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Evaluating the outcomes associated with an innovative change in a state-level transportation project prioritization process: A case study of Vermont

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ABSTRACT

In this paper we examine the outcomes associated with an innovative change in a state-level transportation project prioritization process within the United States (U.S.). A foundational component of the innovation is the development and implementation of a novel multi-criteria analysis (MCA) tool to aid decision-makers. The pre and post-MCA project prioritization processes are described in detail for the state of Vermont, and we use a mixed methodological approach to empirically evaluate the outcomes associated with the innovative change with respect to three objectives: (1) to make the project prioritization process more transparent, (2) to improve the project prioritization process by incorporating well-defined, objective evaluation criteria into the decision-making process, and (3) to reduce inequality in the allocation of transportation project funds between the local jurisdictions. We demonstrate that the innovative change in the project prioritization process was clearly successful in accomplishing objectives 1 and 2, but does not appear to be successful with respect to accomplishing objective 3. The findings are discussed in the context of the state of Vermont, and we offer suggestions for how funding inequality might be addressed in the future.

1. Introduction

In the United States (U.S.), the process of vetting, prioritizing, and funding transportation infrastructure projects can be extremely complex. Various agencies at the national, state, and local levels are responsible for planning, building and maintaining different components of a very large, interconnected, and open access transportation network. Although a specific agency may bear the primary responsibility for building and maintaining a particular infrastructure component, most transportation infrastructure projects are financed through a mixture of public funding sources and are explicitly designed to serve "the public", not just the local constituency within the geographical boundaries of the project. Because transportation infrastructure projects have the potential to affect mobility, accessibility, and economic competitiveness both within and outside of the jurisdictional boundaries where the project occurs; the impacts associated with project financing decisions extend well beyond the immediate vicinity of the individual projects being considered (Novak et al., 2012; Cohen, 2010; Scott et al., 2006). Decisions regarding which transportation projects are ultimately funded are not only important at the local and regional levels, but to the state as a whole.

We define the term *innovation* according to the 3rd edition of the *Oslo Manual* as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" (OECD, 2010, p. 1). The innovation discussed in this paper centers on the development and implementation of multi-criteria analysis (MCA) decision-support tool that significantly changed the entire transportation project prioritization process within the state of Vermont. While the use of MCA by public sector agencies is not necessarily innovative in and of itself, the development and use of an MCA tool in the context of transportation project prioritization by a state-level transportation planning agency within the U.S. appears to be quite innovative. This particular innovation was championed and implemented by the Vermont Agency of Transportation (VAOT), Vermont's state-level transportation agency, and was motivated by collaborative interactions between a wide range of actors within a large intergovernmental network. We frame the study in the context of empirically evaluating the outcomes associated

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with a specific public sector innovation. In this case, the innovation is not a product, but a process-based improvement.

Within the innovation literature, various sources have examined how public sector innovation may be viewed differently from private sector innovation (Mazzucato, 2014; Lee et al. 2012), how characteristics typically associated with private sector innovation may be applicable to the public sector (Mulgan and Albury, 2003), how innovation is implemented and disseminated throughout different types of intergovernmental networks (Edquist and Zabala-Iturriagagoitia, 2012; Aschhoff and Sofka, 2009; Walker, 2006), and how the collaborative processes through which innovation is developed are formed (Hoppe and Schmitz, 2013). However, there is a large gap in the literature related to empirically evaluating the outcomes associated with public sector innovation (Bloch and Bugge, 2013). While there are studies that propose a theoretical framework for analyzing innovation with respect to public transportation (Ongkittikul and Geerlings, 2006), that address the need for more innovative thinking when considering transportation policy issues (Weber et al. 2014), and that provide some empirical assessment of operational level technological improvements in the transportation sector such as smart cards, in-vehicle GPS, weigh-in-motion, etc., (Duncan and Graham 2013; Naphade et al., 2011; Wagner, 2008); there are few, if any, studies that attempt to evaluate the impact that a particular innovation has on public decision-making processes and service outcomes in the transportation sector. The scientific contribution of this paper focuses on the outcomes resulting from the implementation of an innovative decision-making process within the transportation sector.

A mixed methodological approach is employed to evaluate the overall "success" of the innovation with respect three specific objectives: (1) to make the transportation infrastructure project prioritization process more transparent to the critical actors within the intergovernmental network, (2) to improve the project prioritization process by incorporating well-defined, objective evaluation criteria that can be used to compare and contrast projects from different infrastructure asset classifications in the decision-making process, and (3) to reduce inequality in the allocation of transportation project funds to localities throughout the state. The mixed methods approach includes qualitative input from stakeholder workshops as well as an examination of the pre and post-MCA project prioritization process documentation. The feedback from the workshops offered insight into the expectations and opinions of the various actors involved in the project prioritization process with respect to all three objectives. We also examined the post-innovation project prioritization decision-making framework and the MCA tool itself to further evaluate all three objectives. A Gini-coefficient analysis was then used to explicitly evaluate objective 3. The Gini analysis provides a quantifiable means for evaluating how the innovative change impacted funding allocation patterns over time. We also consider the use of Gini coefficient analysis to quantitatively measure inequality with respect to the distribution of federal transportation funds and revenues as a novel contribution to the literature (Altshuler, 2013; Hierro et al. 2007). Detailed transportation project data and the associated funding obligations between 1998 and 2010 (inclusive) along with demographic data are employed in the study.

