users their marginal cost would potentially reduce government revenue. The marginal charges in the transport area would represent a net social gain, in that area, but one must also consider what lowered government revenue would mean for other sectors. Reduced government revenue could force the government to reduce spending in other areas. These other potential spending areas might be expenditures that generate large social benefits. Reducing these expenditures could cause social damages (and inefficiency) that would partly, and perhaps even fully, counteract the social benefits (and efficiency improvements) in the transport area. Alternatively, the government might make up for the revenue lost by

raising taxes in other areas. It is possible that this additional taxation could be even more inefficient than average cost pricing. For instance, taxes on labour (income taxes) are widely believed by economists to have a strong distortionary impact on the economy, resulting in significant social inefficiency in the labour market, stemming from inefficient choices between labour and leisure. If a shift from average cost pricing to marginal cost pricing was financed through an income tax increase, it is *possible* that the net impact on economic efficiency (and social welfare) could be negative.

38. Based on the rational above, one can make the argument that users should pay their average costs, rather than their marginal costs. This is particularly true if looking at the subsidy question from the government financing perspective. From the social subsidy perspective, the argument for average pricing is not as strong, since in the social context the "cost", or damage, is a cost to the whole of society. The ability of society to bare these costs does not have a finite cap in the same sense that government budgets have a cap. Social costs in one area do not need to be offset by social benefits in another area, in the same literal sense by which government spending and government revenue (over time) has to balance. However, there may still be an argument to be made in favour of average social cost pricing on perceived social equity grounds, as discussed below.

39. Average pricing is a simple concept and is generally perceived as "fair" – in that it forces system users to fully pay for the costs that they impose (either on society or the government). In the case of government costs, it may appear desirable that those who benefit from a government service, reimburse the government for the full costs of providing that service. Although not a very strong economic argument, this approach may appear to many to be the most "fair" way to charge for public services, and as such it can often be politically more popular. The idea of fairness can also be particularly relevant if one considers the question of users paying for the full *social* cost of their activities. For example, suppose for the sake of argument that the total social cost imposed by car traffic amounted to 1€ billion. In other words, that cars created 1€ billion worth of social costs for society. It might seem reasonable then, that drivers should reimburse society for the costs that they create. So collectively, drivers should pay back 1€ billion to society, each driver paying the average cost (1€ billion divided by the number of drivers).

40. Economic theory, however, would suggest that for efficiency purposes, drivers should be charged only for the marginal social damages that they cause. If marginal damages are less than average damages, then this would have drivers paying back into the social pool (reimbursing society), an amount which is less than the damages that they have (collectively) caused. Many people might feel it to be unfair that drivers, as a group, should receive a net benefit at the expense of society. For these reasons, average cost pricing may appear to be more socially fair, and – as a result – be politically attractive.

41. It is important to note, however, that in the case of congested transport infrastructure, marginal costs (including the cost of congestion) will exceed the average costs of providing the infrastructure. Where a large part of a road or rail network is subject to congestion, it will not be necessary to consider average costs for purposes of political fairness.

2.3 Summary

42. Before one can begin to measure or assess subsidies in different areas, one must first decide what exactly is meant by a "subsidy". In order to define a subsidy for the purpose of a particular study or analysis, numerous decisions must be made regarding specific definitions. At the highest level, however, the two most important questions are:

• Should subsidies be defined from the perspective of government action, or from a social welfare perspective?

• Should subsidies be considered to be the failure of users to pay for the *marginal* cost of their actions, or the failure of users to pay for the *average (or total)* cost of their actions?

43. The response that is chosen to each of these questions will fundamentally alter how large subsidies appear to be in different areas, both in absolute terms, and relative to other areas. In each case, both approaches have merits, and there are numerous examples of all approaches in the literature.

3. Measuring Subsidies

44. In order to measure subsidies, it is obviously critical to first define what is meant by a "subsidy". Even once a general definition is agreed upon, however, it can still be very difficult to measure subsidies, and a variety of different approaches can be used.

45. As discussed in the previous chapter, subsidies can be defined from a social cost or a government support perspective. They can also be defined based on marginal costs or total costs. But within these broadly defined categories, there are numerous ways to approach actually measuring subsidies. Analysts and policy-makers need to determine what sort of scale to use for measuring subsidies. They need to decide which elements are important enough to include in the measurement, and which measures are reliable enough to be trusted. And they must select from a wide range of tools and approaches that can be used to measure the subsidies that they have defined.

46. This chapter discusses some of the issues involved in subsidy measurement, and some of the approaches that are used.

3.1 Total Subsidies versus Relative Subsidies

47. One of the most important decisions in measuring subsidies is the decision of what metric to use for the measurement. For example, should subsidies be measured simply in terms of "dollars"? Should one measure the subsidy *per passenger*? Or perhaps subsidies should be measured as a fraction of total costs. The choice of whether to look at subsidies from an absolute or relative perspective significantly affects the perceived level of subsidy that different industries and transport modes receive. Similarly, the choice between different *bases* for measuring relative subsidies can also drastically alter the calculations. Several examples are presented below.

48. In most countries, governments spend far more on building road infrastructure, than rail infrastructure. So, in terms of direct government spending, road transport receives much more government support. However, in most countries, far more passengers travel by road than by rail. In terms of the amount of government funding received *per passenger*, rail often receives much more government support than road does. This example ignores the government revenue side, and focuses only on government spending, so in reality the case is more complex. However, this simplified example serves to demonstrate the different results that are obtained when using either an absolute or a relative approach to measuring subsidies. In the example, road transport receives a larger absolute subsidy, but rail transport receives a larger relative subsidy. Supposing that the goal of policy-makers was simply to "reduce subsidies", one approach would lead them to conclude that the largest subsidies are in the road sector, while the other approach leads to the conclusion that subsidies are larger in the rail sector.

49. By the same token, the choice of precisely what relative metric to use for measuring subsidies can similarly alter the results of analysis. For example, most public transit systems receive a high level of their total funding from different levels of government. In many cities, 50% or more of the operating costs of public transit are covered by public authorities, and in some cases, the proportion can be as high as 80 or 90%. By contrast, most airlines make their money on passenger tickets. The air transport industry does receive significant government aid in many countries, but for most airlines, the majority of their revenues still come from ticket sales, not from government transfers. So if we look at government support as a percentage of operating costs, or revenue, it is clear that public transit receives more support than the air transport industry. One could conclude that "public transport is more heavily subsidised than air travel, because most air travel costs are covered by ticket prices, whereas most public transport costs are covered by government." On the other hand, one would come to a very different conclusion if looking at *per passenger* subsidies. The per passenger cost of operating a public transit system is often quite low

compared with other forms of transport. So, although public transit systems receive substantial government support, the amount of funding they get *per passenger* is often quite small. Air lines, by contrast, have very high costs per passenger. So, while airlines may receive a much smaller proportion of their revenues as a result of government support, they probably receive far more (indirect) government support, per passenger that they carry (in the form of preferential tax rates), compared to public transport. One could therefore conclude that "the air transport industry is more heavily subsidised than public transit, because it receives more government assistance per passenger." As this example shows, deciding on the relative basis for measuring subsidies, can completely reverse one's conclusions. From a *per passenger* perspective, air transport is more heavily subsidised than public transport. But from the perspective of subsidies as a *fraction of total costs*, the opposite is true.

50. While the above examples are based on a government support approach to defining subsidies, the question of what metric of measurement to use, either absolute, or some relative measure, is equally important from the perspective of social subsidies. For example, one could say that road transportation receives larger social subsidies than air transport, but that air transport receives a greater social subsidy per passenger. Similarly, while the examples above focus largely on the total (or average) costs of supplying transportation, the relative metric of measurement is equally important if subsidies are defined in terms of marginal costs.

51. By definition, marginal costs must be measured on a per unit basis, *e.g.*, marginal cost per passenger, or per trip. The distinction of what that unit is will affect the measured levels of subsidies across different transport modes. For instance, marginal costs per tonne of freight are much higher in the trucking industry than in marine shipping. But marginal costs per additional vehicle are higher in shipping. So, the relative subsidies received by the shipping industry, compared with the trucking industry, depend heavily on whether one measures marginal costs on a per-vehicle or per-tonne basis.

52. In passenger transportation, subsidies are most often measured in terms of the value of subsidies provided per kilometre travelled per passenger. However, subsidies given per passenger, or subsidies as a fraction of operating costs, are also used. In the freight transport industry, the most common measures of relative subsidy are the value of subsidies per tonne shipped per kilometre, or the value of subsidies per value of shipment per kilometre.

53. Selecting the unit of measurement for subsidies is the most important element of subsidy measurement, besides the definition of subsidies themselves. The decision of what sort of relative scale to use, or even if such a scale should be used, can radically alter the perceived level of subsidy that one industry or transport mode receives relative to another. Furthermore, subsidy measurements based on the same scale can generally be compared with one another, even if other measurement methods differ. Subsidy estimates in different relative units are totally incomparable. The next two sections discuss the specific approaches that can be used to measure subsidies from a social or government finance perspective, respectively.

3.2 Measuring Social Subsidies

54. In principle, measuring the degree to which a particular mode of transport receives a social subsidy, involves adding up all the costs or damages associated with its use, and subtracting all the revenues and benefits that society receives from its use. The difference is the amount by which the use of the transport mode is subsidised by society. So:

$$SS = G_s - G_r + E_p - E_n$$

Where SS = The net social subsidy;

- G_s = Government spending to provide the mode of transport;
- G_r = Government revenue derived from the use of that mode of transport (user fees, fuel taxes, vehicle licensing, etc);
- E_p = Any positive externalities. Social, environmental, or economic benefits created by the user's transport activity, for which the user is not paid;
- E_n = Any negative externalities. Social, environmental, or economic costs imposed on society by the use of transit system, and for which the user does not pay.

55. Certain costs and benefits are generally excluded from the equation above, because they are assumed to cancel themselves out. For example, the cost of purchasing an automobile is usually omitted. Car users are assumed to pay 100% of the cost of a car, and to receive 100% of the direct use benefits of that car. The benefit that the user receives (the new car) is entirely paid for by that user him or herself, so there is no need to include it on both the costs and benefits side of the equation. If the purchase of new cars was subsidised, however, then the value of that subsidy would still show up in the government expenditure part of the equation. It is only the costs of car ownership not paid for by the driver, and the benefits not received by the driver, that need to be considered as part of the above equation.

56. It is worth noting that the equation above is the same whether we address subsidies from a total cost or marginal cost perspective. If a marginal cost perspective is adopted, then all the elements of the equation above can be seen to represent marginal costs and benefits. If subsidies are instead defined in terms of total costs, then the elements in the equation above would represent the total level of government revenue and expenditure, and total external impacts of the transportation system.

57. While the equation above is fairly straight forward, measuring its components can be anything but. The difficulties in measuring and assessing government spending and revenue are discussed later in this chapter. The following sections will look at issues involved in measuring the externalities associated with transport.

3.2.1 Transport as a Driver of Growth

58. One frequently proposed external benefit of a good transport system is that it spurs economic activity. It is sometimes argued that good roads and public transit will attract new business and investment to an area, and create wealth, benefiting many in the region, including those that do not directly use the transport system.

59. The claim that transportation encourages economic growth is often debated. While there is anecdotal evidence that it may promote growth, conclusive proof that additional transportation funding actually draws industry to a region is hard to find. Nash *et al.* (2002) note that "it is often argued that the provision of transport infrastructure has external benefits in promoting economic development. Although evidence of this is limited, there is some reason to suppose that this could be the case in the presence of market imperfections ... " While many authors, such as Nash and others, seem to suggest that potential economic growth benefits of transport investments are uncertain, others take it as virtual certainty. EAI (2005) writes that "An efficient transport system is in fact a major contributor to economic growth, ..." Many policy-makers also seem to support the idea that transport infrastructure is s significant driver of economic growth. Best *et al.* (2005) list a variety of objectives of government policy and transport subsidies, including that "transport subsides are often created to foster economic growth or regional development."

60. Regardless of whether it is in fact true or not, that transportation spurs economic growth, most studies do not include this aspect in the calculation of the net costs (benefits) of transportation. It could be

that it is omitted because of the uncertainty regarding its impact, or more often, it may be omitted because of the difficulty involved in its calculation. Quantifying the level of economic growth in a region, both with and without different levels of transport infrastructure, would be an exceptionally difficult task, which would rely on large assumptions regarding counter-factual scenarios. All the same, it should be recognised that to the extent transportation infrastructure does promote economic growth, failure to account for this positive externality will introduce a bias into the calculation of the net social costs of transportation.

3.2.2 Macroeconomic Impacts

61. Another large and potentially significant area of ignored transportation benefits has to do with economic spin-offs and macroeconomic benefits. For example, it was mentioned above that the purchase of a car by an individual does not enter into the calculation because both the costs and benefits of that purchase are entirely received by the individual user. But what about the benefits received by the car manufacturer? And what, too, about the mining operations, and the steel mills that create the raw materials for use in those cars? Similarly, an efficient road system would lower the cost of transporting goods, which provides benefits directly to the shippers, but it would also provide downstream benefits to all those who receive and use those shipped goods at a lower price. Should these benefits also be considered in measuring the external benefits of the transportation system? Perhaps they should, but they are generally not.

62. Macroeconomic effects are usually excluded for a variety of reasons. First, and possibly most importantly, they can be very *hard to predict and measure*. The more distant a macroeconomic impact is from the initial shock, the more difficult it becomes to predict. For example, a change in car prices affects the demand for cars. This affects the demand for inputs such as labour, and parts needed by auto manufacturers. Changes in the demand for parts, affect the demand for inputs (labour and raw materials). Change in demand for materials can affect supply and prices in the mining sector. And in turn, this can affect demand for labour and materials used in mining. Changes in production and business activity in different industries will alter the environmental and social impacts of those industries, in addition to affecting other industries up and down the supply chain. An initial shock to one area of the economy will cause ripples that affect numerous other parts of the economy. The more distant these secondary impacts are from the initial shock, however, the harder they become to predict or to measure reliably.

63. Besides being difficult to predict, secondary macroeconomic shocks also tend to be *smaller in magnitude* than more direct policy and subsidy impacts. Like ripples from a stone dropped in water, each impact beyond the initial policy shock affects a wider and wider range of industries, but with ever decreasing magnitude. Impacts on industries more than one or two steps removed from the initial source of the shock are often small enough to be virtually unnoticeable. Only in situations where industries are intensely interdependent, are secondary shocks likely to be significant. Because they are so difficult to predict and measure, and because their impacts are most likely quite small, secondary macroeconomic impacts are often ignored for the purpose of measuring social costs and benefits of policy shocks.

64. Nash *et al.* (2002) note that "Ideally, environmental costs of all categories should be quantified for all up- and downstream processes". In practice, this is rarely possible due to difficulties in estimating the up- and downstream impacts. Even were it to be possible, the secondary impacts are usually very minor compared to primary impacts. As a result, most measurements of social subsidies focus on the industry that is directly impacted, as well as possibly one or two other industries that are most closely associated with the effected industry.

3.2.3 Direct "Economic" or Market Impacts

65. In considering removing, reducing or increasing subsidies, policy-makers will generally want to know what the "economic" impacts are likely to be. To answer this question, it is necessary to understand the general economic situation under a base-case and in an alternate scenario. Since a modern economy without any transportation is not feasible, one can safely ignore the scenario in which transportation is eliminated. Since there is no chance of eliminating transportation, it is not meaningful to attempt to measure the "total" economic benefits provided by transportation. What is more meaningful, is to measure how the economic benefits of the transportation sector are likely to *change* due to a policy intervention and a shock to the transport sector. To measure such a change in the economic benefits, one must look at the economic changes between a base-case, and an alternate policy scenario. In other words, one must look at total economy-wide employment, wages, GDP, firm income and prices, under two scenarios. The difference between the two scenarios would be the impact (costs and benefits) of a policy shock that causes a shift from one scenario to the other. The most difficult task in determining a policy's economic benefits would be to identify the most likely alternate scenario that would result from the policy shock. Once this alternative situation is identified, one can begin measuring the economic costs and benefits associated with moving to that situation.

66. One of the theoretical ideals for measuring "economic" benefits of alternate scenarios is to look at changes in producer and consumer surpluses. Producer surplus is very similar to firm profits. Firm profits are the difference between revenues and total costs (known as "accounting profit" which is distinct from "economic profit"). Producer surplus is the difference between revenue and *variable* costs. Because it ignores the role of fixed costs, producer surplus is larger than profit, at least in the short term. In the long term, though, all costs are variable, so producer surplus becomes roughly equivalent to profit over the long term. Producer surplus is generally assumed to represent the benefits that industry receives from economic activity.

67. The analogue to producer surplus is consumer surplus, which measures benefits that consumers receive from economic activity. Consumer surplus is the difference between what consumers are willing to pay for an item, and what they actually have to pay for it. For example, if someone "values" a loaf of bread at \$3, then they should be willing to pay up to \$3 to obtain it. If they are able to buy it for only \$1, then they have received a net benefit of \$2 (the consumer surplus). Summing up the consumer surplus for all consumers who purchase goods or services from an industry would provide the net consumer surplus generated by that industry, or the benefit that consumers derive from the existence of that industry.

68. The sum of producer and consumer surplus is called the social surplus, or total surplus. It is the economic social benefit that producers and consumers receive from a particular industry. Increases in total surplus represent increases in net benefits for society. Thus, in welfare economics, increasing total surplus is often seen as a primary goal. In this sense, the changes in total surplus due to a policy shock could be considered the economic costs, or benefits, of that shock. A policy shock to the transport industry will alter production levels and prices in the transport industry, and – to a lesser extent – in other industries. The economic impact of this shock could be measured based on the economy-wide change in total surplus.

69. Assuming that a base-case and an alternative case are well defined, calculating social surplus is not difficult. Because it is closely linked to clearly defined variables (prices, production quantities, firm costs, and profits), measuring producer surplus is often quite straight forward. In many cases, firm revenues and costs are publicly available, if one knows where to look. In other industries, firm costs or profits may not be well known, but they can often be estimated, at least on average/in aggregate. Estimating consumer surplus is more difficult, because it depends on the willingness of consumers to pay for goods and services. It is easy to see how much consumers *do* pay, but much harder to estimate how much they would be willing to pay. Luckily, unless one is considering the total close down of an industry,

it is not necessary to calculate the total surplus in the industry, in order to calculate the *change* in total surplus. Changes in producer and consumer surpluses can largely be estimated based on observed changes in price and production levels, combined with understanding the source of the shift (demand driven, supply driven or direct government intervention). Assuming one knows how prices and consumption are likely to change in response to a policy intervention, measuring changes in producer and consumer surpluses is a straight forward and reliable method of estimating the "economic" benefits of an intervention.

70. The use of producer and consumer surplus, while popular with economists, is not the only way to measure "economic" costs and benefits associated with transport policies. Policy-makers often like to focus on employment impacts of policy shifts. For example, a shift in transport policy resulting in changes in transport sector operations could "create" additional jobs in that sector, and/or other sectors. From an economic perspective, however, this is not a legitimate "benefit" of policy for several reasons. First, while employment may have increased in the transportation sector, it will most likely have declined in other sectors. Rather than "create" new jobs, it might be more accurate to say that the sector simply "stole" workers from other sectors of the economy. Workers are simply collecting wages, and producing goods and services, in a different sector to where they were before. A policy-shock can really only "create" jobs, if it actually reduces total economy-wide unemployment or increases labour-force participation rates. Specific transport sector policies are unlikely to be able to affect total employment in a way that would be detectable.

71. Furthermore, in spite of the claims that are often made in the popular press, employment is not generally considered to be an economic "benefit". It is a cost. For example, the production of 10,000 new cars is a social benefit. But the fact that 500 people had to work on them for a year is a social cost. The net social benefits are the social benefits of those 10,000 cars, minus the social costs of 500 people working for a year. If those cars had been produced without requiring any labour, then those 500 people would have been able to work elsewhere, or to stay at home. That they had to work making cars is a social cost. Employment levels in an industry may serve as an indicator of the economic significance of an industry, but they should not be considered "benefits" that the industry provides.

72. GDP impacts are also commonly used as a standard for measuring economic benefits. GDP represents the total value of goods and services produced by an economy. As such, it is a useful measure of economic performance and the benefits of economic policy. The economic costs or benefits of a policy intervention, or sectoral shock, might reasonably be measured based on the impacts on GDP, or GDP per capita. Even in the absence of policy intervention, though, GDP is in a state of constant change. It would be incorrect to assume that any difference between GDP before and after a shock, is solely due to the shock. GDP would have changed on its own, regardless of any shocks, so the entire change can not be attributed to the shock. Instead, to measure the economic impacts of a policy shock, one must compare the GDP following the shock with the GDP that would have existed without the shock. Unless a policy shock has a profound impact across numerous sectors of the economy, it is unlikely that any change in GDP or GDP growth rate due to the shock would be noticeable. The impacts of small market shocks are likely to be lost in the overall variability of GDP. Nonetheless, in some situations, it may be reasonable and desirable to refer to the costs and benefits of large sectoral issues, in terms of the GDP impacts.

73. As discussed earlier in this Chapter, the choice of units by which to measure costs and benefits of an activity are critical for assessing which policies receive larger or smaller subsidies. The "economic benefits" of a policy intervention could *e.g.* be reported as:

- a 1% reduction in unemployment;
- the creation of 10,000 new jobs (not truly a benefit in the economic sense, but an example of the type of claim that is often made);

- a \$2 billion increase in GDP;
- a \$500 increase in GDP per capita;
- a \$100 million increase in total (producer and consumer) surplus;
- a 3% increase in consumer surplus;
- or some other similar figure.

74. All of these statements could be considered to represent the "economic benefits" of a policy intervention. Yet clearly they are not all comparable. When different subsidies (policy interventions or industry shocks) are measured according to different criteria, it can be difficult or impossible to determine which subsidies result in the most significant "economic" impact.

3.2.4 Environmental Impacts

75. The specific environmental impacts of the transport sector are discussed in later chapters. This section explores several of the approaches that are used to quantify and measure environmental impacts of transport.

Use Values vs. Non-use Values

76. An important distinction in terms of environmental impacts has to do with whether these impacts are things that are directly experienced by individuals, or whether they are what are referred to as "non-use" values.

77. Some environmental benefits directly impact people's lives through direct personal experience and interaction. These are referred to as use values of the environment. A beautiful view from the window, a walk in the woods, a fishing trip or clean air to breath are all things that a person physically experiences and benefits from. Although these things are rarely bought and sold on markets, there may be markets that are closely associated with them. For instance, housing prices may reflect local air quality, and proximity to parks and natural areas.

78. Non-use values are benefits that people receive from the environment that do not rely on their first-hand experience of the environment. For instance, a person may receive a benefit from the knowledge that there are penguins at the South Pole, in spite of the fact that they have never been to the South Pole, seen a penguin, or consume any penguin-related products. They might wish to preserve penguins because they know that penguins provide use-values to others. They may wish to preserve penguins for future generations. Or they may simply enjoy the knowledge that penguins are alive and well, simply for its own sake. Since there are no associated markets, it can be very difficult to measure a person's enjoyment of the mere existence of penguins. But to the extent that these non-use values contribute to the overall standard of living of individuals, it is appropriate to consider and attempt to measure these environmental benefits.

Willingness-to-Pay

79. The main approach to measuring the "value" of non-market impacts is to determine what the value of those impacts is *to people*. The idea that the environment has an intrinsic value, beyond the (use and non-use) benefits or value that it provides to humans, is a largely philosophical idea, that is rarely adopted by the economics community. Additionally, policy-makers are generally concerned with improving quality-of-life for present and future generations of human beings. They are thus inclined to focus on benefits to humans. Note, though, that focusing on benefits to humans does not limit the analysis to only those elements of the environment that directly impact human consumption or health. Anything

that has value to humans contributes to social wellbeing, and should thus be considered as part of costs and benefits of environmental change. This includes such direct benefits as health related to air pollution, or production related to forestry, but also indirect benefits, such as the desire to leave the environment to future generations, or simply the "warm feeling" that people receive from the knowledge that polar bears and penguins are being protected. The important thing to keep in mind is that it is legitimate to measure anything which provides value to humans, in estimating the costs and benefits of environmental change.

80. Estimating these values to humans can be difficult, however, since they are often not directly observed. For instance, the "value" of a new car can be inferred from its market price. But there is no market for clear skies, or for good health. A person can generally not go to the store and buy "a nice view" or "less asthma." Because these things are not bought and sold on markets, it is difficult to know how much people value them.

81. The approach most frequently used for estimating the value of changes to non-market factors is the willingness-to-pay (WTP) approach. Willingness-to-pay involves attempts to figure out how much people would be willing to pay for something, if it was available for purchase. For example, people obviously can not buy a commodity known as "10% fewer asthma attacks per year." But if they *could* buy such a thing, how much would they be willing to pay for it? By estimating the willingness of a population to pay for a certain non-market commodity, its value to the community can be put in the context of other costs and benefits that are paid for and received by the populace.

82. While the idea of "paying for" environmental goods and services may appear unsavoury to some, it provides a means for policy-makers to objectively choose between options that will enhance overall quality of living. The willingness-to-pay concept might be more appropriately termed a willingness-to-make-trade-offs, or a willingness-to-sacrifice. For example, to say that an orange costs \$2 and an apple costs \$1 does not say anything about the intrinsic value of an apple or an orange. What it does say, is that on average, people would be willing to exchange one orange for two apples. Similarly, values for environmental goods and services, based on WTP estimates, are not designed to put a price on the environment, or to provide information on the intrinsic value of the environment or human health. Rather, they are intended to provide an indication of relative willingness of individuals to exchange one type of benefit for another. For example, if an individual's WTP for "a day with clear air" is higher than his or her WTP for "swimming in a clean lake", all it means is that that particular individual values clear air more highly than being able to swim in a clear lake. If an individual states that his WTP for "access to a clean lake" is \$500, and his WTP for "a new large screen TV" is \$900, it simply means that individual values a new TV higher than he values a clean lake for swimming in.

