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IMPACTS FROM TRANSPORTATION MEASURES IN NATIONAL APPRAISAL GUIDELINES: COVERAGE AND PRACTICES

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Abstract:

Transportation appraisal has a potential important role in prioritization of transportation investment projects and other transportation measures. Appraisal practices vary much over countries and time, but these differences are not fully known. More knowledge on the variation in practices may contribute to smoother knowledge exchange between countries and more informed choices in the further development of each national practice. In this paper, we present both an updated mapping and a meta-analysis of impact coverage in national appraisal guidelines for transportation measures and spatial measures more generally. Our updated mapping of impact coverage covers 18 national and regional guideline sets and 44 sorts of impact. It shows rather similar overall impact coverage in the reviewed guidelines for economic, social and environmental impacts. The most advanced appraisal practices are found in Northern and Western Europe and Oceania. We find that supplementary quantitative analyses are most common for economic impacts, while multi-criteria analyses are most common for environmental impacts. Our meta-analysis covers ours and 15 earlier impact mappings, jointly covering 42 countries and regions. In this examination, we show how impact coverage in appraisal practices has improved over time, particularly for environmental, user and wider economic impacts. The meta-analysis also reveals that Western and Northern European and Oceanian countries and dependencies have had the widest impact coverage from 1998 to 2020, both in CB and overall. To examine what characterize countries with broad and narrow impact coverage, we have applied econometric regression models that are linear (i.e. linear least squares), quasi-linear (i.e. Tobit) and fractional response-based (i.e. fractional probit and fractional logit). In these regression analyses, we control for study-specific characteristics and clustering the standard errors on countries. Our results show that the CB impact coverage tends to increase with economic wealth, equality and population size in developed countries, while we find no such patterns for overall impact coverage.

Keywords: *transportation planning, decision-making, economic impacts, social impacts, environmental impacts*

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1. Introduction

In developing of transportation and spatial policies more generally, it is essential that decision-makers and other stakeholders are informed about how their actions are likely to affect household, economy, environment and public organization, as well as how these impacts will align with other policy objectives. National appraisal guidelines play an important role in prioritization of transportation measures and spatial measures more generally. They systematically provide frameworks for assessing how transportation investments and other spatial measures are expected to affect social welfare, distributional impacts and planning processes, as well as the associated uncertainties associated with inclusion of these effects. Furthermore, the appraisal guidelines designate which impacts that are to be assessed and how – including choice of appraisal tools, valuation methodology and parametric valuation.

To obtain a better understanding of differences in appraisal practices, a reasonable first step would be to map the impact coverage in the national appraisal guidelines and by which appraisal tools each impact is assessed. It will then become easier to further map differences in valuation methodologies and parametric valuation in subsequent steps. The impact coverage and appraisal tools applied to address each impact vary substantially over countries. Some notable and comprehensive studies contribute to this understanding (e.g. Nellthorp, Mackie and Bristow 1998, PIARC 2003, Odgaard, Kelly and Laird 2006 and Mackie, Worsley and Eliasson 2014), but there few recent contributions. A comprehensive review of this literature is provided in appendix A.

An updated mapping of impact coverage in national appraisal guidelines is needed to obtain an overview over the current best practice. Moreover, appraisal practices may be affected by key developments in society and transportation systems, exemplified by the corona pandemics (e.g. Barbieri et al. 2021, Nadimi et al. 2022 and Pivtorak et al. 2022) and smart transportation systems (see Chung 2021 for a review). Developments in appraisal methodology may also affect future appraisal practices and decision-making in the transportation sector (e.g. Atkinson et al 2018., Rothengatter 2017 and Kaczorek and Jacyna 2022 for examples for recent methodological developments, confer Holmen and Hansen 2020 for a review).

New knowledge on the variation in practices may contribute to smoother knowledge exchange between countries and more informed choices in the further development of each national practice. Identifying differences in assessment of various impacts of transportation measures over space will hopefully contribute to more awareness of alternative appraisal methodologies and uncover potential improvements in each country's guidelines. In addition, a systematic review of earlier mappings would help to shed light on recent developments in appraisal practices. A good overview over impact coverage can also come in handy in ex-post studies of impacts of transportation measures. Overall, we believe that our study may be of interests for both practitioners and scientists.

In this paper, we provide an update on impact coverage in national appraisal guidelines, also assessing how impacts are grouped and assessed. We focus on guidelines English, German, Dutch and Scandinavian languages, as these guideline sets have been revealed to have the widest impact coverage by earlier mappings (confer appendix A and section 4). We both map coverage for cost-benefit analysis (CB) and overall methods, which also includes coverage by multi-criteria analysis (MC), supplementary quantitative analysis (SQ) and 'noted'. This provides us with an up-to-date overview over the countries with the most extensive impact coverage within transportation appraisal.

Next, we perform a meta-analysis on how CB and overall impact coverage has developed over time across countries and impacts, based on earlier mappings. We also investigate how impact coverage over countries is related to socio-economic conditions. We aim to investigate how different socio-economic conditions covaries with wide impact coverage across countries, inter alia including wealth, income distribution, population levels and governmental fragmentation. At last, we discuss recent and likely future developments in the guidelines. To our knowledge, this is the first time such a meta-analysis has been conducted.

The structure of the paper is as follow: After this introduction in section 1, we account for the applied methodology in section 2. In section 3, we provide an updated mapping of impact coverage in transportation appraisal, before we conduct a meta-analysis of our own and earlier mappings of impact coverage

in section 4. At last, we synthesis and discuss of our results, and draw our conclusions in section 5.
Additional supplementary analyses are provided in online appendixes. Findings in earlier mappings of impact coverage is provided in appendix A. As advanced appraisal practices may not be reflected in practice decision-making, we have reviewed the literature on how appraisal practices affect de facto decision-making over countries in appendix B. Wide impact coverage constitutes a key dimension in how advanced a countries transportation appraisal is, but it is far from sufficient for having good appraisal practices. Accordingly, some additional features of the appraisal guidelines are mapped in appendix C. Beyond this, we refer to the references rendered in our literature review for further dimensions.

2. Methodology

In the following, we account for the mapping methodologies applied in our updated mapping and our meta-analysis of impact coverage. We measure impact coverage as the percentage of some given guidelines that cover some given impacts.

2.1. Updated Mapping of Impact Coverage

In order to obtain updated information about impact coverage in the national guidelines for transportation appraisal, we have reviewed 18 sets of transportation appraisal guidelines. Wider spatial guidelines and general economic appraisal guidelines are included when they are play a key role in practical appraisal. Our mapping covers 18 guideline sets in 14 independent countries, three dependencies and one supranational region. All countries have more than five million inhabitants and belong to the Great Germanic language group (e.g. English, German, Dutch and Scandinavian). The latter delimitation follows from researchers' primary language skills. In addition, the mapping includes guidelines in four dependent regions (i.e. British Columbia in Canada, New South Wales in Australia, Scotland in the United Kingdom) and the European Union. Our mapping was carried out during the second half of 2018 and 2019.
The guidelines were identified through the websites of relevant government agencies, and Google search for appraisal guidelines and countries in the native languages and in earlier reviews. An overview of the reviewed guideline sets is provided in Table 1.
We have focused on road appraisal in case of separate guidelines for different transportation modes.[1]
In our mapping, we have identified 44 types of impact covered by the public appraisal guidelines reviewed, as depicted in Table 2. Classified in accordance with their impact recipient, 8 are pure economic impacts (i.e. impacts on the production sector), 9 are pure social impacts (i.e. impacts on the household sector), 13 are environmental impacts (i.e. impacts on the environment), 8 are public impacts (i.e. efficiency impacts related to public funding and public measures) and 6 are either economic or social depending on the institutional sector the impact's recipient belongs to. This classification is not always strict, as the impacts may affect several institutional sectors directly. Alternatively, the impacts could be classified into 22 direct impacts and 24 indirect impacts, reflecting their attachment to the markets were the transportation measure is implemented (mainly the transportation and construction markets).
In the practice, our mapping of the guidelines involved an assessment of the inclusion of the listed impacts in every guideline set, and the applied appraisal tools for each considered impact. To avoid errors in review of each set of guidelines, our mapping was quality assured by researchers from AIT Austrian Institute of Technology, Institute of Transport Economics and Panteia, and reviewed by representatives from the Conference of European Directors of Roads. Earlier mappings of impact coverage were also applied for quality assurance purposes.
Our study captures both which impacts are considered in transportation appraisal, and by which appraisal method they are assessed. We have reviewed three types of assessment tools; cost-benefit analysis (CB), multi-criteria analysis (MC) and supplementary quantitative analysis (SQ), as well as qualitative noting of impacts that are not discussed directly in context of these analyses. In addition, our mapping involves some cases where guidelines recommend both CB and MC or SQ and MC for analyses of an

[1] Note that Norway and Switzerland have separate guidelines for railways, which are excluded in the review. While the Suisse guidance for railway appraisal cover some impacts not covered by its counterpart on road appraisal, this is not case for the Norwegian guidance for railway appraisal.

impact, depending on size, characteristics and how well the quantitative method is considered to capture the impacts in question. Due to the width of the national appraisal guidelines' coverage, we focus on overall impact coverage (regardless of appraisal method), coverage by CB and quantitative coverage (i.e. CB or SQ).

CB constitutes the primary appraisal tool in most national guidelines for transportation appraisal and spatial appraisal more generally. It helps to measure all impacts from spatial by the same measurement unit (i.e. money) and aids planners and decision-makers in identifying the relevant trade-offs in their project prioritization. Accordingly, many of the earlier mappings of national guidelines for transportation appraisal focus on CB rather than alternative assessment frameworks (e.g. Holmen and Hansen 2020 and appendix A for details).

When the value of an impact is considered too small or uncertain to include in the CB, the impact is often handled by multi-criteria analysis (MC) of non-priced impacts, where impacts are ranked according to qualitative assessment of their size. By this definition, both quantitative indexes and qualitative discussions leading up to ranking of impacts are included. In our mapping of MC impact coverage, we include extensions and modifications such as multi-actor multi-criteria analysis (i.e. stakeholder-specific rankings along Likert's scale, which are aggregated based on different weights) and goal-oriented assessment methods (i.e. rankings along Likert's scale based on achievement of objectives rather than size). Multi-criteria for decision-making (i.e. ranking based on outcomes from various appraisal tools) is not included, as this analysis concern compilation of appraisal results rather than evaluation of each impact.

SQ are applied for impacts that are considered to be potentially large, but still uncertain and possibly overlapping with CB estimates (e.g. Wangsness, Rødseth and Hansen 2017 and Holmen and Hansen 2020). In case of wider economic, supplementary quantitative analysis typically also violates the neoclassic perfect competition assumption applied in CB, which rules out market failures in secondary markets that are left unaccounted for by economic agents (see for instance Harberger 1964 and Mohring 1993). Cost-efficiency analysis constitutes another form of supplementary quantitative analysis, where relative costs and benefits are compared over different courses of action. In the category 'mentioning', we have also included impacts that concern other aspects than total social welfare, such as distributional and uncertainty aspects.

Table 1. Reviewed public guidelines for transportation and spatial appraisal (General economic appraisal guidelines that are included in the mapping due to their role in practice appraisal are marked by *)

Country	Guideline
Australia	Hollins et al. (2004) and Australian Transport (2019)
Australia (New South Wales)	Transport for NSW (2018)
Austria	Bundesministerium für Verkehr, Innovation und Technologie (2010 and 2011)
Belgium	Rebel Group Advisory (2013a, 2013b and 2013c)
Canada	Transport Canada (1994) and Treasury Board of Canada Secretariat (2007)*
Canada (British Colombia)	Ministry of Transportation and Infrastructure in British Colombia (2014) and Apex Engineering Limited (2018)
Denmark	Transportministeriet (2015)
European Union	European Commission (2014)
Germany	PTV Group, Transport Consulting International and Ulrich-Mann (2016)
Ireland	Department for Transport, Tourism and Sport (2016)
Netherlands	Centraal Planbureau (2013, 2018a and 2018b), Rijkswaterstaat (2018) and Romijn and Renes (2013)*
New Zealand	NZ Transport Agency (2018)
Norway	Statens vegvesen (2018)
Sweden	Trafikverket (2018)
Switzerland	Bundesamt für Strassen (2018)
United Kingdom	Department for Transport (2019)
United Kingdom (Scotland)	Transport Scotland (2019)
United States	Federal Highway Administration (2012), Transportation Research Board (2014), Weisbrod et al. (2014) and US Department of Transportation (2018)

Table 2. Overview of impacts with descriptions and categorization

Group	Market	Impact	Description
Economic	Direct	Construction costs	Costs of planning and implementation of the construction process
		Maintenance	Upkeep, system operating costs and infrastructure repair
		Resilience	Durability and resistance of the infrastructure
		Operator impacts	Income and costs for providers of public transportation
	Indirect	Economic performance	Agglomeration, competitiveness, productivity and innovation
		Imperfect markets	Lowering of market power exploitation from increased competition
		Labor market	Labor market participation and frictions
		Induced investments	Supply of fixed and financial assets except land and reinvestments
Economic or social (*depending on recipient*)	Direct	Direct journey costs	Operations and maintenance costs for means of transportation
		Journey timesavings	Value of travel timesavings through alternative time utilization
		Journey quality	Travel experience and spread in travel time values across modes
		Journey time reliability	Uncertainty in arrival and departure times for transportation
		Disruption from construction	Traffic diversion and community disturbances from construction
	Indirect	Land value and use	Supply and attractiveness of land areas
Social	Direct	Accidents and safety	Material damage, health costs and administrative costs
		Security	On-site prevention of crimes, terrorism and natural disasters
		Physical activity	Health and consumer gains from physical transport
		Option and non-option	Possibility or lack of possibility to utilize transportation services
	Indirect	Accessibility and connectivity	Access and connectivity to commodities, services and public goods
		Severance and relocation	Moving, physical or trade-flow related separation of neighborhoods
		Urban consumer variety	Consumer agglomeration and love of variety
		Affordability	Personal income and income-related social inclusion
		Cohesion and inclusion	Social inclusion beyond income, integration and unity in the society
Environmental	Direct	Local air pollution	Emissions of nitrogen oxides, sulfur oxides, dust and odorous
		Global air pollution	Emissions of climate gases such as carbon dioxide and methane
		Noise	Annoyance and health impacts from construction and traffic sounds
		Vibration	Annoyance and health impacts from construction and traffic quakes
		Solid waste	Garbage and abandoned assets
		Land contamination	Soil contamination, emission, acidification and carbon loss
		Water quality and quantity	Pollution affecting water purity and supply
	Indirect	Mitigation and clean-up	Cleaning and purification associated with pollution
		Biodiversity	Animals and plants at stock and individual levels
		Natural resources	Resource consumption and extraction in the nature
		Landscape	Esthetic perception of scenery, farming and geological heritage
		Townscape	Esthetic perception and visual intrusion in urban and built-up areas
		Cultural heritage	Historical buildings, areas and sites
Public	Direct	Direct tax costs	Costs related to tax funding of infrastructure constructions
		Public income	Income from public transportation and tolls
	Indirect	Indirect tax generation	Generation of tax income through higher tax base
		Tax distortion	Marginal of costs of public funds through public accounts impacts
		Emergency services	Accessibility and provision of emergency services
		Education services	Accessibility and provision of education services
		General policy integration	Integration of the spatial measures with general policy objectives
		Spatial policy integration	Integration of the spatial measures with spatial policy objectives

2.2. Meta-Analysis of Mappings on Impact Coverage

Earlier mappings of impact coverage in national appraisal guidelines have been identified in three ways. First, we have identified mappings through our network at AIT Austrian Institute of Technology, Institute of Transport Economics and Panteia, as well as in the Conference of European Directors of Roads. Second, we have identified earlier studies by identified by searches on regular Google Search and Google Scholar. Applied search words and phrases

in this regard include different combinations and variants of 'impact coverage', 'transpiration appraisal', 'spatial appraisal', 'national appraisal guidelines', 'economic impacts', 'social impacts', 'environmental impacts' and 'public impacts'. Third, we have applied backward and forward snowballing with basis in the reference lists of the identified mappings.

In our meta-analysis of impact mappings, we have sorted the impacts in earlier studies into the same classification as applied in our study. Based on the meta-analysis, we study how impact coverage for different sorts of impacts and countries' coverages evolve over time. For impacts, we measure the coverage against full coverage, while we for countries measure the coverage relatively to the widest coverage in each study. We distinguish between impact coverage in CB and overall. Some few impacts not captured by our study and transversal impacts such as 'residual value', 'distributional impacts', 'other benefits' and 'other costs' are omitted from comparison of impacts in different studies, but included when addressing overall impact coverage in each country or region. In studies that provide more than one impact mapping, we start from their most detailed impact classification and merge results across modes up to regional level or country level. In cases where impacts are much more narrowly or broadly defined in a study than in ours, we have omitted them from our comparison to ensure comparability. Some earlier mappings provide comparative discussions on impact coverage without explicitly summing up their findings in a table. In such incidents, we have summed up the findings on national impact coverage in tables based on their mapping.

In addition to assessing the development in impact coverage over time, we investigate the characteristics of countries with high and low impact coverage by econometric analyses in Stata. As our dependent variables in separate regressions, we use CB impact coverage and overall impact coverage compared to best practice. We make use of four regression models: general least square, Tobit, fractional probit and fractional logit. For observation i of a country's coverage compared to the widest coverage, let $\boldsymbol{y}_i$ be a vector of our two dependent variables, $\boldsymbol{x}_i$ be a vector of socio-economic explanatory variables, $\boldsymbol{D}_i$ be a vector of geographic dummies and $\boldsymbol{z}_i$ be a vector of control variables related to the study of observation.

In all cases, we cluster the regression's standard errors on countries and dependencies to avoid exaggeration of significance in the socio-economic explanatory variables' coefficients. We are less interested in the coefficients for our study control variables, so we do not co-cluster on each study, which implies that the significance level of these coefficients may be overestimated.