1.1. Project background

This research relates directly to work originally discussed in Zia (2010). [1] As part of the 'Navigating Trade-offs in Complex Systems' project, several workshops were organized by the Chittenden County Metropolitan Planning Organization (CCMPO), which is the only MPO in the state of Vermont. The primary purpose of these workshops was to evaluate a number of long-term state-level transportation development scenarios, and then to select one of those scenarios for implementation. Prior to these workshops, the research team contacted the VAOT and the CCMPO to see if they would be interested in a research project focused on how the adoption of the MCA tool and new project prioritization process had impacted different localities within Chittenden County. Both organizations expressed interest in the idea, and included discussions on project prioritization, scoring criteria, and weighting in the agenda. Authors A. Zia and C. Koliba were key participants in the workshops, where they were introduced to Vermont's transportation project prioritization process and were able to listen to the opinions of the various actors. This was the first time that the VAOT had gathered various stakeholders and solicited formal feedback from them regarding their perceptions of the innovative MCA tool and the new project prioritization process. During the workshops, concerns over funding allocation "inequity" were mentioned by several stakeholders. After the research team shared their informal results with the VAOT, the VAOT expressed interest in investigating how "successful" the MCA tool had been, and more specifically, if and how the MCA tool and the new project prioritization process had affected the allocation of project funds throughout the state. The Gini coefficient analyses evolved from these discussions. While the focus of this paper is on empirically evaluating the outcomes associated with an innovation in a state-level transportation project prioritization process (centered on the development and implementation of the MCA tool), the project described in Zia (2010), also led to separate publications addressing, governance informatics (Koliba et al. 2011) and the development of agent-based models for intergovernmental decision making (Zia and Koliba, 2013).

The remainder of the paper is structured as follows. In Section 2, we provide an overview of innovation within public governance networks and briefly discuss the evolution of public sector decision-making models. In Section 3, we describe how transportation infrastructure projects are typically prioritized and funded at the state level in the U.S. We note a number of challenges faced by state, regional, and local transportation planning agencies and discuss how the federal transportation asset management (TAM) programs can influence state-level project prioritization planning. An overview of MCA is presented in Section 4, and the pre and post-innovation project prioritization processes within the state of Vermont are discussed in Sections 4.1 and 4.2 respectively. The data and methods used in the study are presented in Section 5, along with a brief discussion of different views on the concept of equity with respect to transportation policy in Section 5.1. In Section 6, we present the results from the Gini analyses and discuss the effectiveness of the innovative change in the transportation infrastructure project prioritization and funding allocation process with respect to the three objectives identified previously. Section 7 provides a concluding discussion where we consider the implications of this study in the state of Vermont and offer suggestions for future research.

2. Evaluating the impact of innovation within public governance networks

The introduction and proliferation of new practices and ideas within intergovernmental networks is of critical importance with respect to public policy and administration, as government agencies are increasingly being called upon to institute more "innovative" approaches and procedures concerning policy formulation and

[1] This report summarizes research activities performed under a 2010 sponsored grant award, 'Navigating Trade-offs in Complex Systems', Zia (2010), awarded by the University of Vermont's Transportation Research Center.

decision-making to improve the delivery of public services and the execution of regulatory functions (Weber et al., 2014; OECD, 2010; Walker, 2007). We define an *intergovernmental network* as a "relatively stable pattern of coordinated actions and resource exchanges involving governmental entities across different political jurisdictions and geographic scales, that coordinate their activities to some degree in the pursuit of some public policy objective(s)" (Koliba et al., 2010, p. 35).

While the role that public governance networks play in public policy and service innovation has received some attention, their role continues to be largely overlooked in the research community (Sørensen and Torfing, 2011). Public sector innovation is often viewed as inefficient, inflexible, and not particularly cost effective when compared to private sector innovation (Weber et al., 2014). This point of view may be largely motivated by outdated misconceptions of decision-making in public administration networks, as models of public decision-making have evolved considerably over time. The tradition model of public sector administration holds that most decisions are made at higher governmental levels and then implemented by passive, lower level public officials following a fairly strict hierarchy. The newer, New Public Management (NPM) model, builds on the tradition model by incorporating market-based concepts and incentives into the public-sector decision making process to increase competitiveness and to improve effectiveness and efficiency. While the NPM approach is more results-oriented than the traditional approach, it is still constrained by private-sector market concepts that may not hold in many public sector decision-making settings such as objectives focused on serving the public as opposed to maximizing profit or efficiency.

More recently, the New Public Governance (NPG) framework has been introduced to accommodate the increasingly multi-sector, multi-jurisdictional qualities of governance networks (Salamon, 2002; Osbourne, 2006). The NPG framework allows for more collaborative approaches to decision making as embodied in notions of public–private partnerships build around mutual resource exchanges carried out to achieve shared goals and objectives. Most recently, a new public decision-making model was introduced in the network governance literature (Weber et al., 2014; Benington, 2011). This model argues that public services are too complex to be viewed solely through a market-based lens, and that interactions between the various actors within an intergovernmental decision-making network are not necessarily controlled by fixed hierarchies. The foundational concepts of this model are a focus on collaborative public–private partnerships related to decision-making and innovation, and the idea of creating "public value" for citizens and society as a whole (Weber et al., 2014; Baumann and White, 2012; Sørensen and Torfing, 2011; Williams and Shearer, 2011; Bommert, 2010). Instead of simply disseminating private sector innovation, public sector actors are encouraged to take leading roles in initiating, developing, and managing innovative processes to better serve the public. Examples of such collaborative efforts include innovation related to climate change, pollution, and traffic congestion.