83. Willingness-to-pay estimates establish the relative value that people place on environmental goods and services, relative to one another, or relative to other market commodities. In developing policies, decision-makers must often decide between policies that offer different benefits. WTP¹ estimates provide a guideline to policy-makers, allowing them to make tradeoffs between alternative policy benefits, that reflect the willingness of the citizens to make those same tradeoffs.

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Besides the willingness-to-pay, there is also a similar concept known as the willingness-to-accept (WTA). Willingness-to-pay answers the question "if you could buy X, how much would you be willing to pay for it." Whereas willingness to accept, focuses on the question "you have the right to X, how much will you accept to give up that right?". For the same good or service, X, WTA should always be higher than WTP. It could be argued that for environmental goods and services, it should be assumed that individuals have the right to a clean environment, which would make willingness-to-accept the logical approach. In practice however, WTP is usually used rather than WTA, in large part due to difficulties in measuring WTA.

84. Because WTP is not something that can be observed on markets, it can be difficult to measure. Some of the techniques used to estimate WTP are discussed below.

85. 'Hedonic pricing' is an approach that tries to estimate the value of a non-market good or service, by looking at the prices of goods and services in markets that are closely related to the non-market feature in question. One of the main approaches used for hedonic pricing involves looking at prices in housing markets, and attempting to determine how house prices change to reflect environmental amenities. For example, if two houses were identical in absolutely every conceivable way *except* that one house was next to a park, and the other house had no nearby green space, and was \$5,000 cheaper, one might conclude that the proximity to a park had a market value of \$5,000. Similarly, if two cities were of roughly equal size, had similar climates, and had equal social services and employment opportunities, but with the only major difference being that one city had poor air quality, then any difference in housing prices between the two cities might be attributed to the premium on clean air. In practice, it is difficult to find houses, or cities, that are virtually identical in all respects save one. But through statistical analysis, it may be possible to determine the *average* premium on house prices, that would result from a nice view, clean air, access to parks or similar characteristics. This premium indicates how much the average person is willing to pay for access to a certain environmental good or service.

86. Another approach to valuation of non-market goods or services is based on travel costs. For example, access to a public park might be free, or very low cost. Not much can be discerned about how much people value access to the park, based simply on the access price. But access price is often not the main "cost" for people to visit parks. If these parks are in remote locations, the main "cost" of visiting them, is in the costs of travel to and from the park. Both the financial cost for transportation, and – more importantly – the time cost. People's time is valuable. If they were not travelling to the park, they could be working and making money, or they could be engaging in other forms of leisure activity. The willingness to spend time and money to reach an environmentally desirable location provides a strong indication of the value that people have for such a location. Travel cost methods can be particularly appropriate for valuing outdoor recreational activities such as hunting, fishing, camping, canoeing, etc.

87. Some of the most significant environmental costs associated with transport are human health costs, related to air pollution. Air pollution can create a range of effects ranging from aggravation of asthma, to cardiac hospital admissions, and even death. The social impacts of these illnesses are some of the main contributors to estimated external costs of transport. It is crucial to understand that the social welfare impacts of sickness and death are not limited to the medical costs, nor are they associated with the loss of economic productivity. The social welfare "cost" of a serious illness or death is far larger than simply the cost of medical treatment, or the cost of lost worker productivity. The social welfare cost includes these medical and productivity impacts, but it also includes the value of pain and suffering, which are generally the most significant component of welfare impacts. Since the goals of government are generally to improve standard-of-living, not simply reduce medical costs or increase GDP, the non-market pain and suffering impacts of air pollution or accidents are critical to assessing transportation costs and benefits.

88. Social welfare health impacts are usually estimated using willingness-to-pay techniques. It may not be possible for a person to pay to avoid a hospital admission for respiratory illness. But hypothetically, if they could pay to avoid it, how much would they pay? Or, to be more accurate, how much would they pay to reduce their risks by a small amount. On an individual level, government policies can not eliminate the risk of a particular individual getting sick. But at an aggregate level, government policies can reduce the probability of people on average getting sick. Doing so will generally require they spend money raised through taxes, or reduce pollutant emissions related to electricity generation by increasing electricity costs, or limit access to public roads, or somehow do something that will generally *involve a downside* for people. Governments are not usually expected to implement policies if the downside for people is more

than they are willing to pay (sacrifice). So the question for policy-makers is how much are people willing to sacrifice, to obtain small reductions in the probability of illness. For example, if a government policy would reduce the risk of developing asthma by 2%, but it would cost an average of \$50 per person, would that policy be in the public interest? To answer that question, governments need to know whether the average person consider a 2% reduction in their probability of developing asthma to be worth \$50 or not? If the average person values this risk reduction at more than \$50, then the policy would produce net benefits. If, on the other hand, the average person does not feel this policy to be worth the cost, then it is a socially inefficient policy. From a social welfare standpoint, it does not make sense to provide people with a benefit, and then charge them more than the benefit was worth to them in the first place. Several approaches are available to provide these types of estimates.

89. The wage-risk approach is often used to measure the social welfare values of injury and death. This approach looks at the wage premium workers make, for choosing to work at a riskier job. Obviously no worker is going to choose a job where they are certain to die, and risk-wage rates vary considerably between sectors. But if data is aggregated over multiple sectors, employers and workers, a clear pattern emerges. On average, jobs that are riskier pay their workers more. The premium that is paid for riskier jobs can be considered the "market value" of increased personal risks. Some people will value their safety more highly that this, and those people will work at safer jobs. For other people, the increased income is more than worth the trade-off of slightly higher personal risk. On average though, the market wage-premium is an indication of how much the *average* individual is willing to accept as compensation, for a slightly more dangerous job.

90. Hedonic pricing, travel cost, and wage risk modelling are all examples of revealed preferences valuation techniques; so called, because consumers "reveal" their preferences with respect to non-market goods and services, through their in-market actions. Economists tend to like revealed preference approaches because they allow market forces to demonstrate the sacrifices and exchanges that people are willing to make, avoiding bias created by simply asking people their preferences.

91. An alternative to revealed preference is the stated preference technique. Simply put, stated preference means asking people how much they would be willing to pay for something. It might be as simple as "how much would you pay to have unlimited access to a park, 5 minutes from your house?" Or it could be of the form "if a new drug came onto the market, that could reduce the frequency of your asthma attacks by 20%, but the drug cost \$40 per month, would you buy it?" One method used for revealed preferences are contingent valuation (CV) surveys. These surveys are administered to large groups of people, and then responses are aggregated and averaged to determine the average willingness of people to pay for certain goods or services. Obviously, one of the keys in such a survey is to develop an approach which will make sure that respondents give responses that are both well thought out – and honest. An alternative to CV, is the contingent choice (CC) method. It is similar, except that instead of asking "how much would you pay for X?" the survey asks "would you rather have X, or Y?" By framing the questions as a choice, usually between two desirable alternatives, the CC method attempts to ensure that responses are well thought out, and that there is less chance for respondents to deliberately try to skew the results in one way or another.

92. One of the most important (and also one of the most controversial in terms of valuation) components of the environmental costs of transport, is associated with the risk of mortality. The value of a statistical life (VSL) is a measure of the social welfare impacts of a single fatality. It is not meaningful at an individual level, and is not a measure of how much an individual life is worth. It is a measure of how much society values risk-reductions that will, on average, save one life. It is a measure that is often misunderstood. To provide an example, a VSL of \$5 million means that an average person would be willing to pay \$5, in support of a policy that would reduce their chances of dying by one in a million. A policy that saves one life, out of every one million people, at a cost of \$5 or less per person, would be an

efficient policy. VSL is a measure of the value of very small changes in mortality risks, aggregated across large numbers of people.

93. VSL can be calculated using either wage-risk studies, or through CC and CV survey techniques. Numerous studies have been completed, and the estimates vary substantially. Typical estimates range from slightly less than \$1 million to \$8 or \$9 million, with values of around \$3 or \$4 million being the most common. Even at the low end of the value measures, however, the human mortality impacts of air pollution tend to dominate the overall estimates of social costs of air pollution. The choice of how to measure VSL, or what value to use, can therefore profoundly influence any estimate of the social cost of transport, or of social transport subsidies.

Marketed Environmental Costs and Benefits

94. The discussion above focused on environmental costs and benefits that are not marketed goods or services. But some environmental costs and benefits are actually direct market impacts. For example, if acid rain reduces fish stocks by 50%, and fisheries are able to catch 50% fewer fish, this is a direct impact on a market commodity. In such cases, the environmental costs and benefits can be computed directly from market prices of the affected goods or services. Other examples would include the effects of acid rain or ozone on the growth of commercial timber.

95. Even in these cases however, measurement of the "value" of environmental impacts is not always straight forward. It depends heavily on the underlying assumptions connecting environmental impacts with the market commodity. For example, if acid rain reduces the growth rate of trees, and the volume of wood in forests, but this does not affect annual tree harvests, how would one calculate the impacts? At one extreme, one could figure out the volume of wood in the forest that was destroyed due to acid rain, and then multiply this by the market price for cut timber. At the other extreme, one could argue that because the tree destruction from acid rain has not affected annual harvest levels, it has no impact on firms' profits and hence no economic impact. Between these two extremes lie a variety of assumptions that could be made to relate lost wood volumes to market prices, in order to estimate the market value off the loss.

Ecological Services

96. Another approach to measuring the value of environmental impacts is to calculate the costs to provide equivalent services through other means. For example, wetlands purify water systems, reducing the need to build water-treatment facilities. If wetlands are destroyed, then more treatment facilities will need to be built. The cost of building such facilities is the cost of replacing the water-treatment service provided by the wetlands. Therefore, the water-treatment capabilities of the wetlands provide a social benefit, equivalent in value to the cost of replacing it. Of course, this would only be *one* of the benefits of the wetlands. Other benefits of the wetlands would need to be measured using other means.

97. Calculating replacement values of ecological services is a fairly straightforward process, in situations where it is applicable. In many situations, though, this approach can not be used. The approach is only valid for situations in which a man-made alternative to the ecological services actually exists. For some goods and services, there are no man-made alternatives, or at least no true alternatives. For instance, a day at the amusement park, or a trip to the movie theatre, is clearly not a perfect substitute for a walk in the forest. On a larger scale, the regulation of the planetary ecosystem is not something that can be replaced by man-made equipment. For these reasons, this approach to measuring environmental goods and services (seeing how much they would cost to replace), is only practical for certain ecological services that can conceivably be replaced. This leaves many aspects of the environment unaccounted for, so these must be measured with methods discussed above.

98. Another potential problem with the replacement value approach is that it supposes replacement of the services is the best option. For example, a certain ecological service might cost \$50 billion to replace. But it might not be worth replacing at even a fraction of that cost. For instance, if the benefits that people receive from a particular ecological service are only worth \$100 million, to those people, then it would be foolish to spend \$50 billion building something to replace it. It would cost more to replace the service than the value of the benefits it provided in the first place. In this respect, it is possible for the replacement value approach to provide significant value overestimates. Care should be taken to only use the replacement value of ecological services in situations where replacement of those services would in fact be initiated if they were destroyed.

3.2.5 Positive Externalities

99. One element that is often ignored in calculating the social costs (and hence the social subsidies) of the transport sector, is the existence of positive social externalities, beyond the purely economic impacts. While they may not be as significant as the negative externalities, the existence of transport systems does create benefits for non-transportation users. For example, an efficient road system will allow ambulances and fire trucks to quickly reach emergencies. Thus, even someone who never drives a car, can benefit from a good system of roads. Benefits of this type are generally omitted from total cost calculations on the grounds that they are either a) *too small* to be worried about, b) *to difficult to calculate*, or c) that they are *already captured* in other aspects of government spending and social benefits, and should thus not be double-counted. To the extent that such positive externalities exist, and are excluded from the subsidy calculations, the net costs of transport may be overestimated. However, over-estimates in this respect are often more than compensated for by omissions of negative externalities.

3.2.6 Section Summary

100. If subsidies are defined as the failure of transport users to pay for the full social costs of transport activity, then measuring subsidies requires that we measure all costs and benefits associated with transport. This includes government spending and revenue (discussed below), as well as economic, social, and environmental costs and benefits of transport. The accuracy and comparability of subsidy estimates depends on the reliability of estimates of costs and benefits, the measurement techniques used, and the units of measurement. Different approaches, or different units, yield subsidy estimates that can vary substantially and are not readily comparable.

101. Ultimately, it may be impossible to calculate the total social subsidy received by the transport sector. To do so, one would need to compare the costs and benefits to society of current transportation levels with a zero transport-activity alternative. It is not particularly meaningful to compare current (base-case) transport activity with an alternate scenario in which there is no transport activity. Such an alternate situation could not feasibly exist. And it is not possible to calculate the effects such a situation would have on society, even if it were hypothetically possible.

102. Though it may not be possible to calculate the total social subsidies of transport against a zero transport case, it is possible to see how social subsidies would *increase* or *decrease* in response to changes in the transport sector. One can compare the current state of the transport sector to some alternate scenario, in which transportation increases or decreases. One could then measure how economic, social and environmental costs and benefits vary between the two situations. In this manner, one can measure changes in social subsidy levels, without needing to measure the levels themselves in absolute terms.

103. Similarly, the relative level of social subsidies between different transport modes can be calculated by comparing base levels of transport by mode, with alternative transportation sector structures. For example, the social subsidies that road transport receives compared to rail transport can be estimated

based on observed or estimated changes in social, economic and environmental costs and benefits to society, in a *status quo* case, compared with an alternate case of increased rail and decreased road transport.

104. In all cases, measuring social subsidies depends on the ability to define two alternative transport scenarios, and to then measure the differences in costs and benefits (social, environmental and economic) between the two scenarios. Differences in units of measurement for these different social, environmental and economic benefits can render calculation or comparison of subsidy levels difficult or impossible. Differences in units, or in measurement techniques, can also lead to different calculations of costs and benefits, and hence different conclusions about the relative level of subsidy between industries or transport modes.

3.3 Measuring Subsidies on the Government Finance Side

105. Almost all definitions of subsidy include some element of government financing or support as part of the definition. If subsidies are defined in social welfare terms, then government expenses and revenues are a subset of the social costs and benefits of transport. If subsidies are defined in terms of government support, then these are the only measures that matter.

106. There are many different ways to measure the value of transport subsidies, in terms of government support. These depend mainly on specifically what types of revenue, expenditures and other support measures are included; and which are excluded. From a social subsidy perspective, all government revenues, and all expenditures, should be considered in calculating the cost of transportation. If using a government finance definition of subsidy, however, it may be desirable to exclude certain revenues or expenditures from the calculation. Discussed below are various ways of classifying and measuring government revenue or expenditures, which may or may not be considered part of subsidy calculations.

3.3.1 On / Off Budget Expenditures

107. One of the main considerations in measuring net public cost of transportation is whether to look only at on-budget subsidies, or to include both on- and off-budget subsidies. And, if the latter, the question of how to calculate off-budget subsidies becomes important. On-budget subsidies include expenses that appear in the government's budget as such. For instance, a direct transfer to automakers, a rebate offered to vehicle drivers, or direct financial support for public transit services. Because they appear directly on the government books, "measuring" budget subsidies is quite easy. Off-budget subsidies include those things that government do to support transport activities, but which do not immediately appear as expenses on the government's books. For example, providing reduced tax rates for companies in certain industries. By allowing companies to pay less income tax, governments are providing financial support to the industry, resulting in reduced government revenues. The results are the same: Public revenue is reduced in order to support industry. But unlike direct transfers, or other on-budget subsidies, the actual amount of financial support industry receives is hard to estimate, since it does not appear directly on the government's books.

108. Measuring off-budget subsidies relies to a large extent on assumptions about counterfactual scenarios. For instance, determining the value of a tax exemption requires knowing how much additional taxes the industry *would have* paid, if they had not received the exemption. Depending on the type of support provided to industry, it can be extremely challenging to determine what the situation would be in the absence of such support, and how this would impact government revenue.

109. Although on-budget subsidies are the most obvious and easy-to-calculate subsidies, off-budget subsidies can be just as important. In some countries, and for some industries, off-budget support is much larger than on-budget support. Off-budget subsidies include things such as trade barriers against foreign

competition, granting or allowing monopolies, other forms of support to keep prices higher than the free market price, government regulations to keep certain costs below market costs, loan guarantees, and allowing companies to use public resources at below market value. To measure the value of these subsidies, one must determine how much *additional* revenue governments would have available for other projects, if they were not providing such off-budget support.

110. Alternatively, if subsidies are defined according to government *support*, rather than net financial support, then one must measure the *value* of government support to industry, which may not be the same as the net impact on public finances.

111. Unless an exceptionally narrow definition of subsidy is used, government subsidies should include the net impacts on the government's revenue. Any activity or policy targeting a specific sector, which causes government revenue to be less than it would otherwise be, is a form of government support. Failure to account for all such activities, and a focus on only direct budget expenses, will lead to significant underestimates of the true value of public support (subsidy) received by an industry.

3.3.2 Government Revenue

112. Just as all government actions that specifically support an industry should be considered part of government subsidies, so too all government revenue derived specifically, or uniquely, from that industry should be subtracted from the estimated level of subsidies.

113. Generally, it is only appropriate to deduct revenues associated *specifically* with a certain industry, above and beyond what is received by other industries. In the transportation sector, government revenue should include transportation specific revenues, but not revenues received equally from other industries. For example, fuel taxes are a form of government revenue unique to the transportation sector. So revenue from fuel taxes should be deducted from the measurement of transport sector subsidies. On the other hand, corporate income taxes are paid by companies operating in all industries, so corporate taxes paid by transport firms should not be counted towards "revenue" from the sector. Unless, of course, transport firms are subject to higher income tax rates, in which case any excess could be considered as specific transport sector income. Similarly, income from the sale of public transit tickets should be included as part of transportation sector revenues, but general purpose sales taxes (VAT taxes) should not be included, since these are paid by all sectors.

114. Government revenues, and government expenditures, that are very closely related to each other, will generally either both be included, or both be excluded from subsidy estimates. For instance, if a specific revenue stream is earmarked for reinvestment into the industry, it would not make sense to count the revenues and not the expenditures when calculating subsidies, or *vice versa*. These expenditures and revenues go hand in hand, and should thus not be separated as part of subsidy calculations. Similarly, if there are other revenue and expenditure streams that are linked hand-in-hand to one another, then they should either both be entered into the subsidy estimates, or neither should. These revenues and expenditures may cancel each other out, if they are equal, but if one exceeds the other, it would be the net amount that should be included in subsidy estimates.

115. In the transport sector, the main sources of sector-specific revenues include fuel taxes, vehicle licensing and registration fees, vehicle circulation fees, ticket prices from government-run transportation services, and charges for the use of government-provided infrastructure (road charges, airport charges, port charges, etc). In most cases, these revenues are fairly straightforward to calculate, as they are largely "on-book" revenues. The only thing that may complicate measurement or comparison of subsidy estimates, would involve the inclusion or exclusion of different elements. For example, including VAT on vehicle purchases would greatly increase the government revenue associated with transportation, and greatly

reduce the calculated level of subsidies in the sector, making such estimates incomparable to other estimates. The decision to exclude infrastructure charges would have the opposite effect. So long as the included elements are well-defined, though, calculating government revenue from transportation is one of the more straightforward measurements involved in calculating transport subsidies.

3.3.3 Infrastructure

116. There is significant debate about whether government provision of infrastructure should be considered part of government "subsidies" or not. This question depends to a large extent on whether subsidies are defined in terms of the *total costs* of transport, or the *marginal costs* of transport. Building roads, airports, ports and railways contribute to the total cost of transportation to governments. Once built, however, they have fairly little to do with the marginal costs of driving. If subsidies are defined in terms of the government spends on transport, and how much the government receives from transportation activities, then infrastructure expenses can probably be included. If, on the other hand, subsidies are defined in terms of the gap between the marginal costs of operating the system, and the marginal revenue per user, then the only infrastructure costs that should be included would be maintenance costs.

117. This decision is hugely important in the transport sector, since by far the largest government costs in the sector have to do with providing infrastructure. If infrastructure development expenses are included, then issues that may become relevant include how to spread those costs over time. For example, singleyear revenues will rarely be sufficient to cover major infrastructure projects, particularly at lower levels of government. If such expenditures are counted as part of a single year's expenses, then government subsidies for that one year will be estimated to be huge, in comparison to subsidies in other years. It may be more reasonable when measuring subsidies to average infrastructure spending over a longer period of time. The question then becomes how long an averaging period should be chosen, and what sort of interest/discount rate should be used. Again, these decisions will affect the calculation of how much subsidy an industry or transport mode receives over time.

3.3.4 Incidence / Policy Target

118. Another important aspect of measuring government subsidies involves deciding whether or not to include subsidies, based on who receives them. In the transport sector, not all government support *related* to transport goes directly to transport service providers. Some government support targets consumers, such as giving consumers incentives to use certain transport modes. Other government support may provide assistance to upstream manufacturers associated with the transport industry. An important question then, is which of these up- and/or down-stream supports should be added to the measures of industry support.

119. Traditionally, support provided directly to consumers of transport services is usually considered part of transport sector support. The question of upstream support is somewhat more controversial. For example, government support of auto manufacturers, or to airline manufacturers, is often considered to be government support (subsidisation) of the transport sector. On the other hand, it could just as easily be considered a support/subsidy for the manufacturing sector. Government-funded research into green transportation could be considered government support for the transport sector. But it could also be classified under government environmental spending. Depending on who receives a subsidy, how it is delivered, and who benefits from it, different subsidies and support mechanisms may or may not be considered "transport subsidies". In many cases, transport subsidies are assumed to be only those support mechanisms that are directly targeted at transportation consumers and service providers. But this approach is by no means universal. Individual approaches vary, but it is important to recognize that if different support mechanisms are, or are not included, subsidy estimates will naturally vary considerably.

3.3.5 Transfers from Consumers Directly to Producers

120. Not all government policies to provide financial support to industry involve reductions in the *government* finances. Some policies, rather than transferring income from governments to an industry, transfer money directly from consumers to the industry. This is the case with some forms of price support. For example, a government policy that keeps prices artificially high, may simply force consumers to pay more, without significantly affecting government revenue in either direction.

121. Depending on the definition used, such government activity may or may not be considered a subsidy. If subsidies are defined in terms of the reduction in net government finances, due to a government's support of industry, then such transfers from consumers would not count as government subsidies. If on the other hand, subsidies are defined to be the value of any support industry *receives* as a result of government intervention, then these transfers from consumers would be considered.

122. The OECD producer support estimate (PSE) of agricultural support is one measure that does include transfers from consumers. The PSE is defined as "an indicator of the annual monetary value of gross transfers from consumers and taxpayers to support agricultural producers, measured at farm gate level, arising from policy measures, regardless of their nature, objectives or impacts on farm production or income", OECD (2007). Thus, any income transferred from the public to agricultural producers is considered part of the support received, regardless of whether it first passes through government.

123. Although there is no equivalent to the PSE applied in the transport sector, it will be important to consider whether government subsidies should, or should not, include transfers directly from consumers. This may be particularly relevant in cases where prices are kept high due to exclusion of foreign competition. For instance, protection for local airlines may increase domestic flight costs for consumers. Whether or not higher ticket prices are considered part of the subsidy that airlines receive could significantly alter the estimated level of subsidy in the industry. Similar situations may be present with respect to other forms of price support or government aid in other areas of the transportation sector.

3.4 Summary

124. Chapter 2 dealt with some of the broader theoretical issues involved in defining subsidies. But defining subsidies is only the first step toward measuring them. This Chapter has focussed more on some of the lower-level difficulties involved in actually trying to measure specific subsidies. Decisions about what to include as part of subsidy measurements, decisions about what type of scale to use, and decisions about which measurement tools to use, can all profoundly affect estimated subsidy levels. It is possible for different analyses to estimate widely divergent levels of transport subsidies, even if they work from the same definition.

125. The next Chapter will look at some of the definitions and measurement techniques that have been used in the literature, and present some of the estimates that have been produced using those definitions and measurements.

4. Subsidy Data, Definitions, and Measurement Techniques in the Literature

126. The previous two Chapters explored the issue of how subsidies are defined and measured. This chapter will present an overview of some of the relevant data and definitions that have been used in the literature. The purpose here is not to provide a comprehensive survey of all available data and literature on transport subsidies. Rather, this Chapter provides an overview of the range of estimates that exist in the literature, and of the approaches that have commonly been adopted in different analyses.

127. The concept of a subsidy in the transport sector is rather complicated and, as shown below, there is no commonly agreed-upon definition. This can present problems for policy-makers who wish to reduce "environmentally harmful" subsidies. As noted by the EEA, "analyses using different definitions and classifications can arrive at opposite conclusions." (Best *et al.*, 2005) Different conclusions can lead to different policy actions, with possibly unintended environmental consequences. Care must therefore be taken in developing subsidy estimates, and interpreting estimates in the literature, lest the choice of definition may lead to undesirable policy outcomes.

128. Presented below is a wide range of data that has been used, by various authors, governments or agencies, to measure transport related subsidies. For each approach that is used, this paper will examine both the estimates themselves, as well as the definitions and measurement techniques used to derive those estimates. The purpose is to present not only the broad range of estimates that are available, but to show how different definitions, or measurement techniques, can lead to widely divergent subsidy estimates, with very different policy implications.

4.1 Data and Approaches that Define Subsidies in Terms of Government Action

129. As discussed in previous chapters, one widely used approach to defining and measuring subsidies focuses on the impact of transfers to and from government. In other words, subsidies are defined according to how much the "cost" is to government. Even within this broad definition, however, different sub-definitions or measurement techniques exist, that can lead to very different subsidy estimates.