A linear least square (LS) specification as reported in equation 0 is included as a benchmark. Here, the error term is assumed to be normally distributed with standard errors clustered on regional unit. The limitation of $\boldsymbol{y}_i$ to the possibility range between 0 and 1 is neglected.

$$\boldsymbol{y}_i = \boldsymbol{x}_i\boldsymbol{\beta}_{x,LS} + \boldsymbol{D}_i\boldsymbol{\beta}_{\boldsymbol{D}_i,LS} + \boldsymbol{z}_i\boldsymbol{\beta}_{z,LS} + \boldsymbol{\varepsilon}_{i,LS} \quad (1)$$

To correct for the restriction in $\boldsymbol{y}_i$'s possibility range (e.g. estimated coverage below 0 or above 100 percent), we make use of the Tobit regression in equation (2). This regression model is linear between 0 and 1 and censored beyond these limits. $\boldsymbol{y}_i^*$ represents an unobserved modified version of $\boldsymbol{y}_i$, which equals $\boldsymbol{y}_i$ within the possibility range and may fall outside of the possibility range when $\boldsymbol{y}_i$ is at its limits. It is estimated by max. likelihood estimation.

$$\boldsymbol{y}_i^* = \boldsymbol{x}_i\beta_{x,Tobit} + \boldsymbol{D}_i\boldsymbol{\beta}_{\boldsymbol{D}_i,Tobit} + \boldsymbol{z}_i\boldsymbol{\beta}_{z,Tobit} + \boldsymbol{\varepsilon}_{i,Tobit} \quad (2)$$

with $\boldsymbol{y}_i = \min(\max(\boldsymbol{y}_i^*, 0), 1)$

As alternatives to the Tobit regression, we make use of fractional probit and fractional logit regression models, to address the robustness of our results. Both models build on quasi-maximum likelihood estimation and assume that the fractional distribution follows a probability distribution rather than being linear. The fractional probit model is assumed to follow the standard normal density distribution and is specified in equation 0.

$$\boldsymbol{y}_i = \phi\big(\boldsymbol{x}_i\boldsymbol{\beta}_{x,probit} + \boldsymbol{D}_i\boldsymbol{\beta}_{\boldsymbol{D}_i,probit} + \boldsymbol{z}_i\boldsymbol{\beta}_{z,probit} + \boldsymbol{\varepsilon}_{i,probit}\big) \quad (3)$$

The fractional logit model is defined analogously in equation (4) with basis in the logistic density function. Logit resembles probit, but it has somewhat

flatter tails in its frequency distribution. For both methods, we have recalculated the estimated coefficients to marginal effects, which correspond to the partial derivatives of the outcome variable with respect to each explanatory variable.

$$\boldsymbol{y}_i = \frac{\exp\left(\boldsymbol{\beta}_{x,logit}\boldsymbol{x}_i + \boldsymbol{D}_i\boldsymbol{\beta}_{\boldsymbol{D}_i,logit} + \boldsymbol{\beta}_{z,logit}\boldsymbol{z}_i + \boldsymbol{\varepsilon}_{i,logit}\right)}{1 + \exp\left(\boldsymbol{\beta}_{x,logit}\boldsymbol{x}_i + \boldsymbol{D}_i\boldsymbol{\beta}_{\boldsymbol{D}_i,logit} + \boldsymbol{\beta}_{z,logit}\boldsymbol{z}_i + \boldsymbol{\varepsilon}_{i,logit}\right)} \quad (4)$$

In our econometric meta-analysis, we attempt to capture how the explanatory variables are associated with impact coverage. As indicated by our presentation of the estimation techniques above, the respective estimation results will depend on the underlying impact coverage distributions implicitly assumed by each technique. Note that what we here interpret as impact coverage distributions in other applications commonly are interpreted as probability distributions. To get a better grip of the differences in distributional assumptions of each technique, we have illustrated the essence of the frequency and cumulative impact coverage distributions in Figure 1. The actual curves will of course depend on the estimation results, but the shapes of each distribution will be analogous to our example in the figure.

Our hypothesis is that the widest impact coverages are found in countries that are rich and egalitarian with large populations and a small degree of diffusion of appraisal responsibilities between different levels of governments. To investigate this, we make use of three socio-economic explanatory variables in $\boldsymbol{x}_i$ – inequality measured by the Gini Index, the natural logarithm of economic prosperity measured by gross domestic product by capita in fixed international 2011 dollars harmonized with the purchasing power parity and population size measured by the logarithm of population size. Data for the Gini index was gathered from the World Bank and supplemented with data from OECD, while data on population and GDP per capita in current prices were gathered from the International Monetary Fund. In case of years with missing data for Gini indexes, we have assumed the same index as the closest observation in time for missing observations in the outer range and linear growth between the closest observations in case of missing observations in the inner range. In case of countries and dependencies with missing data, we supplemented with data from national statistical agencies, and harmonized these with the data in the primary sources. In case of missing observations for population and GDP per capita in the outer range for dependencies, we have assumed the same growth rates from the closest observation as in the motherland.

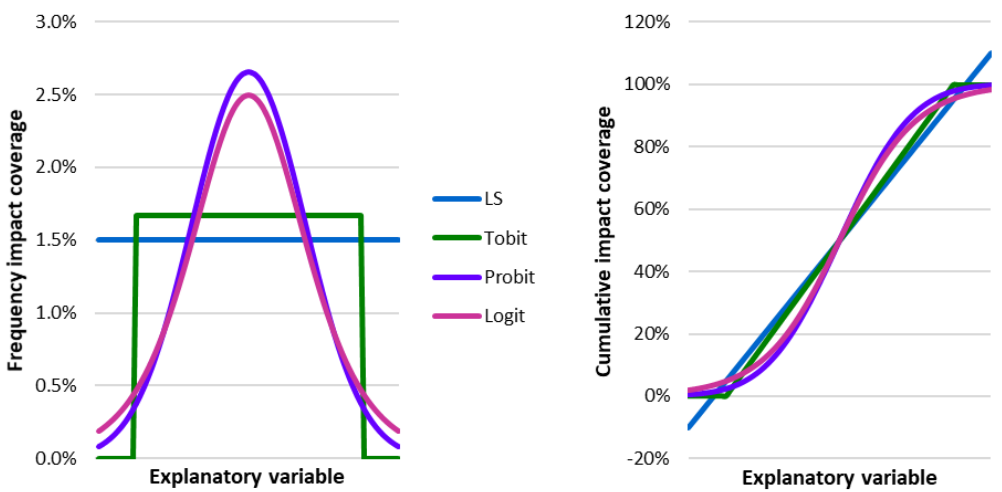


Fig. 1. Example illustration of the a) frequency cumulative impact coverage distributions (l.h.s.) and b) cumulative impact coverage distributions (r.h.s.) across estimation techniques.

We utilize two sets of geographic dummies in $\boldsymbol{D}_i$, which may capture socio-economic differences. The first set addresses how the regions are organized by attaching a common dummy to federal states, unions, states, supranational regions and dependencies, but not unitary countries. We experimented with splits of the first group, but chose a common dummy, since the coefficients were about the same. The second set concerns which world region the region is located in, including Europe, North America, Africa and Asia, and Oceania. Although the socio-economic explanatory factors are largely exogenous to the impact coverage in appraisal guidelines, they may reflect other omitted variables through correlation. For instance, prosperity is positively correlated with transportation investments, while inequality is negatively correlated with the relative size of the public sector. Thus, the results should be interpreted as correlation patterns and not be taken as causal effects.

Ideally, we should have applied a study-fixed effects model to adjust for differences between studies mapped in the meta-analysis. Yet, countries that are poor or located in certain regions are only represented once in the data, while explanatory variables change little over time. Instead, we control for the most important characteristics over studies and include regional dummies. The study-related control variables in $\boldsymbol{z}_i$ include the year of the investigation (which should not be confused with the year of publication) and the natural logarithms of the number of regions involved, in addition to best practice coverage compared to complete coverage in CB and overall, indirect impacts' share of impacts and the intercept coefficient. Note that the year trend could to some extent capture expansion to wider impact coverage over time, but it is also likely to be affected by broadening of the impact investigations over time.

3. An Updated Mapping on Impact Coverage

We will now depict the results from our updated mapping on impact coverage. Supplementary analyses on other indicators for the complexness and focus of different appraisal framework across countries are provided in appendix C.

3.1. Coverage of Different Sorts of Impacts

The overall impact coverage of the four impact groups in all public appraisal guidelines reviewed is shown in Figure 2. The results are of course dependent on how impacts are defined. The estimated value of the impacts defined (i.e. measured by money or utility measures) is not taken into account. For instance, our mapping suggests that public impacts have the lowest coverage among the impact groups, but this impact group would have had the widest coverage if impacts on public measures were to be excluded. Note that the scientific literature suggests that wider economic impacts often are of larger monetary value than other impacts omitted from CB (e.g. Holmen and Hansen 2020). Hence, the figure should not be taken literally, but it still gives an impression of how different impacts are captured.

Our results suggest that the overall impact coverage over impact groups is not too different. Economic impacts have the widest coverage both overall and in CB, followed by environmental impacts overall and social impacts in CB. SQ is most common for economic impacts and is commonly applied for wider economic impacts. MC is most common for environmental impacts, particularly for environmental capital impacts.

Many guidelines recognize wider economic impacts in terms of their potentially relatively large magnitude and thus recommend quantitative assessment. Yet, these estimations are only supplementary, due to the value estimates uncertainty, complex contextual dependency and possible overlap with impacts covered by the CB. In addition, wider economic impacts are caused by market failures in secondary markets, which implies a violation of the neoclassic perfect competition assumption assumed in CB (e.g. Holmen and Hansen 2020 and Wangsness, Rødseth and Hansen 2017). Analogously, environmental impacts dominate MC in most countries assessed. Public impacts have the poorest impact coverage both in CB and overall, followed by social impacts. Some social and public impacts are vaguely defined and often more focused upon in assessments of distributional aspects, stakeholder involvement and other policy objectives than the economic appraisal of efficiency impacts (see for instance Geurs, Boon and Van Wee 2009 and Holmen and Hansen 2020; e.g. 'affordability', 'cohesion and inclusion', 'general policy integration' and 'spatial policy integration' in the mapping). MC constitutes a relatively common appraisal tool for social impacts, while policy impacts often are recognized without being appraised as efficiency impacts.

In Figure 3, we depict how each impact is covered by the guidelines. Not surprisingly, impact coverage is generally wider for direct impacts than for indirect impacts. Yet, there are examples of indirect impacts of high coverage (e.g. economic performance, landscape and general policy integration) and direct impacts with low coverage (e.g. resilience, option and non-option value and security). Maintenance and construction costs[2] holds full CB coverage, which is expected, considering that these impacts regard the infrastructure directly. Other key impacts captured by CB in all countries include direct journey costs, journey time savings, accident and safety, and impacts on operators. Local and global air pollution and noise are also included in all guidelines reviewed. Yet, these impacts are occasionally assessed by other appraisal tools than CB. The poorest coverage is held by urban consumer variety and affordability. Impacts on urban consumer variety require large investments and are hard to measure, whereas the impacts on affordability are more connected to distribution (i.e. the distribution of social welfare cake pieces) than efficiency (i.e. the size of social welfare pie).

We see that production agglomeration is assessed through SQA by most guidelines, whereas landscape and townscape are the most common impacts addressed by MC. Among public impacts, general and spatial policy generation are widely acknowledged, but often not appraised as efficiency impacts. Direct impacts on tax generation are mostly accounted for, while public service provision and tax distortion have low coverage. Among social impacts, accidents and mixed socio-economic impacts hold the highest coverage, while security and social community impacts are recognized by about half of the guidelines.

3.2. Coverage in Different National Guidelines

It is not necessarily best practice to quantify as many impacts as possible in CB, considering the rationale behind MC and supplementary quantitative analyses, as these methods often are applied due to uncertainty in the quantitative estimates, potential overlaps and inconsistent assumptions. This can help to explain a correlation coefficient between CB and overall impact coverages of just 0.270 over guideline sets. In mappings of the width of the impact coverage over countries, the country rankings of impact coverage will be affected when the guidelines are updated. This has less impact on the ranking of the best practice guideline sets, which are commonly updated continuously. It will have more influence on the ranking of guideline sets that are less frequently updated over time.

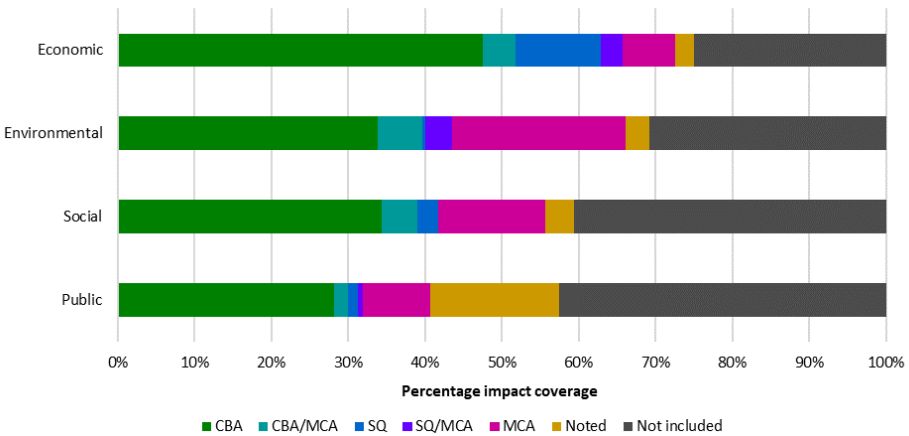


Fig. 2. Coverage of impact groups in all reviewed national guidelines across appraisal methods. Explanation of abbreviations applied in the table: CB – Cost-Benefit Analysis, MC – Multi-Criteria Analysis, SQ – Supplementary quantitative analysis

[2] Note that construction costs strictly speaking is costs of the transportation measure and not an impact of the spatial measure itself, but it can still be considered as an impact of the decision to carry out the spatial measure.

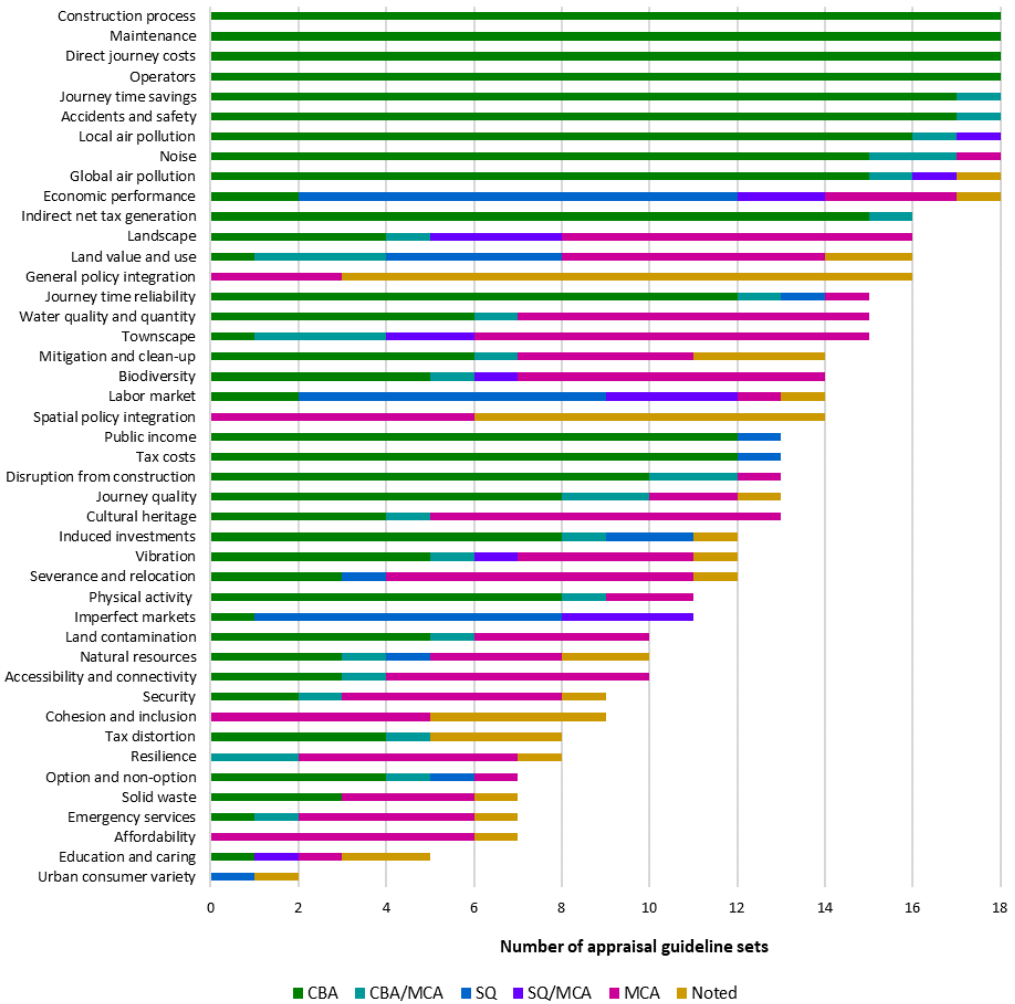


Fig. 3. Detailed coverage of impacts in all reviewed national guidelines for transportation appraisal across appraisal methods. Explanation of abbreviations applied in the table: CB – Cost-Benefit Analysis, MC – Multi-Criteria Analysis, SQ – Supplementary quantitative analysis

In Figure 4, we have illustrated the impact coverage and applied assessment tools over guideline sets. The detail level of the guidelines' impact descriptions varies quite a lot, but this does not show in the figure.

We see that Anglo-Saxon countries in Europe and Oceania have the widest impact coverage overall, including Scotland (widest coverage), New South Wales, the United Kingdom, Ireland, New Zealand and Australia. Among guidelines in other languages than English, the Dutch and Norwegian guideline sets holds the widest impact coverage. The lowest overall impact coverages are found in North America (i.e. Canada and the United States), and in European countries with both relatively small population and land areas (i.e. Denmark and Switzerland).

The Anglo-Saxon dominance is however less prevalent for CB and quantification impact coverages. New Zealand has the widest CB impact coverage, followed by Austria and the European Union. The

widest quantitative impact coverages are found in New Zealand, followed by the European Union, Belgium and the Netherlands. The lowest CB impact coverage is found in Germany followed by the United States, Australia and Switzerland, while the lowest quantitative impact coverage is found in Germany followed by the United States and Switzerland. Admittedly, much of the impact coverage in many American and Canadian states and territories is wider than national guidelines suggest, considering that there are many guidelines at state level (exemplified by British Columbia in Canada in our mapping). Contribution schemes at national and state level also demand economic appraisal at a level of detail that could go beyond the guidelines reviewed. In addition, the Canadian and American guidelines are older than the other guidelines, and the private sector plays a more prominent role in infrastructure investments. In addition, environmental impacts are often conducted in separate environmental impact assessments (see for instance Weisbrod 2013).

A detailed summary of our results is provided in Tables 3.A. and 3.B. The tables reveals that the countries with the poorest overall impact coverage have fallen behind in particular when it comes to inclusion of social and environmental impacts (e.g. the United States, Canada, Belgium, Denmark and Switzerland). For the countries with the widest overall impact coverage (e.g. New Zealand, Scotland, New South Wales, the United Kingdom, Ireland, the Netherlands and Norway), the omitted impacts from the guidelines are more evenly distributed over impact groups, except for public accounts impacts, which are covered by most guidelines with high impact coverage. Countries with relatively high overall impact coverage, but more mediocre CB impact coverage, typically appraise social and environmental impacts by MC.