While the models of public decision-making have evolved, it is still quite difficult to identify the specific outcomes associated with innovation within public governance networks. Private sector innovation is typically driven by market-oriented profit maximization and efficiency goals. On the other hand, public sector organizations do not operate in a market-based framework so innovation goals are generally driven by a more ambiguous desire to improve services, governance structures, and decision-making (Bloch and Bugge, 2013; Bommert, 2010). As opposed to focusing on improving the financial performance of a particular organization through new product and process development, public sector innovation tends to focus on improving social performance or social welfare by changing decision-making processes (Moore and Hartley, 2008). Because the benefits from public sector policy or service innovation may accrue over long periods of time, may not be separable from other external factors, and tend to yield benefits that cannot be readily priced in the market, the outcomes associated with public sector innovation are often difficult to clearly define and measure.

A number of research studies have focused on how innovative practices and ideas are diffused throughout intergovernmental networks (Berry 1994; O'Toole, 1997; Dhanaraj and Parkhe, 2006; Frederickson and Frederickson, 2006; Provan and Kenis, 2008; Kenis and Provan 2009). These studies document how the emergence of new products, practices, and ideas within and across intergovernmental networks is inextricably linked to the underlying assumption that innovation leads to "desirable" outcomes. That is, innovation is positive. At the same time, actor perceptions regarding exactly what outcomes are desirable and the empirical evaluation of outcomes can be highly subjective. Outcomes are judged by the standards and expectations set by the various actors involved with, and affected by the innovation. The relative success of an innovation is viewed in light of the particular goals, objectives, and judgmental biases of the different actors (Lupo, 2013; Radin, 2006). The presence of more actors leads to a larger, more complex governance network and as the complexity of the network increases, the more divergent individual goals, objectives, and priorities are likely to be (Koliba et al., 2010).

Adding to the complexities associated with evaluating the outcomes associated with innovation in large governance networks are temporal complexities. Public innovation tends to unfold as a continuous process carried out over time, and can potentially involve different actors at different points in time. Documenting exactly how innovation unfolds across a public network is therefore extremely difficult, particularly when the goals and objectives are fragmented and differentiated across actors who may become more or less involved at different points in time (Berry, 1994; Berry et al., 1998). The ultimate goal behind public sector innovation clearly appears to be a desire to overcome all these complexities, and to produce or offer "better" products, services, processes, policies, or decisions. A key assumption in this paper is that the successful development, adoption, and implementation of the innovation is predicated on some type of notable improvement in performance, or a positive outcome.

In the case of the intergovernmental transportation planning network examined here, the development and implementation of the MCA tool is the key component in the evolution of the entire transportation project prioritization process in the state of Vermont. The outcomes associated with the project prioritization decisions affect transportation infrastructure funding decisions throughout the state. These funding decisions, in turn, directly affect the people within the state, as well as people traveling throughout the state. While the stated goal of the innovation was not explicitly to improve social welfare, the outcomes associated with the innovation ultimately impact social welfare in the form of increased (or decreased) mobility, accessibility, economic competitiveness. The motivations behind this particular innovation were fueled by a collective desire to make the transportation project prioritization process "better" by improving transparency and objectivity, and by fostering equity in terms of the allocation of transportation-related funds throughout the state.

3. Transportation project prioritization and funding allocation: an overivew

In the U.S., the process for determining which transportation infrastructure projects are funded occurs in a large intergovernmental network that includes federal funding programs sponsored by the U.S. Department of Transportation (USDOT), the planning and engineering functions for the state department of transportation (SDOT), metropolitan and regional planning organizations (MPOs/RPOs), local government agencies, and a wide range of civic and business actors. Within this large and diverse network, different visions, goals, and priorities often lead to conflicting opinions regarding how best to manage various trade-offs related to effectively allocating resources versus equitably allocating resources. Balancing different goals and priorities is a challenging undertaking, and the complexity associated with decision-making increases when matters of product, process, and/or service innovation are involved (Weber et al., 2014).

State and local governments rely heavily on federal funding programs to support most transportation infrastructure projects. These programs, in turn, are shaped by federal guidelines. Federal law stipulates that all state transportation projects that receive federal funds must appear on both the Regional Transportation Improvement Plan (RTIP) and the State Transportation Improvement Plan (STIP) within a particular state. This stipulation requires that local governments coordinate with their MPO/RPO counterparts as well as with their SDOT to synchronize planning efforts. Historically, relationships between many MPO/RPOs and their corresponding SDOTs have been weak or non-existent (Goldman and Deakin, 2000). This changed to a large degree with the implementation of the Intermodel Surface Transportation Efficiency Act (ISTEA) in 1990. ISTEA effectively provided MPO/RPOs with more decision-making responsibilities and increased flexibility in developing transportation plans tailored to specific regional needs as opposed to focusing on the priorities of the SDOTs. Despite improved relationships between most MPO/RPOs and their corresponding SDOTs, federal transportation funding programs are designed such that the planning priorities of the MPO/RPOs may not be directly accounted for in funding decisions, as funds flow directly from the federal government to each SDOT, and then from each SDOT to the individual MPO/RPOs and localities throughout the state.