130. In a recent report, the US Department of Transport (DoT) (2004) defined subsidies as follows: "Subsidy, for the purpose of this analysis, represents a simple accounting calculation of the net flow of funds to or from the federal government for individual transportation modes. The excess of expenditures over revenues is the net subsidy." According to DoT's calculations, public transit in the US receives the largest net Federal subsidy, followed by air transport and passenger rail. In terms of subsidy on the basis of distance travelled, passenger rail received the highest relative subsidy, at \$186 per thousand passenger miles, followed by transit at \$118 per thousand miles, and air which received relatively minor subsidies on a per-distance basis. Road transport in the US was found to actually contribute more to Federal revenue than is spent by the Federal government on road transport. "On average, highway users paid \$1.91 per thousand passenger-miles to the federal government over their highway allocated costs during 1990-2002." These estimates are measures of the *relative* level of subsidy between different modes of transport, where the metric for comparison is defined as the level of subsidy, per thousand passenger-miles travelled.

131. The DoT report focuses on subsidies from the perspective of only the *Federal* government. This includes direct Federal funding of transport, as well as grants and transfers to lower levels of government explicitly for use on transportation projects. It is unclear from the report how inclusion of additional state and local government spending and revenue would affect this analysis.

132. Although the focus of the Department of Transport's report was on subsidies from a Federal finances perspective, the report also acknowledged that assessment of marginal social cost could be an important, and possibly more relevant approach to measuring subsidies. It stated that "A strong case can be

made that comparing the magnitude of the subsidies to the magnitude of net social benefits, by mode, provides a better view of the relative subsidy than does normalising by a physical measure such as passengers or passenger-miles. We have not included analysis of the social costs and benefits of different transportation modes because of the difficulty of providing a value of these costs and benefits."

133. Though it acknowledges relevance of the social subsidy approach, the Department of Transport continues to approach subsidy measurement from the perspective of net financial expenditures and receipts by government. In the most recent Transportation Statistics Annual Report, the net level of Federal transport subsidies is "estimated as federal outlays minus federal receipts from transportation taxes and user fees," (Bureau of Transportation Statistics, BTS, 2006). As shown in this report, US net Federal subsidy estimates have fluctuated considerably from year to year. From 1993 to 2002, Federal subsidies for transport varied between a high of \$8.6 billion (current US\$) in 2002, and a low of negative \$5.5 billion in 1999. The main factors influencing these subsidy levels were net revenues from highway traffic, and net outlays for aviation and (public) transit. In every year since 2002, the Federal government has received substantially more revenue from highway traffic (mostly private cars) than it has spent. During this period, net revenues from highway transport reached a high of \$11 billion in 1999 and a low of \$4 billion in 2002. Since 1999, aviation has generally received net government subsidies of \$3 to \$5 billion per year, though the government did receive small net revenues from the aviation sector in 1999 and 2000. Transit has consistently received substantial net Federal government support, which has increased steadily from \$3.5 billion in 1993, to \$7.6 billion in 2002.

134. The figures in the preceding paragraph provide examples of the *total*, or net, subsidy received by different modes, rather than a relative measure such as the value of subsidies received per passenger kilometre. This approach provides a contrast to the relative subsidy levels reported further above. As discussed in Department of Transport (2004), on the basis of Federal subsidies per 1000 passenger miles travelled, rail is the most heavily subsidised of all transport modes, while air travel receives fairly modest subsidies. But if viewed simply in terms of the net level of subsidy, passenger aviation in the US has generally received huge subsidies compared to rail transport. This provides a good example of the possible confusion that can often arise in discussion of transport statistics. One approach would lead to the conclusion that rail transport is far more heavily subsidies than air, while the other approach leads to the conclusion that air is much more heavily subsidised. Yet the subsidy measures in question come from virtually the same source, and are based on the same data. The only difference is the metric used to report the estimates. Such differences need not be a problem, as long as one is conscious of underlying definitions and measurement approaches. The policy implications can be profound though, when one looks at subsidy removal or reform policies. For instance, the policy goal to "reduce unequal levels of subsidy between transportation modes" could lead to very different outcomes, depending on how subsidies are defined and measured.

135. Also of note, the Department of Transport statistics discussed above, whether in terms of total subsidy, or subsidy per passenger-mile, focus on *total costs*, rather than *marginal cost*. By looking only at the *total* flow of funds to and from the Federal government, this accounting does not get into issues related to marginal costs per passenger. The data presented above on net Federal subsidies simply shows the *total* cost to government of supplying transport. The data on subsidy per passenger-mile travelled is a measure of the *average* cost of supplying transport, per passenger-mile. Neither total cost, nor average cost, are directly related to marginal cost. Marginal cost would be the *additional* cost to government incurred by one more transport user. Depending on the characteristics of the transport system, marginal costs could be higher or lower than average costs. The DoT data indicates how much subsidy transport receives as a whole, and it indicates the amount of subsidy received by the *average* user. But it does not indicate how subsidy levels will respond to one *additional* user, or how much subsidy that one marginal user would receive.

136. In addition to focusing on a total financial approach to subsidies, rather than a social or marginal cost approach, the Department of Transport work also largely excludes indirect or implicit subsidies. For example, revenues from gasoline taxes are included as government revenue from transport. However, there is often no distinction made for preferential tax rates. The accounts look at the *net* tax revenue from transportation. They do not (normally) look at the difference between transport tax rates and tax rates in other sectors. This is an important distinction since, as has been discussed in previous sections, it can significantly effect the calculation of net subsidy levels, or of the relative level of subsidy between different industries or transportation modes. Similarly, although direct government financing is included in subsidy measurement, many less direct (non-financial) forms of industry support may not be included. Because it focuses only on direct revenues and expenditures, the approach of the Department of Transport does not fully account for the net impact of transportation on government finances.

137. The financial definition of subsidies used by Department of Transport (2004) and BTS (2006) is the same approach generally followed in most US government accounts and publications, and it is similar to what is used in the national accounts of many OECD governments, and national statistical organisations.

138. Like the Department of Transport data, many subsidy discussions also choose to omit indirect government support as part of the measures of subsidy. One potential reason for this focus could be the difficulty and large degree of uncertainty involved in measuring implicit, or "off-budget" subsidies. Figuring out how much revenue was received from fuel taxes is fairly straight forward. Figuring out how much revenue could have been generated, if tax rates were different, is much more complicated. It would require a detailed understanding of how existing consumption and production patterns might shift in response to a different tax regime. Similarly, it could be difficult to estimate the value of government-granted price controls, service provision, resource access or other indirect support measures. Due to these difficulties in measuring indirect and non-financial support, many subsidy estimates have focused on on-budget subsidies. However, some estimates of indirect government subsidies are available.

139. One of the most significant indirect subsidies in the transport sector is the low or non-existent tax rates on aviation fuel. These indirect subsidies very obviously have a large impact on government finances. Billions of dollars could be generated in tax revenue, if airline fuel was taxed at a rate comparable to automobile fuels. The exact value of these forgone revenues is difficult to calculate, however, due to uncertainty about the potential response of the air transport industry to increased tax rates. Nonetheless, numerous attempts have been made to quantify the magnitude of these tax brakes. Sewill (2003) estimates that the tax exceptions given to air transportation in the UK provide the industry with an implicit subsidy worth over GBP 9 billion per year.

140. The Environmental Assessment Institute (EAI) has used several subsidy definitions in their work, including some that would allow for indirect subsidies and others that would not. In a recent paper on *Environmentally Harmful Subsidies*, the Environmental Assessment Institute (EAI, 2005) defined subsidy as a "Policy intervention that allows consumers to purchase goods and services at prices lower than those offered by a perfectly competitive private sector, or raises producers' income beyond those that would be earned without this intervention." This definition of subsidies is one based primarily on a government policy (or government finance impact) approach, rather than social costs of transport.

141. It is interesting to note that the EAI's definition is a modification of a definition originally provided by Richard Damania. In EAI (2005), Richard Damania is quoted as defining subsidies to "comprise all measures that keep consumer prices at a level below that which reflects the true opportunity costs that would prevail in competitive markets *if all external costs and benefits were internalised* or all measures that keep producer prices above true opportunity costs in competitive markets *if all external costs and benefits were internalised*, or that reduce costs for consumers and producers by giving direct or indirect support. [emphasis added]" By altering this definition and removing all references to

internalisation of externalities, the EAI chose to restrict their analysis to exclude consideration of the social costs of transport as part of the definition of subsidies. This decision is specifically noted by the EAI saying that "In this report, non-internalised externalities do not fall within the category of a subsidy" EAI (2005).

142. Although it does not consider social impacts to be subsidies, the EAI definition above extends subsidies to include indirect or off-budget support. The focus on "policy intervention" rather than direct government spending and revenue, implies that issues such as market price support, preferential tax rates, access to public resources, and other forms of off-budget support, is considered a form of subsidy by the EAI's definition.

143. It is noteworthy that while the EAI's general definition of subsidies focuses on policy intervention, the transport section of the report provides an alternative definition of subsidies "in which [road] transport subsidies can be defined [as] the net balance between the governmental costs and revenues from road transport." The paper further clarifies that this definition of subsidies "reflects the costs of providing road users with the infrastructure, space and complementary traffic services to drive their cars, not covered by the government's revenue (cost recovery)." This definition is in stark contrast to the one provided earlier in the report, as it appears to focus almost exclusively on financial (on-budget) money transfers and receipts. Note, however, that this definition does still include infrastructure investment as part of subsidies.

144. The EAI provides a brief overview of some of the available estimates of the value of transport subsidies worldwide, including Myers and Kent (2001), van Beers & de Moor (2001), and Delucchi (2000). Although some of these studies included social costs, the EAI focused on governmental costs, derived from these studies. The EAI adopts the "very conservative" estimate of global transport subsidies of \$225-\$300 from van Beers & de Moor. This would be equivalent to less than 0.7% of global GDP. That is considerably more than the US Department of Transports estimates of net Federal subsidies for transportation, which amounted to less than 0.1% of GDP. But it is far less than many of the social-cost-based subsidy estimates, such as the UNITE project (discussed below), which places the value of transport subsidies at over 4% of GDP.

145. The perspective that "subsidies" are provided by government, rather than by society (social subsidies) is frequently adopted as part of national accounting measures. This may be in part due to the prevalence of this definition in common use. In many cases, though, this choice may be made more on practical, rather than theoretical grounds. Governments or researchers may choose to define subsidies according to government financial criteria, simply because to do otherwise would create measurement difficulties. The US Department of Transport, and the EEA, have indicated this to be part of the reason for choosing a government finance perspective.

146. Subsidies, Taxes & Charges in the European Transport Sectors, a report prepared for the European Environment Agency, provides a thorough overview of a large number of approaches to defining subsidies. The report used a definition of subsidies that focuses more on government financing than on social cost, writing "In this report, a subsidy is defined as 'a result of a government action that confers an advantage on consumers or producers, in order to supplement their income or lower their costs", (Best *et al.*, 2005). This definition was taken from *Environmentally Harmful Subsidies: Challenges for Reform*, (OECD, 2005), though its context in that paper is somewhat different than what Best *et al.* suggest. Note that though it excludes social costs, this definition very clearly includes indirect government support measures.

147. In choosing a government perspective to defining subsidies, Best *et al.* (2005) noted that "the marginal social cost *vs.* price method [is] the theoretical ideal for maximising social welfare, but is limited

by difficulties and uncertainties involved." Although framing the general analysis primarily in a financial, rather than a social cost framework, the report does also present a wide variety of statistics on both the social and private costs of transport in Europe. This data is drawn mainly from earlier papers, some of which are discussed in more detail later in this report.

148. In addition to discussing some of the more high-level problems of defining subsidies, Best *et al.* (2005) also explores in some depth a variety of specific measurement approaches. As discussed in previous Chapters, in order to measure a subsidy one must first address broad theoretical issues for defining a subsidy, for example, whether to focus on financial or social costs. Even after a broad definition or approach has been chosen though, there are still choices that must be made regarding further refining the definition, and choosing a method for measuring the subsidies. The report presents an overview of different ways to classify subsidies. Among the options presented, subsidies can be classified based on the source of the subsidy, the purpose, the recipient, the use of on versus off-budget subsidies, the subsidy mechanism, or various other ways. All of these methods for classifying subsidies generally fall under the approach for measuring subsidies that focuses on government financing, rather than a social cost approach.

149. The EEA report (Best *et al.*, 2005) presents a variety of measures and estimates of transport subsidies, corresponding to a variety of measurement/definition approaches. For instance, transport infrastructure investment in the EU-15 was approximately $60-65 \in$ billion between 1990 and 1995. Over 60% of total infrastructure spending was for roads, with rail infrastructure accounting for approximately another 20%. Transport infrastructure spending during this period was equivalent to about 0.7% of GDP in the EU 15. As noted in the report, there is no consensus among governments or analysis whether infrastructure spending as a "subsidy", but some accounts, and many economists do. Best *et al.* (2005) classify these infrastructure expenses as "off-budget subsidies".

150. One of the main sources of government support for transport comes as a result of public service obligations (PSO). Many governments arrange for certain modes of transport to be made available below cost, in order to support low-income groups, or groups in remote geographic regions. In some cases, this takes the form of direct government-supplied transport, and in other cases it takes the form of government payments or incentives to third-party transport suppliers, so that they will offer below market value transport options. There is some disagreement about whether government funding of transport, as part of PSO, ought to be considered a "transport subsidy", or whether it should instead be treated as social service spending. It can be argued that governments actually receive a benefit in exchange for the money they spend on PSO. The benefit they receive is fulfilment of their public obligation to provide affordable transport. For this reason, PSO funding is generally not considered a subsidy, within the context of a government support definition of subsidies. Whether they are termed subsidies or not, PSO support for transport can be substantial. The bulk of PSO payments are directed toward public transit and the rail sector. Best et al. (2005) report that PSO-related compensation to the rail sector in each of Austria, France, Italy, and the UK totalled about 2€ billion per year. PSO payments to rail in Germany were over 6€ billion per year.

151. Recently, the EEA released *Size, Structure and Distribution of Transport Subsidies in Europe* (EEA, 2007). This report was prepared for the EEA by many of the same authors as the above 2005 report, and expands on the material provided in that report. It works from the same basic definition of transport subsidies as "a result of a government action that confers an advantage on consumers or producers, in order to supplement their income or lower their costs." As part of this definition, the EEA excludes government activity to fulfil public service obligations, but includes general infrastructure spending. The report also divides subsidies are defined as "cash transfers paid directly to industrial producers, consumers and other related bodies… (that) appear on national balance sheets as government expenditures." Off-budget subsidies are

defined as "transfers to ... producers and consumers that do not appear on national accounts as government expenditures."

152. The EEA definitions of on- and off-budget subsidies are inconsistent with some other definitions that also appear in the literature. The line between on- and off-budget subsidies is often unclear. This concerns, for instance, the classification of preferential tax rates. One school of thought would hold that "reduced revenue, due to lower-than-standard fuel tax rates" is not actually an item that appears on the expenditure side of government accounts, and hence it is not an "on-budget" subsidy. The other school of thought would argue that although preferential taxes do not explicitly appear in government budgets, they still clearly have an extremely direct impact on budgets, and hence should be considered an on-budget subsidy. By this approach, off-budget subsidies should be limited only to government interventions that do not directly impact the budgets, such as regulated price support, market access restrictions, or use of public resources. For example, OECD (1998a and 1998b) lists preferential sales and VAT rates as on-budget subsidies. By EEA's definitions, however, fuel tax or VAT exemptions and rebates are clearly defined as off-budget subsidies.

153. In addition to the distinction between on- and off-budget subsidies, the EEA also classifies subsidies based on the mode of transport, and based on the incidence of the subsidy (who or what is initially impacted). These different incidences, and the types of subsidies that fall within each classification, are summarised in Table 4.1.

Initial incidence	Description	Relevant subsidies quantified in this study
Infrastructure	Public spending on transport infrastructure network (roads, rail, waterways, airports and air traffic control) including investment, running and hidden costs; minus charges for use or access to infrastructure	Infrastructure subsidies
Fuel	Subsidies for production, distribution and use of fuels	Fuel-tax exemptions and rebates
Means/vehicles	Subsidies for production, distribution, use and disposal of vehicles	Other on-budget subsidies
Users/services	Subsidies for transport provisions and activities of companies, households, private and public institutions, including subsidies to operators for reduced fares	VAT exemptions and rebates; Other on-budget subsidies
Other	Subsidies with indirect impact on transport demand (e.g. for housing, building, settlement, regional development, trade and distribution)	Note: subsidies with indirect transport impacts are not quantified in this study

Table 4.1: Classification of Transport Subsidies, by incidence.

Source: EEA (2007), p 12.

Table 4.2 presents an overview of the data that the EEA collected on transport-sector subsidies in Europe. Infrastructure-spending is clearly the dominant form of financial subsidy, with most infrastructure-spending being devoted to road networks. It is interesting that, based on the available data, on-budget infrastructure subsidies were found to be zero.

	On-budget subsidies		Off-budget subsidies		Total
	Infrastructure subsidies (EU-15)	Other on-budget subsidies	Fuel-tax exemptions and rebates	VAT exemptions and rebates	
Road	110	7	0	9	125
Rail	37	33	0-1	3	73
Air	0	1	8-16	18	27-35
Water	10	1	3-19	0	14-30
Multiple modes		30			30
Total	156	73	11-36	29	269-293

Table 4.2: Overview of total annual subsidies found by incidence and mode (billion 2005 EUR)

Note: Numbers may not add to totals shown due to rounding. Infrastructure subsidies equal infrastructure costs minus infrastructure charges (see Box 1 on page 14). For fuel-tax exemptions and rebates, low and high estimates are provided; for road transport the tax rate for fuels exceeds the rates selected as references to calculate subsidies. For further methodological details — see Chapter 5. This table is based on incomplete data; the total value of European transport subsidies remains unknown. This note must accompany any use of this table.

Source: EEA (2007), p 15.

154. This data can be interpreted a number of ways. For instance, road transport clearly receives by far the largest total subsidy. However, road use in the EU far exceeds use of other forms of transport, in terms of passenger-km or freight-km travelled. If the above figures were expressed in terms of support per passenger-km, or per tonne-km, then road transport would receive the smallest subsidy. Also of note, almost all of the subsidies to road transport are in the form of infrastructure spending. As previously discussed, many authors and national governments exclude infrastructure spending from "subsidy" measurements – on the grounds that infrastructure is a public good. If infrastructure costs were removed from the above table, road transport in Europe would be one the *least* subsidised of all transport modes, along with water transport.

155. Because the infrastructure data is for the EU-15, and the other data is for EU-25, it is difficult to compare total EU subsidy levels. One can note though that the 156 billion EUR per year spent on infrastructure is equivalent to approximately 2% of GDP in the EU-15. The approximately 125 billion EUR worth of non-infrastructure subsidies, is about 1.5% of GDP in the EU-25.

156. In addition to excluding any social costs or externalities from the subsidy measurements, the data above also excludes estimates of non-financial support from governments. The EEA's definition of subsidies was not limited to financial support. Subsidies were defined as "government action that confers an advantage on …". Such advantages need not be a monetary payment, or a tax rebate; it could be any government policy. In theory then, the measure of off-budget subsidies should include things such as granting firms increased market-access, protection from foreign competition, price fixing, and other government actions that benefit transport firms or consumers. Calculating the value of such government support would be extremely difficult. And the values might end up being small compared to other forms of government support. But it is still important to recognize the absence of such support measures ("subsidies"), from the above figures.

157. The papers discussed above provide good examples of some different approaches that are taken to defining and measuring subsidies. All have basically taken the approach that "subsidies" are support measures provided to the industry by governments. Yet within these broad definitions, very different subclassifications and measurement techniques have been used. As can be seen, these different definitions and measurement techniques lead to very different conclusions regarding subsidy levels. And the reports above represent only a small number of the definitions and measurement approaches commonly being used. Additional detailed information on specific subsidy calculations, beyond those presented above, will not be included in this section. Listed below, however, are a number of additional approaches to defining and measuring subsidies, all of which rely on a government support perspective.

158. The Real Cost Reduction of Door-to-Door Intermodal Transport (RECORDIT) project was a large study on the full costs of European freight transport, including both user costs and external costs. As part of the project, the team provided an overview of taxes, charges and subsidies in freight transport. The project relied on a government perspective of subsidies, but employed a somewhat unusual definition. Subsidies were defined as "Contribution by a government for which it receives no products or services in return. The purpose of such payments is to make a particular service or product available at a price that the public can readily afford, when the service or product cannot otherwise be profitably supplied at this price" (Maas et al., 2001). This definition is curious, in that it seems to focus on public service obligations (PSO). Most authors seem to take the position that if the government is supporting an industry, for the specific purpose of making something affordable, then this should be considered social service spending, and not a subsidy. By contrast, Maas et al., have not only included PSO as part of their definition of subsidies, they have gone so far as to restrict the definition of subsidies to apparently only include PSO spending. The findings of the RECORDIT project were that for the main European freight corridors, intermodal transport (freight and sea) received much larger subsidies than road transport, and that taxes and charges were much higher for road transport than for intermodal transport (Maas et al., 2001).

159. Eurostat, the statistical unit of the European Commission, defines subsidies as "current unrequited payments which general governments... make to producers, with the objective of influencing their levels of production, their prices or the remuneration of the factors of production" (Eurostat, 1995). This definition is fairly restrictive, excluding many things that would be considered subsidies, even by member governments. For instance, non-financial government support would not be included, nor would financial measures that target *consumers* rather than producers. The highly restrictive nature of this definition is most likely intended to reduce legal disputes between countries.

160. The World Trade Organisation (WTO) uses an even more restrictive and precise definition of subsidies. The WTO definition, see Box 4.1, is part of the General Agreement on Tariffs and Trade (GATT). The GATT is a binding agreement between participating nations, and as such it must be extremely precise. There is no room for ambiguity about what may or may not be considered a subsidy; hence the highly regimented definition. Though the precision of the definition makes it useful in resolving trade disputes, this definition is not widely used beyond the courtroom. It is so narrow that many types of government support, which are almost universally considered subsidies, are excluded due to difficulties in their precise quantification.

Box 1. WTO definition of a subsidy
1.1 For the purpose of this Agreement, a subsidy shall be deemed to exist if:
(a)(1) there is a financial contribution by a government or any public body within the territory of a Member (referred to in this Agreement as "government"), i.e. where:
 (i) a government practice involves a direct transfer of funds (e.g. grants, loans, and equity infusion), potential direct transfers of funds or liabilities (e.g. loan guarantees);
 (ii) government revenue that is otherwise due is foregone or not collected (e.g. fiscal incentives such as tax credits)(1);
(iii) a government provides goods or services other than general infrastructure, or purchases goods;
 (iv) a government makes payments to a funding mechanism, or entrusts or directs a private body to carry out one or more of the type of functions illustrated in (i) to (iii) above which would normally be vested in the government and the practice, in no real sense, differs from practices normally followed by governments;
or
(a)(2) there is any form of income or price support in the sense of Article XVI of GATT 1994;
and
(b) a benefit is thereby conferred.
161 In Environmentally, Hanneld Subsidier, Challenger for Defam, the OECD rotes that "there is

161. In *Environmentally Harmful Subsidies – Challenges for Reform*, the OECD notes that "there is no definition of a subsidy that is universally accepted by all who use the term... In general, a subsidy is a result of a government action that confers an advantage on consumers or producers, in order to supplement their income." (OECD, 2005) This definition has been widely quoted. It is important to recognize, however, that the OECD itself has not adopted this as an "official" definition. This definition was merely presented in the paper as *one* of the definitions of a subsidy. Indeed, the paper goes on to state "However, the more detailed definitions differ between sectors and, sometimes, between countries, organisations, and analysts for a given sector... [in the transport sector], the concept of a subsidy or support measure is more complex." At present, there is no official or widely accepted definition of subsidy, although the one noted above is one of the most frequently used, and certainly one of the most widely referenced.

162. In a report to the European Commission, the Institute for European Environmental Policy (IEEP, 2006) chose to work with multiple distinct definitions. They made use of the Eurostat definition, the WTO definition, the definition from OECD (2005), and a social cost approach. Energy subsidies were classified and measured according to each definition.

163. de Moor & Calamai (1997) defined subsidies as "any measure that keeps prices for consumers below the market level or keeps prices for producers above the market level, or that reduces costs for consumers and producers by giving direct or indirect support." This is one of the broadest definitions of subsidy available. If the "market level" was deemed to be market prices in the absence of externalities, then this definition would fall under the social cost approach to defining subsidies. Even without including externalities, this definition is still one of the broadest non-social definitions of a subsidy. This definition encompasses infrastructure spending, public service obligations, any sort of financial transfer, access to public resources, preferential tax rates, or market controls, all of which alter the market price of goods and services faced by consumers or producers.
164. The perspective that subsidies are provided by governments is the approach most used in the mainstream media, and in day-to-day speech. In many circumstances, it can often be assumed that "subsidies" refer to government subsidies, unless explicitly stated otherwise. Many authors will use the term subsidy without providing a definition, for example, ECMT (2006 and 2007), the European Commission (2006), Myers (1998), de Borger *et al.* (2004), and OECD (2002). In such cases, it is usually clear that they are talking about government support measures. But it is frequently unclear whether the authors consider only on-budget/direct subsidies, or also indirect/off-budget subsidies, whether they include infrastructure, or PSO, spending as part of subsidies, whether they are looking at marginal user costs or total costs, or on what basis they are measuring subsidies. Given the uncertainty regarding subsidy definitions, analysts might be encourage not to use the term without providing at least a line or two explaining what is meant, and what is included. Where such a description is absent, policy-makers should take care in interpreting "subsidy measurements" that appear in the literature or the common press, lest they draw incorrect conclusions regarding actual government support levels.

4.2 Subsidy Data and Definitions from a Social Cost Perspective

165. Although subsidies are most often interpreted as a form of government support, there is an equally valid approach which considers subsidies to include social subsidies, in the form of external costs that are born (paid for) by society. This approach is popular among transport economists and some government bodies. Although less common than the governmental perspective of subsidies, this approach has certain benefits, especially in regards to identifying and eliminating environmentally harmful subsidies. The US Department of Transport and the EEA both noted the potential benefits of a social cost perspective on subsidies, though they ultimately opted for a government-focused definition, for practical reasons. Other authors have supported a social cost perspective of subsidies. Presented below are various estimates of the magnitude of social subsidies in the transport sector, along with a discussion of the definitions and measurement techniques used in developing these estimates.