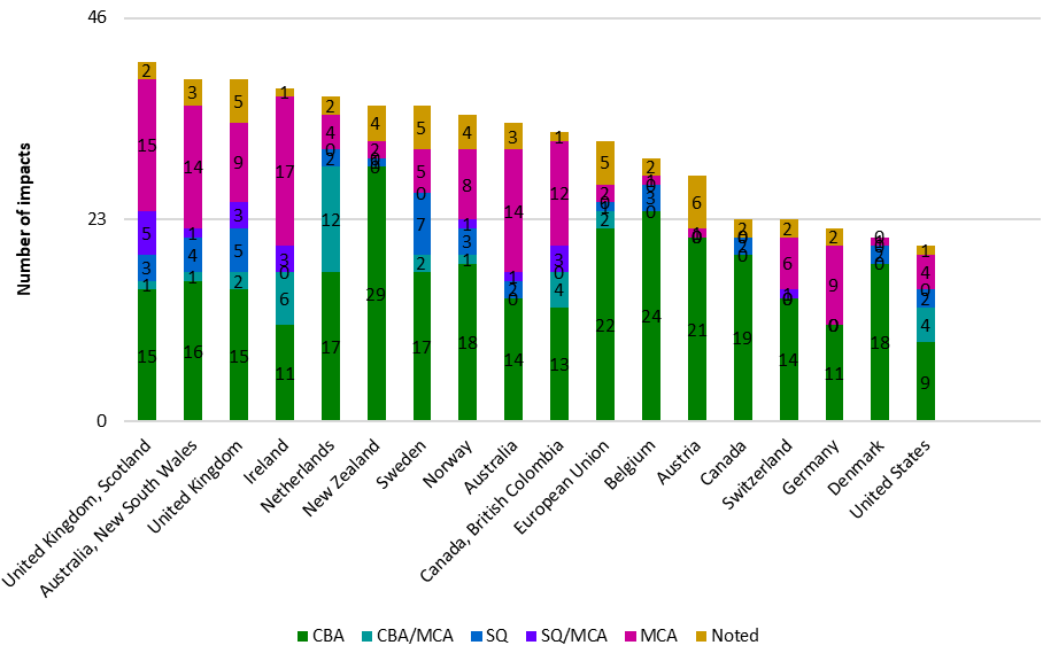


Fig. 4. Total coverage of impacts in national guidelines across appraisal methods and countries. Explanation of abbreviations applied in the table: CB – Cost-Benefit Analysis, MC – Multi-Criteria Analysis, SQ – Supplementary quantitative analysis

Table 3.A. Overview over coverage of impacts across national guidelines for transportation appraisal. Explanation of abbreviations applied in the table: CB – Cost-Benefit Analysis, MC – Multi-Criteria Analysis, SQ – Supplementary quantitative analysis, spat. – spatial appraisal, trsp. – transportation appraisal, AT – Austria, AU – Australia, NSW – New South Wales, BE – Belgium, CA – Canada, BC – British Colombia, CH – Switzerland, DE – Germany, DK – Denmark

Group	Impact \ Country	AT	AU	AU-NSW	BE	CA	CA-BC	CH	DE	DK
Economic	Construction process	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Maintenance	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Resilience	MCA	MCA	MCA					MCA	
	Operators	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Economic performance	Noted	SQ	SQ	SQ	SQ	MCA	SQ/MCA	MCA	SQ
	Imperfect markets		SQ	SQ	SQ					SQ
	Labor market	Noted	SQ/MCA	SQ/MCA	SQ					CBA
	Induced investments	CBA	CBA		CBA		CBA			CBA
Economic or social (*depending on recipient*)	Direct journey costs	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Journey time savings	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Journey quality		MCA	CBA	CBA			Noted	MCA	
	Journey time reliability		CBA	CBA	CBA	CBA	MCA	CBA	CBA	
	Disruption from construction	CBA	CBA	CBA	CBA	CBA	MCA			CBA
	Land value and use	Noted	MCA	CBA/MCA		SQ	MCA	MCA	MCA	
Social	Accidents and safety	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Security		MCA	MCA		CBA				
	Physical activity	CBA	MCA	MCA						CBA
	Option and non-option			CBA		CBA	MCA			
	Accessibility and connectivity		MCA	CBA		CBA	MCA		MCA	
	Severance and relocation	CBA	MCA	MCA	CBA		MCA		CBA	
	Urban consumer variety									
	Affordability		MCA	MCA			MCA			
	Cohesion and inclusion	Noted	Noted	MCA				MCA		
Environmental	Local air pollution	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Global air pollution	CBA	CBA	CBA	CBA	Noted	CBA	CBA	CBA	CBA
	Noise	CBA	CBA	CBA	CBA	CBA	CBA/MCA	CBA	CBA	CBA
	Vibration	CBA	MCA	MCA	CBA		CBA/MCA			
	Solid waste			MCA			CBA			
	Land contamination	CBA		MCA	CBA	CBA	CBA/MCA			
	Water quality and quantity	CBA	MCA	MCA	CBA	CBA	CBA/MCA	MCA		
	Mitigation and clean-up		CBA	CBA		CBA	MCA			CBA
	Biodiversity	CBA	MCA	MCA	CBA	CBA	SQ/MCA			
	Natural resources	CBA		Noted	CBA		MCA	CBA	MCA	
	Landscape	CBA	MCA	MCA	CBA	CBA	SQ/MCA	MCA	MCA	
	Townscape	CBA	MCA	MCA	MCA		SQ/MCA	MCA	MCA	
	Cultural heritage	CBA	MCA	MCA	CBA				MCA	
Public	Tax costs			SQ	CBA		CBA	CBA		CBA
	Public income			SQ	CBA		CBA	CBA		CBA
	Indirect net tax generation		CBA	CBA	CBA	CBA	CBA	CBA		CBA
	Tax distortion			Noted		Noted				CBA
	Emergency services						MCA			
	Education and caring		Noted							
	General policy integration	Noted	Noted	Noted	Noted		Noted	Noted	Noted	MCA
	Spatial policy integration	Noted			Noted		MCA	MCA	Noted	

Table 3.B. Overview over coverage of impacts across national guidelines for transportation appraisal. Explanation of abbreviations applied in the table: CB – Cost-Benefit Analysis, MC – Multi-Criteria Analysis, SQ – Supplementary quantitative analysis, spat. – spatial appraisal, trsp. – transportation appraisal, EU – European Commission, IE – Ireland, NL – Netherlands, NO – Norway, NZ – New Zealand, SE – Sweden, UK – United Kingdom, SC – Scotland, US – United States

Group	Impact \ Country	EU	IE	NL	NO	NZ	SE	UK	UK-SC	US
Economic	Construction process	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Maintenance	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Resilience			CBA/MCA			CBA/MCA		Noted	MCA
	Operators	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Economic performance	MCA	SQ/MCA	CBA	SQ	CBA	SQ	SQ	SQ	SQ
	Imperfect markets		SQ/MCA	SQ	SQ/MCA	CBA	SQ	SQ/MCA	SQ	
	Labor market	MCA	SQ/MCA	SQ	SQ	CBA	SQ	SQ	SQ	SQ
	Induced investments	SQ		CBA/MCA	CBA	CBA	CBA	SQ	Noted	
Economic or social (*depending on recipient*)	Direct journey costs	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Journey time savings	CBA	CBA/MCA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Journey quality	CBA	CBA/MCA	CBA/MCA	CBA	CBA	CBA	CBA	CBA	
	Journey time reliability	CBA	CBA/MCA	CBA	CBA		CBA	SQ	CBA	CBA
	Disruption from construction	CBA	CBA	CBA/MCA	CBA/MCA	CBA		CBA		
	Land value and use	CBA	MCA	CBA/MCA	SQ	Noted	SQ	SQ	MCA	CBA/MCA
Social	Accidents and safety	CBA	CBA	CBA/MCA	CBA	CBA	CBA	CBA	CBA	CBA
	Security			CBA/MCA	Noted	CBA		MCA	MCA	MCA
	Physical activity		CBA	CBA/MCA	CBA	CBA	CBA	CBA	CBA	
	Option and non-option					CBA	SQ	CBA/MCA	CBA	
	Accessibility and connectivity		CBA/MCA		CBA	MCA		MCA	MCA	
	Severance and relocation		MCA	Noted		SQ	MCA	MCA	MCA	
	Urban consumer variety						SQ	Noted		
	Affordability		Noted	MCA				MCA	MCA	
	Cohesion and inclusion	Noted	MCA	MCA				Noted	MCA	
Environmental	Local air pollution	CBA	CBA/MCA	CBA	CBA	CBA	CBA	CBA	SQ/MCA	CBA
	Global air pollution	CBA	CBA/MCA	CBA	CBA	CBA	CBA	CBA	SQ/MCA	CBA
	Noise	CBA	MCA	CBA	CBA	CBA	CBA	CBA	CBA	CBA/MCA
	Vibration	CBA	MCA			CBA	Noted	SQ/MCA	CBA	MCA
	Solid waste	CBA	MCA	CBA				Noted	MCA	
	Land contamination	CBA	MCA	CBA	MCA				MCA	
	Water quality and quantity	CBA	MCA	CBA	MCA	CBA	MCA	MCA	MCA	
	Mitigation and clean-up	Noted	MCA	CBA	MCA	CBA	Noted	CBA/MCA	MCA	Noted
	Biodiversity	CBA	MCA	CBA/MCA	MCA	CBA	MCA	MCA	MCA	
	Natural resources			CBA/MCA	MCA	Noted	SQ			
	Landscape	CBA/MCA	MCA	MCA	MCA	CBA	MCA	SQ/MCA	SQ/MCA	
	Townscape	CBA/MCA	MCA	CBA/MCA	MCA	MCA	CBA/MCA	MCA	SQ/MCA	
	Cultural heritage	CBA	MCA	CBA/MCA	MCA	CBA	MCA	MCA	MCA	
Public	Tax costs	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	
	Public income	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	
	Indirect net tax generation	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA/MCA
	Tax distortion	Noted	CBA		CBA		CBA		CBA/MCA	
	Emergency services		MCA		Noted	CBA		MCA	MCA	CBA/MCA
	Education and caring		MCA			CBA	Noted		SQ/MCA	
	General policy integration	Noted	MCA	Noted	Noted	Noted	Noted	Noted	MCA	
	Spatial policy integration	Noted	MCA	MCA	Noted	Noted	Noted	Noted	MCA	MCA

4. Meta-Analysis of Mappings on Impact Coverage

We now present a meta-analysis of impact coverage in national appraisal guidelines for transportation, where we address the development in impact coverage over countries and impacts. Furthermore, we investigate what characterizes countries with wide impact coverage. A supplementary review of the studies in our meta-analysis, as well as related studies, are provided in appendix A.

4.1. Studies Included in the Meta-Analysis

Our meta-analysis of impact coverage in national appraisal practices covers ours and 15 earlier mappings. The mappings reviewed vary in many ways, inter alia in catchment of geographical area, transportation modes and types of impacts. In order to summarize the findings in earlier mappings of impact coverage in a compact, yet meaningful way, we have colored all studies mapped systematically in accordance with their scope in terms of geography, spatial modes and sort of appraisal.

Green and blue indicate that studies cover all transportation modes and impact groups with geographic catchment in the World and Europe respectively. Bilateral comparisons covering all transportation modes and impact groups are colored yellow. Mappings only covering road are colored cyan, while mappings only covering rail are colored pink. Studies focused on a particular impact group are colored purple. In addition, we shade studies in gradually darker colors the newer they are. The studies reviewed are listed in Table 4 with color codes.

Beyond the countries included in our comparison, some mappings shed light on impact coverage in other countries and dependent areas (e.g. Australia, Italy and Japan in Gleave 2004 and Minnesota and Washington State in Kamis 2004). However, these results were not directly comparable to the results from other countries and dependencies, and for that reason they are omitted. We have supplemented the study of Wangsness, Rødseth and Hansen (2017) with findings on dependencies documented in a related report (Wangsness, Rødseth and Hansen 2014). In addition to the detailed impact mapping of HEATCO, the research project encompasses a mapping of impact coverage across transportation modes with a more aggregate impact classification (e.g. Odgaard, Kelly and Laird 2006, which extends the work of Odgaard, Kelly and Laird 2005). These mode-specific mappings are to some extent discussed, but they are not included in our quantitative assessment.

Again, impact coverage is recognized as the percentage of some impacts that are covered by some guidelines. We both look at coverage for specific impacts and for specific countries or dependencies. The widest impact coverage in a study is typically lower than full coverage. How large these wedges are, depends on what impacts, regional units and modes of transportation that are assessed at what time. There are also considerable differences in how many direct and indirect effects are included and which impact group each study focuses on. For instance, Gwee, Currie, and Stanley 2011 and Olsson, Økland and Halvorsen (2012) focus mainly on direct impacts across impacts groups, while Geurs, Boon and Van Wee (2009) and Wangsness, Rødseth and Hansen (2017) focus on indirect impacts for particular impact groups. An overview over these characteristics of the studies in the meta-analysis is provided in Figure 5.

4.2. Coverage of Different Sorts of Impacts

Our mapping of developments in impact coverage for different impacts shows that impact coverage has generally broadened over time, as depicted in Figure 6. These illustrations contain a lot of information and become much easier to read if one is aware of the color codes accounted for in subsection 4 and of the fact that the studies are sorted chronologically according to each study's publication year. There are some exceptions where the coverage appears to have become narrower, but these are mostly due to differences in country selection, impact definition and definition of coverage, not narrower impact selection. Moreover, the improvements in impact coverage are larger for CBA than overall and larger for indirect effects than direct effects, in line with the ex-ante potential for improvements.

Among wider economic impacts, economic performance has reached full overall impact coverage and land use and prices have reached nearly full coverage in the most recent mappings, which is a significant improvement from rather low coverages in studies in the early 2000s. Meanwhile, the corresponding development in CBA impact coverage is more unclear, possibly due to different handling of the coverage definitions. Similar development pat-

terns are seen for impacts on labor markets and imperfect competition, although the impact coverage here is narrower and fewer earlier mappings have addressed these impacts. The impact coverage for induced investments was only mapped by Wangsness, Rødseth and Hansen (2014 and 2017) before our mapping, with a strong progression since this study.

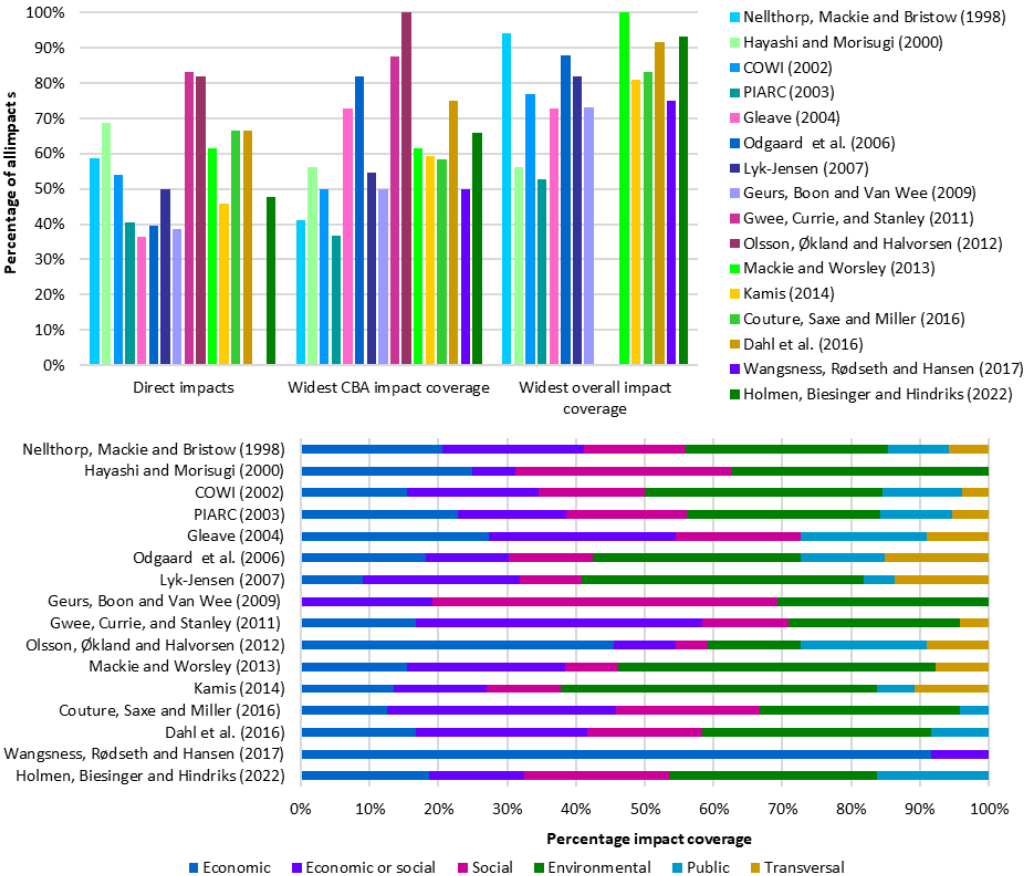
In all studies assessed, most countries have covered the largest direct economic and social impacts in monetary terms (e.g. maintenance, construction process, direct journey costs, journey timesavings and accident and safety), and today's coverage of these impacts is practically complete. Other direct social and economic impacts with more than fifty percent CBA impact coverage include operator impacts, journey time reliability and journey time quality. The coverage of these impacts appears to have decreased in our study, compared to the most recent earlier mappings. This is however due to more limited country selection in the earlier studies and may also reflect that appraisal coverage is considered differently in different studies. Three impacts have not been mapped at all in earlier mappings (i.e. urban consumer variety, education and caring, solid waste), while two impacts were only included in bilateral comparisons (i.e. resilience and physical activity).

Among wider economic impacts, economic performance has reached full overall impact coverage and land use and prices have reached nearly full coverage in the most recent mappings, which is a significant improvement from rather low coverages in studies in the early 2000s. Meanwhile, the corresponding development in CBA impact coverage is more unclear, possibly due to different handling of the coverage definitions. Similar development patterns are seen for impacts on labor markets and imperfect competition, although the impact coverage here is narrower and fewer earlier mappings have addressed these impacts. The impact coverage for induced investments was only mapped by Wangsness, Rødseth and Hansen (2014 and 2017) before our mapping, with a strong progression since this study.

Table 4. Mappings reviewed in the meta-analysis with descriptive statistics. Studies marked in bold is recognized as main studies, where the year of publication is used as study year. * indicates this study.

Scope			Notation		Mapping	Catchment	
Location	**Modes**	**Group**	**Method**	**Color**	**Studies**	**Regions**	**Impacts**
World	All	All	All	Green	**Hayashi and Morisugi (2000)**	5	16
World	All	All	All	Green	**Mackie and Worsley (2013)** and Mackie and Worsley (2014)	7	13
World	All	All	All	Green	**Couture, Saxe and Miller (2016)**	4	24
World	All	All	All	Green	**Holmen, Biesinger and Hindriks (2022)***	18	44
Europe	All	All	All	Blue	**Nellthorp, Mackie and Bristow (1998)**, Bristow and Nellthorp (2000), Grant-Muller et al. (2001) and Marcial Echenique & Partners et al. (2001)	34	15
Europe	All	All	All	Blue	**COWI (2002)**	8	26
Europe	All	All	All	Blue	**Odgaard, Kelly and Laird (2005** and 2006**)**	26	33
Europe	All	All	All	Blue	**Lyk-Jensen (2007)**	4	22
World	All	All	All	Yellow	**Kamis (2014)**	2	38
Europe	All	All	All	Yellow	**Dahl et al. (2016)**	2	12
World	Road	All	All	Cyan	**PIARC (2003)**	18	57
World	Rail	All	All	Pink	**Gleave (2004)**	5	11
World	Rail	All	CBA	Pink	**Gwee, Currie, and Stanley (2011)**	12	24
Europe	Rail	All	CBA	Pink	**Olsson, Økland and Halvorsen (2012)**	7	22
Europe	All	Economic	All	Purple	**Geurs, Boon and Van Wee (2009)**	2	26
World	All	Social	All	Purple	**Wangsness, Rødseth and Hansen** (2014 and **2017**)	32	12

Fig. 5. Direct impacts' share of all impacts and widest impact coverage in CBA and overall (top) and distribution of impacts over recipient-based impact groups (bottom) in the studies in the meta-analysis



Most countries also include disruptions from construction in their appraisals, with clear progress in both overall and CBA impact coverages compared to earlier mappings. There are no clear improvements in the coverage for the remaining social impacts, except for the overall impact coverage for cohesion and inclusion, physical activity and possibly security, and the CBA impact coverage for option and non-option values. For many of these, the overall impact coverage appears to have deteriorated (i.e. accessibility and connectivity and affordability) or shows no clear pattern (i.e. severance and relocation and option and non-option). Analogously, CBA impact coverage seems to have worsened for severance and relocation, and cohesion and inclusion, and shows no clear development for accessibility and connectivity.

The CBA impact coverage for local and global air pollution and noise is also nearly complete today, but was far poorer ten to twenty-five years ago. Other environmental impacts with clear progress in coverage both in CBA and overall include landscape, townscape and vibration.

There are signs of wider impact coverage of biodiversity, water quality and quantity and natural resources as well, but these patterns are less clear except for the CBA coverage of natural resources. Also mitigation and clean-up, cultural heritage and land contamination show clear tendencies towards improved overall coverage- Surprisingly, their CBA

impact coverages have seemingly decreased in recent years, but this is due to different country selections.