Transportation funding decisions are therefore not determined via a democratic process. There is an explicit organizational hierarchy that leads to a representative decision-making process. The lack of direct regional and local representation in federal funding allocation decisions is not necessarily intentional on the part of the SDOTs – there are simply too many individual localities and MPO/RPOs in most states to be directly involved in establishing funding priorities with the federal government. However, the lack of direct representation can result in some SDOTs minimizing or ignoring input from localities and MPO/RPOs with respect to their priorities. In some cases this can lead to SDOTs not granting localities and MPO/RPOs their full statutory rights (Goldman and Deakin, 2000), or to SDOTs selecting state-level priorities over local and regional priorities when these priorities conflict. The way transportation funds are allocated to the different MPO/RPOs and localities within each state can also lead to competition instead of collaboration between regional and local actors, as they may not necessarily agree on regional and local project priorities.

The funding allocation strategies employed by the federal government are typically based on well-established transportation engineering performance measures that prioritize the allocation of federal dollars to those states and regions with more lane miles, greater vehicle miles traveled (VMT's), and larger contributions to the U.S. Highway Trust Fund (HTF). Funding allocation decisions based on the strategies used by the federal government (i.e. lane miles, VMT, etc.) can result in spatial discrepancies that may minimize the needs of low-income, more remote, or less-populated communities (Scott and Horner, 2008). These funding strategies not only raise questions about the appropriate balance between efficiency versus equity regarding the allocation of financial and physical capital, but may create points of conflict between local, regional, and state actors regarding transportation funding priorities throughout the state, and can give rise to notions of unfairness (Sinha and Labi, 2011).

3.1. *Transportation asset management planning in the U.S*

Under the MAP-21 legislation of 2012, each state in the U.S. is required to develop a risk-based asset management plan for the National Highway System (NHS), referred to as transportation asset management (TAM) plan (FHWA, 2014). TAM planning defines a systematic process of operating, maintaining, and improving physical transportation assets such as federal interstate highways and bridges, with a focus on engineering and economic analysis. TAM planning does not explicitly involve the prioritization or selection of transportation projects at the state level, but focuses on the management, evaluation, and preservation of certain types of federally supported physical transportation assets.[2]

The purpose of TAM is for each state to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement activities in order to achieve an acceptable level of repair and operation over the lifecycle of its physical transportation assets at a reasonable cost (FHWA, 2014). According to MAP-21, individual states are encouraged, but not required, to develop state-level TAM plans for non-NHS assets as well. It is important to recognize that TAM planning is separate from, but may not be completely independent from, state-level transportation project prioritization and funding allocation decisions. Potential co-dependence can result from the fact that certain infrastructure project classes, such as bridges and pavement, fit very nicely into federal-level TAM planning. From the state perspective, prioritizing and funding transportation projects throughout the state that are clearly defined and valued based on federal TAM asset classes, may be much easier to justify than prioritizing and funding projects that are not clearly associated with federal TAM asset classes.

Individual states may have widely disparate transportation project prioritization or selection processes. These process involve different actors in different ways, each with different levels of political influence and capacity depending on the state. While most U.S. states appear to group transportation projects using some type of project classification scheme that separates projects according to the type of project, both the project classification scheme and the state-level TAM classification scheme (if the state has a state-level TAM plan), can vary by state. States may use different evaluation criteria or scoring metrics to prioritize transportation projects, and may use different project classification schemes that may depend on whether or not the state has a well-developed state-level TAM plan.[3] State-level project prioritization processes also depend on the level of sophistication, available resources, and experience within the individual SDOT. There are no agreed upon project classification categories and performance metrics that are used to prioritize and rank different transportation projects universally across all 50 states. It is also relevant to note that data collection and inventory capabilities can vary dramatically between states and by locality or region within a given state.

[2] As a side note, it appears that the U.S. lags behind many other developed countries with respect to TAM planning and implementation.

[3] Information regarding state-level infrastructure management systems is based on phone survey responses collected from the New England states in 2008 and 2009 as part of a sponsored research project awarded to Watts et al. (2008) "Infrastructure Management Systems Enhancement and Integration to Support True Integrated Decision-Making" from the New England Transportation Consortium (NETC).

The total transportation funds available to the individual states varies annually and may be directly impacted by the availability of asset-specific federal funds as well as by other federal funding restrictions, programs, and incentives (FHWA, 2005, 2012). For example, certain federal funds may be restricted to a particular TAM asset class or type of project such as the maintenance of interstate highway bridges. While the 2005 SAFETEA-LU and the 2012 MAP-21 legislation both outline high-level transportation funding priorities at the national level, and provide structure and guidance in terms of which federal programs are responsible for funding which types of projects and activities, actual funding amounts and incentives may change to some degree from year-to-year. Overall, it is not particularly clear how the federal government determines asset-specific priorities or how asset-specific restricted funding is allocated to the individual states outside of the traditional volume-based engineering metrics, HTF contributions, and demographic data.