166. Chris Nash has been one of the more prolific authors on the topic of transport subsidies, and has generally supported the position that subsidies should be defined in terms of the failure of transport users to cover the *marginal social* costs of their activities. In a paper prepared for an OECD workshop on environmentally harmful subsidies, Nash (2002) provides an overview of costs and revenues associated with transport in Europe. The data on transport "costs" include infrastructure and transport system operating costs, as well as the external environmental costs. Estimates of both total and marginal costs are also included. The data in this paper is largely superseded by the estimates in the UNITE project (Nash *et al.*, 2003), which is discussed below, so the subsidy estimates from Nash (2002) are not listed here. As Nash notes, though, this data could be used to calculate subsidies from either a government, or a social cost perspective. Depending on which perspective is used, Nash notes that the policy implications could vary considerably:

"With both approaches, the results obtained are fairly diverse. In almost all countries revenues from road transport cover the costs of providing and maintaining the infrastructure and in many countries, revenues from road transport cover the total social cost, although in some they do not. By contrast other modes are heavily subsidised. The effect of removing subsidies in total would therefore be to divert traffic from other modes to road. Although there might be some reduction in total transport, the effects of removing subsidies in this way might well have overall consequences which were damaging for the environment. If removal of subsidies was accompanied by removal of surpluses generated from taxes on road transport, the environmental consequences would be greatly worse, as a large increase in road traffic would be produced.

By contrast, road transport often has charges which are below marginal social cost especially in congested areas. Public transport and rail tend to have marginal costs that are well below average

costs, due to economies of scale in production and low externalities. Thus the implementation of marginal social cost based pricing to remove subsidies at the margin would generally have environmentally benign results, with reductions of road traffic typically of up to 15% in urban areas, and rather less elsewhere. Air would also typically lose traffic whilst rail would gain. However, even this pattern varies between the member states. In some cases, rail is already so heavily subsidised that marginal social cost pricing would divert traffic from rail to road. This is particularly true of freight." (Nash, 2002)

167. To put these statements in the context of the subsidy definitions that have been used in this report, this means that in almost all European countries, road users pay more in taxes and charges than what the government pays to provide road transportation services. Thus, from the perspective of government finances, there is no subsidy for road transport. In many, but not all of the countries studied, the total amount of money paid by road users exceeds the total social costs (both costs to government, plus external environmental costs) of road transportation. Hence from a total social cost perspective, road transportation is subsidised in some countries, but not others. Although road users, taken together, more than cover the social costs of their activities in many countries, the *marginal* social cost imposed by each additional road user is often greater than what that marginal user pays. Thus from a marginal social cost perspective, road transport is frequently heavily subsidised, especially in congested areas. To summarize, if subsidies are defined in terms of government costs vs. government revenues, then road transport is not subsidised. If subsidies are defined in terms of total social costs vs. total user charges, then road transport is subsidised in some, but not all countries. If subsidies are defined in terms of the marginal cost per user vs. per user charges, then road transport is subsidised in most countries. For rail transit, these conclusions would in many cases be reversed.

168. With respect to which approach is the best for measuring subsidies, Nash (2002) writes that "[comparing total costs and revenue] is often seen as important politically and in the consideration of equity issues... It is [considering the relationship between marginal social cost and price], however, that is appropriate in the consideration of economic efficiency." Nash also stresses that in the transport sector "marginal and average social costs are highly divergent". This gives rise to very different subsidy estimates between transport modes. In rail for instance, marginal costs are very low compared to average costs, while in road transport, marginal costs can be much higher than average costs (Porter, 2002).

169. As quoted by the EAI (2005), Richard Damania, economics professor at the University of Adelaide, defined subsidies to "comprise all measures that keep consumer prices at a level below that which reflects the true opportunity costs that would prevail in competitive markets if all external costs and benefits were internalised or all measures that keep producer prices above true opportunity costs in competitive markets if all external costs and benefits were internalised, or that reduce costs for consumers and producers by giving direct or indirect support." In a perfectly competitive market, the quantity produced and consumed, and the market price, are set by the equalisation of supply and demand. By definition, this requires that the price charged be equal to the marginal cost of production. If all externalised, then the priced paid must correspond to the marginal *social* cost of their activity. This definition therefore implies that subsidies are zero, when the price of transport equals the marginal social cost of roducers and/or consumers.

170. The non-internalisation of externalities has also been treated as a form of subsidy in certain OECD and ECMT publications. For example, *Reforming Transport Taxes*, (ECMT, 2004) states that "the non-taxation of negative externalities is, in effect, a subsidy. It reduces social welfare by encouraging consumption even where marginal social costs exceed marginal social benefits. It also distorts inter-modal choice by introducing a bias in favour of those modes which are most favoured by this subsidy – in

particular, urban roads." In the glossary, a subsidy is defined as a "transfer defined as a difference between chargeable income and the full social costs of freight transport."

171. In a perfectly competitive, well functioning market, user charges would be equal to marginal social costs. As ECMT notes, though, transport markets are not well functioning competitive markets. "In the field of transport, markets do fail in a manner which is systematic and predictable and to a degree which is measurable and large." Transport markets fail for two very important reasons. Firstly, they fail because they often have *increasing returns to scale*. That means, each additional "customer" can be served at a lower cost than the previous customer. Such a system promotes an industry with a single large producer, rather than multiple small producers, since a single large producer would be able to provide services to many customers more cheaply than multiple producers could serve smaller numbers of customers. Increasing returns to scale encourage a market run by a monopoly, which would be the opposite of a perfectly competitive market.

172. The other major market failing in the transport sector is that (without regulation) the free market will *not account for externalities*. Neither users nor producers will take into consideration the external costs that they are imposing on others. Because of these very substantial market failures in the transport sector, governments must play an important role. Proper intervention can reduce, or eliminate the negative economic and social implications of these market failures. By *increasing* the level of government support or intervention, it is possible to improve market efficiency and to *reduce* the level of (social) subsidies.

173. Myers and Kent (2001) also consider the non-internalisation of externalities to be a form of subsidy. For road transportation, they estimate that non-internalised externalities amount to \$380 billion worth of subsidies per year, globally. Myers and Kent list only those externalities that they consider to be documented and quantified (Note how small this estimate is compared to other external cost of transport estimates discussed below).

174. In addition to \$380 billion in social subsidies, Myers and Kent (2001) estimate that global road transport received an additional \$800 billion per year in "traditional" subsidies. Traditional subsidies are defined to be both direct financial support, as well as indirect support via preferential taxation and similar methods. Total subsidy estimate for the road sector therefore comes to \$1.2 trillion per year. Myers and Kent estimate that 50% of conventional subsidies are "perverse", or socially non-beneficial. 100% of non-internalised externalities are perverse. Perverse subsidies for road transportation are thus estimated to be worth \$780 billion per year, globally. The approach used by Myers and Kent is a prime example of measuring subsidies in terms of the difference between *total* social costs of transportation, and *total* user charges. Note the difference between the approach recommended by Nash of comparing *marginal* costs with user charges.

175. One of the main objections to defining subsidies in terms of social costs lies in the difficulties in measuring social costs. Subsidies that appear on government accounts are obvious and easy to measure. Off budget-subsidies, such as the value of preferential tax rates, are somewhat more difficult to measure, but can still be estimated with a reasonable degree of accuracy. Social subsidies, however, can only be measured if transport externalities are valued. Due to the uncertain magnitude of some of these externalities, and difficulties involved in monetary valuation of non-market (social and environmental) impacts, social subsidy measurements are inherently less precise than financial subsidy estimates.

176. Although difficult, quantifying the physical impacts of transport externalities, and putting a monetary value on these impacts, is by no means impossible. Numerous approaches exist to quantifying transport externalities. Some studies that have attempted to put a value on transport externalities are listed below. Note that these studies have not necessarily advocated that externalities should be considered part of the definition of a subsidy. But if externalities *are* included in transport subsidies, then these studies

provide an indication of the range of values that can be used, and some of the available measurement techniques.

177. The UNITE project (Nash *et al.*, 2003) was a major study on transport spending and costs in Europe. The project was funded by the European Commission and received input from a large number of authors and partner organisations. Although the objectives of the project as stated were not directly related to transport subsidies, much of the data gathered is relevant for analysing subsidies from various perspectives. As described in the final report of the project, the core aspects of the project were "marginal costs [of transport], transport accounts, and integration of approaches." The marginal cost data collected focused on "the way in which different categories of costs and benefits [of transportation] vary with an additional vehicle kilometre." This marginal cost data would be essential in estimating the magnitude of transportation subsidies from the perspective of marginal social welfare. Approaches for measuring marginal social costs of transport that were developed or refined as part of the UNITE project could also be used to help measure the level of social subsidies. The transport accounts of the UNITE project involved "a comprehensive statement of all the costs, benefits and revenues associated with a given mode of transport, in a geographic area and for a set period of time." Such data can be used to help measure net costs and benefits of transport, and hence net subsidies, from both a government financing and a social perspective.

178. Interesting results of UNITE include the following conclusions:

"For road, total revenues cover total infrastructure costs in all countries except for Hungary. In more than half of the countries studied, the total revenues exceed the total costs of infrastructure, accidents and the costs of air pollution, global warming and noise. However there are substantial shortfalls in Austria, France, Germany, Greece, Hungary, Spain and Switzerland. By contrast, the degree to which rail system costs are covered by revenue from passengers and freight differs substantially between the countries studied, from a maximum of 63% in the case of Finland to a minimum of 8% in the case of Hungary."

179. These results can be interpreted a number of ways, depending on how one defines subsidies. From the perspective of total impact on government finances, it would appear that road travel is not subsidised in any country studied except Hungary. From a *total social* impact perspective though, road transportation would be seen as subsidised in a number of countries, particularly those noted above.

180. Table 4.3 presents results of the UNITE calculations of costs and revenues associated with road transportation in Europe.

	Infrastructure	External (social)	Total Social	Total Government	Net effect on gov	Net social	
	Costs	impacts	Costs	Revenues	revenue	impact	
Austria	4,382	4,120	8,502	4,923	541	(3,579)	
Belgium	1,570	3,828	5,398	6,239	4,669	841	
Denmark	400	1,847	2,247	4,558	4,158	2,311	
Finland	1,119	1,031	2,150	3,626	2,507	1,476	
France	25,520	39,508	65,028	44,016	18,496	(21,012)	
Germany	26,176	50,478	76,654	41,416	15,240	(35,238)	
Greece	2,802	10,111	12,913	5,520	2,718	(7,393)	
Hungary	6,075	2,326	8,401	1,882	(4,193)	(6,519)	
Ireland	263	1,470	1,733	2,393	2,130	660	
Italy	13,645	16,482	30,127	36,185	22,540	6,058	
Luxembourg	105	186	291	406	301	115	
Netherlands	4,411	7,003	11,414	10,286	5,875	(1,128)	
Portugal	1,791	1,789	3,580	3,819	2,028	239	
Spain	6,224	12,125	18,349	12,870	6,646	(5,479)	
Sweden	2,172	1,935	4,107	5,266	3,094	1,159	
Switzerland	4,030	2,767	6,797	4,482	452	(2,315)	
UK	12,728	34,717	47,445	43,983	31,255	(3,462)	
Total	113,413	191,724	305,137	231,870	118,457	(73,267)	

Table 4.3: Transport Costs, Revenues and Externalities

Net Costs of road transport (million Euros)

Source: Adapted from UNITE final report, Tables 9-12 (Nash et al, 2003)

181. Nash *et al.* (2003) provides estimates of costs and revenues associated with road, rail, and air transportation in 17 European countries. The estimates include costs of infrastructure, congestion, air pollution, noise, global warming and external costs of accidents, and are presented as total costs, costs a as percentage of GDP, and costs per kilometre travelled. Revenues include infrastructure use charges, vehicle registration and related taxes, and fuel taxes. Combining this data would make it possible to assess the level of subsidies in various sectors from a variety of perspectives.

182. For road-based transportation alone, the UNITE project estimated that "The total social cost of road provision and use (excluding vehicle operating cost) amounts on average to some 4% of GDP in Western Europe." 1.5% is the cost of infrastructure provision and use, 1% is due to congestion costs, 1% for environmental externalities, and 0.5% due to the external costs of accidents. Note that if this data were used to provide an estimate of transportation sector subsidies, it would not be appropriate to include congestion measures as part of the *total* subsidy received by transport users, since most congestion costs are born by the same people who cause them: transport users. It would, however, be appropriate to include congestion caused by one additional driver is felt by all drivers equally, rather than that one driver alone. It is also interesting to note that global warming impacts are considered one of the least important environmental impacts. The value of global warming impacts is estimated to only be one third as large as the air pollution impacts of road transport. This contrasts with other studies (see below) that have estimated that climate change is the main environmental cost associated with transportation.

183. The *External Costs of Transport* was a major European study completed by INFRAS and IWW to identify, measure, and value the social and environmental impacts of transport. An initial report was completed in 2000, and an updated report was completed in 2004 with a revised methodology. Although the report does not focus on subsidies, it provides a great deal of important estimates for what could be considered social subsidies in the transport sector. The report provides data and estimates on total transport externalities, average costs per 1000km, and marginal costs per 1000km. This data could thus be used to evaluate subsidies from either a total social cost or a marginal social cost perspective, as well as on the basis of relative subsidy levels between modes.

184. For the EU-15, Norway and Switzerland, INFRAS (2004) estimates that the total external cost of transport amounts to 650 billion euros, per year, as of 2000. This is equivalent to 7.3% of GDP. The most significant external cost due to the transport sector was found to be in the climate change impacts, which were estimated to account for 30% of the total value of impacts. Air pollution impacts and accident costs were the next most important external costs, accounting for 27% and 24% of transport externalities respectively. Because congestion costs are (mostly) non-external to the transport sector, they were not included in the *total* externalities of transport. They are relevant in terms of marginal costs though. Some of the air pollution impacts of transport are also closely related to congestion issues as well. The estimated total costs of transport, by mode, and by type of externality, are shown in Table 4.4 below:

TOTAL COSTS IN 2000 BY COST CATEGORY & TRANSPORT MODE														
[million Euro/year]			Road						Rail		Aviation		Water- borne	
	Total	%	Car	Bus	мс	LDV	HDV	Pass. total	Freight total	Pass.	Freight	Pass.	Freight	Freight
Accidents	156'439	24	114'191	965	21'238	8'229	10'964	136'394	19'194	262	0	590	0	0
Noise	45'644	7	19'220	510	1'804	7'613	11'264	21'533	18'877	1'354	782	2'903	195	0
Air Pollu- tion	174'617	27	46'721	8'290	433	20'431	88'407	55'444	108'838	2'351	2'096	3'875	360	1'652
Climate Change High	195'714	30	64'812	3'341	1'319	13'493	29'418	69'472	42'911	2'094	800	74'493	5'438	506
Climate Change Low ¹⁾	(27'959)	(4)	(9'259)	(477)	(188)	(1'928)	(4203)	(9'925)	(6'130)	(299)	(114)	(10'642)	(777)	(72)
Nature & Landscape	20'014	3	10'596	276	233	2'562	4'692	11'105	7'254	202	64	1'211	87	91
Up-/Down- stream ²⁾	47'376	7	19'319	1'585	335	5'276	16'967	21'240	22'243	1'140	608	1'592	170	383
Urban Effects	10'472	2	5'782	147	127	1'220	2'634	6'112	3'797	426	137	0	0	0
Total EU17 ³⁾	650'275	100	280'640	15'114	25'491	58'824	164'346	321'301	223'114	7'828	4'487	84'664	6'250	2'632

Table 4.4: Transport Externalities, by category & mode

Source: INFRAS (2004), table 2.

185. Of the different transport modes, road based transport was found to be by far the largest contributor to total external costs of transport, accounting for 84% of total costs. For air pollution, and accident costs, road accounted for 94% and 99% of total costs, respectively. Climate change was the only cost category for which any mode besides road made a significant contribution. Air transport accounted for 41% of the climate change related costs of transportation, with road transport accounting for all the rest.

186. In terms of the *average* social costs of transport, road was the most costly means of transporting people, followed by air. On average, every 1000 passenger km travelled by road generates 76 euros worth of externalities. Aviation is close behind; with an estimated external cost of 53 euros per passenger-km. Travel by bus incurs social externalities worth about 38 euros per passenger-km, followed by rail at 23 euros per passenger-km. The picture is different for freight transport, where aviation is by far and away the most costly means of transport, in terms of external costs. Shipping a tonne of freight 1000 km by air generates an average of 271 euros worth of external social costs. Road externalities were valued at 88 euros per 1000 tonne-km. Transport by rail and water create minimal externalities, valued at only 18 and 23 euros per tonne-km respectively.

187. The picture for marginal costs is less clear because data depends on a much greater range of variables. For example, the average cost of air pollution simply depends on the total damages caused by air

pollution divided by the number of passenger-km or freight tonne-km. On the other hand, marginal damages from air pollution depend on what type of car (or other vehicle) is in use, what time of day the driving occurs, what region the driving occurs in, and various other factors. As a result marginal, cost estimates in INFRAS (2004) are presented as a wide range. In most cases, the lower estimates of marginal costs are below average costs, while the upper estimates are well above average costs.

188. Because it accounted for the largest share of both marginal and total external costs of transport, it is worth taking a closer look at the climate change impacts estimate. Of all the social and environmental impacts of transport (health impacts of air pollution, congestion delays, noise, wildlife impacts, accident costs, etc), climate change impacts are probably the most uncertain. Though there is generally consensus in the scientific community that global warming is occurring, and that man-made greenhouse gas emissions are responsible, it is not vet well-known just how much global temperatures will rise. It is even more uncertain what the physical effects of a global temperature increase will be, and how to measure and monetize those effects. It is thus difficult to put a value on the social damages that are occurring (or will occur) due to CO₂ emissions from transport. Rather than try to value the physical impacts of CO₂ emissions, INFRAS relied upon estimates of a shadow-price for CO₂ emissions. That is, the "price", or cost, of reducing CO₂ emissions. By emitting a certain volume of CO₂, the transport sector is assumed to create social damage equal to the value of the CO₂ reductions that would be required to cover/offset those emissions. The price of emission reductions would depend on how steep an emission reduction target government pursued. If drastic emission reductions were desired, the marginal cost of reductions would be quite high, resulting in a high shadow-price. More modest targets would result in a lower shadow-price. INFRAS produced climate change externality costs estimates based on a high shadow price of 140 euros per tonne, and a low price of 20 euros per tonne. The figures quoted above are based on the high value. Use of the lower value would produce a corresponding reduction in total externality costs, and in the relative importance of climate change impacts relative to air pollution and other impacts. Since aviation impacts are based largely on climate change impacts, using a lower social impact estimate for the effects of climate change would also reduce aviation external cost estimates, so that road would become the most environmentally damaging transport mode for both passengers and freight.

The other major contributors to the external costs of transportation were accidents and air 189. pollution. In both cases, the costs are driven to a large extent by fatalities. The cost to society of traffic accidents, and air pollution, is determined almost entirely by the number of people killed from these causes, and the estimated social welfare impact per fatality. The number of accidents and fatalities due to transportation is easy to measure. Measuring air pollution related fatalities is more difficult, but it relies on an extensive body of epidemiological research. The exposure-response function used by INFRAS indicates that if one million people are exposed to a 10 μ g per m³ increase in PM₁₀, then, on average, annual fatalities related to air pollution will increase by 350. To calculate the expected mortality impacts of air pollution from transport, this ratio was applied to the contribution of transport to PM_{10} formation in different regions, times the exposed population in those regions. The social welfare impacts of mortality were then calculated by multiplying expected fatalities by the estimated social welfare impact of a (statistical) fatality. Fatality valuation is also difficult, and controversial, but it too relies on an extensive body of literature, which is based largely on the willingness of individuals to trade-off between personal risk and personal income. The value used for air pollution related mortalities in INFRAS (2004) is 915,000 euros. This value is consistent with similar values in the literature, though it tends towards the low end. For instance, a value of USD 6.1 million is recommended for use in the US (ABT, 2005). Using a higher mortality value estimate would greatly increase the total, average and marginal social subsidies estimates for road.

190. Another recent source of transport externality data is the EEA's Transport and Environment Reporting Mechanism (TERM) project. Numerous reports have been released as part of the TERM project covering multiple issues related to transport and the environment. A majority of these reports focus on

physical data related to transport and the environment in Europe, such as emission data, transport volumes, and modal structure. They thus do not provide data that could be used to directly estimate social subsidies in the transport sector. However, since measuring subsidies requires measuring externalities, the TERM project and related fact sheets do provide a step in this direction. Also, although the report does not focus on subsidies, one of the recent reports from the TERM project (EEA, 2006) makes several points that are relevant to the discussion of marginal social subsidy estimates. As noted in the report, transport charges are beginning to be used in some European countries to bridge the gap between user fees and marginal social costs. In other words, fees are being implemented to reduce the level of subsidy to certain transport modes, in terms of a marginal social cost subsidy. The EEA notes that while these charges are beginning to be used, user prices for road and aviation transport in Europe are still far below marginal social costs.

191. Some of the reports above, particularly UNITE (Nash *et al.*, 2003) and INFRAS (2004), provide excellent overviews of the external impacts of transport and demonstrate several measurement approaches. The above data also demonstrates how sensitive external cost estimates are to measurement techniques and assumptions. Depending on the choice of a shadow-price for CO_2 emissions, the climate change impacts of transport could be either the most important cost associated with transportation, or they could be insignificant. The selection of a value estimate to measure the social welfare loss associated with accident or air pollution related fatalities will also profoundly affect the calculations of external costs of transport. If transport subsidies are defined relative to the social costs of transport, it is important to consider *which* social costs should be included, and how these costs are being measured.

192. Though it is still less common than the government support perspective, the social cost approach (either marginal or total) is a valid approach to measuring and defining subsidies. It is an approach that is endorsed either directly or implicitly by numerous authors and governmental organisations. And while social costs may be more difficult to calculate than government spending, numerous measurement techniques and estimates exist. As with other definitions though, the choice of a specific sub-definition, and the measurement approaches used, can drastically alter the calculated level of subsidies and the subsequent policy implications.

4.3 Summary

193. As the above discussion demonstrates, there is a myriad of different definitions and approaches to measuring transport sector subsidies. Different definitions and approaches naturally lead to different estimates of the absolute and relative level of subsidies in the transport sector and for different transport modes. Key considerations include:

- Are subsidies defined based on the difference between the *social* cost of transport and the fees users pay, or on the difference between the cost to *government* and the fees users pay?
- Are subsidies defined based on the average cost per user of supplying transport, or on the marginal cost per user?
- Should all forms of government aid, or preferential treatment, be considered government subsidy, or only those forms of support that include direct financial transfers?
- Should support for transport that is intended to fulfil public service obligations (PSO) be considered a subsidy?
- Should infrastructure spending be considered a subsidy?
- Which external costs of transport can be included as part of social subsidies?
- What are the net (or marginal) environmental impacts of transport?
- What method should be used to measure the value of non-market environmental impacts?

• Should subsidies be defined on a per passenger basis, on a per unit of GDP basis, on some other basis, or simply in net terms?

194. As shown above, different responses to these questions lead to widely divergent estimates of subsidy values. The transport subsidy estimates cited above range from low values of less than 1% of GDP reported by the US Bureau of Transport Statistics, which considered only direct funding at the Federal level, to high values of as much as 7% of GDP, when external environmental costs are included.

195. And the papers cited here by no means represent a complete overview of the available literature and estimate ranges. The intent of this section has simply been to demonstrate that a wide range of approaches exist, and that they lead to very different estimates.

196. The difficulties in defining and measuring subsidies lead to difficulties in addressing "environmentally harmful subsidies". This has been noted in numerous publications on tax, pricing, and subsidy reform. *Subsidy Reform and Sustainable Development*, (OECD, 2006c) noted the importance of, and the difficulties in defining, subsidies for the purpose of subsidy reform. Some papers have attempted to address environmental problems associated with transport subsidies (OECD, 1997) noted that "in the current study, the OECD has deliberately avoided choosing a single definition of 'subsidy', but instead has explored the practicality of a range of definitions, and their relevance to the project's main aim." Similarly, Pieters (2002) attempts to develop an approach for identifying target subsidies for removal, without the necessity of pinning down a precise definition. Other papers, like many of the ones discussed above, first decided upon a definition, and then proceeded to measure subsidies and evaluate environmental impacts on the basis of that particular definition.

197. Issues regarding subsidy definition figured prominently in a 2002 OECD workshop on environmentally harmful subsidies, see Hokatukia (2002), Pearce (2002), Porter (2002), and Steenblik (2002). Steenblik provides an overview of some definition issues, and takes steps towards reconciling the different approaches. He notes that "Approaches to defining, classifying and measuring subsidies differ markedly among practitioners... there are no internationally agreed accounting frameworks for subsidies." Porter provides a general overview of issues relating to environmental subsidies, including the difference between a social cost and government accounting approach, as discussed in this paper. "A transport subsidy could be defined either in terms of the gap between government expenditures to transport systems and the revenues collected from those systems (cost recovery) or by the failure to internalise external costs and other marginal social costs (congestion, scarcity, accidents, operating costs) in a specific mode of transport." (Porter, 2002). Hokatukia also provides a general overview of OECD work on subsidies prior to 2002.

198. The purpose of this paper is not to resolve the debate, or to provide guidance on which definition or measurement technique is the "best". Each definition and approach can serve a certain purpose, and be appropriate in a given context. Some suggestions later in this paper provide guidance on which definitions and approaches may be more appropriate under different circumstances.

199. The purpose of this section rather, is to encourage policy-makers and analysts to be clear about what they consider to be a subsidy, and to realise that "definitions matter" (Pearce, 2002). When two wildly different estimates of subsidy level appear in the media, or in different reports, it is important to understand that the estimates themselves may not be incompatible with one another. It is likely that the authors simply relied upon different definitions, or different measurement techniques, to interpret the same basic data. While the estimates themselves may not be incompatible, however, the policy implications very well could be.

5. Environmental Impacts of Transport

200. The environmental impacts of transport are numerous. Impacts include global warming, various forms of air pollution, destruction of species habitat and other wildlife impacts, pollution of waterways, and noise pollution.