Most public impacts show progress in overall impact coverage, although general policy integration and tax costs show more uneven growth patterns than the others (i.e. indirect tax generation, spatial policy integration and emergency services). Indirect tax generation and tax costs show similar development patterns overall with current CBA impact coverages above fifty percent. However, tax distortion and public income show apparent declines in coverage overall and in CBA, which appears to be caused by country selection. General policy integration also seems to get worse coverage in CBA, but this is probably caused by different criteria for being recognized as CBA impact coverage.

4.3. Impact Coverage in Different National Guidelines

In Figure 7, we show how extensive impact coverage different countries and dependencies have had in CBA and overall, compared to the country or dependency with the highest impact coverage. As in Figure 6, these complex figures become easier to read when one is aware of the color codes presented in subsection 4 and the fact that the studies are sorted chronologically according to each study's publication year. In addition to the coverage depicted in the figures, some independent countries and dependencies come out of studies with zero coverage.

Looking at earlier mappings of impact coverage, Western European countries dominate both the lists of countries with the most extensive coverage and the list of countries being investigated. The United Kingdom had both the widest CBA and overall impact coverage in Hayashi and Morisugi (2000), as well as the widest overall impact coverage in Gleave (2004), Odgaard, Kelly and Laird (2005) and Couture, Saxe and Miller (2016). The United Kingdom also has the widest overall impact coverage for transportation modes (aviation, inland waterways, railways, roads and seaways) in Odgaard, Kelly and Laird (2006). Scotland has the widest overall impact coverage in our mapping and also performs well in Wangsness, Rødseth and Hansen (2019). Generally, the British guidelines have come out with wide overall coverage in all previous mappings, but they have been somewhat reluctant to include impacts in CBA. The Netherlands do not perform well in earlier mappings, having the poorest CBA impact coverage in both COWI (2002) and PIARC (2003). Since then however, the Netherlands have been close to the best practice frontier. In Odgaard, Kelly and Laird (2005), the country had the widest coverage in CBA and close to the widest overall. In addition, the authors find that the Netherlands is among the countries with widest CBA impact coverage in aviation appraisal. The country also had the widest impact coverage in Geurs, Boon and Van Wee (2009), Mackie and Worsley (2013) and Wangsness, Rødseth and Hansen (2017), as well as both the widest CBA and overall impact coverage in the bilateral comparison of Kamis (2012).

Germany had the widest CBA and quantitative impact coverage in early mappings including Nellthorp, Mackie and Bristow (1998), COWI (2002) and PIARC (2003). Germany also has close to the widest CBA impact coverage in Odgaard, Kelly and Laird (2006) and is among the countries with the widest CBA impact coverage in case of inland waterways. Yet, the width of the German impact coverage has fallen behind best practice, partly because the Germans have taken a restrictive stand as to what impacts are to be appraised, as also argued and exemplified by Dahl et al. (2016). In the bilateral comparison of German and French appraisal practices conducted by Dahl et al. (2016), the countries have the same level of CBA impact coverage, while Germany has slightly wider overall impact coverage. France and the European Union have mostly decent impact coverage where they are included, without standing out in any way.

Although holding one of the widest overall impact coverages in COWI (2002), France ranked as one of the countries with poorest overall impact coverage in the mapping of Nellthorp, Mackie and Bristow. This partly illustrates how impact classification affects such rankings and partly reflects the presence of a wider impact coverage in COWI than in Nellthorp, Mackie and Bristow (e.g. new coverage for conformity to sector plans, land use, landscape and social cohesion), which could be seen in relation to the update in the French guidelines in 2001.

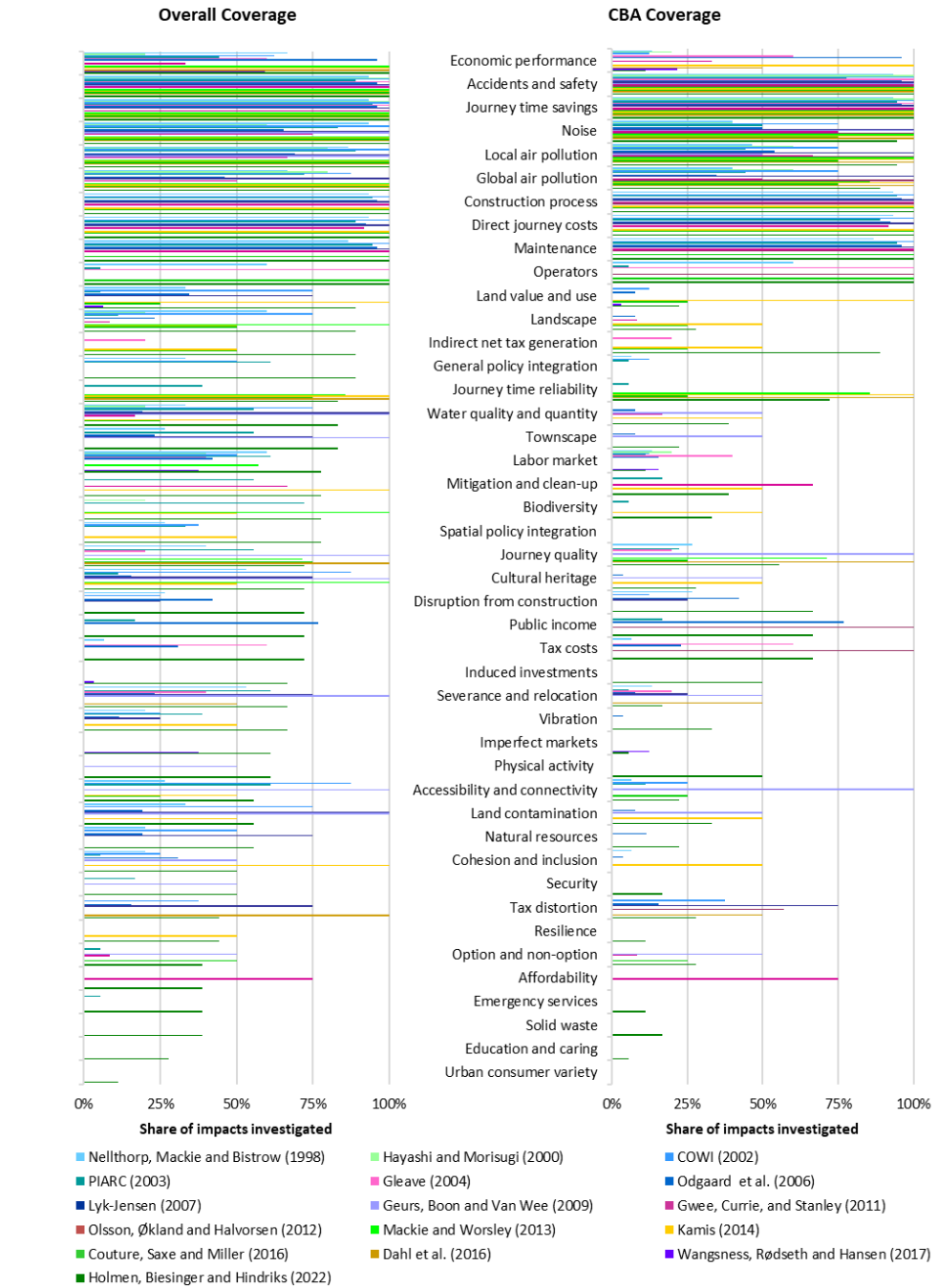


Fig. 6. Impact coverage over impacts and mappings for a) all appraisal methods (l.h.s.) and b) CBA only (r.h.s.) for all countries in each study

Ireland had superior overall impact coverage in Wangsness, Rødseth and Hansen (2017) and solid overall impact coverage in our mappings, while the Irish impact coverage has been less extensive in CBA and in earlier mappings. An exception is the aggregate impact mapping of roads in HEATCO, where Ireland was identified to provide full impact coverage inter alia together with Switzerland. Elsewise, Switzerland and Austria have had moderate impact coverage in earlier mappings, Switzerland performing particularly poorly in PIARC (2003) with one of the lowest impact coverages both in CBA and overall. Among Western European countries, Belgium has the poorest performance across mappings.

The Nordic countries have had relatively good impact coverage in most mappings they are involved in. Sweden, Finland and Norway have had relatively better overall impact coverage than CBA impact coverage. On the other hand, Denmark distinguishes itself as a country with relatively high CBA impact coverage, but limited use of other appraisal methods. Finland had among the widest quantitative impact coverages in Nellthorp, Mackie and Bristow (1998) and overall impact coverage in COWI (2002), both investigations on European countries. Denmark has the widest CBA impact coverage in European rail appraisal in the investigation by Olsson, Økland and Halvorsen (2012). Although Denmark had decent CBA impact coverage in both Nellthorp, Mackie and Bristow (1998) and COWI (2002), the country also had the lowest impact coverage overall due to the fact that it uses neither MCA nor SQ. Norway is close to best practice both in the context of CBA and overall impact coverage in PIARC (2003). Investigating European impact coverage for peculiar transportation modes with the aggregate impact classification in HEATCO, Odgaard, Kelly and Laird (2006) find that Denmark, as the sole country, has the widest CBA and overall impact coverage for appraisal of both roads and railways. Furthermore, Sweden and Finland constitute two of the countries with the widest CBA impact coverage within seaways and inland waterways. Sweden also has the widest CBA impact coverage for aviation appraisal, while both Finland and Sweden were among the countries with widest impact coverage for seaways. In her investigation on appraisal practices in the Nordic countries, Lyk-Jensen (2007) shows that these countries have rather similar impact coverages, focusing much on direct and environmental impacts. Denmark has the widest CBA impact coverage in the investigation, while Norway provides a wider coverage overall.

Eastern European countries appear in the mapping of PIARC (2003) and HEATCO, and are far behind in CBA impact coverage according to both studies. Yet they perform relatively better on overall impact coverage, especially the Czech Republic and Hungary. In PIARC (2003), Hungary comes out as one of the countries with widest overall impact coverage. In HEATCO, the overall impact coverage was above 50 percent of best practice in Lithuania, Poland and the Slovak Republic, while it was below 50 percent of best practice in Estonia, Slovenia and Latvia, where Latvia had close to the poorest coverage. Lithuania is also among the countries with widest overall impact coverage in appraisal of seaways, while the Slovak Republic had full overall impact coverage for road appraisal (Odgaard, Kelly and Laird 2006).

In their extensive investigation, Nellthorp, Mackie and Bristow (1998) rank Greece as the country with highest impact coverage overall. In contrast with this, PIARC (2003) find that Portugal had the poorest impact coverage. In his investigation of impact coverage in railway appraisal, Gleave (2004) ranks Spain as best practice both in CBA and overall. However, the Southern European countries make a poor appearance in Odgaard, Kelly and Laird (2005) with lowest impact coverage among the European regions. Impact coverage is particularly low in Cyprus, Malta and Portugal, with Portuguese impact coverage coming out as the poorest in the whole mapping both in CBA and overall. Yet, Cyprus and Malta have far smaller population sizes than other countries investigated. Greece, Italy and Spain had rather moderate coverages.

United States and Canada have been far from best practice in the recent mappings where they are represented. United States is among the countries with widest overall impact coverage in PIARC (2003), but has had a negative trend compared to best practice since then. Kamis (2014) lists several impacts in the appraisal documents for Washington State and Minnesota which are neither included in the Dutch nor the American federal appraisal guidelines. Gwee, Currie, and Stanley (2011) find that the United States had close to the widest CBA impact

coverage in railway appraisal. Couture, Saxe and Miller (2016) find that the Greater Toronto-Hamilton Areas (i.e. central Ontario) had a relatively wide impact coverage. They argue that the Canadian appraisal methodology has fallen behind due to lack of recent updates of the national guidelines. In our own mapping, British Columbia had the widest impact coverage in North America, while Canada have not introduced new guidelines since the previous mappings.

Mexico and South Africa were only represented in PIARC (2003), both having decent overall impact coverage and CBA impact coverages less than half of best practice. Among Asian countries, Japan was measured as just best practice both in CBA and overall in Hayashi and Morisugi (2002), but in PIARC (2003) the Japanese guidelines were among the least developed. Hong Kong, Singapore and South Korea are only presented in Gwee, Currie and Stanely (2011). In this study, Singapore and Japan had the poorest CBA impact coverage followed by Hong Kong. The Japanese guidelines neglected congestion, while neither Hong Kong nor Singapore accounted for environmental impacts. The coverage in the South Korean guideline was somewhat wider than in the other Asian countries investigated, but still far from best practice.

Despite its relatively low population size, Oceania stands out as the world region with the widest impact coverages besides Northern and Western Europe. Australia's overall impact coverage at national level has evolved to be close to best practice, while the CBA impact coverage has fluctuated more. Australia held the widest CBA impact coverage in the mapping of rail appraisal by Gwee, Currie, and Stanley (2011), while the country's CBA impact coverage is only half of best practice in our own mapping. For many years, the Australians omitted global air pollution from their CBA, since this externality already was addressed by a carbon tax.

New South Wales mostly performs well with impact coverages close to best practice both in CBAs and overall, inter alia holding The Australian state had the widest overall impact coverage in Mackie and Worsley (2013). Victoria only had mediocre impact coverage for railways in Gleaves (2004), but it was compared to far larger independent countries which, unlike the Australian state, had built high-speed railways at the time. New Zealand also comes out with relatively wide CBA and overall impact coverage, having the widest overall impact coverage in Mackie and Worsley (2013) and our mapping and close to the widest CBA impact coverage in PIARC (2003) and Gwee, Currie, and Stanley (2011).

For some countries various components of transportation appraisal are a part of their legal framework, which could expedite inclusion of impacts (e.g. injunction of environmental appraisal by the National Environmental Policy Act in the United States and appraisal requirements in EU and WTO funded projects). However, legal frameworks can also have the reverse effect (e.g. late inclusion of global air pollution in CBA in Australian appraisal).

4.4. Explanatory Factors for National Impact Coverage

Differences in appraisal practices are not random, but they are related to socio-economic circumstances. In Table 5, we depict our empirical results on explanatory factors for national impact coverage in CBA and overall, based on the methodology accounted for in subsection 2. We remind the reader that each observation represents a regional unit in a study. It should be noted that most regions in our investigations are or belong to developed countries.

The different methods applied provide rather similar results. Moreover, none of the estimates for marginal impacts across methods are significantly different from each other. Linear least squares (LS) violates the condition of coverage being between 0 and 1. Among the three other methods that we employ, we do not know a priori which is the most correct in our case. Moreover, it will depend on whether the true distribution of impact coverage nearly follows a truncated linear distribution (Tobit), a standard normal distribution (probit) or a logistic distribution (logit). We will not investigate the details on this matter, but rather interpret the similarities in the estimates as signs of robustness.

Rationales for investigating whether prosperity covaries with impact coverage could be that more developed countries are richer partly due to more advanced technologies and have more money to spend on spatial investments and planning. Such a relationship seems to materialize in a comparison of high-income and low-income countries, but it is not as obvious what to expect in a more homogenous sample consisting of mainly developed countries. Our results imply that one percent higher GDP per capita in current prices suggests approximate 0.06 percent

higher CBA impact coverage. This result is significant at 10 percent significance level. In principle, GDP per capita in current prices capture inflation in addition to real output, but here we apply year trend as one of our controls to limit this challenge.

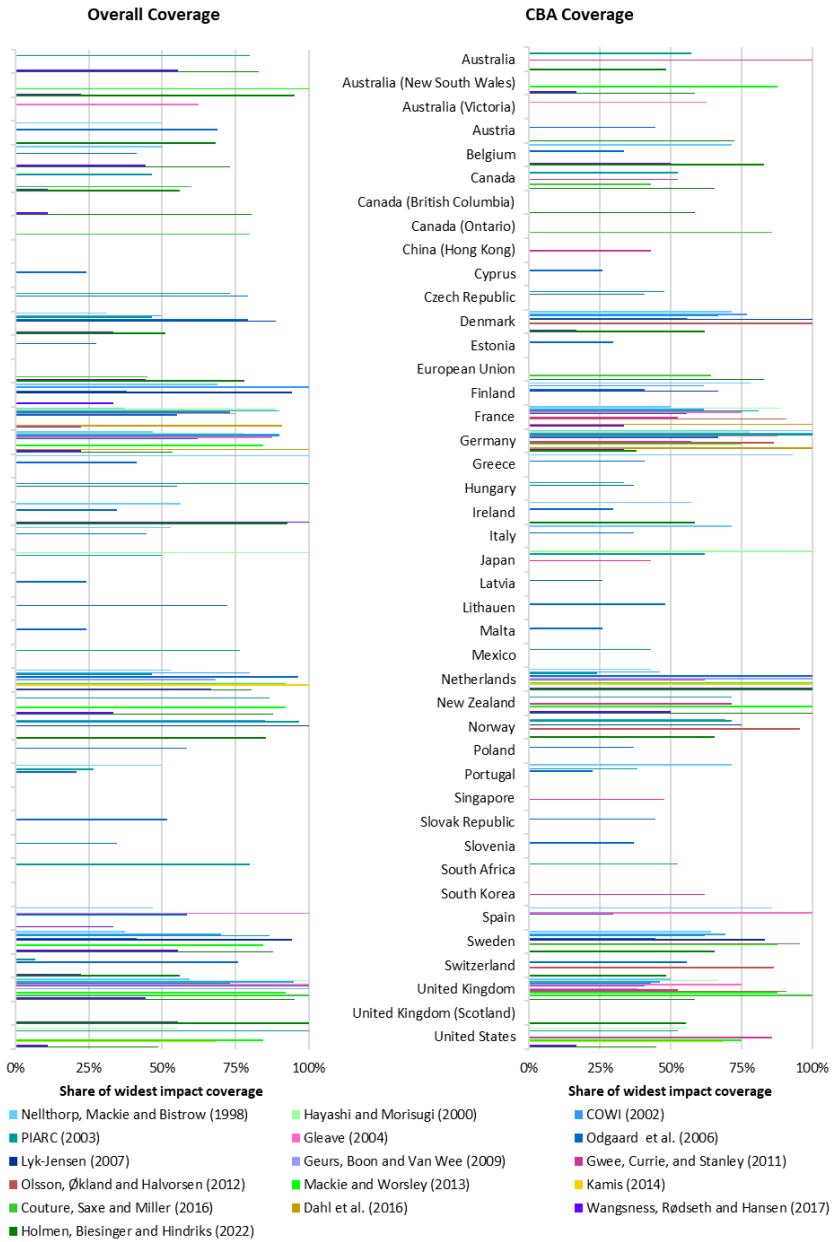


Fig. 7. Total impact coverage over countries and mappings for a) all appraisal methods (l.h.s.) and b) CBA only (r.h.s.), benchmarked against the country in the investigation with widest coverag

Table 5. Explanatory factors for CBA and overall impact coverage in national appraisal practices (stars show significance at * 10 percent, ** 5 percent and *** 1 percent significance levels)