Compared to many others states, Vermont (and the VAOT) is fairly advanced with respect to both its state-level project prioritization process and its state-level TAM program, and is specifically mentioned by the Federal Highway Administration (FHWA).[4] Vermont's TAM plan extends to state-level transportation assets beyond those required in MAP-21, and is based on the AASHTO TAM Guide, Volume 1.[5] The plan is designed to provide a flexible framework for managing all VAOT's transportation assets including physical transportation infrastructure systems, human resources, financial capacity, equipment and vehicles, real estate, as well as all data and information assets (VAOT, 2014b). Vermont began work on a state-level TAM plan prior to the development of the MCA tool (VAOT, 2002); and the VAOT was able to draw on its experiences with TAM asset classifications in conceptualizing some the project categories that are used in the state's project prioritization process. This is relevant in the context of this study, as there are not necessarily well-established state-level models, or explicit federal guidelines for states to draw upon when establishing transportation project prioritization processes.

4. The MCA tool and its impact on the transportation project prioritization process

The use of MCA in public sector transportation planning is not new (Gokey et al., 2009; CLGP, 2009; Berechman and Paaswell, 2005; Kulkarni et al., 2004; Piantanakulchai and Saengkhao, 2003); however, the application of MCA appears to be extremely limited in the context of state-level transportation planning within the U.S. In the case of Vermont, the VAOT had little to no experience with MCA techniques prior to the development of the new project prioritization process.

MCA techniques first began to emerge in the early 1970s in response to a myriad of shortcomings associated with the use of traditional, neoclassical economics-based standards to make complex decisions involving trade-offs among a variety of performance criteria (Kiker et al., 2005; Belton and Stewart, 2002). MCA involves making decisions in the presence of multiple, often conflicting criteria, and can be an effective decision-support technique for multi-faceted policy decisions involving many different stakeholders with different goals and priorities. MCA techniques can be used to simultaneously evaluate multiple heterogeneous objectives, and generally involve assigning different weights to various criteria and then assigning rankings or scores to different decision alternatives. MCA is designed to explicitly identify different alternatives and the expected contribution of each of those alternatives, and all MCA techniques require the exercise of judgment (CLGP, 2009).

The use of MCA is not predicated on monetary valuation techniques such as cost effectiveness analysis (CEA), financial cost analysis (FCA), and cost–benefit analysis (CBA), and can therefore provide an excellent complement to these types of evaluation techniques. For example, MCA can be used to guide policy decisions that simultaneously involve quantified, but not monetized data (i.e. the number of households or people), monetized data (i.e. travel time savings, construction costs), as well as qualitative data (i.e. occupation, stakeholder opinions). Like all decision-making techniques, MCA has limitations including: (1) MCA is a time consuming, iterative process that often involves extensive negotiation; (2) MCA requires reliable data; (3) MCA is best employed when stakeholders agree on the overall objective of the policy or program; (4) MCA can be a complex technique, which requires the evaluator or facilitator to have solid data management skills; (5) MCA is a subjective tool. Even though structured MCA techniques are designed to overcome limitations and biases associated with human judgment, MCA is still prone to subjective interpretation of outputs; and (6) there are certain public policy questions where the diversity of views and the political, scientific, and social factors surrounding the issue may make the use of MCA unrealistic.

We next describe both the pre-MCA and post-MCA project prioritization processes for the state of Vermont.

4.1. The pre-MCA transportation project selection process in Vermont

The existing transportation project prioritization process in the state of Vermont is a continually evolving process that is largely the result of state-level legislation passed in 2005 and 2006[6] (VAOT, 2014a). Through legislative Acts 80 and 175, the VAOT was directed to systematically explain how transportation projects are prioritized and selected throughout the state, and to develop a numerical method to score and rank projects using explicitly defined evaluation criteria (VAOT, 2014a). The output from the prioritization process is then used to guide project funding allocation decisions throughout the state. Acts 80 and 175 therefore provided the catalyst for the development of a new transportation project prioritization process, where the MCA tool serves as the key component of the numerical scoring and project ranking portion of the process.

Prior to the development of the MCA tool, the lone MPO and the nine RPOs across the state were asked to prioritize – apparently by whatever means they chose to use[7] – all municipal and regional transportation projects, and then to submit their respective lists of ordinal, rank-ordered projects in descending order by priority to the VAOT through the STIP process. While the specific criteria used to evaluate and rank projects varied by organization, all MPO/RPO boards were required to vote out a final ranking of their priorities. At this time, there was not a clearly defined, objective evaluation framework that was used to prioritize and select projects at the state level, and exactly how the regional rankings submitted by the MPO/RPOs incorporated local input, and exactly how these regional rankings ultimately impacted the STIP (if at all), was ambiguous at best.

[4] FHWA, Asset Management http://www.fhwa.dot.gov/asset/.

[5] ASSHTO, 2002. 'Transportation Asset Management Guide: A Focus on Implementation', Washington, DC.

[6] Section 53 of Act 80 in 2005 and Section 48 of Act 175 in 2006.

[7] The details associated with exactly how the various MPOs/RPOs actually prioritized projects are vague, poorly documented, and appear to be largely ad-hoc. Some regions were more sophisticated and had more experience with techniques for objectively evaluating projects than others.