201. The environmental impacts of the transportation sector have been discussed in great detail in numerous publications. This paper will therefore not discuss these issues in-depth. A general overview of some of the key environmental impacts from the transportation sector is, however, provided. For a more thorough overview of the physical and socio-economic impacts of air pollution, see Nash *et al.* (2003), INFRAS (2004), and EEA (2005).

202. The focus of this paper is to examine the environmental impacts of transport subsidies. Understanding how transport subsidies affect the environment is a two-part process. First, one must know how transport subsidies affect the use of different modes of transport. Then one must understand the impacts that use of these modes have on the environment. Other Chapters of this report discuss in detail the impact of subsidies on the use of different transport modes. This Chapter provides an overview of the environmental impacts of transportation.

5.1 General Impacts

5.1.1 *Climate change*

203. Air, sea, road and rail transportation all contribute to global climate change via greenhouse gas (GHG) emissions. In terms of its global warming impacts, carbon dioxide is the single most important component of anthropogenic GHG emissions. The transport sector is estimated to account for about 23% of global CO_2 emissions (IEA, 2006). Transport emissions of other GHG are much lower than the CO_2 emissions, but transport is still a main contributor to total GHG emission (mostly due to its CO_2 contributions).

204. The Intergovernmental Panel on Climate Change (IPCC) estimates that most of the global warming observed over the last 50 years has been due to human actions, particularly GHG emissions. Global warming trends are predicted to continue due to ongoing human pressures on the environment (IPCC, 2007).

205. The effects of global warming on the environment, and the resulting effects on humans, are difficult to predict. It is believed that climate change will lead to sea level rises, species extinction, and possibly increased occurrences and severity of environmental disasters, such as floods, hurricanes and droughts.

206. Due to the extensive, far ranging, and highly uncertain impacts of global climate change, it is extremely difficult to put a value on the potential impacts of climate change. However, some attempts have been made to quantify the socio-economic value of climate change impacts. Estimates vary widely. The estimated value of a tonne of CO_2 ranges from \$5 to \$150. Some estimates place the potential impact of unaverted climate change at as high as 5-20% of GDP (Stern, 2006).

207. Though transportation is by no means the only contributor to global climate change, it is one of the major contributors. As such it is important to consider the impacts discussed above, and their potential value, in analyses of the environmental impacts of transport subsidies. Reducing the climate change impacts of the transportation sector could provide some of the largest benefits of reducing or restructuring transportation sector subsidies.

5.1.2 *Air Pollution*

208. In addition to contributing to GHG emissions, the burning of fossil fuels in internal combustion engines is a source of many primary air pollutants, such as carbon monoxide, nitrogen oxides, volatile organic compounds (VOCs) and others. Transport emissions also contribute to secondary air pollution formation, such as fine particulate matter (PM), ground level ozone and acid deposition. These pollutants have a variety of direct and indirect human and environmental health impacts.

Health Valuation

209. For use in cost-benefit analysis, it is often desirable for human illness impacts to be quantified in social welfare terms, so that the relative costs and benefits of different policies can more practically be compared. To this end, numerous studies have been conducted in attempts to "value" the benefits of reduced illness resulting from air pollution reductions. Methods and results vary dramatically, but most studies show that the social-welfare impacts of air pollution related illness are in billions of dollars for many developed countries. For example, Health Canada estimates 5,900 Canadians deaths are influenced by air pollution each year (Health Canada, 2005), with an estimated social welfare costs of over CAD 20 billion (Chestnut *et al.*, 1999).

210. Additional discussion on the health impacts of air pollution, and approaches for measuring the social welfare costs, can be found in the ExternE project [Mayerhofer *et al.* (1997)] and OECD (2006a).

Particulate Matter

211. Particulate matter (PM) posses significant threats to human health. Different transport modes contribute to airborne PM in a variety of ways. Direct emissions of sulphur particles from burning fuels with a high sulphur content, as well as road dust, are significant sources of course PM (particles with a diameter of 2.5 to 10 microns). Fine PM (smaller particles) are a secondary pollutant that are produced when vehicle emissions react with the atmosphere. Both coarse and fine particulate have been found to pose a variety of threats to human health, ranging from aggravation of asthma symptoms to premature death.

212. One of the most widely cited studies on PM effects on human health is Pope *et al.* (1995) which identified a significant link between PM and illness and mortality. Although the precise quantification of the relationships varies between studies, the general conclusions of Pope *et al.* have been confirmed by numerous medical and epidemiological studies. For an overview of relevant studies, see Chestnut *et al.* (1999) or OECD (2006b).

Ozone

213. Emissions of nitrous oxides (NO_x) and volatile organic compounds (VOCs) from fuel use contribute to the formation of ground-level ozone. Ozone can in turn pose a variety of problems for human and environmental health.

214. Many of the same studies that examined PM effects on human health have also looked at the effects of ozone on human health, and have found strong causal relationships between ozone-exposure and various illnesses. For instance, Chestnut *et al.* (1999) estimate that for every one part per billion increase in ground level ozone, affecting a population of one million people, and over a period of one year, the number of asthma symptom days will increase by 686,000, the number of emergency room visits will increase by 17, and the number of premature mortalities will increase by 1.5.

215. In addition to the human health effects of ground-level ozone, plant life has been shown to react negatively to high levels of ozone exposure. Impacts vary substantially between plant species, but they can be significant in some species. Those species of plant life that are seriously impacted by ozone exposure include a number of commercially important agricultural and forestry species.

Acid Rain Effects

216. Sulphur emissions from transportation are an important contributor to acid deposition in many parts of the world. Although it poses no direct threat to human health, acid deposition is a serious threat to many ecosystems.

217. The effects of acid rain on forests can be devastating. Large areas of forest in Europe have been seriously damaged by acid deposition. In eastern Canada and the US, acid rain is a recognised threat to regional forests and the forestry industry. Acid rain is also emerging as an important issue affecting the forestry sector in China.

218. Acid rain also adversely affects the health of inland waterways and the wildlife that depends on them. Higher Ph levels in small lakes and rivers lead to the loss of certain aquatic plants and animals, with additional impacts further along the food change. In some regions, acidification has reached a level where entire populations are at risk, as well as local economies that depend on them. In Eastern Canada, acid rain is believed to be largely (though not exclusively) responsible for the decline in Atlantic salmon populations. These population decreases have lead to the closure of Eastern Canada's wild salmon fishing industry.

5.1.3 Wildlife Impacts and Habitat Destruction

219. Transport, and transportation infrastructure, directly impact the wildlife in many regions of the world. Millions of animals each year are struck and killed by vehicles of all types. Millions more are killed by transportation related pollution, such as air and water pollution. But by fare the most significant impact on wildlife comes from transportation infrastructure.

220. Roads, in particular, can have a disruptive influence on ecosystems. Besides the obvious danger that passing cars pose to local wildlife, a large road can impose an artificial boundary or restraint on the size and shape of existing ecosystems. Species that once crisscrossed an area freely, have their territory effectively cut in half. This can reduce the hunting grounds or forage area of numerous species. The more roads that are built, the more constrained species become. Noise from roads can also make life difficult or impossible for certain species in the vicinity. Water drainage issues related to road infrastructure can also drastically alter local waterways and watersheds, with significant consequences for wildlife. Although they are generally less invasive, rail roads present many of the same problems for wildlife habitat that roads do, all be it on a smaller scale.

221. Sea transportation can be highly damaging to aquatic life. As discussed in more detail below, marine spills, combined with high traffic density, make many shipping-lanes inhospitable for marine life. Large ship-wakes also damage coastal regions, with particularly strong impacts on water-nesting birds.

222. It is difficult to quantify the extent of wildlife impacts and habitat destruction due to transportation, as opposed to other forms of development and pollution. It can be even more difficult to attempt to quantify the social welfare impacts of these impacts. But wildlife impacts are still an important element of the social costs of transport. Both in terms of the use- and non-use values, people derive a positive benefit from the existence of wildlife. When this benefit is lost, it is a meaningful social cost. INFRAS (2004) for instance, estimates the nature and landscape impacts of transport create negative social impacts worth 20 Billion euros per year, in Europe.

5.2 Mode-Specific Impacts

5.2.1 Road Transport

223. Road transportation is often considered the most environmentally harmful method of transportation in absolute terms, and one of the worst in relative terms.

224. The majority of world-wide transportation, as measured by person-km travelled, or tonne-km shipped, is conducted by road. It is not surprising then, that road transportation is responsible for more harmful environmental emissions than any other mode.

225. In relative terms, road transportation is often regarded as the most harmful, though this of course depends on the measurement used. Naturally, an ocean freighter, or a commercial aircraft, requires a lot more fuel to travel 1 km than a car does. And a ship or plane produces far more emissions from one km of travel than a car does. If measured on the basis of environmental impact per km travelled, road transportation is therefore much less polluting than sea or air transportation. This would however fail to account for the much larger capacity of a plane or ship, compared to a road vehicle. A fully loaded airplane requires less fuel *per passenger* to travel one km than a single passenger car requires to go one km. In other words, transporting 100 people by plane is generally more fuel efficient (and less environmentally damaging) than transporting the same 100 people by private cars (INFRAS, 2005).² Similarly, although a ship requires much more fuel per km than a truck does, large ships require much less fuel *per tonne of freight* to travel one km than a truck requires per tone of freight to go the same distance.

226. The metrics that are most commonly used to measure the relative environmental impacts of different transportation modes are the use of "passenger-km" travelled for passenger transport, and "tonne-km" shipped for freight. By either of these metrics, road transportation is one of the most environmentally harmful transportation methods, relative to other modes.

Air Pollution and GHGs

227. The main environmental pressures from the road transportation sector come from emissions due to the burning of fossil fuels. The vast majority of road transportation around the world is conducted in vehicles that make use of petrol or diesel engines. Burning of fossil fuels is the largest contributor to global warming and one of the primary contributors to urban air quality issues.

228. Within the road sector, passenger vehicles create the most emissions, both in absolute terms, and in relative terms. Though individual cars vary, the average passenger vehicle produces more GHG emissions, and more air pollutants, per passenger-km, than any other form of transport. Poor environmental performance per vehicle, combined with the huge number of passenger vehicles world wide, means that the largest portion of GHG emissions and air pollution problems caused by the transportation sector, are attributable to personal vehicles. Transport by road also creates more GHG emissions per tonne-km than any other form of freight transportation, save for air, and it is the largest contributor to urban air quality per tonne-km of freight basis.

229. Both GHG and air pollution emissions are closely tied with fuel consumption, although the connection is not always a linear relationship. Emission control technologies can reduce some emissions,

^{2.} One should, however, keep in mind that the option of going by plane can make people travelling longer distances than what they otherwise would have done (*e.g.* due to reduce time-costs involved). Only considering emissions per km travelled could, hence, give an underestimate of the negative externalities related to aviation.

without corresponding fuel use reductions. Similarly, technologies put in place to reduce fuel consumption may not always be accompanied by corresponding emission reduction. In some cases, technologies to reduce GHG emissions are not as effective at reducing air pollution emissions, and *vice versa*. And in some cases, vehicle technologies actually involve a trade-off, increasing CO_2 emissions, but reducing NO_x , or *vice versa*. Most of the time, though, cars that consume more gasoline also tend to produce more GHG and air pollution emissions.

230. Emissions vary substantially between vehicles, with engine power, and engine efficiency, being two of the key determinants of vehicle emissions. Larger, heavier vehicles require more powerful engines, and thus generally use more fuel for the same distances travelled. High-performance cars similarly have high power, and high fuel consumption engines. Busses and large trucks naturally use more fuel than private cars or small trucks. But because they often carry much larger numbers of passengers, or more freight, busses and large trucks are often more fuel efficient on a per passenger, or per tonne of freight basis.

231. In recent years, new technologies have helped reduce vehicle emissions from road transportation. The development of petrol-electric hybrids has reduced the dependence of cars on petrol for power. GHG and air pollution emissions have been reduced hand in hand with the petrol use reductions in these vehicles.

232. Some cars have also in recent years been designed to run on alternative fuels, reducing or eliminating the use of petrol or diesel entirely. The biofuels sector in particular has been an area of rapid growth. Numerous countries worldwide have begun to produce bio-ethanol, bio-diesel, and other biofuels, and an increasing number of cars are run partially or entirely on biofuels. Although burning biofuels in car engines also produces environmentally harmful emissions, these are generally less harmful than the corresponding emissions from a diesel or petrol engine. Other things being equal, driving a car one kilometre using biofuels produces fewer environmentally harmful emissions than driving the same size car the same distance using a diesel or petrol engine.

233. It is important to note that although biofuel-driven cars produce fewer emissions than diesel or petrol-driven cars, and far fewer GHG emissions in particular, it does not necessarily follow that a shift to biofuel driven cars would definitively produce environmental benefits. Producing biofuels requires energy and resources, just like the production of petrol and diesel. And like the production of conventional motor fuels, biofuel *production* involves negative environmental impacts. Energy is used to harvest and process biofuels, land is required to grow the crops, fertilizers and pesticides are used in the crop production, and other chemicals are used in the processing. All of these activities impose various environmental pressures. Some studies suggest that *producing* biofuel is less environmentally friendly that producing petrol or diesel. Some even suggest that the net environmental impacts of a shift to biofuels could be negative, or at the very least socially and economically inefficient (ECMT, 2007). Results differ substantially, though, depending on the type of biofuel being produced, and the region in which it is produced. It is clear that in some cases, production and use of biofuels in motor vehicles would create net environmental benefits. However, this should not be assumed to be the case in all situations, and the potential benefits should be analysed on a case-by-case basis.

234. Substantial improvements in the fuel-efficiency, and/or emission-intensity of road vehicles have been achieved in the last 30 years. Despite these improvements, road vehicles are still the most polluting form of transportation, both in aggregate, and on a per passenger basis. Efforts to reduce the air pollution and global warming impacts of the transportation sector will thus have to pay close attention to road transport and the use of personal passenger vehicles.

Congestion

235. More so than for any other form of transportation, congestion is a major problem in road transport. Besides creating obvious inconveniences for drivers, resulting in net social welfare losses, congestion also increases the environmental impacts of road transport. Cars that are idling, moving slowly, or in stop-and-go traffic, use much more fuel, and hence produce much higher emissions, than cars that are moving smoothly.

236. Congestion is mainly a problem in large cities, particularly in downtown areas. From an air pollution perspective, this serves to further increase the environmental (human health) impacts of road transport and congestion. CO_2 emissions at the earth's surface have the same global warming impact regardless of geographic location. But air pollution has a much more direct impact on human health, and as such, it is most damaging when produced in or near large population centres. A tonne of NO_x , SO_2 , or VOCs produced in a city will have a greater impact than if it is produced in the countryside, simply because more people will be exposed to the harmful effects in the city. Not only do cars that are stuck in downtown traffic create more pollution, but each unit of pollution that they create will be more damaging because a larger population is exposed to it.

5.2.2 Air Transport

237. Although it accounts for a relatively small amount of total pollution from transport, the air sector is one of the most environmentally harmful modes of transport. On a per-tonne basis, air transport is the most energy intensive and environmentally harmful method of freight transport. On a per passenger basis, air travel is only slightly less environmentally harmful than private passenger vehicles, and far more environmentally harmful than other methods of passenger transport.

238. Globally, less than 1% all freight and passenger transport is conducted by air. However, the share of air in the transportation of both people and goods is increasing. The air transport industry is becoming an increasingly important contributor to the environmental impacts of the transportation sector.

Climate Change Impacts

239. By far the most significant environmental impact of the aviation industry is its climate change effects. Like other forms of transport, the aviation sector produces greenhouse gasses through the burning of fossil fuels. Emissions from airlines, however, can be even more damaging due to their high altitude.

240. A majority of commercial air planes operate on kerosene-based jet fuel. Some small aircraft operate using aviation gasoline instead. Regardless of the specific fuel used, burning aviation fuel releases carbon dioxide into the atmosphere. In this, aviation is no different from other forms of transport, except that planes tend to burn fuel much faster, and hence release more emissions, than do other transportation modes. Aviation is the most fuel inefficient means of freight transportation available. A tonne of freight shipped one kilometre by air requires far more fuel, and hence produces more CO_2 emissions, than shipping a tonne by any other means. For passenger transport, aviation is only marginally more fuel-efficient than personal automobiles.

241. Although it accounts for less than 1% of global transportation, air transport accounts for a disproportionately large amount of CO_2 emissions. International aviation accounts for 6.5% of all CO_2 emissions from transport (IEA, 2006). Domestic aviation accounts for roughly the same amount, so that total aviation accounts for almost 13% of transport based emissions. INFRAS (2004) estimated that in Europe, aviation accounts for 41% of the climate change related externalities from the transport sector. Furthermore, the share of aviation in transport-based GHG emissions is expected to grow. From 1990 to

2002, aviation passenger-km increase by 56%, and aviation freight tonne-km increased by 68% (UN database). Air transport is projected to continue to grow.

242. The aviation sector also contributes to global warming in several unique ways. The high altitude of most commercial flights results in creation of greenhouse gases in the upper troposphere and lower stratosphere. Emissions at these altitudes contribute much more to global warming than do emissions at the Earth's surface. Air transport is also believed to contribute to global warming via the formation of contrails. These high-altitude contrails contribute to the formation of ice-particles that help to insulate the Earth, keeping warmth from escaping, and thus contributing to global warming.

243. Due to the greater global warming impact of high-altitude airline emissions, combined with the effects of contrails, IPCC (2007) estimates that a litre of fuel burned by a high-altitude airplane produces global warming effects two to four times greater than the CO_2 emissions alone. And, as mentioned, aircraft already consume fuel at a higher rate than most other forms of transport. While its absolute impacts are much less than other modes of transport, the aviation sector thus has the highest relative impact on climate change per passenger, or per freight tonne, out of any transport mode.

Noise

244. The aviation industry also generates significant social externalities in the form of noise in the vicinity of airports. Airport noise, and vibrations from passing planes, are a major nuisance and source of irritation for individuals that live near airports. This can result in higher levels of stress and anxiety. The noise itself can also contribute to potential hearing loss. These social impacts are generally not always fully considered by airports and aviation authorities. To a certain extent, these social impacts are captured by housing prices near airports. Land near airports tends to be much cheaper, and rents lower, due to the presence of excessive airport noise. It might be argued that because people who live near airports pay lower rents, or pay less for their houses, they are already compensated for noise they are forced to endure. However, it may be the case that housing prices fail to fully internalise the social externalities caused by noise, because they do not fully account for the social (rather than personal) impacts of hearing loss and noise related mental stress. Further, regardless of whether noise impacts are internalised through housing prices, it is clear that reducing the numbers of flights, particularly at night, would reduce the social costs imposed by air travel. Although less significant than the climate change impacts of aviation, this is a social cost that still needs to be assessed in determining socially efficient levels of air transport.

5.2.3 Sea Transport

245. After road, sea transport is the most heavily used mode of transport in the world. Although it is rarely used for transport of passengers nowadays, shipping is the main mode of freight transport globally. Shipment by sea accounts for over two-thirds of the volume of international trade, and almost half of the value. Increasing volumes of international trade in the past 20 years have seen rapid increases in sea transport, particularly in the transport of commodities, or "containerised" shipping. On a per-tonne basis, shipping is one of the more environmentally friendly forms of transportation. Due to the sheer volumes involved though, shipping is still a significant contributor to global environmental damages from the transportation sector.

Climate Change Impacts

246. Like most other forms of transportation, ships burn fossil fuels, and thus creates GHG emissions. The quantity of fuel burned, per tonne-km of goods shipped, is significantly lower in the shipping industry than it is in road or aviation transport. However, the sheer volume of international marine traffic results in significant GHG emissions from the shipping industry, in absolute terms.

247. Most shipping conducted around the world does not make use of the most environmentally friendly technologies or practices for emission reductions. This is in large part due to difficulties in regulating the practices of ships on the high seas. Individual countries are able to set regulations governing ships that enter their national waters, but ships in international waters operate under far fewer restrictions than those in domestic waters.

248. The fuel efficiency of transport ships has improved in recent decades. In general though, fuel efficiency has not improved as much as in many other transport sectors. International laws governing fuel use on the high seas are considerably less stringent than comparable fuel and emissions laws that exist in many countries.

Air pollution

249. Ships can be a significant contributor to urban air pollution in the vicinity of ports and major shipping lanes. While emissions on the high seas have only small impacts on global air pollution, emissions in port areas cause major problems for certain port cities. In some cities in western North America, shipping emissions are beginning to catch up to road emissions as the primary contributor to urban air quality problems.

250. The fuels burned in international shipping are generally of much lower quality than road or aviation fuels. Thus, although fuel burned per tonne-km is much lower in the shipping industry, burning a litre of marine fuel generally produces more harmful emissions than a litre of road or aviation fuel.

251. While many countries have implemented strict vehicle emission programs, the same has not occurred in the shipping industry, at least not nearly to the same scale. Shipping emissions are being reduced somewhat, but not nearly as fast as in other sectors, on a per tonne-km basis. If this trend continues, shipping will eventually be the primary cause of air quality problems in many OECD country ports.

Wildlife Impacts

252. Due to marine spills, marine dumping and habitat disruption, shipping has a serious impact on marine wildlife. The most serious problems involve oil spills, or toxic chemical spills, but these are relatively rare. Accidental or deliberate discharges of waste products from ships are much more common, and can have serious effects for marine life.

5.2.4 Rail Transport

253. Overall rail is the most environmentally friendly means of transport. It is also the transport mode that is being used the least globally, in terms of passenger-km and tonne-km. And the rates of rail use are falling in many OECD countries. Even where rates are remaining constant, or increasing slightly, the share of rail in global transportation is gradually decreasing, as other modes of transport continue to grow at a much faster rate. In terms of GHG emissions, air pollution and other environmental costs, rail transport is by far the least polluting mode of transport on a per passenger-km or per tonne-km basis, assuming reasonable loading of the trains. If operated far below capacity, rail transport can be somewhat less efficient than buss transport. Unless capacity utilisation is extraordinarily low, however, rail transport would still be more efficient than transport by air or personal automobile.

5.3 Comparison of Modes

254. Globally, road transportation causes the most environmental damages in absolute terms, followed by air, water, and rail.

255. On the basis of environmental damages per passenger, or per tonne-km shipped, air is by far the largest contributor to climate change problems. After air, road transport contributes the most to climate change on a per passenger or per tonne-km basis. On a per passenger or per tonne-km basis, rail and marine shipping both have comparatively very minor impacts on climate change.

256. For air pollution, on a per passenger or per tonne-km basis, air transport produces the most air pollutants. However, many of these pollutants are released at high levels where they do much less damage than ground level emissions. Road transportation emits less on a per passenger or per tonne-km basis than air, but because these emissions are at ground level, they have a larger relative environmental and human health impact. As a result, transporting a passenger or a tonne of freight one km by road will generally have a more serious air pollution impact on human and environmental health, than transporting that person or tonne of freight by air. Sea freight transport can have a significant impact on local air quality, but this is mainly in the vicinity of ports. Overall, sea transport produces fewer air pollution impacts than either road or air, on a per-tonne-km basis. Of any mode of transport, rail has the lowest air pollution impacts on a per passenger or per tonne-km basis.

257. Comparing relative wildlife impacts is somewhat more difficult. On a per passenger or per tonnekm basis, road transport clearly has larger impacts on local wildlife than either rail or air. Rail impacts on wildlife tend to be spread out, whereas air transport impacts are generally localised in the area of airports. The wildlife impacts of sea transport are not particularly comparable with road or rail. INFRAS (2004) estimated that the (average) external cost of wildlife impacts due to freight transport were largest for light duty vehicles, followed in order by aviation, heavy duty vehicles, marine, and rail.

258. Although the wildlife impacts of marine transport can be significant, estimates of their environmental impacts, in social welfare terms, tend to be much smaller than corresponding estimates of the impacts of air pollution. For instance, the Exxon Valdez oil spill was one of the most serious maritime environmental disasters over the last 50 years. Environmental damages of the disaster were estimated to be on the order of USD 3 billion, in social welfare terms (Carson *et al.*, 1992).

259. Though significant, this figure pales in comparison with the damages from many climate change predictions, or the estimates of the social welfare damages caused by human mortality due to air pollution. For instance, Health Canada estimates that air pollution is a factor in the death of at least 5,900 Canadians *each year*, with an estimated social welfare loss valued at over CAD 24 billion per year. Transportation is the largest contributor to urban air pollution. But even if transport was responsible for only one quarter of these fatalities, it would still be an *annual* social welfare impact valued at more than double the damages from the Exxon Valdez. The Exxon Valdez was one of the most environmentally damaging marine spills in the past 50 years. But the damages still fall well short of annual costs associated with air pollution from transport in a single country. It therefore seems unlikely that the welfare impacts of marine environmental damages are of comparable order of magnitude to the impacts of air pollution or greenhouse gas emissions caused by the transportation sector.

260. Identifying which of the different modes of transport is, on average, the "most environmentally harmful" depends on the relative weight assigned to different environmental impacts, such as human health effects of air pollution, global warming damages, plant and wildlife impacts from acid rain, spills, or direct damages, etc. If the primary concern is on global warming, then clearly air transportation is the most damaging form of transportation on a per passenger or per tonne-km basis. If air pollution and human health impacts are the main concern, then road transportation has the largest relative environmental impact.

261. There is a great deal of uncertainty about the potential physical impacts of climate change, and there is even greater uncertainty about the potential resulting socio-economic damages. The impacts of air pollution on the other hand have been much more extensively studied, and are better understood both in

terms of physical effects and the socio-economic value of the impacts. This makes it difficult to provide a relative weighting to the value of air pollution impacts, compared with the value of climate change impacts. INFRAS (2004) estimated that average environmental damages were slightly higher for road traffic in terms of passenger-km, but much higher for air traffic in terms of freight tonne-km. However, these estimates are very sensitive to the assumptions used. The costs of road transport are driven equally by air pollution, climate change, and in the case of passenger transport, accident costs. If accident costs were removed, in order to focus only on "environmental" externalities, then air would be the most environmentally damaging mode of transport, for both passengers and freight. On the other hand, the air transport damages are almost entirely dependent on climate change impacts, and INFRAS elected to use a fairly high estimate of the social costs of CO_2 emissions. If a lower value of CO_2 emissions was used, the road-based transport would be by far the most environmentally damaging mode of transport.