Impact coverage compared to best practice	CBA Coverage				Overall Coverage			
	LS	Tobit	Probit	Logit	LS	Tobit	Probit	Logit
Marginal effects: Socio-economic variables								
GDP PPP per capita in fixed prices (natural logarithm)	0.068*	0.067*	0.056*	0.055*	0.029	0.026	0.055	0.036
	(0.038)	(0.039)	(0.034)	(0.033)	(0.097)	(0.101)	(0.267)	(0.433)
Gini coefficient	-0.008**	-0.008**	-0.008***	-0.007***	0.001	0.003	0.004	0.005
	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)	(0.014)	(0.023)
Population (natural logarithm)	0.031***	0.035***	0.029***	0.029***	0.007	0.004	0.017	0.044
	(0.008)	(0.009)	(0.007)	(0.007)	(0.018)	(0.019)	(0.051)	(0.082)
Marginal effects: Regional dummies								
Unions, federations and states (compared to unitary countries)	-0.083***	-0.106***	-0.088***	-0.087***	0.020	0.031	0.074	0.126
	(0.029)	(0.036)	(0.029)	(0.030)	(0.048)	(0.058)	(0.146)	(0.235)
North America (compared to Europe)	-0.068	-0.080*	-0.068	-0.067	-0.207***	-0.247***	-0.663***	-1.104***
	(0.044)	(0.045)	(0.043)	(0.043)	(0.076)	(0.089)	(0.252)	(0.413)
Africa and Asia (compared to Europe)	-0.125***	-0.130***	-0.128***	-0.130***	0.001	0.055	0.057	-0.015
	(0.034)	(0.038)	(0.034)	(0.033)	(0.108)	(0.111)	(0.314)	(0.530)
Oceania (compared to Europe)	0.170***	0.191***	0.144***	0.139***	0.063	0.036	0.147	0.212
	(0.042)	(0.043)	(0.035)	(0.036)	(0.066)	(0.074)	(0.205)	(0.335)
Marginal effects:Controls for study characteristics								
Year trend	0.004	0.005	0.004	0.004	0.010***	0.011***	0.032***	0.057***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)	(0.011)	(0.018)
Countries involved in the study (natural logarithm)	-0.131***	-0.158***	-0.139***	-0.139***	-0.104***	-0.137***	-0.365***	-0.629***
	(0.021)	(0.033)	(0.027)	(0.029)	(0.024)	(0.032)	(0.091)	(0.167)
Best practices coverage compared to complete coverage	-0.159*	-0.158*	-0.122	-0.120	-0.409**	-0.436**	-1.149**	-1.987**
	(0.083)	(0.084)	(0.075)	(0.073)	(0.185)	(0.191)	(0.529)	(0.921)
Indirect impacts' share of impacts	-0.386***	-0.365**	-0.339**	-0.332**	-0.597***	-0.576***	-1.629***	-2.754***
	(0.141)	(0.164)	(0.142)	(0.142)	(0.124)	(0.137)	(0.392)	(0.672)
Other regression results								
Constant (intercept)	-7.506	-9.421			-20.23***	-21.78***		
	(6.99)	(7.66)			(6.83)	(7.16)		
Constant (odds ratio)			-22.1	-37.0			-61.89***	-110.0***
			(19.1)	(30.9)			(20.9)	(34.8)
Error variance (root mean square error)	0.173				0.206			
Error variance (sigma)		0.035***	1.000	3.290		0.048***	1.000	3.290
		(0.010)	(by ass.)	(by ass.)		(0.007)	(by ass.)	(by ass.)
R square	0.494				0.424			
Pseudo R square		1.357	0.092	0.092		0.886	0.105	0.106
Observations	138	138	138	138	132	132	132	132
Observation groups	42	42	42	42	39	39	42	42

Another hypothesis is that relatively egalitarian democracies ceteris paribus are more concerned about economic appraisal than other countries. Egalitarian countries typically also have larger public sectors, which could contribute to more focus on quality assurance of infrastructure investments. The Gini index measures inequality on a scale from 0 to 100. Our results suggest that an increase in the Gini index of one point implies a worsening in CBA impact coverage of 0.08 percent. The finding is robust over econometric specification and significant at one percent significance level.

A third hypothesis is that impact coverage is better the more populated a country is, ceteris paribus. The thought here is that countries with large populations will be able to put more resources into developing appraisal practices than smaller ones, and therefore also have wider impact coverage, provided that the countries' location and government structure is the same. We find that one percent higher population in-

creases CBA impact coverage by around 0.03 percent. The influence of population density and area was also tested, but they gave insignificant results.
Countries structured as unions or federations and their states may have appraisal guidelines at different regional levels. Thus, they could be expected to have poorer impact coverage than unitary independent countries. We find that countries structured as unions or federations and their states hold about 0.009 percent lower impact coverage than unitary independent countries. Furthermore, our results suggest that European countries hold a better impact coverage than countries in Africa and Asia, and possibly North America, given levels of income, population and inequality, as well as government structure. Oceanian countries do however appear to have a better impact coverage than European countries, conditioned on these factors.
We do not find significant impacts of GDP per capita, the Gini index or populations on overall impact coverage, although the point estimates share the sign. North America has significantly worse impact coverage overall. Otherwise, the differences between government structure and regions have no significant impact on overall impact coverage.
Considering the significance levels, our controls for study characteristics appear to function as intended. There are only weak signs of a positive trend in impact coverage overall. As GDP per capita is measured in current prices, inflation may cause some degree of multicollinearity between these variables. In addition, the 'true year trend' becomes hidden in the inclusion of more and more impacts over time, implying that the year trend cannot be interpreted as a progress trend for impact coverage.

5. Synthesis, Discussion and Conclusions

In transportation planning, a good information foundation on impacts of potential transportation measures are important when deciding upon which measures are to be carried out and when. In this regard, national appraisal guidelines provide appraisal frameworks and designate which impacts are assessed and how. Moreover, these appraisal frameworks can be a useful set of tools in the prioritization of projects and clarification of impacts. Accordingly, an overview over which and how impacts are considered in transportation appraisal over countries and time constitute important knowledge, when further developing guidelines and practices.

In this paper, we reviewed transportation and spatial appraisal practices provided in public appraisal guidelines today and over time. Our study contributes to this knowledge pool both by reviewing earlier mappings and through an updated mapping.
This paper can help researchers and practitioners to get an overview over how various impacts are covered by different national guidelines for transportation appraisal. Such an overview may inter alia be useful when mapping the potential for knowledge exchange between guidelines and when addressing decisions to carry out transportation measures. Our study also contributes to obtain a better understanding of what characterize countries with wide impact coverage.
Admittedly, impact coverage only constitutes one of the key dimensions of transportation appraisal. Furthermore, there is no guarantee that advanced appraisal practices will end up in good decision on transportation measures. These limitations, as well as earlier mappings of impact coverage, are addressed in the paper's appendixes and the references provided there.

5.1. Information Basis from Impact Coverage Mappings

In our own mapping of impact coverage, we review 18 guideline sets from 14 independent countries, three dependencies and one supranational region in Northern and Western Europe, North America and Oceania. Our selection of countries more or less the countries with the most extensive impact coverage in earlier mappings. In total, we have mapped 44 impacts, including eight purely economic ones, 9 purely social, 13 environmental, 8 public and 6 that can be either economic or social, depending on the recipient of the impact. There is substantial variation on how broadly each impact is defined, so our results should be interpreted as indications and not be taken too literally. We also map how the impacts are appraised with CB, MC, supplementary analysis, CB in combination with the two former methods, noting of impacts and no coverage at all as possible outcomes.
We also perform a meta-analysis of impact coverage based on ours and 15 previous mappings from 1998 to 2020, together covering 42 countries and regions. In the meta-analysis, we base ourselves on the same impact classification as in our own mapping and distinguish between CB and overall impact coverage.

In addition to assessing the impact coverage over countries and sorts of impacts, we carry out econometric analyses to achieve a better understanding of what fosters advanced appraisal practices.

5.2. Findings on Coverage over Groups of Impacts

Looking at all the public appraisal guidelines at once, economic and environmental impacts have slightly broader impact coverage than social and public impacts. Yet, environmental impacts have the poorest CB impact coverage and are often recommended assessed by MC. Such results do of course depend on how impacts are classified and should therefore not be taken too literally. Supplementary quantitative analyses are mostly applied for wider economic impacts, which can have rather large value estimates. Moreover, wider economic impact can be problematic to include in CB due to uncertainty about its magnitude, possible overlap with other impacts and violation of the neoclassic CB assumption about the absence of market failures in secondary markets. All guidelines reviewed include maintenance and construction costs, air pollution, noise and direct journey costs, while affordability and urban consumer variety are rarely included. As expected, the impact coverages for direct effects and other effects that are easy to monetize are wider than for indirect effects and effects that are challenging to monetize.

The meta-analysis reveals substantial improvements in impact coverage, especially for environmental, user and wider economic impacts. Other areas of progress include valuation of travel time, modelling of climate change, more quantification of impacts and wider impact coverage in general. The progress is somewhat larger for CB impact coverage than for overall impact coverage, but here the initial potential for improvements was larger as well. Over a 0twenty years' period, global and local air pollution, noise and journey reliability and quality have gone from less than half to nearly full CB impact coverage. By the same token, landscape, townscape and economic performance were most often not recognized as impacts in public appraisal guidelines twenty years ago, while they today are included in most of the assessed guidelines. Similar patterns are seen for other wider economic impacts and public impacts, although these are less often included in the mapping of appraisal practices. There are also signs of improvement in coverage for social impacts, but these patterns are less clear.

Present days' efforts and trends towards inclusion of wider economic impacts in CB in transportation appraisals resemble the process that led to the inclusion of air pollution in the early 2000s. Wider economic impacts and impacts related to air pollution have in common that they are rather complex and often involve relatively large, but uncertain, value estimates (e.g. Wangsness, Rødseth and Hansen 2017 and Holmen and Hansen 2020). This is particularly the case for productivity impulses from regional integration and impacts related to climate changes. However, an important difference between these developments is that air pollution implies negative consequences of the spatial measures concerned, while wider economic impacts primarily involve positive impulses from the measures. From a loss insurance perspective, one might be more reluctant and patient regarding the integration of wider economic impacts in CBs as long as these impacts are assessed by other appraisal tools. Typically, the environmental movement will press for inclusion of environmental impacts in CB, while local economic interests might see wider economic impacts as a way of making regional projects more beneficial for society (cf. Holmen and Hansen 2020 for a related discussion).

5.3. Findings on Coverage over Countries

Our present impact mapping suggests that Scotland (United Kingdom), New South Wales (Australia) and the United Kingdom now have the widest overall impact coverage. Among the non-English guidelines, the Dutch and Norwegian guideline sets hold the widest overall impact coverage. The Swedish guideline set quantifies the most impacts, while the guidelines of New Zealand include most impacts in the CB. The poorest impact coverage is found in North America and countries in Continental Europe with both relatively small populations and land areas. It should be noted that it is not necessarily best practice to quantify as many impacts as possible in CB, considering that MC and supplementary quantitative analyses often are chosen instead due to uncertainty in the quantitative estimates, potential overlaps and inconsistent assumptions. Countries with poor impact coverage tend to be less focused on environmental and social impacts. The impacts

omitted from the guidelines are more evenly distributed over impact groups among the countries with the widest overall impact coverage. An exception are public accounts impacts, which are covered by most guidelines with high impact coverage.

Our meta-analysis of impact coverage over countries reveals that Western and Northern European and Oceanian countries and dependencies have had the widest impact coverage from 1998 to 2020, both in CB and overall. Australia, Norway, the United Kingdom and Sweden (except for the very first mappings) have had among the widest overall impact coverages the whole period, while Denmark and New Zealand have had stably high CB impact coverage. The Netherlands have had remarkably wide CB impact coverage since 2005, although impact coverage was limited in earlier studies. Germany has among the widest impact coverage in the beginning of the period, but has fallen behind in recent years, partially due to a stricter stance with regards to which impacts are to be included. Among other European countries, Finland, France, Greece, Hungary and Spain perform well in some early investigations, while Ireland has moved close to best practice in recent mappings. Countries outside Europe and Oceania seldom stand out in these investigations, except for the United States and Japan in some early studies.

When addressing what characterize countries with a wide impact coverage towards the end of our meta-analysis, we focus on how countries' impact coverages correlate with potential covariates, including economic wealth, equality and population size. In this examination, we apply econometric regression models that are linear (i.e. linear least squares), quasi-linear (i.e. Tobit) and fractional response-based (i.e. fractional probit and fractional logit), controlling for study-specific characteristics and clustering the standard errors on countries. We find that a one-point increase in the Gini index (which measures inequality) corresponds to a decrease in the CB impact coverage by 0.08 percent. Analogously, one percent increase in population or economic wealth (measured by higher GDP per capita in fixed purchase parity prices) corresponds to 0.07 and 0.03 percent higher CB impact coverages respectively. The examination confirms the differences between world regions. Furthermore, countries structured as unions or federations and their states have poorer CB impact coverage than unitary independent countries. We do not find similar patterns between the potential covariates and overall impact coverage.

5.4. Future development

For further development of guidelines, we believe that the trends towards inclusion and quantification of more impacts will continue in the following years. Hopefully, further development and new implementation of appraisal tools with complementary research will contribute to an improved allocation of spatial measures in the future. More integration with other parts of the planning process could be considered. There is also a need for improving and continuously updating metrics applied in appraisal. In addition, appraisal practices for road and rail transportation investments are likely to be spread to other spatial modes with less developed appraisal guidelines and practices, including transportation modes (e.g. aviation and seafaring), other infrastructures (i.e. energy and ICT), other objectives (e.g. area usage) and policy interventions (e.g. spatial regulations rather than spatial investments). Mapping of public appraisal guidelines and practices over these dimensions will largely be up to future research.

The relatively large magnitude of wider economic impacts in some empirical studies (e.g. Holmen and Hansen 2020) suggests that inclusion of these impacts in CB should continue to be a focus in development of national guidelines and research in the years to come. This requires higher estimation precision, handling of complex features and handling of potential overlaps with conventional impacts already included in the CB, as well as revision of the CB assumption about perfect competition. Recent contributions that address this topic include Venables (2017) and Graham and Gibbons (2019). We also believe that the complexity related to climate change impacts will lead to more research and improvements in the valuation of these impacts in spatial appraisal in the years to come, although it does not follow directly from our mapping. Another feature identified by our mapping is the presence of impacts on policy objectives. This implies that spatial measures interact with and influence the fulfilment of other policy objectives. Inclusion of impact on public measures in spatial appraisal involves many potential challenges, among them the confusion between efficiency and distributional objectives, and how additional fulfillment of public objectives

should be valued. A more detailed discussion on this type of impacts including a survey of the scientific literature on this kind of effects can be found in Holmen and Hansen (2020). We believe that there is a potential for more extensive treatment and inclusion of such impacts in future appraisal practices with the support of new research. Impacts on policy measures already play a central role in the planning process, so there may be a potential for knowledge transmission from other planning stages.

Although a wide impact coverage in coteries paribus facilitate a better foundation for decision-making within transportation appraisal, inclusion of impacts on a weak knowledge foundation may contribute to bad decisions. Whether inclusion of more impacts in CB and economic appraisal generally reinforces or dislocates the practical influence of other parts of the planning process remains and open question for future research. The current knowledge on how appraisal outcomes affect decision-making is incomplete with considerable differences across developed countries (confer appendix B for details). Further investigation in the relations between appraisal outcomes and decision-making could possibly also exploit the knowledge our paper provides on characteristics of countries with wide impact coverages.

Distributional impacts (i.e. impacts on distribution of social welfare) constitute another aspect that is less developed than efficiency impacts (i.e. impacts on total social welfare) in public guidelines for spatial and transportation appraisal. Distributional impacts have not received much attention either in our or in earlier mappings, suggesting that a systematic mapping of the coverage of these impacts could be useful. Usage of different appraisal tools and coverage of different distributional effects appear as natural parts of such a mapping.

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A. Appendix: Earlier Mappings of Impact Coverage

Appraisal practices including their impact coverage and choice of appraisal tool have varied substantially both countries and years. A good overview over impact coverage is useful both to reveal differences and possible points of improvements in the appraisal frameworks and to understand how various impacts may affect the appraisal of a given project. This appendix provides a review over earlier mappings of impact coverage and thereby background information to our meta-analysis in section 4 of the main paper. The reviewed articles are mapped in connection with meta-analysis. We first review mappings shedding light on differences in impact coverage over countries, before we turn to differences over impact groups.

A.1 Coverage over Countries

In the following, we review studies on transportation appraisal in Western countries, where the best practices are found. Thereafter, we take a look at practices in the Non-Western World.

Western Countries

The principle that an investment decision should meet the criterion of benefits exceeding costs was established by Dupuit (1844), who applied the method on the calculation of an optimal toll for a bridge. The history of modern spatial appraisal as we know it today is more than 80 years old. In the United States, federal regulations requiring comparison of costs and benefits for proposed infrastructure projects dates back to the Federal Navigation Act of 1936 and the Flood Control Act of 1939. These federal acts

mandated analyses showing positive net benefits for all federally funded waterway and flood control projects. In Europe and Oceania, cost-benefit analyses became common practice during the 1960s and increasingly formalized in the 1970s, exemplified by ACTRA (1979), the first British guideline, the German Standardisierte Bewertung (e.g. Gühnemann 2013) and Australian practices (e.g. Douglas and Brooker 2013). Grant-Muller et al. (2001) review progress within European transportation appraisal since the 1950s.

Studying the British appraisal guideline for transport, Vickerman (2000) finds that it involved very rigorous economic evaluation of direct user benefits at the turn of the millennium. Yet, it was less developed in its handlings of accessibility and reliability. He argues that it is easy to expand the scope to involve more application in terms of different types of measures, modes and finance. At the time of the study, changes in the guidelines were being made to develop a common framework for multi-modal applications.

Two early mappings of impact coverage in European transportation appraisals were conducted by Nellthorp, Mackie and Bristow (1998) and COWI (2002). Nellthorp, Mackie and Bristow study 14 Northern, Western and Southern European countries, while COWI investigates impact coverage in eight Western and Northern European countries. Note that the mapping of Nellthorp, Mackie and Bristow is also analyzed by Bristow and Nellthorp (2000) and Grant-Muller et al. (2001) and Marcial Echenique & Partners et al. (2001). Bristow and Nellthorp (2000) conclude that there is some consensus on which direct effects to include, even though values and methodology diverge for non-market impacts (e.g. travel time and accident costs). They find less consensus on how to appraise indirect impacts and under which circumstances social and economic impacts should be assessed. Bristow and Nellthorp remark that the EU countries were developing more comprehensive multi-modal appraisal methodologies at the time. All countries in both mappings had good coverage of direct effects and impacts related to pollution, while the coverage for environmental capital effects (e.g. townscape, landscape and cultural heritage) and socio-economic effects was more mixed. Authors of both studies also point out that economic appraisal was most developed for road investment projects at the time.

In another mapping, Hayashi and Morisugi (2000) compare appraisal practices in the World's five largest developed economies. They find small differences in impact coverage in their study, except for the United States, which had substantially poorer coverage than the others. Hayashi and Morisugi find that the countries share a common methodology for transportation appraisal, particularly with regards to the aspects assessed, conceptual modeling of transportation demand and valuation of direct impacts. However, they reveal that there are substantial differences in parameter values and how distributional and indirect impacts are assessed. For future research, the authors point at determination of parameter values and valuation of indirect impacts.

PIARC (2003) compares the public appraisal guidelines for road investments in 18 member countries of the Permanent International Association of Road Congresses. Almost all countries used CBA, often in conjunction with MCA and other appraisal methods. Socio-economic impacts and wider economic impacts were commonly excluded from the guidelines at the time. Investigating the developments from 1997 to 2003, PIARC (2003) finds that more public and political attention towards economic evaluation of road projects had contributed to more focus on improving methodology and data quality. PIARC remarks that the British guidance since 1997 had noticeably widened its evaluation methodology to present information on environmental and social impacts and to cover other modes of transport. Many countries had shifted towards more extensive use of MCA as a supplement to CBA over the period (e.g. the United Kingdom, Sweden, Portugal and Australia). Multi-mode comprehensive appraisal (i.e. transportation appraisal covering several transportation modes) was becoming more common in some countries (e.g. the United Kingdom and Sweden) and was about to be pursued by others (e.g. Czech Republic and Norway). Discount rates were lowered in many countries, while methods for monetary valuation were becoming more sophisticated. This was particularly the case for accident costs, which to a larger extent were connected to the valuation of a statistic life. More attention was devoted to assessments of risk and uncertainty, as practical methods for risk analyses were developed. For future methodology development in the appraisal guidelines, PIARC (2003) recommended wider inclusion of impacts, cooperation between member countries in the organization, expansion of methodology to cover all land transportation modes and development of more sophisticated quantitative risk analysis.