The state of Vermont currently separates transportation projects into different transportation project classes such as paving, bridges, roadway, safety and operations, bike/pedestrian, park and ride, and aviation. Some of these project classes are consistent with the infrastructure asset classes listed in Vermont's TAM plan (like bridges and pavement), but the transportation project classes are not identical to the TAM asset classes. For example, bike/pedestrian is a transportation project classification, but it is not a TAM asset category. Before the adoption of the MCA tool and the development of the new project prioritization process, the evaluation criteria that were used to rank and compare different projects were often poorly defined and highly subjective. Projects that directly corresponded to the TAM asset categories identified in the 2002 TAM Vision Statement, such as pavement and bridges, incorporated the use of well-defined, objective evaluation criteria that could be used in the project ranking process; however other types of projects often had no specific, or well-defined and objective evaluation criteria. Given the inherent difficulty associated with comparing infrastructure projects with different objectives and characteristics, many actors throughout the state simply assumed that the transportation projects that readily "fit into" to the TAM asset classes, were privileged in the project selection and funding process. Projects that did not have a clear set of objective evaluation criteria, or project that did not fit into the TAM asset classification scheme, such as bike/pedestrian projects and park and ride projects, were thought to be at a substantial disadvantage in the project selection process.

Many stakeholders expressed frustration with the subjectivity and lack of transparency that plagued the project prioritization process from RTIP to STIP, and felt that the lack of objective evaluation criteria associated with certain projects or project classes presented opportunities to disregard many local and regional preferences. Furthermore, it was widely believed that state legislators with responsibility for oversight of the VAOT budget could manipulate the decision-making process to favor their "pet projects", and that the localities which could afford to hire more experienced planning personnel and that had strong political connections had a clear advantage over localities with less capacity in terms of resources, political connections, and experience. Overall, the entire pre-MCA project selection process was routinely criticized for a lack of transparency and the absence of well-defined evaluation criteria that could be used to objectively compare disparate projects.

4.2. The post-MCA tool project prioritization process in the state of Vermont

The development of the MCA tool can originally be traced back to an informal initiative that was undertaken by the VAOT. The goal of the initiative was to incorporate "more objectivity" into the transportation project prioritization process, and to establish some consistency between the state-level TAM planning and project prioritization and funding allocation decisions. The initiative was specifically focused on ways to improve the project prioritization process by incorporating more quantifiable, objective performance measures into the evaluation and scoring of all projects, regardless of whether or not they belonged to a TAM asset class. The initiative was largely undertaken in response to concerns expressed by many local and regional actors related to the ambiguity and lack of transparency associated with the pre-MCA project prioritization process outlined in the previous section.

At roughly the same time the VAOT began the informal initiative to improve the project selection process, Vermont's State Senate Transportation Committee (SSTC) responded to these same concerns in a more formalized manner by directing the VAOT to explain how transportation projects are prioritized and selected for funding (VAOT, 2014a). The original, informal VAOT initiative was thus transformed into a formal initiative based on legislative mandates in 2005 and 2006, which resulted from the recommendation from the SSTC. The formalized legislative initiative ultimately led to the development of the MCA tool and a development of a completely new project prioritization process within the state of Vermont.

In response to these legislative mandates, the pool of stakeholders involved in the development of the new project prioritization process was widened to include many more actors outside of the VAOT. The stakeholder groups involved in the development of the MCA tool included VAOT engineers from each of the different TAM asset classes (such as bridges, traffic operations, etc.) representatives from the MPO and the different RPOs across the state, regional representatives from the Federal Highway Administration (FHWA), non-governmental organizations (NGOs), and state lawmakers (Zia, 2010). The stakeholder pool largely consisted of transportation and planning professionals, but did include several non-transportation/planning professionals (NGOs and state lawmakers). Each stakeholder group contributed in different ways and to different extents, and each group had its own ideas of how their viewpoints should be factored into project selection and funding decisions. It is important to point out that the MCA tool is a state-level decision-support tool that was championed and implemented by the VAOT, and that the VAOT is the primary actor in the state's project prioritization process.

Table 1 illustrates the VAOT and MPO/RPO MCA scoring criteria and the specific weights associated with each individual criterion. A key component of the project prioritization process is to assign