262. Regardless of whether one examines air pollution, global warming or wildlife impacts, the rail sector has by far the least environmental impact on a per passenger or per tonne-km basis.

5.4 Summary

263. Road-based transport is currently the most environmentally harmful method of transport in absolute terms, and one of the worst in terms of its impacts per passenger or per freight tonne-km shipped. Transporting a passenger-km or freight tonne-km by road produces more air pollution impacts than transport by other modes, and only slightly less global warming impact than passenger transport by air transport.

264. Air transport is not used nearly as much as other modes of transport, and hence has a small absolute environmental impact. But it is arguably the most environmentally unfriendly form of transport on a per passenger or tonne-km basis. Transporting a passenger or a tonne of freight one km by air has a larger global warming impact than transport by any other means, especially for freight.

265. The main difference between air and road transport is the relative importance of air pollution and climate change impacts. Air transport creates more climate change impacts per passenger-km or tonne-km, but road transport generates larger air pollution problems per passenger-km or tonne-km. If climate change impacts are deemed to be large, then air transport is by a very wide margin the most environmentally harmful method of transporting freight, and roughly equal to road for the transport of passengers. If climate change impacts are thought to be less significant than air pollution, then road transport is by a wide margin the most environmentally harmful method of transporting freight, and roughly equal to road for the transport of passengers. If climate change impacts are thought to be less significant than air pollution, then road transport is by a wide margin the most environmentally harmful means of transporting either passengers or freight.

266. Sea transport can have significant impacts on marine wildlife. But these impacts generally pale in comparison with the much larger and more damaging global warming and air pollution impacts of road and air transportation. Although recent shifts towards higher-speed ships may have reduced the per tonne energy-efficiency of shipping, transporting a tonne of freight by sea is still much more energy-efficient (and environmentally friendly) than shipping a tonne by road or air. There are, however, significant urban air quality problems caused by ships in port cities and along major shipping lanes. Far fewer steps are being taken (or are available) to address ship emissions than for other sources of urban smog.

267. Rail is by far the most environmentally friendly means of transporting passengers. Transporting one passenger or one tonne of freight one km by rail requires far less energy than transporting by road or air. Freight transport by rail generally requires slightly more energy than transport by sea, but the net environmental impacts are roughly equal in either case.

268. Significant environmental improvements could be achieved if existing passenger and freight transport was shifted from road and air transport to sea and rail transport – where possible.

6. Identifying Environmentally Harmful Subsidies

269. As discussed in the previous Chapter, it is well-known that the transportation sector creates a variety of negative environmental impacts, with some modes being more harmful than others. However they may be defined, subsidies to the transport sector, or to particular transportation modes, help to reduce the costs of transportation to users, and hence increase the use of transport. By increasing the use of transportation in general, or specific environmental harmful modes of transportation in particularly, subsidies thus increase environmental pressures.

270. While it is simple to say that transport subsidies increase transport use, and hence environmental pressures, it is much harder to determine *which* subsidies are the most environmentally damaging. And, more importantly from a policy perspective, it is equally difficult to determine which subsidies could be removed to create the greatest environmental benefits.

271. If any single subsidy is viewed in isolation, with everything else held constant, then every subsidy has a harmful environmental impact. In practice, though, some subsidies are more environmentally harmful than others, and some may be environmentally beneficial. In order to determine the benefits of subsidy removal, or to identify possible target subsidies, various tools can be used by policy-makers to guide their choices.

272. A variety of approaches exist that attempt to guide policy-makers in their efforts to reduce environmentally harmful subsidies. These different techniques employ various criteria to help identify the subsidies that are the most environmentally harmful, and that would produce the largest benefits if removed or reduced. This Chapter discusses some theoretical issues related to identifying environmentally harmful subsidies, and examines a number of the specific approaches that have been developed to identify such subsidies. Particular attention is devoted to environmentally harmful subsidies in the context of the transport sector. As will be noted, though, many of these techniques are not focused on or ideally suited to the transport sector. The Chapter 7 will further develop some of these approaches, to make them more directly applicable in the transport sector.

6.1 Sectoral and Macroeconomic Issues

273. As noted, if everything else in the transport sector, and the economy as a whole, were held constant, then any transport subsidy can be considered environmentally harmful. For example, subsidies to rail transport make it cheaper for people to travel by train. If these subsidies were removed, then train travel would become more expensive, and fewer people would take the train. Environmental impacts from rail transportation would thus decrease. And if everything else were held constant, there would be a net reduction in environmental pressures.

274. Of course in practice, other things are *not* constant. The preceding argument would suppose that people who stop taking the train will instead walk, or simply stay home. In practice though, it is likely that people would switch from trains to busses or cars. Environmental pressures from rail transit would go down, but pressures from road transport would go up. Since the environmental impacts of road transport (particularly private automobiles) generally are greater than rail transport, the result would be a net increase in environmental pressure from the transport sector.

275. The reverse could be true as well. If subsidies to rail were increased, it would make rail cheaper for users. This would result in increased rail use and increased environmental pressure from railways. But this *could* be offset by decreased use of road transport, with net environmental benefits.

276. Viewed from the perspective of an individual transport mode, in isolation, all subsidies increase environmental pressures from the subsidised mode. But viewed from a sector-wide, or economy-wide perspective, different subsidies can shift transport patterns between modes, with net environmental impacts that can be positive, negative, neutral, or uncertain.

277. Not only can subsidies alter the modal share of different means of transport, but they can also affect patterns of transport use in other ways. They can alter the time-distribution of transport by either directly or indirectly encouraging or discouraging transport use at certain times. For example, subsidies focused on transport used for business commuting will have the most impact during rush hour, Monday to Friday, while subsidies that have a greater impact on leisure travel, will be felt more on the weekends. Subsidies can also alter the location, or regional aspects of transport use, such as by diverting traffic from city cores to the use of throughways. Transport subsidies can also affect the type of goods that are transported, for instance by making it profitable to ship certain goods that might otherwise be unprofitable. The transport of raw materials, for example, is often highly dependent on transport costs, so more affordable transport could make transport of raw materials more economically viable in certain regions.

278. When trying to determine which subsidies are the most environmentally harmful, it is thus critical to not look at subsidies on an individual basis, but to look at the transport sector, and indeed the economy as a whole. By diverting transport between modes, changing the time and space demand for transport, and by possibly impacting the composition of freight transport, subsidies can have environmental impacts far beyond the direct impacts of the subsidised transport mode. These indirect effects of a subsidy must be considered when attempting to classify subsidies as environmentally harmful, or not.

279. If policy-makers are considering the removal of transport subsidies, with the goal of reducing environmental pressures, it is also essential that they consider the broader sectoral and macroeconomic context of a particular subsidy. Removal of subsidies, without looking at their context, could have the opposite effect to what was intended. For instance, removing subsidies to public transit would most likely have negative environmental results, as it would likely increase the use of private cars, with negative net impacts on the environment.

280. While this example may seem obvious, and simplistic, other cases are more complex. For example, increasing user-fees for road transport would force users to pay more of the costs of driving, effectively reducing the subsidy that they receive (if any). This would probably result in fewer cars on the road, but the net environmental effects could be ambiguous. The environmental benefits would be positive, if car users switched to increased use of public transport. Net environmental impacts could be negative, though, if the increased price of driving on roads resulted in increased use of air travel.

281. In order for policy-makers to know what effects removing a subsidy will have, they must know how consumers and producers are likely to react to the removal of that subsidy. This requires an understanding of the micro- and macroeconomic forces that drive the decisions of transport users, not only for the effected mode, but for the economy as a whole. Various approaches can be used to estimate how transport use-patterns will shift in response to the removal of certain subsidies. For instance, price-elasticities of demand for transport, and the cross-price elasticity of demand for different modes, can be used to estimate how an increase in transport prices (due to a reduction in subsidies) would affect demand for different modes of transport. It can be difficult to know, though, how subsidy-removal will affect the environment. Particularly in the case of subsidies that are long-standing, large in magnitude or which affect a broad segment of the population and industry.

6.2 Environmental Damages vs. Benefits of Removal

282. The subsidies that create the largest environmental damages and the subsidies which would produce the greatest environmental benefits if removed are not always the same. The fact that a subsidy results in, or has resulted in, significant environmental damages, does not necessarily mean that removing that subsidy will reverse or repair those damages.

283. This posses additional problems for policy development. In order to determine how best to reduce environmental pressures from transport, it is insufficient to simply identify the subsidies that have had the largest negative impact. Policy-makers must go one step further and determine what the environmental impacts of subsidy *removal* will be.

284. While identifying environmentally harmful subsidies is a necessary first step, policy-makers must also be able to estimate the environmental *benefits* of subsidy removal. Depending on the nature of the subsidy in question, removing an environmentally harmful subsidy might result in an immediate decrease in environmental pressures, a gradual decrease in environmental pressures with significant benefits only in the long term, or little if any reduction in environmental pressures.

285. One issue that can reduce the environmental benefits of subsidy-removal has to do with technology lock-in effects. Subsidies for a particular technology will reduce the price of that technology to its users, and will thus increase use of that technology. If the technology happens to be environmentally harmful, then subsidies that favour it can be considered environmentally damaging subsidies. Once the technology is already in use, however, removing subsidies may not have immediate impacts.

A common practice in many countries involves subsidisation of "best available technologies". 286. Suppose for instance, that a new technology, call it technology "X", were developed that could reduce car emissions by 30% from their current levels. A government looking to reduce the environmental impacts of vehicle transport might find it desirable to subsidise technology X. In the short term, this would result in more cars being equipped with technology X, and an overall reduction in total vehicle emissions. So all other things being equal, this subsidy would improve environmental quality. Now suppose that in 5 years time, a new technology is invented, technology Y, which can reduce car emissions by up to 70%. This is clearly superior to the existing technology X. By comparison with technology Y, technology X is actually environmentally unfriendly. So in continuing to subsidise technology X, the government would in fact be subsidising an environmentally harmful technology. In this new context, we could therefore consider the subsidy of technology X to be an environmentally harmful subsidy, because it promotes an inferior environmental technology. Hopefully, once the government realises that technology X is not environmentally friendly, they will cancel the subsidy to technology X. But it is important to recognize that removing the subsidy for X in this case will not immediately reduce environmental pressures. Over the five years during which X was subsidised, there will have been a large number of cars produced using technology X. Removing the subsidy will reduce the number of cars produced using technology X in the *future*, but it does not alter the fact that many existing cars are already making use of the technology. These cars are likely to remain on the road for many years. Over the years to come, technology X cars will gradually be replaced by newer cars, but this will be a gradual process.

287. This is not necessarily intended to imply that the subsidy to technology X was a bad idea in the first place, or that there was no point in removing the subsidy. In fact, at the time that it was conceived, the subsidy promoted an environmentally friendly technology, and thus probably improved environmental quality. Later on, the same subsidy was encouraging an environmentally inferior technology. If the subsidy had been maintained, it would have continued to increase the number of environmentally inferior cars on the road. Thus, eliminating the subsidy would have reduced future environmental impacts. The point here

is simply that certain subsidies promote the "lock-in" of technology, and that removal of such subsidies tends to show the greatest results in the long term, with fewer immediate impacts.

288. Direct subsidisation of a particular type of technology is not the only sort of subsidy that promote a lock-in effects. Any subsidy that promotes the use of a certain technology, either directly or indirectly, can result in a lock-in effect of that technology. For example, subsidies to biofuels will make it cheaper to drive cars that run on biofuel. The direct effect of the subsidies will be on fuel prices, but the indirect effect will be an increased demand for biofuel-driven cars. This will increase the number of such cars on the road, resulting in the same sort of technological lock-in, as if the subsidy had initially supported the purchase of the biofuel driven cars in the first place.

289. Lock-in effects can be even more significant in other transport sectors, where capital turnover is much slower. A typical passenger car might see use for 10 to 15 years before being replaced. A commercial aircraft or naval vessels, on the other hand, might remain in service for 30 or 40 years. After the high initial expense of instillation, railway tracks can be maintained with much lower costs, which effectively means that investments in rail infrastructure can last over a hundred years. Removing a subsidy that promotes a particular technology may help influence the technologies that are adopted in the future, but it does not change what has already been adopted. The longer such a subsidy is in place, the greater the amount of the subsidised technology that will be adopted. And the longer the lifespan of that technology, the stronger the lock-in effect will be, and the longer it will be before the *full* benefits of subsidy removal are felt.

290. Lock-in effects are of particular importance where the existence of one "technology" in the market makes it difficult for competing "technology" to penetrate the market.³ For example, "new" motor vehicle fuels would require development of new distribution systems – petrol- and diesel-technologies have largely been locked-in. If subsidies are provided today for the development of a distribution system for *one* "unconventional" fuel, the use of this fuel could be locked-in – and it could become more difficult for an *even "better"* fuel to penetrate the market sometime in the future.

291. Because of the lock-in effects, subsidies to specific technologies are often considered to be a less effective form of environmental subsidy. Over time, even the best current technology will eventually become an inferior technology. From the outset then, it should be recognised that technology subsidies should eventually be removed. And once removed, the effects of these subsidies will remain for as long as the subsidised technology continues to be in use. Political pressures from interest groups, combined with administrative costs, often make subsidy removal difficult. But the longer subsidies for environmentally unsound technologies remain in place, the greater the lock-in effect becomes and the larger the long-term environmental damage from the subsidy. For these reasons, economists generally argue against technology subsidies. Economists often recommend *charges* for environmentally harmful practices, rather than subsidies for environmentally beneficial practices. When subsidies are warranted, however, behaviour-based subsidies can be preferable to technology-based subsidies.

292. The lock-in effect of technological subsidies (direct or indirect) is contrasted by more behaviouroriented subsidies. For instance, suppose that the government agreed to support domestic air travel by offering passengers a rebate on the cost of their tickets. Since flights effectively become cheaper for consumers, they will choose to fly more often. By making domestic air flights cheaper, and thus increasing demand, this subsidy would result in increased environmental pressure from the air transport industry. Now suppose that the government removed this subsidy. The result would be an immediate increase in the cost of air travel faced by consumers. This increase in cost would result in an almost immediate decrease in

^{3.} The familiarity of most keyboard-users with the "qwerty keyboard" makes it difficult for any other, possibly ergonomically better, keyboards to penetrate the market.

the number of domestic air passengers, quickly followed by a decrease in the number of flights. The environmental benefits of removing this subsidy would therefore be felt almost immediately.

293. In general, removing subsidies to technologies tends to have mainly long-term effects, while removal of subsidies on specific behaviours tends to have much more immediate effects. These are not the only differences, though. There are many different types of subsidies. Determining what the impacts of subsidy removal will (or might) be requires assessment of a wide range of issues. These issues are discussed more in the following sections, as are some methods to identify good target subsidies for removal.

294. In deciding which subsidies to remove, in order to benefit the environment, it is important that governments look forward, rather than backward. The key question is not "which subsidy *has* caused the most environmental damage?" but "which subsidy *will* cause the most damage in the future, if it is not removed?" It is important that policy-makers do not simply assume the answer to the second question is the same as the answer to the first.

6.3 Behavioural Impacts of Subsidies

295. The key to figuring out how subsidy removal will, or may, affect the environment *in the future*, is to determine what effect subsidy removal will have on the behaviour of individuals and firms. While this may seem quite obvious, it is something that is often overlooked on many occasions. Consumer and producer choices are influenced by a wide range of economic and social considerations, and are not always easy to predict. Simple assumptions about consumer behaviour may not be valid in a wider economic context.

296. It is often simply assumed, for example, that if public transport was cheaper, more people would take public transport, and fewer people would drive cars. But this is not always the case. In most instances, cheaper public transport will increase ridership somewhat. But in a large proportion of cases, public transport prices have little or no effect on the use of personal cars. Similarly, a naive approach to transport subsidies might suppose that a 50% increase in the price of all modes of passenger transport would affect all transportation modes equally. In reality however, demand for some types of transport is far more price-sensitive than others. A 50% price increase would most likely affect demand for air and rail travel proportionately far more than the demand for road and public transit. This is because road transport is much more price-inelastic.

297. Subsidies effectively alter the prices that consumers and producers face for certain goods, or activities. In order to understand how people will react to price changes, a detailed understanding of their preferences – and the macroeconomic and social context of their decision making – is required. This process is not always simple, and all too often it is ignored, or glossed over, in policy-making.

298. A variety of tools are available to decision-makers to estimate how producers and consumers will respond to subsidy-removal and resulting changes in relative prices. Elasticity estimates can be used to predict consumer behaviour in the transport market. Price elasticities, income elasticities, and cross-price elasticities indicate how consumers are likely to respond to changes in the price of a particular good or service, changes in their income, or changes in the price of related goods and services. Numerous studies have been done to investigate the elasticities in the transport sector; for overviews, see Graham and Glaister (2002), Goodwin *et al.* (2004) and Litman (2007). In general, price-elasticities of transport tend to be fairly low, especially for public transit and road transportation. This means that demand for public transit, or road transportation, do not respond much to price changes. A 10% change in the price of road transport or transit prices, might only result in a 2 or 3% change in total use. Comparing elasticity

measures with the expected price impacts of a policy measure, allows policy-makers to predict the shifts in transport demand that are likely to result.

299. Another approach to estimating changes in consumer behaviour, in response to a policy intervention, involves the use of input-output model (IO). An IO model is a detailed set of tables that indicates which sectors of the economy make use of which inputs from other sectors. For example, an IO model might indicate that the steel production industry requires 3 units of input from the energy industry, 2 units of input from transportation, and 4 units of input from the mining sector, in order to produce one unit of output. The advantage of IO tables is that they can be extremely detailed, involving thousands of industries, with a very detailed regional break down. The downside is that they do not normally allow for input substitutions due to price changes. In reality, if one input became too expensive, an industry might try to substitute that input for inputs from a different industry. IO tables do not allow for this. The high level of detail involved, however, does make IO models a useful tool for tracking small sectoral shocks throughout the economy.

300. An alternative to input-output models is general equilibrium modelling. GE modelling uses almost the opposite approach. Whereas IO models have a very high level of detail, but do not allow for price impacts, GE models generally have much fewer industries, but they allow for a much greater range of price signals and substitutions of inputs between industries. A typical GE model might contain 10 to 50 different "sectors". These might include labour, energy, physical capital, primary resources, manufacturing, land, service sector, transportation, etc. For each sector, however, a GE model will have a detailed supply and demand function. These models can be used to predict how a price-change in one sector will impact supply, demand and prices in the other sectors. A price-shock in one sector alters the demand for factors of production from other sectors, which changes the prices and production level in that sector, which affects other sectors, and so on. The model self adjusts following a price-shock, until supply and demand in all sectors finds a new equilibrium level. GE models can be used to determine how impacts on a particular sector will affect the larger economy. For instance, they might be used to determine the macroeconomic impacts of a price increase or decrease in the transport sector.

301. Elasticity measurements, IO models, GE models, and other approaches can all be used to determine how consumers and producers are likely to respond to a policy shift in the transport sector. This is a critical element of transport policy development and analysis. Unless policy-makers can predict how consumers will respond to a new policy, there is no way to estimate the potential environmental impacts, or measure the expected social and economic costs and benefits.

6.4 Cost-Benefit Analysis

302. Thorough cost-benefit analysis of policy options is the most effective method for determining which subsidies will produce the largest net environmental (and social) benefits if removed.

303. A government wishing to reduce environmentally harmful subsidies must first identify the subsidies that promote or favour environmentally harmful behaviour or technology. Then, more importantly, governments should determine how producers and consumers would respond to reduction or removal of these subsidies. Knowing how behaviour will change in response to subsidy removal indicates what sort of environmental improvement, or reduction in environmental pressures, can be expected from the subsidy removal. As discussed elsewhere in this Section, various approaches exist to identify environmentally harmful subsidies, and subsidies that would produce environmental benefits if removed. These approaches can provide a list of subsidies that can be considered as "candidates" for removal.

304. Knowing that the removal of a particular subsidy would produce environmental benefits, or having a list of such subsidies, is a necessary step towards environmental policy reform. But it is not a

sufficient condition. In order to ensure effective and efficient implementation of social, economic, and environmental policy, the costs and benefits of subsidy reductions should be assessed.

305. Just because a subsidy has negative *environmental* impacts, this does not necessarily guarantee that it is in the public interest for the subsidy to be removed. The subsidy may provide social or economic benefits that outweigh the environmental harm. Only by performing a cost-benefit analysis, to assess the full social, economic, and environmental impacts of subsidy removal, is it possible to determine whether subsidy removal would in fact be in the public interest.

306. Depending on the level of depth required, cost-benefit analysis (CBA) can be either quite straight-forward or tremendously complicated. For a detailed overview of CBA in environmental policy analysis, see *Cost-Benefit Analysis and the Environment: Recent Developments*, (OECD, 2006a). The key to CBA is to identify, measure in physical terms, and then put monetary value on as many of the impacts of a policy as possible. Of course, it is not going to be possible to even identify, let alone measure or value *all* of the impacts of a policy. But efforts should be made to identify and measure the most significant policy impacts.

307. The valuation required for cost-benefit analysis can be technically difficult, and may also be controversial. Some individuals and groups may object to the notion of "putting a price on" health, life, the environment, or other non market benefits. If valuation is not performed, however, it makes deciding between policy options much more difficult. For example, a government might need to decide between two different courses of actions. The first option might prevent 10,000 hospital admissions, and the second option would instead protect one million acres of endangered wetlands. Assuming that a choice must be made between these two options, policy-makers might have a difficult choice deciding which would provide the greater public benefit. Due to the very different impacts, and the different units of measurement, it is hard to compare the social impacts of an avoided hospital admission versus an acre of wet lands. By measuring these outcomes using a common unit (currency), valuation provides a means to compare otherwise incomparable options. The key to using valuation (and cost-benefit analysis) is that values assigned need to reflect the impacts on human wellbeing; not government finances, not national income, but the wellbeing of the citizens. Governments should choose the policy that will provide the greatest benefits to the people. Valuation estimates are simply an attempt to measure the *relative* impact of different outcomes, on the wellbeing of the people. Similarly, cost-benefit analysis is a tool to help select the course of action that is most likely to provide the greatest net benefits to society, in social welfare terms.

308. Because it can be used to compare the values that people have for different categories of costs and benefits, cost-benefit is a useful tool for assessing environmental policies, where the costs and benefits involved may not be suitable for more financially focused analysis techniques. For example, if correctly performed, a cost-benefit analysis can take into account a range of risks and potential outcomes. In its simplest form, a CBA would compare the best guess at what the benefits of a policy are with the best guess at what the costs will be. A more refined analysis however, can take into consideration the range of uncertainty involved in the costs and benefits. For instance, rather than just valuing the existence of a species, valuation approaches can measure the value of a particular risk to a species. Because valuation tools, and cost-benefit analysis, are intended to reflect the values of people, measured costs and benefits need not be linear with respect to risk, any more than people's preferences are linear with respect to risk. If people are strongly adverse to risk, in a particular context, then the cost-benefit analysis can take this into consideration. This can be particularly important in the case irreversible outcomes. Certain environmental impacts, once done, cannot be undone. For instance, severe climate change, or species extinction, represent costs that are both uncertain and irreversible. If people are strongly adverse to even a small risk of irreversible climate change, then a thorough cost-benefit analysis should take this risk aversion, and the irreversibility of impacts, into account. Unfortunately, this is not always done in cost-benefit analysis. But the fault, in this case, lies not with the cost-benefit analysis framework, but rather with its application.

309. Cost-benefit analysis is neither a flawless tool, nor is it the only necessary decision-guidance tool. It can be quite difficult to simply identify the costs and benefits of a policy, and even more difficult to quantifiably measure those costs and benefits. But even an imperfect attempt to identify costs and benefits is certainly better than no attempt at all. Decision-makers who wish to set aside the results of CBA on the basis of unfair distribution, budget limitations or some other economic or social reality, are free to do so. But at the very least, CBA results should be considered in the decision-making process.

310. The usefulness of cost-benefit analysis depends, to a large extent, on the ability to identify and quantify the costs and the benefits. If some of the costs or benefits cannot be identified, or cannot be measured, then CBA will necessarily give an imperfect estimate of the net costs or benefits. However, it is never going to be possible to identify *all* the costs and *all* the benefits of a policy. It is still worthwhile to identify as many of the costs and benefits as possible. And while it is impossible to measure with perfect accuracy the magnitude of social costs or benefits, there are techniques that can be used to produce credible social cost estimates that do a reasonable job at measuring social impacts. Imperfect though they are, using the best available measures of costs and benefits is surely better than not attempting to measure them at all.

311. Notwithstanding its problems, CBA provides a means to compare alternative policies, based on the preferences of the populations at large, and provides a valuable screening tool for identifying policies that are obviously inefficient or inferior to others, from a social welfare perspective. As such, it ought to be considered an essential tool in the decision making-process.

6.5 Need for a Screening Tool

312. Unfortunately, decision-makers can not complete a thorough cost-benefit analysis every time a decision needs to be made regarding potential policies. The range of policy options open to governments are simply too large for a cost-benefit analysis to be conducted for every single decision. From setting tax rates, to determining the optimal level of pollution reduction, to deciding between health care or education spending, governments are literally faced with an infinite set of possible courses of action.

313. To choose from these limitless options for policy intervention, governments require some method to narrow the choices down to those options that are most likely to be productive. Various screening tools have been developed to help identify possible areas for policy intervention. One such screening tool is the checklist approach developed for the OECD. This checklist is intended to help policy-makers identify subsidies that *may* be environmentally harmful. In Chapter 7, some other screening criteria will be discussed, that may be more focused on the transport sector.