The HEATCO project provides a comprehensive overview of practices in transportation project appraisal in the EU-25 countries and Switzerland in 2005, as summarized and accounted for in detail in Odgaard, Kelly and Laird (2005 and 2006) respectively. Their results show that all countries used CBA, but that it is not always required. In Eastern European countries, appraisals by CBA were often motivated by co-funding from the European Union, although its usage was gaining more acceptance. Nine countries also use MCA in combination with CBA. The authors also found that Northern and Western European guidelines in general included more impacts in CBA and were more developed than in Eastern European countries, which in turn included more impacts than Southern European countries.

Odgaard, Kelly and Laird (2005) provide a mapping of impact coverage for all transportation modes with a rather detailed impact classification. They find that appraisal was most developed for road projects, somewhat less for rail projects and even less for projects concerning aviation, inland waterways and seaways. They argue that harmonization of the appraisal value within the European Union would ensure that similar weight is put on people's preferences in different countries and contribute to increasing analysis quality in many countries. In favor of country-specific appraisal values, they argue that such valuation would bring analyses closer to the neoclassic 'willingness-to-pay' concept and make it easier to obtain common acceptance and understanding among stakeholders about these value estimates. The authors reveal large differences in unit of accounts, discount rates values, appraisal periods and transboundary effects. Methods for estimation of construction costs were converging across countries. Most countries had systematic methods to handle uncertainty and optimism biases in cost estimates. Guidelines in all countries included impacts on timesavings and safety impacts, most of them accounting for heterogeneity. The HEATCO project group's detailed recommendations for harmonization of Europe transportation appraisal are provided in Bickel et al. (2006).

In 2013, researchers finalized a detailed, comparative study of public appraisal practices on behalf of the British Department of Transport, summarized by Mackie and Worsley (2013) and Mackie, Worsley and Eliasson (2014). In these studies, the set of British public appraisal guidelines (reviewed in detail by Gühnemann et al. 2013) is mapped and compared to sets of guidelines in Sweden (based on Eliasson 2013), the Netherlands (based on De Jong 2013), Germany (based on Gühnemann 2013), the United States (based on Weisbrod 2013), New South Wales in Australia (based on Douglas and Brooker 2013) and New Zealand (based on Douglas et al. 2013). Mackie and Worsley (2013) and Mackie, Worsley and Eliasson (2014) find that frameworks applied for transportation appraisal are well-established in all countries under investigation with similarities far outweighing differences in values, emphasis and content. Their mappings show that Oceanian guidelines also are among the most advanced along with those in Northern and Western Europe.

All countries assessed used CBA in combination with various non-monetized assessments. The authors find that neither the British guidelines nor other international guidelines have very explicit appraisal procedures for summing up monetized and non-monetized effects (ibid.). Among the appraisal guidelines investigated, the German guidelines were the only ones to have an explicit procedure for summing up the monetized and non-monetized impacts (Gühnemann 2013). In an unrelated study, Weisbrod and Simmonds (2011) show that transportation appraisal in the United States and the United Kingdom tends to incorporate similar factors, but that different scoring systems between and within the two countries could lead to different project selection. Analogously, Gwee, Currie, and Stanley (2011) and Olsson, Økland and Halvorsen (2012) find that different methodologies across countries induce different priority rankings in the railway segment and thereby largely affect whether a project comes out as economically viable or not.

According to Mackie and Worsley (2013), the British set of appraisal guidelines is recognized as a leading model of open documentation of appraisal guidelines, which was frequently applied as benchmark for other countries' guidelines. Gühnemann et al. (2013) find that the British guideline since the 2000s devoted more attention to other appraisal applications beyond road and rail investment than other guidelines, also covering a wide range of other policy measures such as cycling, walking to public transportation and aviation and housing developments. Its coverage of social and distributional impacts was also at the best practice frontier. Mackie and Worsley (2013) point out that none of the guidelines they review contained a clear methodology for verifying the achievement of strategic policy objectives. Appraisal practices also depend on the structure of the government, federal states such as Australia, Germany and the United States often having multiple sets of guidelines and procedures to deal with different levels of regional structures and governments. Mackie and Worley argue that there may be learning possibilities for the developers of the British guidelines from the guidelines of federally structured countries when it comes to handling and restructuring responsibility and accountability of the various parties' work out in practice. Mackie and Worsley's comparative analysis of empirical evidence across countries suggests that countries and regions with relatively much freight transport, such as some American states and to some extent Sweden, are frontier countries in providing input to and modelling of regional economic impacts and impacts on freight flows.

According to Mackie and Worsley, the 'Five Business Case' approach constituted another new feature in the British guidelines at the time. This approach implies that strategic, economic, commercial, management-related and financial considerations are brought together in a formalized manner, as stakeholder interests and opinions also affect decision-making. In parallel, multimodal program appraisal based on business case scenarios for transportation and land use has become increasingly more common for applications in New Zealand's most urban areas (Douglas et al. 2013).

Although not the largest regions, Australian states and New Zealand have broad guidelines for transportation appraisals with much local empirics as inputs. Both draw on knowledge and methodology from the British guidelines, as well as local research (Douglas and Brooker 2013 and Douglas et al. 2013). Up to the beginning of the 2000s, road and rail agencies in New South Wales used different methodologies, inter alia in case of travel timesavings valuation. In 2011, the planning agencies for road and rail transportation were consolidated with the first common guideline being released in 2013 (Douglas and Brooker 2013 and Transport for NSW 2018). Douglas et al. (2013) find that New Zealand's appraisal covers all sort of transportation investments and is more or less continuously updated based on research and best practices.

Weisbrod (2013) finds that the American appraisal practice did not only involve CBA and MCA, but also a wide range of hybrid combinations of these techniques. Practices in different American states varied substantially, with some putting more weight on MCA contra CBA than others. In context of American high-speed rail projects, Weisbrod points out that public criticism in the United States has not been related to the use of impact assessment, but rather the quality of the underlying transportation analyses. He argues that the most important lesson from the American appraisal practice for other countries is its usage of multiple perspectives and analytic techniques. PIARC (2003) finds that appraisal practices vary significantly across American states with some states also having practices to measure impacts on local purposes and wider economic impacts (e.g. employment, land use, personal income and tourism).

Mackie and Worsley (2013) underpin that value estimates for reliability and crowding impacts from policy interventions are found challenging to estimate with different approaches in different countries. Moreover, estimated value of reliability and crowding impacts depends on time estimates produced from transportation models and time values applied, where choice of appraisal metrics varies across countries. The Swedish guidelines were pioneer in estimating reliability as use of the standard deviation of travel time (Eliasson 2013). Concurrently, this topic was under investigation in Germany (Gühnemann 2013) and the Netherlands (De Jong 2013). Gühnemann (2013) identifies two other areas under development in German transportation appraisal, where the German appraisal investigations were frontier. These topics were transportation forecasting with weight on modeling of feedback mechanisms and transparency and assessment of non-monetary elements including procedural aspects and evaluation procedures.

Gühnemann et al. (2013) identify wider impacts, reliability, crowding, air pollution, and social and distributional impacts as the most significant developments in English appraisal guidance in the 2000s. Mackie and Worsley (2013) reveal similar trajectories in the comparator countries of their study. They find an overall tendency across countries towards monetization and inclusion of more types of impacts. They highlight wider economic impacts and reliability as the most important topics for future progress in 2013. The Dutch and the Swedish guidelines investigated the values of time for passenger transportation as an area of progress at the time (De Jong 2013 and Eliasson 2013).

Gühnemann et al. (2013) point out that the British Department of Transport was looking into updating value estimates for travel timesavings and safety benefits at the time of the study, as the values applied were approaching twenty years with possible changes in social preferences and available information sources. According to Gühnemann (2013) recent progress in the German appraisal guidelines leading up to the new guidelines in 2015 involved assessment of reliability, traffic forecasting and development of non-monetary elements such as strategic environmental aspects. The Swedish government was looking into better handling of wider economic benefits, distributional impacts and 'slow mode' benefits, as well as new applications for transportation appraisal such as maintenance, operations and allocation of railway capacities (Eliasson 2013). To ensure knowledge exchange on research and practices, Mackie and Worsley (2013) recommend a new occasional international forum and information exchange on appraisal, involving officials, academics and consultants.

Kamis (2014) looks at possibilities for knowledge exchange between appraisal practices from the United States and the Netherlands. He recommends that the people responsible for the Dutch public appraisal guidelines provide more practical guidance on how to evaluate the linkages between transportation and spatial policies and reconsider the relatively long appraisal period of 100 years due to uncertainty considerations. For the American guideline authors, he recommends drawing on Dutch practices on how to estimate quality and disability adjusted life years, and to include reliability in ex-ante evaluations of transportation appraisal and estimation of wider economic benefits.

Dahl et al. (2016) map the similarities and differences in French and German transportation appraisal guidelines. They remark that both guideline sets had developed to include a machinery of appraisal methods not only involving CBA. Both sets of guidelines come out with advanced appraisal frameworks with different parameter assumptions and methodological choices in some case. France has gone somewhat further in quantification of marginal costs of public funds, reliability, wider economic impacts, but the German reluctance with regards to estimating these effects was to some extent justified by uncertainty and potential overlaps between impacts in the German guidelines. The Germans also monetized some impacts that were left untreated by the French, including separating effects and emissions from transportation infrastructure. In a more recent study, Couture, Saxe and Miller (2016) find that the guidelines of the European Union and Canada particularly lacked coverage of indirect socio-economic and environmental capital impacts (without assessing wider economic impacts beyond land use).

Gleave (2004) assesses differences in national appraisal practices for railways in relation to British investments in high-speed rail. He finds that project appraisal was most common in Europe, where the appraisal practices were converging at the time with the British appraisal system representing best practice in many areas. Gleave advises British authorities to reduce the optimism bias correction for project overruns, to use project-specific time values, to quantify wider economic impacts and to include safety and environmental impacts in the CBA. Gwee, Currie, and Stanley (2011) map the impact coverage in CBAs for the railways segment in twelve countries across the World. All countries use CBA in combination with MCA. Their mapping suggests that European guidelines have somewhat poorer coverage than other Western countries due to missing impact coverage for truck users, and pedestrians and cyclists. Germany and the Netherlands were the only countries to include agglomeration benefits, while the United States was the only country to include option value in CBA. In another study on railway appraisal by Olsson, Økland and Halvorsen (2012), the Danish guideline is the only one among seven European countries that includes crowding effects.

Non-Western Countries

Mappings that include both Western and Non-Western countries suggest that Non-Western countries have poorer impact coverage in their public appraisal guidelines than Western countries. The exception is Hayashi and Morisugi's (2000) mapping of the five largest developed economies, where Japan comes out as best practice with a rough impact classification. In PIARC (2003), South Africa and Mexico (which occasionally is considered Western) have relatively decent impact coverage, while Japanese guidelines were among the least developed. In their review of public appraisal guidelines of railway projects in eight Western and four Asian developed countries, Gwee, Currie, and Stanley (2011) find that the three countries with poorest impact coverage were Asian, with South Korea having somewhat wider coverage than the others.

COMEC (2019) investigates the use of transportation appraisal in countries with membership in the Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation. They find that public appraisal guidelines for transportation in Muslim countries, where they exist, focus on the general procedural steps rather than systematically offering methodology and parameter values. Many Muslim countries have yet to develop advance appraisal practices for transport. Most often, CBA constitutes the main methodology.

Through a survey questionnaire with respondents from twelve Islamic countries, COMEC finds that transportation appraisals for large transportation investment projects were required in 83 percent of instances, while a specific methodology was required in 36 percent of them. Only 43 percent of the respondents were aware of accessible public appraisal guidelines for transport, and 14 percent ruled out they existed in their country. Most national transportation investment plans in Muslim countries focus on road infrastructure and to some extent rail infrastructure, while non-motorized transportation and planning of land use and transportation systems receive less attention. Many of them do not have transportation models, and the ones that exist often overshoot traffic forecasts.

Although the quality level of transportation appraisals in Muslim countries is generally lower than in Western countries, some Asian countries such as Iran and Jordan have relatively developed appraisal systems. Qatar also has both solid methodological focus and data processing (COMEC 2018). In Iran, appraisals with CBA for the region are conducted, but different practices in different public institutions hamper comparability. Yet, the focus so far has been on financial aspects rather than socio-economic impacts, and multi-modal transportation is considered to a limited extent. In Jordan, transportation infrastructure investments that require economic appraisal focused on maximum social welfare for public projects, whereas financial evaluation focused on maximum utility for private stakeholders and is common for public-private partnerships. On the other hand, national project appraisal is neither much developed nor mandatory in Saudi Arabia. Here, MCA constitutes the main appraisal tool. Although not always carried out, assessment of environmental impacts constitutes the most developed part of Saudi project appraisal practice. Afghanistan is strongly dependent on international development partners when conducting transportation investments. The current Afghani institutional framework does not provide a basis for transportation project appraisal (COMEC 2019).
In Africa, economic appraisal is immature and often motivated by international co-funding. Although Mozambique lacks a well-defined legal requirement to prepare transportation project appraisal, CBA is used with traffic analyses and both economic internal rate of return and net present values as measures for viability. Nigeria has developed manuals for the road sector with CBAs and MCAs, which address technical, social and environmental, safety, economic and financial aspects of road investments (ibid.).

A.2 Impact Coverage over Groups of Impacts

In the following, we will review progress for different impact groups, classified in accordance with their impact recipients (as for instance done by Oosterhaven and Knaap 2003, Department for Transport 2019 and Holmen and Hansen 2020). Commonly, impacts on the household sector are referred to as social impacts, while impacts on the production sector are referred to as economic impacts. Environmental externalities are classified as environmental impacts, while impacts on funding and provision of public activities are classified as public impacts.

Social Impacts

Odgaard, Kelly and Laird (2006) find that few European public appraisal guidelines monetized indirect socio-economic impacts at the time of the study, although many of them encompassed at least one of them. Litman (2009) highlights costs of accident risks and costs of stress in case of congestion among the impacts from spatial measures that are commonly ignored by public guidelines. Geurs, Boon and Van Wee (2009) focus on determining categories of impacts and identifying gaps in the treatment of social impacts in public guidelines. On the practical side, the authors also study inclusion of social impacts in the Dutch and British transportation appraisal guidelines. This is partly because the British guidelines follow a relatively objective-led approach, while the Dutch guidelines follow a relatively strict welfare economic perspective. The authors call for inclusion of more social impacts, including externalities from parking, cultural diversity and averting behavior caused by the traffic situation.
The British appraisal guidance includes a much broader spectrum of social impacts than the Dutch one through quantitative and qualitative assessments. Yet, it still does not cover the full range of these impacts as identified in the literature. Geurs, Boon and Van Wee argue that the guidelines lack clear operational definitions of social cohesion and related concepts. Social injustice and alternative welfare weights do not constitute a focus in either of the guidelines, but distributional impacts are assessed. The authors also argue that the evidence on how transportation investment or policy may affect people's level of participation in activities or the number of neighborhood contacts are missing (see also Forckenbrock et al. 2001 and Imperial College Centre for Transport Studies and MacDonald 2006).

Environmental Impacts

Reviewing European appraisal practice, Grant-Muller et al. (2001) identify substantial progress on estimating environmental impacts. Vickerman (2000) finds that environmental impacts in the British transportation appraisal guidance were not very developed at the time. However, other authors find substantial improvement on inclusion of environmental impacts in CBA and transportation appraisal in general (Pearce 1998 and Pearce, Atkinson and Mourato 2006). In 2003, member countries of the Permanent International Association of Road Congresses were cooperating in developing valuation strategies for environmental impacts (PIARC 2003). Odgaard, Kelly and Laird (2006) find that most appraisal guidelines in Northern and Western European countries included environmental impacts in CBA, as opposed to most Eastern and Southern European countries. However, the range applied for valuation varied substantially, with for instance a wedge for cost of carbon dioxide by a factor of nearly five between Sweden and Finland. Lyk-Jensen (2007) finds that much attention in the further development of Nordic appraisal practices was devoted to the valuation of indirect effects, particularly environmental impacts.
Yet, climate changes and discounting of future utility impacts constitute a substantial challenge addressed by some authors (e.g. Tol 2003 and Masur and Posner 2011). Weisbrod (2013) finds that the American guidelines provide no guidance about environmental capital impacts that European countries tend to assess through MCA, since, under American law, heritage is protected against any incursions. Recent developments in climate change prognosis will also improve CBA estimates. IPPC (2018) provides methodology applied in practice for valuing impacts of climate changes, while the World Health Organization (2013) reviews valuation of health risks associated with air pollution.

Economic Impacts

Recent inclusion of new economic impacts in spatial appraisals mainly concern so-called 'wider economic impacts', which are indirect impacts on the production section. While some economists have been skeptical with regards to including wider economic impacts in the cost-benefit analyses for transportation due to the uncertainty associated with the estimates, other have argued that the size of these estimates suggests that one should attempt to include them anyway (see for instance Vickerman 2007 for this

discussion). Early impacts mapping reveals low coverage of indirect economic effects (e.g. Nellthorp, Mackie and Bristow 1998, Hayashi and Morisugi 2000, COWI 2002, PIARC 2003 and Gleave 2004). Both Gleave (2004) and Grant-Muller et al. (2001) see large potential for inclusion of indirect impacts including wider economic impacts in economic appraisal, along with other indirect impacts. In the HEACO project on economic appraisal in Europe, agglomeration impacts were not mentioned explicitly, although economic development, urbanization, employment effects and network effects are mentioned. The Dutch guidance distinguishes itself as particularly developed in the field (Odgaard, Kelly and Laird 2005). During the last twenty years, many economists have argued in favor of such inclusion due to the impacts' magnitude and more precise estimation (see for instance Venables 2007, Vickerman 2007, Banister and Thurstain-Goodwin 2011, and Graham and Gibbons 2019).

Following the early development in the British guidelines, increasingly more countries and regions started to include wider economic impacts in their appraisal guidelines (e.g. Mackie and Worsley 2013). Although value estimates were large, they were not straightforward to integrate in CBA due to uncertainty, possible overlap with other impacts assessed by CBA and violation of the assumption commonly made in CBA about absence of market failure in secondary markets. For instance, Douglas and Brooker (2013) find that benefit estimates for rail investments in the Australian state of New South Wales were from 2008 adjusted upwards based on wider economic impact estimates from the British guidelines. Due to uncertainty of the impacts, Infrastructure Australia[3] was unhappy with this approach and demanded that wider economic impacts and other non-conventional impacts be left out from the core of economic appraisal and only included in supplementary studies. The development of appraisal tools for wider economic impacts associated with the British guidelines has also been important for inclusion of these impacts in other countries' guidelines. In both New South Wales and New Zealand, inclusion of wider economic benefits in supplementary quantitative analyses was under development in 2013, influenced by and building on the British developments (Douglas and Brooker 2013 and Douglas et al. 2013).