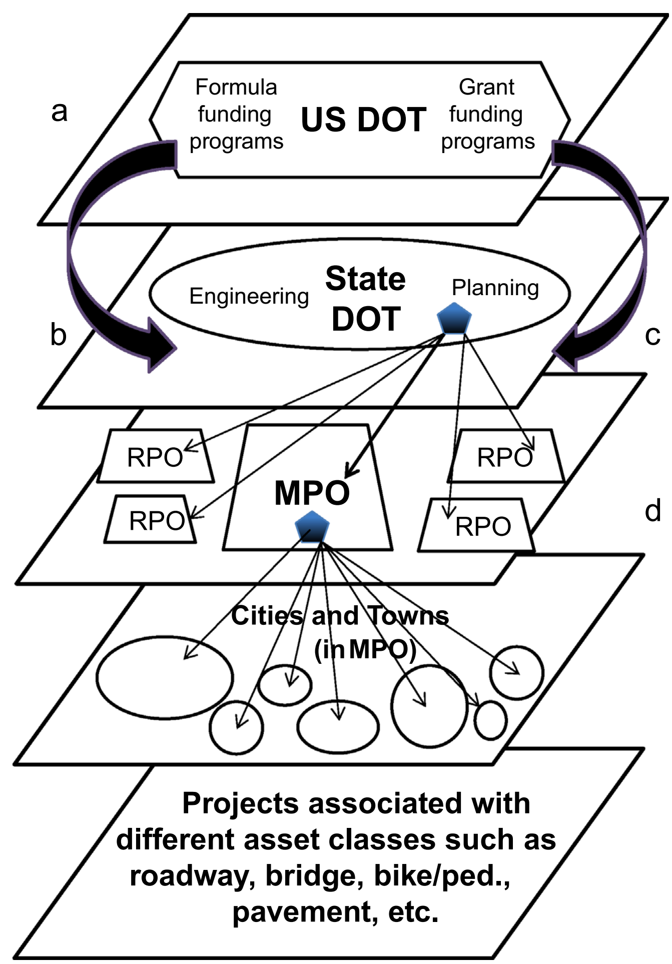

Fig. 1. Intergovernmental Network for Project Prioritization in Vermont.

priority rankings using a quantifiable scoring system that includes objective evaluation factors such as safety, traffic volume, maintenance costs, etc., *and* explicitly includes MPO/RPO priorities in the project rankings. (VAOT, 2014a). The MCA tool explicitly incorporates local and regional project priorities into the project prioritization process via a weighting component and utilizes specific, state-defined evaluation criteria for each transportation project class (roadway, paving, bridges, bike/pedestrian, etc.).

As shown in Table 1 (columns 2 and 3), the evaluation criteria and the weights associated with those criteria can be different for each project class. For example, roadway projects have four evaluation criteria: highway system, cost per vehicle mile, regional priority, and project momentum; while pavement projects have three evaluation criteria: pavement condition index, benefit/cost, and regional priority. The regional priority criteria is the only criteria that is used consistently across all project classes. The sum of all weighted criteria in each project class is 1.0 or 100%. There are also nine MPO criteria listed in the two columns on the far right of Table 1, each of which is weighted at 0.111 ($9 \times 0.111 \approx 1.0$ or 100%). While the MPO/RPOs have some flexibility in how they set regional priorities, they are expected to use the defined MPO criteria in column 5 when ranking their regional priorities. The regional project priority rankings from the MPO/RPOs are then feed into the SDOT criteria weighting as inputs that receive a 0.2 or 20% weighting (15% in the case of bridges). The tool includes an 80%/20% split with respect to weighting the importance of state priorities versus regional priorities for all transportation projects throughout the state with the exception of bridges. The 80%/20% split is designed to mirror the split between the federal and state matching ratios for federal funding programs.

The post-MCA project prioritization process is described as follows. First, the MPO/RPOs prioritize all transportation infrastructure projects within their respective jurisdictions (as illustrated in label (a) of Fig. 1). All local priorities are factored in (aggregated) at the level of the MPO/RPO decision. The process begins with MPO staff conducting a preliminary project ranking using the scoring criteria outlined in the far right hand column of Table 1. Each of the nine evaluation criteria (economic vitality,

Table 1
Multi-criteria analysis for VAOT and MPO/RPOs in Vermont.

Project Class	VAOT State Evaluation Criteria (may be different criteria for each project class)	Weight	MPO Rank Ordering	9 MPO Evaluation Criteria (applied to all project classes)
Roadway	Highway System	0.4		
	Cost per Vehicle Mile	0.2		**Each of the 9 MPO ranking criteria are equally weighted at 0.111**
	Project Momentum	0.2		
	Regional Priority	0.2 ←		
	Total	**1.0**		
Paving	Pavement Condition Index	0.2		Economic Vitality
	Benefit / Cost	0.6		
	Regional Priority	0.2 ←		
	Total	**1.0**		Safety and Security
Bridges	Bridge Condition	0.3	**MPO / RPO rank ordering results for all projects are rolled into the Regional Priority criteria for each of the separate project classes**	
	Remaining Life	0.1		
	Functionality	0.05		Mobility and Connectivity
	Land Capacity and Use	0.15		
	Waterway Adequacy & Scour Susceptibility	0.1		
	Project Momentum	0.05		Environment
	Asset-Benefit Cost Factor	0.1		
	Regional Priority	0.15 ←		
	Total	**1.0**		Energy and Quality of Life
Bike / Pedestrian	Land Use Density	0.2		
	Connectivity to Larger Bike / Ped. Network	0.1		
	Multi-Modal Access	0.05		Preservation of Existing System
	Designated Downtown Center	0.05		
	Project Cost	0.2		
	Project Momentum	0.2		Efficient System Management
	Regional Priority	0.2 ←		
	Total	**1.0**		
Traffic Operations	Intersection Capacity	0.3		
	Accident Rate	0.2		Prior Listing in TIP
	Cost per Intersection Volume	0.2		
	Project Momentum	0.1		
	Regional Priority	0.2 ←		
	Total	**1.0**		
Park and Ride	Total Highway and Location	0.4		
	Cost per Parking Space	0.2		
	Project Momentum	0.2		
	Regional Priority	0.2 ←		
	Total	**1.0**		