6.6 Checklist Approach

314. The checklist approach [Pieters (2002), in OECD (2003)] was developed in order to provide a preliminary screening tool that would help policy-makers identify potential targets for subsidy-removal. The checklist provides a set of easy-to-assess criteria, that help to identify subsidies which have a significant environmental impact and the removal of which would likely result in environmental improvement. The checklist does not allow policy-makers to identify the *magnitude* of benefits from subsidy reduction, nor does it help assess whether the benefits of subsidy removal would exceed any related costs. It simply provides a first screening that can rapidly be applied to a broad set of subsidies, in order to develop a short-list of potential subsidies for further investigation. This short-list could then form

the basis for more detailed study, preferably including cost-benefit analysis, eventually leading to removal or reduction of certain subsidies.

315. Some of the main suggestions and conclusions of Pieters (2002) include the following:

- Subsidies to variable costs affect day-to-day decisions. Removing these subsidies will thus have immediate impacts. Removing subsidies to fixed costs will only have impacts in the long run.
- Removing subsidies to environmentally damaging inputs (materials and energy) will [almost] always have environmentally positive results, whereas removal of subsidies to fixed costs could have ambiguous results.
- The longer a subsidy has been in place, the more likely it is to have negative impacts.
- Subsidies for capital goods, that require the use of a particular input, effectively act as a subsidy to that input.
- If certain firms, industries, groups, or individuals benefit from exemptions of environmental requirements that exist in other areas, removal of these exemptions is likely to have significant environmental benefits.
- The [environmental] effect of removal of preferential tax rates, or increasing infrastructure charges, depends largely on elasticity of demand.

316. Pieters (2002) provides more detailed descriptions of these issues, and suggests numerous other screening criteria, not all of which are relevant in the transport sector. Pieters also suggests ways to classify different types of subsidies (support measures) to help policy-makers identify their potential impacts. Subsidies can be classified according to whether they provide support that depends on output levels, input use, profits or income, or demand. For each category, Pieters suggests likely points of market impact, probable environmental impacts, and the likely effects of support removal.

317. The checklist itself involves four steps. The first step is to determine whether there is an existing "policy filter" that limits the potential harm of a subsidy. For example, subsidising coal fired power plants, other things being equal, would be very environmentally harmful. However, if total electrical utility emissions are capped, this places a limit on the potential harm caused by the subsidy. The most environmentally harmful subsidies occur when no policy filter that helps limit the damages exist.

318. Step two of the checklist is to look at alternative products that could be substituted for the product being subsidised. Removing subsidies to environmentally harmful goods or services may have only limited benefits (in the short-run) if there are few viable, more environmentally benign, alternatives.

319. Step three is to determine whether the existence of the subsidy actually increases production or consumption of an environmentally harmful good or service. A subsidy to an environmental bad is only an "environmentally harmful" subsidy, to the extent that it actually increases the quantity of that environmental bad.

320. The final step in the checklist is to look at the degree of market-power in the affected industry. If there is a high concentration of market-power, predicting the environmental impacts of subsidy-removal is more complicated. If there is limited market-power, and the subsidy passed the other checklist steps, then removing it is likely to generate environmental benefits.

321. The checklist approach was not designed with the transportation sector specifically in mind. Rather, it provides a general set of criteria that can be used to examine any subsidy for potential environmental impacts. As a result, the checklist approach is somewhat lacking when applied in the

transportation sector. For instance, the checklist does not fully address broader macroeconomic issues, which are often more important in the transport sector than in other areas. Other criteria in the checklist approach are either not relevant for the transport sector, or they cannot be applied in the transport sector the same way as in other sector. In fact, the majority of government support measures existing in the transport sector would most likely produce the same response to all the checklist questions. With the exception of public transit and rail transport, applying the checklist to most support mechanisms in the transport sector would lead either to the conclusion that "subsidy removal is likely to have significant environmental benefits" or "effects are indeterminate, but could be large." Although the suggestions made in the bulletpoints above do provide useful guidance, the checklist itself is likely to always give the same, and predictable, results if applied in the transport sector. It will say that rail and public transit support measures are not likely to produce environmental benefit if reduced, and that other support measures will.

322. The following Chapter will provide an additional set of screening criteria that may be more appropriate for the transport sector, and give some example of possible areas for subsidy reform.

7. Transport Sector Policy Guidance

323. The previous Chapter discussed some of the theoretical issues involved in identifying environmentally harmful subsidies, and provided an overview of some of the tools that can be used. This section will refine this analysis further to focus on the transport sector. This section will provide some suggestions for transport and environment policy-makers working on subsidy reform, to help them identify areas where the greatest opportunity for beneficial policy reform may exist. Some examples are also provided of areas in which government support should potentially be reduced.

7.1 Recommendations Regarding Measurement and Definition

324. The OECD does not formally endorse or recommend any one particular definition of subsidy. The numerous definitions that exist in the literature can all serve a particular purpose, and they can be valid definitions for those purposes.

325. Rather than focusing on a "best" definition, it is useful for policy-makers to understand *why* these different definitions exist, and what the policy implications of them are. By the same token, it is not required that all policy-makers agree on what sort of measurement approach to use, what the "measuring stick" should be, or what should be included in measurements. What is important, is that policy-makers *understand* the approaches that are used.

326. When presented with subsidy estimates, policy-makers are encouraged to look beyond the estimates, to look at the underlying methodology. The estimates themselves mean nothing if one does not understand the underlying calculations and assumptions. Failure to look beyond the surface estimates can lead to confusion, and to poorly conceived policies. For example, one might encounter a report which states that in 2004 rail transport was the most heavily subsidised mode of transport in Europe, and road transport received no subsidies. Another report, might say that in 2005, road transport was the most heavily subsidised mode of transport was the most heavily subsidised mode of transport in Europe, while rail received only minimal subsidies. Neither report would need to be incorrect; the authors probably just used different definitions of subsidies, or measured in different ways. If one does not look beyond the surface, one might draw the incorrect conclusion that European transport policy was massively altered from 2004 to 2005, or one could make the (possibly) incorrect assumption that one of the authors must be mistaken. Policies based on one of these incorrect conclusions would be based on a flawed understanding of the situation, and hence could end up having unintended consequences.

327. Agreeing on a particular definition or measurement technique is far less important than simply understanding that these differences exist, and being able to understand the methodologies used in developing different definitions. Ultimately, it is the underlying realities of government funding, indirect government support measures, user costs, and social and environmental externalities that matter. Not the labels that are attached to these things.

328. Having said that, there may be situations in which different definitions and measurement approaches are more common, or more logical.

329. Total subsidy levels may be meaningful in terms of knowing the big picture, how much money is going where, or which industries and transport modes cause the most total damage to society. From a policy perspective, however, relative subsidy rates may be more useful. The most commonly used measures for relative rates of subsidy are the subsidy value per passenger-km or per tonne-km. These measures are readily understood, and there is no compelling need to deviate from them. Total subsidy measurements are meaningful for accounting purposes. If one actually wants to do something about

problematic subsidies, however, then subsidies per passenger-km or tonne-km provide a more meaningful indicator of the relative harm/good that is occurring in different areas.

330. From a pure government budget perspective, the on-budget subsidy definition may be most useful. Governments have revenues, and they have expenses. Knowing how much revenue came from transport, and how much expenditure was directed to transport, is a useful measure for governments to have. This type of subsidy tells them how much direct financial support is going towards transport, in a clear and easy-to-alter manner. Other forms of government support also affect the budgets, but these can be difficult to alter. For example, elimination of preferential tax rates might require new legislation, or reversal of old legislation, and could be politically very difficult. Simply spending more money on public transport requires no more than a line in the budget. Basically, direct (on-budget) subsidies tell governments how much support they are providing to transport, that they can easily play with.

331. If the question to be answered is "how much support does industry X receive from government", then the government support perspective is the most useful definition of a subsidy. Including all support measures, both on- and off-budget support, gives a good indication of which industries receive the most government assistance. This information can be useful in political debate. This also forms the basis for knowing how government can alter support policies. Governments cannot feasibly eliminate pollution. They can eliminate certain forms of support. A government support measurement of subsidies provides an indication of the scope of government's ability to increase or decrease support. It lays out those things that are within the government's power to alter. If one does not know what support government currently provides to transport, it is difficult to develop policies involving reduced or increased government support.

332. From a social justice perspective, total social costs *vs.* total social benefits may be the most appropriate subsidy definition. It may be considered politically and socially desirable that those who create pollution be required to pay for the social costs that they create. If the automobile industry generates pollution that causes USD 100 billion of damages to society, it seems fair that automobile drivers should compensate society for the full USD 100 billion value of those damages.

333. From an economic efficiency perspective, the best definition of subsidies is as a failure of users to cover the *marginal social cost* of their activity. Economic efficiency, and in theory social wellbeing, is maximised when the price a user pays, is equal to the marginal cost that the user imposes. If the user-price falls short of marginal cost, then the difference could be considered the subsidy. This may be an appropriate definition to use for the purpose of developing economic policy and pursuing efficient resource allocations.

334. The above are of course simply suggestions. Policy-makers are free to choose whatever definition suits their purpose. What is important is not the definition, but the understanding of the underlying economic and environmental realities.

7.2 Refocusing the Discussion

335. Current policies in some OECD member countries, and recommendations from some organisations, focus on the importance of reducing or eliminating "environmentally harmful subsidies." While the goal is commendable, this approach provides problems for policy-makers in that it is often hard to define, let alone measure or identify environmentally harmful subsidies. Different approaches may lead to policy conclusions and recommendations that are contrary to desired environmental or social outcomes. To focus too strongly on "subsidies" detracts from the ultimate aim of environmental or transport policy.

336. The ultimate goal of any government policy should be an improvement in the wellbeing of the people. Environmental policy specifically aims to improve welfare, by improving environmental quality.

But policy-makers must not lose track of the big picture. The purpose of environmental policy is not to protect or improve the environment at all cost, but rather to ensure that the environment contributes as much as possible to the wellbeing of citizens. Similarly, the aim of transport policy is to improve or alter the transportation system in such a way as to improve social welfare. And environmental-transportation policy is not simply intended to reduce the environmental impacts of transport, but to improve the relationship between transport and environment in such a way that the wellbeing of society is enhanced. The effectiveness of the transportation system, and the quality of the environment, both contribute to social wellbeing. But so do health, disposable income, leisure time, security, and numerous other factors. Policy goals should not be set according to one single set of criteria, be it environmental quality, transport efficiency, health, GDP, or something else. Rather, the goal of policy is to ensure the mix of these elements that will best meet the needs of the people, and maximize the overall wellbeing of society.

337. This is not intended to suggest that environmental agencies and departments need to start working on ways to reform labour laws, or that employees in tax and finance departments should start researching cures for cancer. The point is simply that all policy-makers should keep in mind the ultimate goal of improved social welfare, rather focus too closely on a much narrower goal. The question that environmental policy-makers need to ask themselves is not "how can environmental quality be improved in a manner that will make people better off?"

338. Indeed, existing environmental, health, economic, transport and other policies around the world are already designed on the principle that a balance needs to be achieved between income, health, environment and other needs and wants. No country enforces a zero-pollution policy, because to do so would require sacrificing all material wealth to live in the forest. Many countries invest in health and environmental spending, even though doing so can reduce the potential growth of GDP. No country funds transportation infrastructures to the point where they cannot afford to invest in education, nor does the reverse occur. People have numerous needs and desires, and social wellbeing requires that these needs and desires be fulfilled in balance. Existing policy already recognizes this. If policy reform is required, it is because the balance is not optimal.

339. In the case of the environment, the balance is very far from optimal. Economic efficiency requires that marginal cost equals marginal benefit. At a social level, this means that goods and services, be they market commodities, or non-market benefits such as health or environmental quality, should be produced and consumed at a level where the long-run marginal cost of production/consumption to society, is exactly equal to the benefit received by society from that production/consumption. In principle, when production levels are such that marginal cost and marginal benefits are equal, net social benefits are optimised. Where the environmental costs are included, marginal costs significantly exceed marginal benefits in numerous areas. For many parts of the transport sector, production and consumption is occurring at a level where the marginal social costs are significantly higher than the benefits.

340. Current markets are, hence, not operating efficiently. In the case of the environment, there generally is no market. However, the thing "environmental quality" is currently being produced at socially inefficient levels in many countries of the world. "Production" is too low. The social cost of increasing environmental quality is much less than the social benefit of increasing environmental quality. On the flip side, production and consumption in many other markets are too high. There is far too much of the thing "travel by private car" being produced. At current levels, the marginal social costs of producing/ consuming travel by private cars considerably outweigh the marginal social benefits of its production/ consumption.

341. Governments need to intervene to fix these socially inefficient outcomes. Existing government policies have significant effects on the quantities of goods and services (both market and non-market) produced and consumed, and on their prices. Altering these existing policies can either increase or decrease quantities or prices. In some areas, too much is being produced and the (marginal) social costs outweigh the social benefits. Each additional unit produced or consumed in these areas costs society more than the benefits that it generates. Government intervention in these areas can help to reduce the quantities produced, thus reducing the social damages. In other areas, too little is being produced, and marginal benefits outweigh marginal costs. In such areas, additional production would generate greater benefits than the cost it would incur. In these areas, government intervention could be used to increase quantities, thereby generating net social benefits.

342. There are numerous ways that government can intervene to increase the quantity of socially desirable things and reduce the quantity of social bads. Governments can alter prices, either through taxes or price rebates, and this will encourage people to consume or produce more, or less, of the product in question. Government can regulate quantities produced. Government could take over production itself. Government can provide incentives (financial or otherwise) for the production of social goods, or provide penalties for the production of social bads. Through various forms of market manipulation, support measures, regulation, or other mechanisms, governments are able to influence production. Various demand management approaches can be used to influence consumer decisions. Governments can encourage the production of things that currently exist in socially inefficiently low quantities. The precise approach used can vary. The objectives should be consistent, however. If the marginal costs of an activity are greater than the benefits it creates, then governments should discourage that activity.

343. Rather than asking themselves "which subsidies should be reduced", policy-makers should instead simply ask, where and how can the government intervene to improve standards of living. Naturally, those working on environmental-transport policy should focus on areas connected with transport and the environment. But the focus need not be on "subsidies", which are difficult to define in any case. The focus should be on *government intervention*, whether it is classified as subsidy or not. Transport economists, and environmental economists, should be looking at the transport system, and trying to find those places where marginal social costs are much larger than marginal social benefits. These are the areas where industry (the free market) is producing too much. Government support should be decreased in these areas.

1.1 Typically, a focus on differences between marginal social costs and benefits might lead to a perceived difference between so call "public transit" versus private transport. Although this may provide a starting point, focusing too hard on private versus public transit risks missing the more critical issue. As with the issue regarding a definition of subsidies, focusing on defining public transport may lead to becoming bogged down in terminology. In some respects, all transport is public. Governments pay for city busses and subways, but they also pay for roads that are used by private cars. The notion that subsidies for public transport are good, and subsidies for private transport are bad, misses the point of this chapter. The key concern is not whether a particular government support measure targets "private" or "public" transport. That is simply a question of semantics. The focus should instead be placed on reducing support in areas where social costs greatly exceed private benefits, and increasing support in areas where social costs are much smaller relative to private benefits. Typically, this might involve increasing support for transport traditional defined as "public". But the focus still needs to be on differences between marginal costs and marginal benefits, rather than on differences between busses and cars.

344. By focusing on government support mechanisms, or government intervention, policy-makers can avoid any confusion that may arise regarding how to define or measure subsidies. A focus on marginal

costs and marginal benefits also encourages more of a social welfare perspective, rather than focusing too narrowly on only environmental issues. Too narrow a focus on the environment risks losing sight of the big picture, and pursuing socially undesirable objectives. Governments do not exist to protect the environment, provide transportation or to give out subsidies. Governments exist to improve the lives of citizens. This goal, rather than subsidies, or the environment, should be the ultimate focus of any policy reform.

345. Ultimately, the question should not be "which subsidies are environmentally harmful?". The question should be "how and where can government support in the transportation sector be either increased or decreased, in a way that would provide net social benefits?" The following section provides some general guidelines to help policy-makers answer this question.

7.3 Identifying Target Policies and Programmes for Revision

346. As suggested above, the goal of environmental-transportation policy should be to improve the transport-environment relationship, in such a way that social wellbeing will be enhanced. The way to improve social wellbeing, via transport-environment linkages, is to work on shifting transport use in the direction of where marginal social costs equal marginal social benefits. And in looking at marginal social costs and benefits, a key concern will of course be the environmental externalities.

347. Certain types of transport damage the environment, creating externalities. These externalities are damages (costs) that are suffered by society as a whole, rather than simply the individual who created them. The (marginal) benefits of the transport use are received almost exclusively be the transport user him or herself. The (marginal) costs, however, are at least partly born by society. If the individual who created these costs does not somehow compensate for them, then the marginal social benefit per user will be less than the marginal social costs per user. Use levels will be too high, net social benefits will be reduced.

348. Government actions can either improve or worsen this situation. Government actions to increase the costs to the individual user will shift the private cost toward the social cost, reducing the net social damages. On the other hand, if government intervention reduces the cost to users, then the gap between marginal user costs and social damages will widen, increasing use levels and net damages to society.

349. While some forms of transport have marginal user-costs that are below marginal social cost, other transport modes suffer from the opposite phenomenon, where marginal costs to individual users are *above* the marginal social damage (cost) of their actions. This too is socially inefficient. Since the cost to individuals is greater than the social cost of their actions, the number of transport users will be inefficiently low. If the social cost of providing additional transport is lower than the private benefit of additional transport, then more transport should be provided. Here too, government intervention can be either beneficial or damaging. If government intervention increases costs to private users, it will create an even larger gap between private and public cost, further reducing transport use and increasing social inefficiency. If government intervention lowers user-costs, it will help to bring private and social costs in line with one another, increasing transport use and providing improvement in net welfare.

350. The above may be clearer if an example is used. Suppose that it would cost a driver USD 10 to drive his car 100km. Suppose also that the benefit he personally receives has a value to him of USD 20. And suppose that by driving his car 100km he creates environmental damages that are worth (negative) USD 15 to society. The total cost to society of that driver's actions equals USD 25: The USD 10 that he himself pays, and the USD 15 worth of damages that society suffers. The benefit to society of him driving his car is USD 20. (Even though he himself receives the full value of this benefit, it is still a benefit to society, since he is a member of society.) From the perspective of society as a whole, his actions cost USD 25, and create a benefit of only USD 20. That is a net social loss of USD 5. So from society's perspective, he should not take his car. But from his personal perspective, taking his car will only cost him

USD 10, and it provides him a benefit of USD 20. That is a net benefit of USD 10 to him. So of course he will choose to take his car. This situation is socially inefficient, in that it results in too many people taking their cars. In this situation, government intervention would be helpful if it increased the costs to the driver so that his decision-making process better reflected the social costs of his actions, rather than just the private costs and benefits.

351. Since the costs of him driving outweigh the benefits of his driving, simply banning him from driving would also solve the problem. That approach would not translate well to a large scale though. For it to be efficient, the government should only ban those drivers for whom the marginal social costs outweigh the marginal social benefits. That would mean only banning those drivers for whom the benefits of driving were less than USD 25, while allowing anyone who receives a greater than USD 25 benefit to continue driving. Since government does not know the private benefits individuals receive, such a policy would obviously be impossible. While government intervention to raise private costs would lower use-levels, resulting in social benefits, government intervention to lower private prices would have the opposite effect.

352. As discussed above, environmental transport policy should seek to increase transport use in those areas where marginal social benefits are greater than marginal social costs, and seek to reduce transport in those areas where marginal costs are greater than social benefits. A number of suggestions for how best to identify those areas that show the greatest potential for social welfare improvements, either via increased, or decreased government supports are outlined below.

7.3.1 Think Big

353. This should be fairly evident, but policy reform should first target those areas where it has the most potential to generate large benefits. Developing new policies and regulations, or modifying existing government support mechanisms, takes time and money. Some problems may simply be too small to worry about. No matter how inefficient the modal share of transport is with respect to the dog-sled / snowmobile split, this is not a big enough problem to invest resources in fixing. Very few people make extensive use of either dog-sleds or snowmobiles, and the social costs and damages are quite small. "Fixing" the market imperfections regarding snowmobile *vs.* dog sled use would simply cost more than the social and environmental improvements would be worth.

354. If governments are going to make the effort of developing new policies and modifying their support measures, they should be sure that the benefits are worthwhile. And naturally, the larger the benefits, the better.

355. The first choices of areas where government support needs to either increase or decrease are those areas where the net social benefits of intervention are greatest. This means both that there should be a *significant gap* between marginal costs and benefits, and also that the activity should be *widespread*. If the activity in question is very limited, then fixing it will produce only limited benefits. But even if a problem is widespread, fixing that problem is only going to produce large benefits if there are significant benefits to be had at the unit level, *i.e.*, there is a significant gap between marginal costs and benefits. Eliminating a market imperfection that occurs 10 million times per year may not be worthwhile if the market is very large, and there are significant social costs involved with *each* (marginal) transaction, then huge social benefits can be generated by reducing the marginal social cost per transaction. Such may be the case in numerous areas within the transport sector.

7.3.2 Target Large Marginal Pricing Gaps

356. The first question policy-makers should ask is what are the areas where the greatest social harm is being done (think big). Other things being equal, the next step should be to determine what are the areas where the most social harm is being done, per marginal unit. These are the areas where policy reform can have the greatest per-unit benefits.

357. In practice, policy intervention involves transaction costs for governments. Depending on the type of intervention, transaction costs could be largely fixed, or they could vary considerably with the number of agents involved in the intervention. For example, a programme that requires monitoring vehicle production would probably have lower variable costs than a programme that involves monitoring vehicle purchases, simply because there are far more locations that need to be monitored in the latter case. If the programme requires monitoring of individual drivers, then this would increase variable costs yet further, and the more often monitoring is required, the higher the variable costs. The cost of a programme can be justified only if the marginal benefits created exceed the marginal costs of the program. For instance, suppose that a government programme would require annual inspections of every car on the road, at a cost of USD 50 per car. This would be justifiable only if the marginal social damages to be avoided would be worth more than USD 50 per car. This would first of all require that the gap between marginal social costs and marginal social benefits is more (probably much more) than USD 50 per car per year. And second, it would require that the programme helps to close this gap by USD 50 or more. A government programme that costs USD 50 per car, actually increases the marginal social costs per car by USD 50. To be worthwhile, it must either increase marginal social benefits of driving a car by more than USD 50, or reduce some other aspect of the marginal social cost of driving (such as environmental damages) by more than USD 50.

358. High variable costs of government programmes are only practical when the marginal social costs of an activity are high; in other words, when the gap between marginal costs and marginal benefits are largest. Policy-makers should therefore look for such situations, as these are the areas where government intervention is most productive. On the other hand, high government transaction costs are less justified in areas where marginal social benefits and marginal social costs are not very far apart. Government funding devoted to closing these small gaps might more productively be spent elsewhere to close much larger gaps.

7.3.3 Low-hanging Fruit

359. If a market problem can be fixed easily, then it should probably be one of the first problems to fix. Some government support structures have centuries of history behind them and are protected by a complex web of bureaucracy and regulation. The less complicated a support mechanism is, the easier it will be reduce or increase. Also, changing the value of existing measures and regulations is often easier than creating entirely new support structures. A road vehicle fuel tax change, for example, would be easy to implement. All OECD countries collect taxes on vehicle fuels. This mechanism is in place, and thus easy to alter. All that would be required would be an increase or decrease in the existing tax rate. By contrast, creating a whole new programme to charge cars based on distances travelled, location travelled, and time of travel, would be rather complicated. Using GPS technology, it could be done, but there is no existing framework for such a programme. The administrative and capital costs involved would both be quite high. Farm subsidies also provide an example of long-standing support mechanism that are fairly complicated and would be administratively difficult to alter.

360. Eventually, policy-makers will wish to tackle all areas that currently are socially *in*efficient. But there is no reason not to tackle the easier problems first – assuming, of course, that they are still large enough problems to have a meaningful social impact.
7.3.4 Work with Markets

361. It is much easier to modify existing markets, than it is to create a new market. And markets can alter people's behaviour much more efficiently than direct regulation can. Market-based approaches, such as pollution permits or pollution taxes, can often achieve the same goal as direct regulation, but at a much lower social cost. Social inefficiency in the transport sector generally occurs because the costs and benefits faced by an individual transport user do not correspond to the costs and benefits faced by society. An individual user will make the choice that is best for him or her, but this choice will not be best for society. Taxes can be used to increase the costs to an individual user to the point where his private costs correspond more closely to the social costs of his actions. If the individual's private costs and benefits are the same as the social costs and benefits, then that user will choose the option that is best for him or her, and also is best for society. Similarly, if production and consumption are too high, relative to the socially optimal level, permits can be used to reduce these levels to the social optimum. For example, if it is determined that the socially optimal number of landings at a certain airport is 50 per day, then the airport can simply issue 50 landing permits per day, sold to the highest bidder.

362. Although direct regulation can often achieve the same results, it will do so less efficiently. The advantage of market mechanisms is that they allow transport users the flexibility to decide for themselves, and among themselves, what is the cheapest way for them to comply with the environmental objective. As a result, pollution reductions are made in the cheapest way possible, and they are made by the people for whom pollution reductions are the least costly.

363. For example, if the social cost of driving a car were USD 100, then the only people who should drive their cars are those for whom the benefits of so doing exceeded USD 100. If some people derive a personal benefit of only USD 50 from driving their cars, then it does not make sense for them to drive. Their actions are imposing more costs on society than the value of the benefits received. On the other hand, if a person receives USD 200 worth of benefits from driving his/her car, it would be socially inefficient to prevent him/her doing so, since the benefits they receive exceed the costs they create. If a tax system was used to increase the private costs of driving to USD 100, the same as the social costs, then a person who only values driving at USD 50 would stop taking his/her car, while a person who values driving will reduce the number of cars on the road. More importantly, it ensures that the people who stop driving are the ones for whom driving provided the least benefit, while the people for whom driving provides the largest benefits will continue to drive.