Wangsness, Rødseth and Hansen (2017) review how wider economic impacts are treated in transportation appraisals in 22 industrialized countries. (Details on dependencies are provided in Wangsness, Rødseth and Hansen 2014). Based on these countries' appraisal guidelines, they find that agglomeration impacts and production changes are included by 14 and ten countries, respectively. However, few countries included these effects in CBAs. Other wider economic impacts were less recognized. According to the mapping, Ireland acknowledges most wider economic impacts, the Netherlands quantifies most impacts and Sweden includes most impacts in their CBA. The English appraisal guideline set stands out as the only one with a comprehensive methodological framework for estimation of wider economic impacts. Seven countries did not assess wider economic impacts at all at the time of the study.

Simmonds (2012) reviews criticism on land-use impacts in transportation appraisal. He finds that these impacts are largely ignored or hidden implicit in transportation benefit. Simmonds also stresses that transportation models focus on timesavings rather than increase in number of travels. Based on his review, Simmonds propose a more complete analysis framework to assess economic efficiency associated with spatial measures.

Public Impacts

Impacts on public accounts have received limited attention in earlier mappings of impact coverage in appraisal guidelines for transportation and more general spatial measures. Marginal costs of public funds reflect the efficiency cost of tax collection and constitute an important public impact in transportation appraisal due to their size. The rationale for such an efficiency cost is that negative impacts on public funds necessarily will draw resources away from the population's true preferences through reduced welfare arrangements or increased taxes in the short run or the long run. Empirical estimates of the shadow price of public funds vary quite a lot, but they are mostly positive. We refer to Holmen and Hansen (2020) for an overview.

In their mapping of impact coverage in Northern and Western European appraisal practices for transport, COWI (2002) finds that the Scandinavians were the only ones among eight countries to include marginal costs of public funds in CBA. Sweden used a shadow price of public funds of 1.3, while Norway and Denmark used shadow prices of 1.2. Many of the other countries recognize marginal costs of funds as an efficiency cost related to public funding, but do not estimate it due to the uncertainty related to its size. In Mackie and Worsley's (2013) mapping of appraisal practices in eight Western countries, Sweden was – as Scandinavian representative in the study – the only country that operated with marginal costs of public funds. Dahl et al. (2016) find that France included marginal costs of public funds in their appraisal framework at the time, and that they recently had decreased the shadow price from 1.3 to 1.2. Germany on the other hand followed the Anglo-Saxon convention of not including these impacts. Yet both Scotland and Ireland today include marginal costs of public funds at a shadow price of 1.3 (Department for Transport, Tourism and Sport 2016 and Transport Scotland 2019).

Spatial measures' impact on the fulfilment of other public objectives has not been a focus in earlier mappings. Yet, several older mappings find relatively high impact coverage for such impact. For mapping guidelines covering either regional policy, conformity to sector plans or both in their economic appraisal, Nellthorp, Mackie and Bristow (1998), COWI (2002) and PIARC (2003) find overall impact coverages of 50, 62.5 and 66.7 percent respectively. The impact mappings are however not consistent for many countries (e.g. Finland, France, Germany and the Netherlands), which could indicate unclear treatment of these impacts in the appraisal guidelines and different interpretation of the contents. Overall, impacts on public objectives from spatial measures are

[3] Infrastructure Australia is an Australian independent statutory body in providing advice on domestic infrastructure measures.

included in Western European countries as well as two Southern European countries. Hayashi and Morisugi (2000) find that Japan and the United Kingdom assess emergency services in relation to accidents, while PIARC (2003) maps that the Dutch guidance assess access to emergency services.

B. Appendix: The Role of Transportation Appraisal in Decision-Making

Even if a country has developed advanced appraisal practices for the transportations sector, there is no guarantee that this is reflected in the de factor policy prioritization. Knowledge on how economic appraisal affect decision-making may important for ensuring more awareness of the potential welfare losses associated with ignorance of appraisal and thereby contributing to improved sectorial spending in the long run. For empirical researchers, this knowledge can also be handy when studying causal relations. Few studies assess the topic, so we will here provide a short review, which complements learning outcomes in our main paper.

Overall, the literature indicates the impact of appraisal recommendations on de facto policy prioritization vary substantially over countries. While some countries largely prioritize projects in accordance with rankings for economic appraisal, others put little weight on the rankings beyond ruling out projects with negative net benefit or even for these projects. In countries where sophisticated economic appraisal influences practical decision-making little, other factors such regional policies and strong public finance may be important. In less developed countries, economic appraisal is typically motivated by the possibility of external funding.

B.1 Western Countries

Advice given in guidelines and actual practices applied in transportation appraisal do in many instances not coincide. Several investigations suggest that the weight put upon transportation appraisals in practical decision-making varies quite a lot over countries (e.g. PIARC 2003, Mackie and Worsley 2013, and Mackie, Worsley and Eliasson 2014). Economic appraisals within the transportation sector are used for project option selection, project priorities and to support development of schemes and strategies (PIARC 2003). Decent productivity prospects concerns constitute a potential driver for investments in transportation infrastructure, but this is not always the case (e.g. Combes, Duranton and Gobillon 2011 and Melo, Graham and Noland's 2009).

According to Mackie and Worsley (2013) and Mackie, Worsley and Eliasson (2014), incomplete valuation and neglect of distributional issues were regarded as the two main shortcomings of the economic value estimates produced by CBA (for efficiency impacts, not to be confused with distributional impacts). Mackie, Worsley and Eliasson (2014) point out that there is often a risk that CBA enters into the planning process too late to play a meaningful role, particularly when the projects in question are considered to be the solution to a challenge perceived as important.

Peters (2003) finds that the EU's transportation investments lack consistency and sustainability due to partially complementary and partially competing development targets, concerning cohesion, polycentricism, missing links and bottlenecks. According to Peters, the EU's decision making is both conflicted and contested within Trans-European Network priority projects, violating cohesion and sustainable development goals by concentrating investments in already privileged areas to obtain growth and competitiveness.

Ranking of projects according to cost-benefit considerations constitutes a starting point for the selection of transportation projects in the United States, the United Kingdom and Germany. In Germany, the general requirement for federal states is that projects should be deemed economically viable with a benefit-cost ratio of at least one (Gühnemann 2013). Nonetheless, state authorities may change priorities within their list according to own preferences in hearings and co-ordination meetings with other stakeholders (Rothengatter 2005). In the subsequent planning stages, results from non-monetary environmental evaluations could induce specific planning requirements. The German decision-making process also integrates transportation policy with regional planning objectives and considers the spatial distributional aspect (Gühnemann 2013). The German Federal Transport Infrastructure Plan is presented for and approved by the parliament roughly every ten years. This implies that agreed projects would not be changed by future politicians under normal circumstances (PIARC 2003).

In the United Kingdom, each projects' value for money is considered based on the cost-benefit ratio with possible adjustment of value for money category based on non-monetarized assessment. Based on records from the British Department for Transport, Gühnemann et al. (2013) find that economic appraisal is important for project selection in the United Kingdom, but they do not rule out that other factors may be of equal importance. The British Department for Transport offers documentation of the Five Business Case approach, where cases are facilitated in three stages with an increasing level of detail. In the approach, five considerations serve as a basis for decision-making: strategic, economic, commercial, financial and management aspects. According to Mackie and Worsley (2013), the proportion of investment spending on schemes with 'high' or 'very high' value for money amounted to 99.6 percent.

The findings of Gühnemann et al. (2013) imply that economic appraisal has become more important for decision-making for transportation measures in the United Kingdom since 2000. PIARC (2003) finds that economic appraisal methodology in the United Kingdom was generally well accepted, with involvement of key stakeholders as an integrated part of the decision process. In an earlier study, Nellthorp and Mackie (2000) examine the relationship between transportation appraisal and project selection in the British Roads Programme by a hedonic choice model. They find that the benefit-cost ratio had no significant impact on decisions in contrast to factors dealt with by MCA such as noise, landscape, heritage, regeneration and reliability. Among CBA factors, construction costs, safety and travel time were also taken into consideration, although the importance of travel time was weighted lower than the CBA estimates. Chilton et al. (2002) study the relationship between public perceptions of risk and preference-based safety valuation in English transportation infrastructure projects. They find that certain factors of private persons' perceived risk also affect safety priority in project implementation. Nonetheless, the perceived trade-off between preventing deaths in various hazard contexts was substantially less pronounced than the value differentials in public policy making would suggest.

Assessing international investment in high-speed railways, Gleave (2004) finds that historical investment decisions generally were not based on economic appraisal. He calls for caution when estimating the optimism bias related to overruns in British railway projects. Studying American transportation infrastructure projects, Flyvbjerg, Holm and Buhl (2002 and 2003) demonstrate how projects tended to underestimate the construction costs (see also Cantarelli et al. 2012 and Love and Ahiaga-Dagbui 2018), while Flyvbjerg, Holm and Buhl (2005) show how transportation forecasters tended to overestimate the traffic forecasts with higher overshooting for rail transportation than road transport.

In the United States, there is very strong and nearly universal recognition that CBA has an important role to play in the funding approval process for large transportation projects. Even when state and federal authorities do not require CBAs, they are often applied to test the defensibility of spending. The American highway systems and some of the largest airports are planned, constructed, owned and operated by federal government, while state and local government plans, constructs, owns and operates highway facilities, public transportation systems, seaports, rail stations, local roads and most airports. This distribution of responsibilities between government levels is reflected in the responsibilities for planning and appraisal. Federal funding is allocated by distributional formulas that account for user volume (e.g. population and traffic volumes), program areas (e.g. metropolitan planning, state highway projects, safety projects and rural transit) and process (e.g. requirements to ensure sufficient quality on appraisal and planning). In addition to formula funds, the federal government allocates money through discretionary grant programs to state and local agencies for projects on airports, maritime measures, high speed rail, major highways and transit capital investments. Beyond federal co-funding, local and state authorities make their own prioritizations (Weisbrod 2013).

As in the United States, Canadian projects are also subject to public funding constraints. CBA and MCA of road projects are mainly carried out for selection of options for projects within the same mode. Yet, funding availability often overrides the priorities indicated by the economic appraisal, which is often not well known by the general public (PIARC 2003). Couture, Saxe and Miller (2016) relate lack of systematic use of CBA in Canada due to no recent updates in the public guideline.

In Australia, decisions should be based on evidence beginning with analysis of land use, objective assessment techniques and close monitoring of the effectiveness of initiatives. Yet, Douglas and Brooker (2013) find that the implementation of the largest projects is often decided upon at an earlier stage than the full impact assessment and that impacts on neighboring regions may not be internalized. According to PIARC (2003), Australian road projects with low benefit-cost ratios are usually not funded. Prioritization based on subjective criteria and achievement of strategic objectives also mattered for decision-making. Projects with both high benefit-cost ratio and high MCA ranking are mostly implemented within short time frames.

Formally, transportation projects in New Zealand are decided upon based on CBA and the strategic fit with policy measures and effectiveness, with the initial priority ranking of road projects based on CBA (PIARC 2003 and Douglas et al. 2013). PIARC (2003) reveals that benefit-cost ratios greater than four used to be needed to get funding from the central government before 2002, when government transportation priorities also were considered. Nonetheless, Douglas et al. (2013) reveal that these criteria no longer explain the decisions being made. In line with PIARC (2003) findings, Douglas et al. find evidence of declining benefit-cost ratios for the schemes approved. First year rate of return is used as an indicator for optimal timing for projects.

CBA plays a less important role for decision-making in the Netherlands, Norway and Sweden, where other political interests are more influential (e.g. Eliasson et al. 2015 and Annema et al. 2017). According to PIARC (2003), the most extensive evaluation of Dutch road projects takes place at the planning stage. Different options often reflecting best practices for different policy measures (i.e. most beneficial for the environment or highest increase in road capacity) are assessed by both CBA and MCA and benchmarked against a reference option for status quo development. There is disagreement about weighting of impacts, and high priority of economic appraisal does not guarantee implementation.

De Jong (2013) finds that Dutch transportation projects with a low benefit-cost ratio are rejected, but that projects with a high benefit-cost ratio may not be approved either due to other policy concerns. This result has been confirmed by Annema et al. (2017) by discrete choice analyses. They find that CBA also plays a less important role for decision-making related to Dutch transportation projects. Investigating 67 CBAs for transportation and spatial development projects made in the period from 2000 to 2012, Annema and Koopmans (2015) find that many analyses omit or do not monetize environmental impacts. In addition, uncertainties from CBA and implicit assumptions on the discount rate are most often not communicated to decision makers. Mouter, Annema and van Wee (2013) find that Dutch decision makers consider the neglect of non-monetized effects in CBA as substantial with transportation appraisals.

The Swedish general public is mostly not aware of how road projects are ranked and selected, but interest groups are generally better informed. Yet, CBA is accepted as an evaluation tool by decision makers in the central government (PIARC 2003 and Eliasson 2013), while it in earlier years was somewhat more disputed at local government level (PIARC 2003). Economic appraisal constitutes a tool for choosing routes for new road corridors and for deciding whether projects should be included in the Swedish national master plan for transport, which is updated every fourth year (PIARC 2003 and Eliasson 2013). Studying Nordic and large Western European countries, COWI (2002) find that Sweden was the country that had come furthest in comparing projects over transportation modes. The finding was confirmed by Lyk-Jensen (2007), who compares transportation appraisal practices in the Nordic countries.

Based on interviews, Eliasson and Lundberg (2012) find that planners' rankings of investments are influenced by benefit-cost ratios, particularly in case of low and moderate rates. Yet, politicians' rankings are not influenced by this. The authors find that CBA forced investment design to be more efficient. They also suggest that politicians tended to put more weight on freight benefits and less weight on traffic safety than what was suggested by CBAs. Based on survey investigations within the Swedish Public Transport

Authorities, both Ljungberg (2007) and Vigren and Ljungberg (2018) find that cost-benefit analyses are not used to support decisions. Projects included in the master plan had a benefit-cost ratio exceeding one. However, they find that decisions made by politicians for larger projects were also affected by other concerns such as perception of local, regional and national economic compacts. Benefit-cost ratio tended to be larger for approved road projects than approved railway projects (Eliasson 2013).
In an econometric study on the decision-processes leading up to road investments in Sweden and Norway, Eliasson et al. (2015) confirm that only Swedish projects with a positive benefit-cost ratio are realized, but that the priority ranking is random beyond this point. While bureaucrats' decisions are strongly affected by the benefit-cost ratios and particularly by high expenses, politicians' decisions were only weakly affected for small projects. Eliasson et al. also find that both Swedish and Norwegian politicians tended to favor investments in regions where they had strong local support. Furthermore, the authors find that the benefit-cost ratio had no impact on whether Norwegian road projects were realized or not, even with benefit-cost ratios well below unity. Neither benefits nor costs seemed to affect project selection. Considering that both Norway and Sweden use substantial resources on transportation appraisal, Eliasson et al. evaluate their findings to be worrying, particularly for Norway.
Findings in Boge (2006) confirm that project selection is even more random in Norway than in Denmark and Sweden. A similar conclusion for Norway is drawn by Odeck (1996) and Fridstrøm and Elvik (1997). Nevertheless, they find that high net benefits increase selection probability slightly in rural areas. Halse and Fridstrøm (2018) find that Norwegian road projects yield higher net social benefits in urban areas than in rural areas. Note that rural regions are overrepresented both in the Norwegian parliament and in the Norwegian county councils. Because of vested political interests and solid state finances, Norwegian investigators' list of prioritized projects tends to change a lot after submission of cost-benefit analyses to the national politicians (Sager 2016). Strand (1983 and 1993) find that the distribution of road investments over counties is stable over time (see also Nyborg and Spangen 1996 and Strand et al. 2015 for further discussion). PIARC (2003) refers to poor correlation between benefit-costs ratios and final project ranking in Norway, but points out that the ratio was becoming more important for decision-making at the time. At the time of the study, the Norwegian appraisal methodology received some criticism for lack of monetarization and some disagreement about valuation of value of time and costs of accidents. Elvik (1995) finds evidence that road standards have been decisive for the distribution of road investments in Norway. Holmen (2020) reviews studies on decisive factors for Norwegian road investments with focus on CBA and productivity concerns' lack of practical influence.
Moreover, national assessments of Norwegian road investment projects put little weight on non-monetized impacts (Rasmussen set al. 2010, Norwegian Public Road Administration 2012, Lædre et al. 2012 and Bull-Berg, Volden and Grindvoll 2014). Due to uncertainty and possible pressure from lobbyists, two expert committees appointed by the Norwegian Ministry of Finance (Finansdepartementet 1997 and 2012) recommended to omit wider economic impacts from CBAs, explaining why these impacts were not included in earlier guidelines. The Norwegian national master plan for transportation has received criticism for random order of priority and lack of overall objectives (e.g. Finansdepartementet 2015 and Strand et al. 2015).
In the early 2000s, environmental impacts were assessed separately in Denmark and taken into account in addition to the economic appraisal when deciding whether or not to implement a road project. Economic evaluations are accepted as an indication of priority, but could be overridden by political decisions (PIARC 2003). Today, environmental assessment is an integrated part of the economic appraisal (Transportministeriet 2015). Also in France, economic appraisal of road projects is conducted both for project selection and to choose between project options including design and timing (PIARC 2003). In their project selection, French politicians tend to be more interested in projects' economic impacts on a regional level than their internal rate of returns (COWI 2002). Studying the French decision-making, Damart and Roy (2009) find that decision-makers struggle to balance between the expert knowledge produced by CBA methods and the knowledge produced through stakeholder involvement. They argue in favor of adjusting appraisal practices so that they become more relevant and constructive for the debate on infrastructure projects. In 2003, economic evaluation was not common for Swiss road projects. Instead, major road projects in Switzerland aimed to complete, further develop and supplement the existing motorway network (PIARC 2003).
In Eastern and Southern Europe, co-funding from the European Union has contributed to the use of CBA (Odgaard, Kelly and Laird 2006). Castells and Solé-Ollé (2004) analyze public transportation infrastructure investments in Spain from 1987 to 1996, by applying a governmental objective function which accounts for equality-efficiency trade-offs and deviations caused by electoral productivity at regional level. They apply Arellano and Bond's dynamic general method of moment estimator with slow investment adjustments on a panel data of regional investments and capital stock over transportation modes. Their results suggest that the geographical distribution of government investments is largely explained by specific regional infrastructure needs and political factors, while efficiency concerns play a limited role.
In the Czech Republic, there is a strong correlation between indicators of project worth and project implementation. Hungarian prioritization of road projects on the other hand is significantly influenced by politicians. Yet, economic appraisal is still used to assist in investment decisions, inter alia to obtain co-financing from the European Union. In Portugal, decisions of which projects to proceed with have mainly been based on the plan to complete and complement main road networks, while economic appraisal is included in the decision basis (PIARC 2003).

B.2 Non-Western Countries

Economic appraisal also affects economic decision-making in several Non-Western countries. According to PIARC (2003), the Japanese government requires CBA for transportation projects, often in an expanded or modified version that includes considerations about amenity, environment and equity balance. CBA is used for acceptance or rejection of projects, while project prioritization hinges on MCA, inter alia allowing for social factors. In Mexico, both the benefit-cost ratio and the internal rate of return are

used in project prioritization, with about 70 percent of highly ranked projects being implemented in the years just prior to 2003. Yet, political considerations and trunk network completion often override results from economic appraisal. In South Africa, about 85 percent of projects were viable in the years up to 2003. The remaining 16 percent are carried out due to other concerns such as objectives on design of a coherent transportation system, socio-economic considerations not included in the CBA and technical reasons related to materials or construction.

Soberanis (2010) accounts for how the Mexican institutional framework ensures that high social return is given preference. In Mexico, the Federal Law of Budget and Financial Responsibility establishes as prerequisite for federal investments the obligation to carry out CBA and to obtain Investment Unit approval on the CBA and policy objectives, The Inter-Ministerial Commission for Financing and Expenditure chooses which project to include in their Budget of Expenditure Draft. Soberanis (2010) recommends that CBA is used even more actively in the early planning phase and that more stakeholders are involved in this process.

Stead and Pojani (2017) review urban transportation planning in twelve large developing countries including the BRICS countries. Their main finding is that all countries reviewed lack effective transportation governance coordination due to weak administrative arrangements, limited planning capacities and lack of coordination between land use and transportation planning. Typically, local authorities have uncoordinated plans for the transportation system, which are dependent on funding from the central government to be realized. Often, central governments do neither have the funding nor the will to support local projects, which come with the risk of political tensions. Public-private partnerships increase funding in some cases, but in other cases they could harm transportation provision through legal and financial disputes. Robison and Thorsvik (2005) argue that infrastructure investments in developing countries are misallocated due to 'white elephants', which are major infrastructure projects motivated by political benefits rather than social surplus.

Investigating planning procedures for transportation infrastructure in member countries of the Organization of Islamic Cooperation, COMCEC (2018) finds that planning in Muslim countries often has taken place in a policy vacuum and that a systematic basis for project priority is largely missing. Muslim countries in Asia outside the Middle East tend to not have national transportation plans, unlike Muslim countries in Africa and the Middle East. Consequently, investments in Asian Muslim countries outside of the Middle East are typically based on more flexible medium run investment plans instead, which also cover other sorts of infrastructure. Most national transportation master plans are products of intervention by international financial institutions, which aim to contextualize their investments. Transportation planning in Muslim countries is mostly top-down with limited involvement of the private sector and academia, although stakeholder involvement is common. Sustainable development is seldom taken into account. COMCEC finds that Malaysia is most satisfied with its own planning of transportation infrastructure, followed by Turkey and Kuwait, while Somalia was least satisfied.

Transportation plans in many Muslim countries focus on outputs (e.g. meters of road and number of particular constructions) rather than outcomes in terms of efficiency impacts, for example in Kazakhstan, Oman, Senegal and Uganda. In some of these countries, outcome measures supplement the plans, such as financial and socio-economic measures in case of the Senegalese plan. Transportation investments in Senegal are centralized, but stakeholder involvement and consultancy assistance are also important factors. Investigation of alternative solutions for transportation projects and mapping of transportation users' needs are used to shape the national transportation agenda, but the importance of user affordability is limited. Ugandan transportation policy is important for transportation infrastructure investments in the country, although its role is largely informal. Transportation planning is centralized and heavily dependent on outsourcing to consultants (ibid.).

In Nigeria, project appraisal is conducted for all transportation investment projects with international funding and for most projects funded by domestic funds. Economic project appraisal is not legally required, but some sort of appraisal is required for projects to receive a 'no objection status' for procurement. Economic appraisal is often used to justify transportation investments. Results from appraisal processes are both applied to justify investments and to prioritize projects in Mozambique. Due to transportation's importance for the country's development mandate, capacity for building activities receives increasingly more attention (COMCEC 2019).

There are large differences in transportation planning and appraisal among Asian Muslim countries outside the Middle East. In Malaysia, stakeholder involvement is important in the design of the national plan for transportation investments. Moreover, Malaysian transportation investments are largely driven by the private sector. The Malaysian plan for national transportation investments is outcome-based, based on measures such as connectivity, safety, transportation service, sustainability and resilience. In Kazakhstan, transportation appraisal plays a limited role for national transportation investments, which to some degree instead are affected by a national objective to increase transit traffic through the country (COMCEC 2018).

Following the availability of oil money, relatively large investments under the auspices of the Qatari public sector have been carried out in the country in recent years, increasing the focus on monitoring and evaluation. The earlier Qatari national transportation investment planning practices have been evaluated to have a high achievement of objectives related to increased accessibility and user benefits, but negative consequences such as accidents, congestion and pollution are not taken into account by these objectives. Yet, Qatari implementation studies for transportation investments also include assessment of environmental and social impacts, which in turn are important for decision-making processes and financing. Also in Oman, public investments are policy driven by oil funding. Omani authorities conduct market surveys over transportation user needs and consequences for affordability, but the country lacks a clear plan for transportation investments. The Omani national investment plan does not focus on pricing of transportation infrastructure, but environmental impacts play a central role (ibid.).

C. Appendix: Supplementary Mappings of Current Appraisal Guidelines

In section 4 of the main paper, we provide an updated mapping of impact coverage in national appraisal guidelines for transportation. In this appendix, we supplement this mapping with more information on the guidelines. This include the extent of the appraisal guidelines, which can be considered as another proxy to impact coverage for how complex and detailed the guidelines are. We also map the appraisal guideline sets' categorization of impacts and organization.

Addressing impact classification, it becomes clear that recipient and the highlighting of particular impacts are the most commonly applied impact dimensions. Impact recipient constitutes the most common primary dimension for the classification of impacts. All guideline sets use two to five dimensions to classify impacts. Combined, the guidelines apply eight dimensions in total to classify impacts, and there are large variations in regard to which dimensions are applied.

C.1 Categorization of Impacts

The level of detail in the impact coverage varies quite substantially across national guidelines. Our mappings of the magnitude of each guideline set and their design shed some light on this heterogeneity. Consideration of impacts is partly reflected in how they are classified. Thus, we also map how impacts are classified by different sets of guidelines. To our knowledge, impact classifications in guidelines have not been mapped before.

We start by mapping how impacts are classified in different sets of national appraisal guidelines. Dimensions highlighted in headings or presented as main categories in tables that classify impacts in the appraisal guidelines are recognized as primary classification dimensions. Dimensions highlighted in subheadings, tables or in applicable classification in the text in the appraisal guidelines are recognized as secondary classification dimensions. We also map the magnitude of each guideline set (i.e. number of words and pages) and provide some qualitative descriptions to illuminate the similarities and differences between the guidelines.

National appraisal guidelines categorize impacts from transportation measures in various ways. We refer to Oosterhaven and Knaap (2003) and Holmen and Hansen (2022) for discussions. In our mapping, we have identified eight dimensions explicitly or implicitly applied by the guidelines:

- **Recipient:** Impacts are classified in accordance with their recipient, typically in terms of households (i.e. social impacts), businesses (i.e. economic impacts), environment (i.e. environmental impacts), possibly efficiency costs related to public funds and measures (i.e. public impacts) with possibly further segmentation. Other recipient-oriented classifications concern different user groups of transportation.
- **Market linkage:** Impacts are classified in accordance with their relation to the infrastructure or spatial measure in terms of direct impacts, indirect impacts and possibly externalities. Market linkage could also concern whether the impact is related to the implementation phase (e.g. construction process) or the consequences of the spatial measure after implementation (e.g. impacts of the transportation system).
- **Inclusion in CBA:** Impacts are classified in accordance with how they are assessed with focus on the inclusion in CBA, typically over monetized, non-monetized and potentially partly monetized impacts. Other methodological classifications are also possible.
- **Duration:** Impacts are classified according to their duration, which can be permanent or temporary. Most appraised impacts are permanent, so temporary impacts mostly concern the construction process and indirect effects of the related activities.
- **Mode:** Classifications of impacts based on modes involve different means of transportation (e.g. road, rail, aviation and seafaring), infrastructures (e.g. transportation, energy and telecommunication), spatial objectives (e.g. infrastructure and area usage) and policy interventions (e.g. investments and regulations).
- **Space:** Classification based on geography concerns geographical distribution. Some guidelines use this dimension to distinguish between national and foreign impacts.
- **Impact size:** In classification based on impact size, impacts considered to be large are highlighted as own groups of impacts.
- **Impact sign:** Classifications based on impact sign distinguish between benefits, costs and possibly impacts for which the value sign is context dependent.

In Table C 1, we depict the impact classification dimensions applied by the guideline sets. We distinguish between the primary and secondary classifications, as explained above.

We see that impact size is the most common dimension in impact classification with application in 16 out of 18 guideline sets. Yet, only five among these use impact size as a primary dimension for classification. Recipient of the impacts constitutes the second most applied dimension and is applied in 13 guideline sets. This is also the most common primary classification dimension with application in eleven sets of guidelines.

All other classification dimensions are used in less than half of the guideline sets. Overall, there are large variations with regards to which dimensions are applied. On average, guidelines use 2.39 primary dimensions and 3.22 dimensions in total to classify impacts. Analogously, the median number of primary and total dimensions applied to classify impacts are 2 and 3 respectively. All guidelines make use of at least two dimensions for impact classification.

The Netherlands operate with most impact dimensions, involving several guideline documents which largely categorize impacts differently. Sweden operate with the second most complex impact classification (the former due to different classification in different guidelines) with five impact categories applied. British Columbia, Germany and the United States use the least classification dimensions (2 each). All guideline sets use one or two primary classifications, except for the Netherlands and Sweden, which apply five and three dimensions respectively.

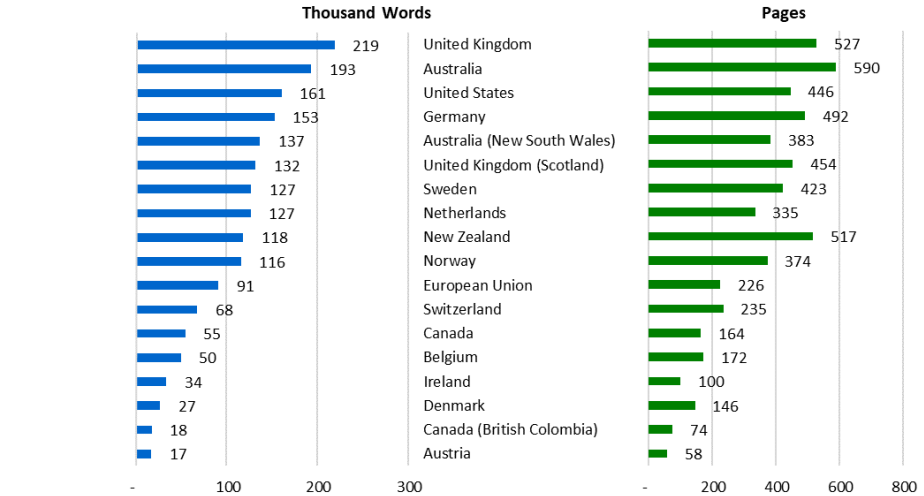

Fig. C 1. Total size of national appraisal guidelines for transportation measured by a) number of thousand words (l.h.s.) and b) number of pages (r.h.s.). Text regarding other infrastructure and actual transportation planning is excluded in the figures, as well as parts not regarding appraisal in online guidelines.

Table C 1. Impact classification in sets of national appraisal guidelines for transport. Dark green indicates primary classification and light green indicates secondary classification

Set of guidelines	Recipient	Market linkage	Inclusion in CBA	Duration	Mode	Space	Impact size	Impact sign
Australia								
Australia (New South Wales)								
Austria								
Belgium								
Canada								
Canada (British Columbia)								
Denmark								
European Union								
Germany								
Ireland								
Netherlands								
New Zealand								
Norway								
Sweden								
Switzerland (road)								
United Kingdom								
United Kingdom (Scotland)								
United States								

C.1 Extent and Design of the Appraisal Guidelines

Obviously, number of words is more precise on text extensiveness than number of pages, but number of pages also captures space used on tables and figures. The mapping only includes guidance on appraisal of spatial and transportation measures. Many of the other guidelines refer to the British ones, particularly guidelines in other Anglo-Saxon countries, but also others including the Dutch, Swedish and Norwegian.

Comparing the extensiveness of guidelines is not a straightforward task. Some guidelines treat other topics in addition to economic appraisal, such as planning, financial appraisal, transportation modelling and assessment of other infrastructures. Most guidelines for transportation measures are supplemented by other guidelines, inter alia in terms of parameter sheets and more general guidance on economic appraisal, typically prepared by transportation and financial authorities respectively. Different complementary guidelines will have varying overlap and synergies, such as Transport Canada (2007) in Canada and Romijn and Renes (2013) in the

Netherlands (consisting of 21,504 and 79,792 words and 53 and 192 pages respectively). There are also large variations in the appraisal guidance's compactness and level of methodological detail. Thus, our results should be interpreted with caution. Still, both length in terms of number of words and number of pages constitute decent proxies for the guidelines' extensiveness.
The guidelines of the United Kingdom and Australia are the most comprehensive guidelines in terms of number of words and pages. The guidelines of Australia are the longest measured by number of pages and do in addition refer to the old guideline sets for some transportation modes. All four guideline sets were among the guidelines with the most extensive impact coverage. Austria and British Columbia have the least comprehensive guidelines, while their impact coverages were at a medium level. Overall, there is no clear correlation between the size of the guideline sets and the width of their impact coverage. The magnitude of each guideline set tends to increase with the country's size and how general the appraisal topic is in terms of application.
Figure C 2, we compare the extensiveness of the guidelines measured by words and pages with impact coverage in CBA and overall. Surprisingly, CBA impact coverage has negative correlations with the guidelines' extensiveness in terms of words and pages of minus 0.301 and minus 0.317 respectively. Moreover, large countries such as Germany and the United States have large guideline sets, but no extensive impact coverage, while the opposite holds true for the Netherlands (transport) and British Columbia. On the contrary, overall impact coverage has coverage has positive correlations with the numbers of words and pages of 0.153 and 0.123 respectively. Given the level of impact coverage, countries with large populations tend to have more extensive guidelines than countries with smaller populations.

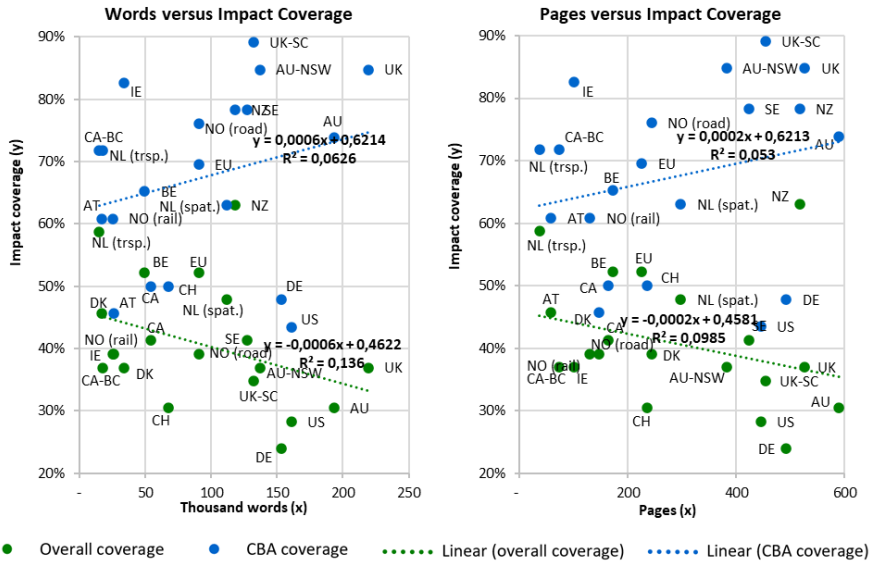

Fig. C 2. Comparison between the extent of the guidelines measured by a) words (l.h.s.) and pages (r.h.s.) and impact coverage in CBA and overall. Explanation of abbreviations applied in the figure: AT – Austria, AU – Australia, NSW – New South Wales, BE – Belgium, CA – Canada, BC – British Colombia, CH – Switzerland, DE – Germany, DK – Denmark, EU – European Commission, IE – Ireland, NL – Netherlands, NO – Norway, NZ – New Zealand, SE – Sweden, UK – United Kingdom, SC – Scotland, US – United States

In Table C 2 below, we have provided short descriptions of the characteristics of each guideline set. We have also noted whether the guideline set is published as an online guidance or in traditional report form, and how many guideline reports each guideline set consists of.
There is a lot of heterogeneity in scope, focus, conceptual explanations and methodological level between the guideline sets. Application catchment varies between general spatial appraisal, general transportation appraisal, appraisal of particular modes or different regional catchment areas, as well as catchment of only investments or also other spatial measures. Focus varies from the planning process and assessment of each impact and further to methodology and practical implementation. Some guidelines focus on technicalities such as formulas and parameter statistics, while others focus more on concepts, systematization and illustrations in figures and cases. There is also large variation in dependency and synergies between the guidelines within a guideline set, and dependency on other general economic appraisal and planning documents.
The guidelines of the United Kingdom and Australia are well-integrated online guidelines. The Dutch and the American guideline sets are example of extensive guidelines, where the appraisal documents apparently are less integrated. This does not mean that complement each other in practice uses by practioneers. Some guidelines, such European Commission (2014) for the European

Union and Rijkswaterstaat (2018) for the Netherlands, both regards transportation appraisal and other sorts of spatial appraisal. In other countries, the most extensive guideline is limited to road appraisal (e.g. Bundesamt für Strassen 2018 in Switzerland and Jernbanedirektoratet 2018 in Norway), possibly with a separate guideline addressing rail appraisal (e.g. Jernbanedirektoratet 2018 in Norway). Department for Transport (2019) in the United Kingdom and Australian Transport (2019) are example of guideline sets, where the different transportation nodes both involve common and separate documents.

Table C 2. Short description of content and composition in public appraisal guidelines reviewed in terms of catchment area, form, number of guidelines and a description of the guideline set

Set of guidelines	Form	No.	Description
Australia	Online	1	All transportation modes are covered with additional guidelines for some modes. Parameter values are in given separate documents.
Australia (New South Wales)	Report	2	The guidelines focus on both optimal transportation service provision and transportation investments. They complement national guidelines.
Austria	Report	2	The guidance focuses much on different appraisal tools and less on impacts. Treatment of emergence of new traffic in CBA is handled in a separate report.
Belgium	Report	3	A separate report is devoted to parameter values. Some topics are treated in adjusted short reports. Authorities refer to methodology in project reports.
Canada	Report	1	The national guidance is more than 25 years old and supplemented by the general economic appraisal guidance and state guidelines. It is methodologically structured.
Canada (British Columbia)	Report	2	Concepts and parameter values are provided in distinct reports. Indirect impacts receive less attention. Online calculation tools come in addition.
Denmark	Report	1	The guidance is supplemented by unit price statistics and discussion notes of the Danish appraisal model, Teresa.
European Union	Report	1	The guidance has a conceptual focus. It covers CBA for different infrastructures and is relevant for EU funding. 154 out of 381 pages do not regard transport.
Germany	Report	1	The guidance is the basis for the federal transportation plan's methodology manual. Methodologies are presented in a planning context with case illustrations.
Ireland	Report	1	The guidance focuses on different assessment tools rather than each impact. Ireland also has regional guidelines.
Netherlands (spatial)	Report	5	The guidelines focus on concepts rather than technicalities. Separate reports are devoted to different transportation and spatial measures and impacts.
New Zealand	Report	1	In addition to constituting a standard review with a conceptual focus, the guidance contains many parameter values. These are also given in separate files.
Norway	Report	2	The guidelines put impacts into a methodological context. Transportation models in cost-benefit analysis is treated separately. Road and rail have separate guidelines.
Sweden	Online	1	ASEK guidance has strong impact focus, particularly environmental and traffic impacts. Parameter values come separately.
Switzerland	Report	2	The guidelines concern road transportation and focus on impacts. The appraisal tool eNISTRA in Excel supplements this and is documented separately.
United Kingdom	Online	1	The guidance consists of separate topical reports including reports on each mode, analysis and impact group. There is also much supplementary WebTag material.
United Kingdom (Scotland)	Online	1	In S-Tag, conceptual overview and methodological treatments are given in different guidelines. The overview accounts for appraisal at different stages.
United States	Online	3	The guidelines consist of agency and research reports. Wider economic impacts are a focus. Legal documents and state reports come in addition.

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