364. Permits can also achieve the same result, in a different manner. The number of people who drive their cars, land at airports, use a train system, etc., would be limited by the fixed number of permits. The groups for whom that mode of transport was least beneficial will not wish to buy any permits, and they will sell any that they have. Those who value the transport quite highly will want to use their permits, and may buy others. The result is that the people who stop using transport, are the same ones who valued transport the least.

365. If the environmental externalities of transport are too high (marginal social costs exceed marginal benefits), then society would like to reduce transport externalities. Ideally, the reductions should be made by those who can most easily (cheaply) make those reductions. Regulation can force reductions to occur. But only market-based mechanisms can ensure that the reductions are made as cheaply as possible.

366. Government support mechanisms that are rigid, for example subsidies to specific technologies, should be considered targets for removal. Support mechanisms that work with market forces allow producers and consumers the flexibility to work towards environmental objectives in the most efficient manner. These types of support measures could be increased.

7.3.5 Support Measures should be Direct

367. If governments wish to reduce NO_x emissions, then they should develop a policy which targets NO_x emissions as directly as possible. The more indirect the approach, the greater the opportunities for it to back-fire. When governments provide financial or non-financial support, they should focus and tie that support as directly as possible to the desired outcome.

368. If governments wish to support Z, then they should directly support Z. This will be much more efficient and reliable than supporting some X, which contributes to Y, which contributes to Z. If for some reason, it is not possible to support Z directly, then support Y, rather than X. The more direct the support measure is, the less opportunity there will be for the support to be diverted to other ends, or for it to have unforeseen consequences.

369. Indirect support measures tend to be much less reliable, and much less economically efficient, than more direct measures. Indirect support mechanisms should, therefore, be considered as candidates for policy reform.

7.3.6 Be Aware of Unforeseen Price Signals

370. As noted previously, one of the most efficient ways to reduce negative externalities is to internalise them in market prices. If the private costs of driving are too low, then people will drive too much, and the marginal social damages will exceed marginal social costs. Markets can be made more efficient by simply raising private costs. But the reverse is also true. Social damages will be increased, if already too low prices are lowered further.

371. It is critical to be conscious of government interventions that may inadvertently lower prices that are already too low. This can often occur in the form of indirect and unintended price effects. For example, any policy measure that makes it cheaper to drive a car will result in more cars being driven. "Cheaper" here, does not simply refer to the out of pocket financial expense of driving, but also the *opportunity cost* involved. Policies that reduce congestion may help reduce externalities, all other things being equal. But reduced congestion also means that people can get where they are going faster. This reduces the opportunity costs of driving, and may encourage people to drive more; ironically, possibly increasing congestion. Government support that makes it easier for people to buy fuel-efficient vehicles effectively lowers the price of driving for them, encouraging them to do more of it. Highway improvement that makes driving a more pleasant experience, also encourages people to drive. Any government measure that makes driving less expensive, faster or more enjoyable, effectively reduces the opportunity costs of driving, which will encourage more people to drive, and encourage existing drivers to drive more.

372. Before providing support to the transportation sector, governments should consider how this support mechanism will affect prices (opportunity costs of use) in the transport sector. Many existing policies may indirectly be altering transportation prices in a direction that is environmentally and socially harmful. Such support mechanisms should be considered for removal or revision.

7.3.7 Be Aware of Macroeconomic Up- and Downstream Effects.

373. No policy exists in a vacuum. A policy that affects the transport sector also affects every other part of the economy that makes use of the transport sector, which means it affects the entire economy. Obviously, it is neither possible nor practical to predict every impact of a proposed government intervention. But the largest and most probable impacts should be considered. In the transport sector, the main issues to consider are up- and downstream impacts, as well as the largest transport-dependent sectors.

374. Downstream impacts involve recycling and disposal of old automobiles, parts, and waste. Policies that affect the volume of transportation, and the types of vehicles in use, could have potential social and environmental implications when those vehicles are repaired or replaced.

375. Upstream impacts include the production of fuels and vehicles. Smelters, foundries and vehicle factories consume significant amounts of energy and are often among the major industrial emitters of various pollutants. Extraction and processing of oil, or other vehicle fuels, can also have substantial environmental impacts, in some cases rivalling those of the transportation sector itself.

376. Policy-makers may also wish to consider the externalities associated with infrastructure construction. Not just the externalities of the infrastructure itself, but rather the externalities associated with the actual *construction* process, which are often forgotten.

377. Other key macroeconomic impacts of transportation sector support involve those industries that rely most heavily on transportation. Cheaper, or more expensive transportation, could affect the profitability of certain industries, such as raw material producing industries, which could lead to either positive or negative externalities.

378. Transport policy workers need to be aware of the broader impacts of transport policies, in order to ensure that policies are not having unintended consequences. Some existing support measures may be set up in opposition to policies in other areas. For example, support for certain modes of transport, and support measures in the petroleum industry, may be working against one another. These counter-productive support measures, where they exist, ought to be targets for support restructuring. On the other hand, synergies could be achieved to produce dual benefits, in areas where transport support mechanisms and policies in other areas can be mutually supporting.

7.3.8 Be Aware of Elasticities and Substitution Effects

379 Predicting how consumers will respond to changes in prices requires knowledge of the elasticities of demand. Elasticity is a measure used by economists to determine how behaviour will respond to changes in various market prices. The price elasticity of a commodity is an indicator of how consumer demand will respond to changes in the price of that commodity. Generally, if prices go up, demand goes down. The income elasticity of a commodity is an indicator of how demand for it will change, if consumers' income increases or decreases. For most goods, when consumer income goes up, demand for those goods goes up. Though this is not the case if the good is an "inferior" good. An inferior good is something that people will consume less of, if they have more money, for example low quality food products. Public transport can sometimes be considered an inferior good. The cross-price elasticity of two products is a measure of how demand for one product will be affected by changes in the prices of some *other* product. For instance, the cross-price elasticity of bus transport with respect to train transport would provide an indication of how the demand for bus transport would be affected by a change in the price of train transport. Since busses and trains often are substitutes for one another, an increase in the price of train tickets, would result in an increase in the demand for bus travel. If two things are compliments (they go well together) then the opposite would occur. For example, an increase in the price of tourism would result in a decrease in the demand for airline trips.

380. Predicting the effects of a transport sector intervention requires that policy-makers understand the elasticities involved. This is particularly important when considering modal shifts. If policy-makers want to promote a shift from private cars to public transit, via price changes, then they need to know the price elasticity of both automobile transport and public transit, and of the cross-price elasticity between them.

381. In considering transport policy implications, it is also essential that policy makers be aware of differences between short and long term elasticities. Often the response of consumers to a price change in the short run is very different from the response in the long run. For instance, in the short term, an increase in gasoline prices may not have much of a noticeable effect on gasoline consumption. The short run price elasticity of gasoline is low. If prices remain high for a long period of time, however, consumers may decide to buy more fuel efficient cars, or get rid of their cars in favour of bus passes, and there may be a significant decline in gasoline consumption. Overall fuel consumption tends to respond more to long run changes in fuel prices, than to short run fluctuations. The long run elasticity of fuel demand is higher than the short run elasticity. If policy makers are not aware of the likely short and long term responses of consumer to price changes, then policies may be incorrectly targeted to achieve maximum net benefits over the long term.

382. Failure to properly account for the elasticities involved can lead to government interventions and support measures that have far less impact than expected, and which may actually have negative consequences. There is some evidence that there are certain support measures in the transport sector that fall into this category. These support measures should be revaluated and possibly removed in favour of more effective measures.

7.3.9 Environment is not the Ultimate Goal

383. It was noted above, but will be repeated here. The goal of environmental policy is not to improve the environment. The goal of environmental policy is to improve standards of living. Just because an environmental policy intervention does not have a visible effect on the environment, that does not mean the policy was unsuccessful. And just because a policy *does* have an effect on the environment, that does not mean the policy was a success. The failure or success of environmental policy ought to be judged not simply by its environmental impacts, but by its social welfare impacts.

Social welfare (efficiency) is not maximised when, or just because the environment is improved. Social welfare (efficiency) is maximised when transport users cover the marginal costs of their activities. Just because fuel taxes, or some similar measure, do not have a large impact on car use, does not mean they were a failure. They force car users to account for the externalities that they create. If car users are forced to cover *all* the costs of their driving, and they *still* choose to drive anyway, then it would not be in the public interest to stop them from driving. To do so would be depriving them of a larger personal benefit than the damages that they are causing. This would lead to a net social loss.

384. There is sometimes a tendency among environmental policy-makers to recommend eliminating policies that do not appear to have environmental benefits. But this is a mistake. Although the policy may not have environmental benefits, it may have social or economic benefits that make it a socially beneficial policy. Such policies ought not to be targeted by environmental subsidy reforms. The contrary in fact. Support measures that vigorously pursue environmental goals, to the exclusion of social and economic efficiency, may be harmful to society. For example policies that achieve small environmental benefits at large social costs, or policies that seek to increase private costs above marginal social costs, are ultimately harmful to society. These policies should be targeted for reform.

7.4 Example Cases of Environmentally Harmful Transport Policy

385. One of the most readily apparent opportunities to improve the social efficiency of transportation would be reduction of government support for aviation. Of any transportation mode, aviation generates the second largest environmental externalities per passenger-km, only slightly behind car transport. And aviation is by a huge margin the most polluting means of freight transport on a per tonne-km basis. Yet aviation benefits from a variety of government support measures. One of the most significant being the

exemption from fuel taxes on international (and in most countries, also domestic) flights. High marginal costs of transport, combined with significant government support for variable costs (fuel), means that aviation is the transport mode for which private costs and marginal social costs are the furthest out of whack. Reforms of Government support practices for aviation could therefore go a long way towards equating marginal costs with marginal benefits, producing significant efficiency improvements.

386. Besides being significant at the margin, government support measures for air transport are also large in total terms. According to the estimates from Sewill (2003), tax exemptions for airlines are worth GBP 9 billion per year in the UK alone. Reductions in government support to airlines would produce large increases in government revenue. This measure thus also fulfils the criteria that reforms should target first those areas where total benefits are likely to be greatest.

387. Air transport also qualifies as a good target area for policy reform by many of the other criteria discussed above. Since sales taxes and fuel taxes already exist in most world economies, shifting these taxes to include air transport would not be a radical departure from existing taxation schemes. Increased taxation of aviation would also work with markets to help alter transport behaviour and promote efficiency. As noted above, working within markets, when practical, tends to achieve the same results far more efficiently than regulatory approaches. From a macroeconomic standpoint, and from the standpoint of modal substitution, there is little downside to increased aviation prices or decreased aviation use. Other transport modes might increase in use, but since aviation is one of the most polluting forms of transport, a shift to other modes would likely produce net environmental benefits (and improve socio-economic efficiency).

388. For these reasons, government support of aviation stands out as a prime example of an area in which policy reform could produce substantial social benefits. Reducing support for air travel would generate large gains in both marginal efficiency and net social benefits. It would work within existing market and policy frameworks, and it could easily be done in a very efficient manner using market approaches. Improvements in environmental and economic efficiency in the air sector could be substantial, while any decreases in environmental quality or efficiency in other sectors or for other modes would be minimal in comparison. Governments may therefore wish to look at air transport as a candidate for "subsidy" reform, or at least for altering government support levels.

389. Some similar arguments *might* be made for international marine shipping. However, there are key differences between the shipping and air transport industry. It is true that, like for air transport, sea transport benefits from many tax exemptions. These exemptions create market distortions that result in economic inefficiency and environmental damages. But numerous other factors need to be considered before deciding that sea transport "subsidies" ought to be reduced.

390. For one, the marginal social costs of sea transport are low, compared to aviation or road transport. Naval emissions do contribute to air pollution and global warming, and sea spills also create social damages. These social damages (externalities) are not accounted for in the private costs of shipping. Hence the marginal social cost of shipping is higher than the marginal private cost, creating inefficiency, and promoting environmental harm. However, the marginal inefficiency in sea transport is much smaller than in other areas. The social damages caused by shipping a tonne of freight one km by sea are insignificant compared to the social damages caused by transporting the same volume by air or road. So, although there is a gap between private and social costs of marine transport, this gap is not nearly as large as for road transport or aviation. Thus, marine transport does not meet the requirement of large marginal inefficiencies.

391. Marine transport also fails to meet the criterion that policy reform should first target areas where total benefits are likely to be greatest. Not only are the marginal social damages from marine transport

smaller than in other areas, but the *total* social damages are also much smaller. The total social and environmental damages caused by sea transport are trivial compared to road or aviation. INFRAS (2004) estimates that *inland* water transportation is responsible for less than half of one percent of all external costs caused by transportation. In 2004, international marine transport contributed only 8% of global CO₂ emissions from transport (IEA, 2006). This is slightly more than air transport. However, about 200 times more freight is transported by sea than by air. Furthermore, there is evidence that GHG emissions from ocean vessels are less harmful than emissions from land vessels, whereas emissions from aviation are two to four times more environmentally harmful than land based emissions (IPCC, 2007). Due to the relatively modest environmental damages associated with sea transport (compared with other modes), the potential benefits of reforming government support measures in this area are relatively modest.

392. Most importantly, marine transport support needs to be viewed in a broader macroeconomic context. It is true that if government support was reduced for marine transport, then marginal private costs would be closer to marginal social costs in the sector. And it is also probably true that some modest environmental benefits would be achieved in the sector. But what about other transport modes, and other sectors of the economy? A decrease in shipping volumes would likely be accompanied by an increase in the use of other, more environmentally harmful and socially inefficient, modes of transport. For this reason, more so than any other, reducing government support for maritime transport is probably not recommendable; at least not as a first step.

393. Note that the discussion above applies to overall global marine transport. Reducing government support for global maritime transport is not warranted. However, the same is not necessarily true on a regional basis. For ships on the high seas, far from land, the difference between the marginal private costs of operation, and the net social costs of operation are small, and the total social damages are also small. Hence, additional government intervention would provide limited benefits. The same is not true close to land, especially in port areas.

394. Ships in harbour can be a substantial contributor to urban air pollution. In Vancouver, Canada, for example, marine emissions account for 33% of SO₂ and 22% of NO_x emissions (Environment Canada, 2007). In such cases, the marginal social costs of marine operation are far larger than the private operating costs. This creates considerable environmental inefficiency, and thus it is an opportunity for substantial efficiency gains, through government intervention. At the national and international level, the total damages caused by marine transportation tend to be small. But on a city scale, marine transport can be one of the leading causes of environmental (and human health) damages. Port cities can therefore achieve significant local benefits by reducing support for marine transportation, effectively raising the prices that operators face for generating emissions in their vicinity. Since individual cities might not wish to lose business to other cities, reduced government support (or increased charges) for ships in port areas, might best be co-ordinated at a regional level.

395. Commuter transport represents an interesting case for government support. Government support of public transit is often justified on public service obligation grounds. Government is expected or required to provide affordable means of transport to all citizens. It therefore funds public transport. Particularly in the case of subway systems, extremely high infrastructure and capital costs, combined with extremely low marginal costs, also justify a government role in public transport support. While it is generally accepted, both economically and politically, that government should play a role in public transport, the precise level of support that is most socially efficient is rarely clear. And the appropriate level of support often varies considerably between locations. In some cities, there may be substantial social, environmental and economic benefits that could be realised by increasing government support for public transport. In other cases, increased government support would only increase social and economic inefficiencies, without generating any benefits. Public transport therefore deserves attention as part of transport policy reform, since it could potentially be a target for either increased or decreased levels of support.

396. As with any other area, economic efficiency in public transport is achieved when the price that users pay, is equal to the long-run marginal social cost of providing them with that service. In some cases, there may be benefits to decreasing user-prices to even less than social costs, but *only* if it is expected that this would induce car drivers to instead take public transit. Setting public transit prices below marginal cost would create inefficiency for public transport, but this inefficiency could be more than offset by much larger efficiency gains in road transport, as fewer people take their cars. Note that from a marginal efficiency perspective, improving service quantity or quality would have similar effects to lower prices. Lowered user-prices would reduce private costs further below social costs. Improved quality would increase social costs further above private costs. Both would essentially result in a widening in the gap between private and social costs. This is merited only in the event that efficiency gains in other areas would more than offset these efficiency decreases.

397. In many cities and countries, however, lower prices, or improvements in public transport service will *not* result in a modal shift away from car transport. Even if public transit was completely free to use (as it is in some parts of the world), many people would still choose to take their cars. Improved service quality might induce more people to take public transit, but in some cases the service expansions would need to be so significant that public transport costs would begin to rival private automobile costs. On the other hand, in some places, price reductions and modest service quality increases would encourage people to use public transport over private cars, and net economic and environmental efficiency could be increased. In the absence of evidence, one way or another, it is not safe for policy-makers to simply assume that public transport price reductions or service improvements will reduce car traffic. To understand if it will or not, policy-makers must understand the elasticity of demand for different transport modes, with respect to price, income and the price of competing modes. Numerous studies have investigated the price elasticity of public transport and car use. For a summary, see Litman (2007). In general, transit elasticities tend to be very low, indicating that even large price increases will result in fairly small shifts in ridership. A policy that reduces public transport prices below the marginal social costs, and which is not accompanied by a reduction in car traffic, is a bad policy. It would be economically inefficient and environmentally pointless. It would reduce the overall wellbeing of society. Such policies, if they exist, would be good targets for reducing government support.

398. From an economic efficiency perspective, if public transport prices are higher than marginal social costs, then there is no reason *not* to lower prices or improve quality. Lowering prices to bring them in line with social costs can only produce efficiency improvements. There is no (economic) reason to charge people more for something, than what it costs society to produce. The only counter-argument would involve limited government finances. Reducing public transport prices might reduce total government revenue from transport. This might require reducing spending in other areas, with net consequences that could be negative. However, assuming that the finances are available, and do not need to be taken from an even more important source, lowering public transport prices towards marginal social costs would be a socially beneficial practice. It would increase the social efficiency of the public transport system, and could produce even greater efficiency improvements, accompanied by large environmental benefits, if it also happens to encourage a modal shift from cars to public transit.

399. The provision of free parking (or parking at below market rates) is a form of government support that is almost universally recognised to be inefficient. Many authors have referred to it as a perverse subsidy. Whether it ought in fact to be classified as a subsidy, is not important. It is clearly a government policy that reduces the costs of driving, costs which are already too low. In many areas, the marginal social costs of driving a car 1km far exceed the private cost to the car user of driving 1km. This is particularly true in city centres and congested areas, where the marginal social costs of driving are highest. If drivers had to pay fair market price for parking spots, it would make driving more expensive for them. Free, or below market-value parking, essentially makes it cheaper to drive a car in a city. This further increases the gap between marginal social costs and private costs, increasing inefficiency. Even if drivers do have to pay

market value for parking spots, drivers in cities would still be paying much less than the social costs that they are creating, and receiving a substantial "social subsidy." There is no reason for governments to subsidise them yet further with the provision of cheap parking on city streets.

400. Government support for hybrid vehicles provides an interesting example of the importance of indirect price effects. Many governments are supporting the development and or purchase of hybrid cars. This support may have unintended consequences, that undermine its benefits. A hybrid car uses less petrol than a normal car. Petrol costs money. A hybrid car driver has to spend less money on fuel. Therefore, it becomes cheaper for him to drive his car. If it is cheaper for him to drive his car, he may do it more often. Although the hybrid vehicle creates less pollution per km-travelled, it could end up being driven more often, which would partially offset the emission reductions. Evidence of the magnitude of this "rebound" effect is mixed. Litman (2005) estimates that if fuel efficiency were to increase by 10%, drivers would increase mileage driven by 2-4%, so that the net decrease in fuel use would be only 6-8%. Government subsidization of fuel efficiency improvements alone. This highlights the importance of considering consumer responses (elasticities) to changes in price incentive structures.

401. In other cases, hybrid cars may not even use any less fuel per km than a non-hybrid car. Some cars are being manufactured with hybrid technologies that are used to increase engine power, rather than reduce fuel consumption. Government support for such vehicles produces absolutely no environmental benefits.

402. These hybrid examples demonstrate the importance of using direct support measures, rather than indirect measures, to achieve policy objectives. Presumably, the goal of programmes that support hybrid vehicles is to reduce environmental impacts of transportation. If this is the case, then the goal is not that "more people drive hybrid vehicles". Nor is the goal that "people drive more fuel efficient vehicles." The goal is that fewer vehicle emissions are produced. Hybrid vehicles, or more fuel efficient vehicles, may be a means of achieving that goal. But they are not the only means, nor are they necessarily the best means. If the goal is lower emissions, then the policy should target emissions, rather than some intermediary step that contributes to emission levels. This example shows how indirect policy measures can end up having unintended and non-beneficial consequences.

403. Rather than provide support for people who *buy* fuel-efficient vehicles, governments who wish to reduce vehicle emissions should provide support for people who produce fewer emissions – or they should tax those that create large emissions (*e.g.* through fuel taxes). Those that buy fuel-efficient vehicles, and those that create fewer emissions, are not necessarily the same.

404. Biofuel support is another example of government policy that *may* end up having unintended consequences. Whereas the unintended consequences of hybrid vehicle support are due to price signal effects, the unintended consequences of biofuel support lie in the upstream macroeconomic effects. Driving a car that runs on biofuel is generally better for the environment than driving a car running on conventional fuel. But this does not mean that government support for biofuel is necessarily good for the environment. It may be, but it may also be harmful. To understand if biofuels are environmentally beneficial (and socially efficient), one must not only look at the use of biofuels, but also the production. Biofuel use is not very bad for the environment, but biofuel production often is. Growing, harvesting, refining, and eventually burning one litre of biofuel, may be only marginally better for the environment than extracting, refining and burning a litre of unleaded petrol.

405. Whether or not biofuels are better for the environment depends largely on the type of biofuel produced, the region it is grown in, and the production methods used. Furthermore, environmental benefits, if any, of biofuel production may not be socially efficient. It could cost substantial amounts of money to

obtain only moderate environmental benefits. This money might be better spent on other programs to improve the environment, or increase social welfare via other means. ECMT (2007) has concluded that "with the exception of ethanol from sugar cane, most research concludes that the cost per tonne of CO_2 saved [by producing biofuels] is high." Given relatively high costs to reduce CO_2 reductions via biofuel production, it is likely that the same environmental benefits could be achieved at a lower cost (more efficiently) by some other means. Government support for biofuel development might be more effectively used to increase social welfare, and improve the environment, if it was directed elsewhere.

406. There are numerous other areas in which there are large market inefficiencies resulting in environmental damage. The six examples above demonstrate, at least at a high level, how policy-makers may wish to address "subsidy reform" – or better yet, how policy-makers can work on transport support reforms, with the goal of improving social welfare. These examples demonstrate how the guidelines in the previous section might be used to help identify areas where reduced government support would be warranted, as well as those areas in which increasing government support might ultimately be environmentally harmful and socially inefficient.

8. Summary and Conclusion

407. The purpose of this paper has been to provide some guidance for policy-makers who wish to implement environmental reforms in the transport sector, by reducing transport support measures.

408. The first half of this report was devoted to the problems involved in measuring and defining subsidies in the transport sector. Chapters 2 and 3 discussed some of the theoretical approaches, and the issues involved in measuring and defining subsidies. Chapter 4 presented an overview of the available subsidy estimates in the literature, and the definitions and measurement techniques used to calculate them. It should be clear that there are a great many approaches available to both defining and measuring subsidies. Hopefully, the first half of this report will have helped clarify *why* all these different approaches exist. It is important that policy-makers understand that the different definitions exist for different purposes. By understanding the range of estimates available, and the underlying approaches used to derive these estimates, policy-makers may be less likely to draw incorrect conclusions about transport sector support measures, based on an incomplete understanding of the source of estimates. Different estimates, based on identical data, could lead to very different policy recommendations. It is therefore imperative that policy-makers understand the underlying issues, before deciding to reduce transport sector "subsidies". Ultimately, the specific definitions used are largely irrelevant. What really matters, are the underlying realities, such as government funding, market support, user fees, and environmental externalities.

409. The second half of this report has focused more on how policy-makers may wish to go about reducing subsidies (or "support measures") that adversely affect the environment. Although the environmental impacts of transport are well documented, it still is often unclear how best to reduce environmentally harmful subsidies. The transport sector is so full of government support mechanisms, that it is difficult to know where to begin. Road transport and aviation are by far the most environmentally harmful transport modes. But it is not necessarily easy, or even efficient, to simply reduce road and aviation subsidies. The transport sector is so complicated, with so many intermodal linkages, and linkages to other sectors, that it can be difficult to predict the impact of altered transport support measures. A variety of tools exist, and these have been reviewed in Chapter 6. Chapter 7 also provided some additional suggestions on where policy-makers should focus. If policy-makers are not careful, however, there are significant risks that subsidy revisions could have far-reaching and unintended consequences. Alternatively, some policy interventions could end up having little or no impacts. It all depends on the nature of the support measure, and how it is removed.

410. If, or when, policy-makers look into the available options for removing environmentally harmful subsidies, they will first need to decide how to define subsidies. Once they have a definition, they will need to determine how to measure subsidies. Once they know the existing level of subsidies, they can look at the environmental impacts of the subsidised modes of transport. Then, they can attempt to figure which of the subsidies, to the various modes, can be considered environmentally harmful. And finally, they can try to figure out how best to remove or reduce those subsidies. Every step along the way is critical, and can profoundly alter the final decisions. If policy-makers are not careful in how they choose to define, measure or identify environmentally harmful subsidies, they may find that the ultimate policy-implications end up being environmentally unfriendly, socially inefficient, or both. Care must be taken, and policy-makers should have a good understanding of the issues involved each step of the way.

411. Of course, policy-makers can avoid having to worry about many of these issues, if instead of focusing on "environmentally harmful subsidies", they instead simply focus on socially inefficient support practices. That they should do so, is one of the few recommendations of this report. After all, the policy goal is not simply to lower subsidies, or to improve environmental quality. The ultimate goal is to improve quality of life. The final recommendation to policy-makers is this: do not simply ask yourselves how you can reduce environmentally harmful subsidies. Instead, ask yourself, how can government support for the transportation sector be altered, in such a way that it would improve overall social wellbeing.

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