safety and security, etc.) are weighted equally at .111 of the total project score. This is done independently of project class, and the project with the highest total score is ranked first; the project with the second highest total score is ranked second; and so on. The ranked project results are then shared with members of the MPO/RPO Technical Advisory Committees (TAC) comprised of town planners from the city and towns within the region, MPO/RPO staff members, and various local planners working on behalf of their local governments. Project details and the preliminary project rankings are discussed and debated by the TAC. Post-discussion, the TAC votes on a regional ranking for each project, regardless of project class. Second, the regional TAC ranking is reviewed by the MPO board, which is comprised of appointed representatives from every town in the MPO/RPO's region as well as VAOT and regional Federal Highway Administration (FHWA) officials. The proposed TAC rankings are then voted on by the full MPO board during a regularly scheduled monthly meeting. Although there may be disagreement on the TAC rankings, and the discussions regarding how specific projects are ranked may become very intense, it is unusual for the full MPO/RPO board to alter the proposed TAC rankings determined in the first step. Third, once the prioritization of the regional projects is finalized by the full MPO/RPO board, the regional priorities are submitted to VAOT's Planning Department. Fourth, the VAOT incorporates the regional priorities from the MPO/RPOs into the MCA decision process using the regional priority score for each of the class-specific criteria (see arrows in Table 1). The weighting criterion is applied to all six asset classes of projects: roadway, paving, bridges, bike/pedestrian, traffic operations and park and rides. A 20% weight is given for regional priority, while the remaining 80% weight is based on evaluation criteria associated with the project class to which the project belongs. Each project is assigned to a single 'primary' project class, and is evaluated using the criteria associated with that project class.

A detailed illustration of the state of Vermont's intergovernmental transportation planning network is shown in Fig. 1. The network is presented as a series of three dimensional institutional planes designed to capture the distinctions between the different levels of decision-making authority. The pentagons labeled (c) and (d) in Fig. 1 represent the institutional locations where transportation projects are typically evaluated and prioritized.

5. Data and methods

The state of Vermont's roadway infrastructure network is largely defined by two interstate highways, I-89 (≈ 130 miles) and I-91 (≈ 177 miles), 2,707 miles of state maintained highways and 11,415 miles of locally maintained roads. The state is predominately rural, and local roads provide about 80% of the overall transportation infrastructure within the state. The total population of the state is a little over 650,000 people. Chittenden County is state's largest county and is comprised of 19 independent localities/municipalities with a total population of around 155,000 people. There are approximately 3,200 total roadway miles in Chittenden County with about 80 miles belonging to the federal Interstate highway classification and about 300 miles belonging to the state highway classification. The county is home to the state's only MPO, which is coupled with the regional land use planning commission, referred to as the CCMPO. The CCMPO competes with nine other RPOs for federal and state resources.

Data used in the study include the classification for each project, the individual project scoring data from the VAOT and the CCMPO TAC, the location of each project, and the project obligation amount. Transportation project obligation amounts for the years 1998–2010 are used as a proxy indicator of the actually

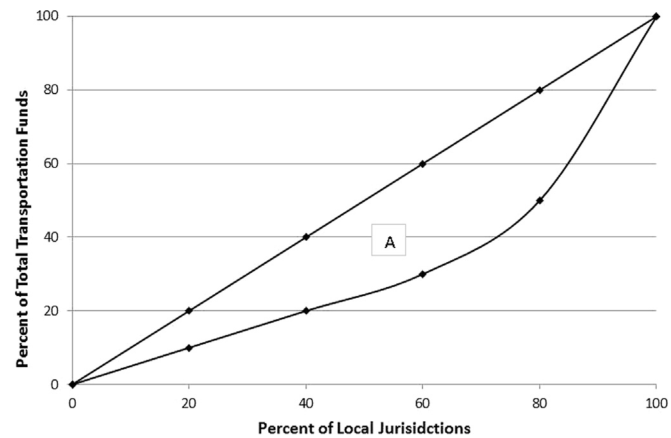

Fig. 2. A hypothetical Lorenz curve illustration.

dollar values allocated to each jurisdiction, as the final dollar amounts associated with individual projects are not available. Formula funds are allocated to states according to each federal program while competitive funds include grants and earmarks.[8] We employ Gini coefficients to quantify how, and to what extent the adoption of the innovative MCA tool and project prioritization process changed transportation funding allocation patterns between the 19 local/municipal jurisdictions within the CCMPO.

The Gini coefficient is the most commonly used measure of inequality in the distribution of a particular variable of interest, such as money or income over time and provides a simple, yet consistent metric to summarize economic data (World Bank, 2011). The value of the coefficient is continuous and ranges between zero (which indicates perfect equality), and one (which indicates maximal inequity) inclusive. In transportation-related research, the Gini coefficient has been used to examine mobility with respect to bus service to neighborhoods (Levinson, 2002) and to examine equity in road pricing schemes (Maruyama and Sumalee, 2007).

From a graphical perspective, the Gini coefficient is represented by the difference between a line of relative equality, where each percentage of population has a corresponding percentage of the total resources, and the Lorenz curve. The Lorenz curve represents the cumulative share of some quantity or resource (Q) on the vertical axis such as wealth, income, land, food, etc. and the distribution of the total population on the horizontal axis. The Lorenz curve for a resource Q is $y=L(p)$, where the poorest fraction of the population (p), has the fraction $L(p)$ of the total resource (Farris, 2010). For example, we could mathematically express the poorest 30% of the world's population possessing only 1% of the total wealth in the world as $L(.30)=0.01$. If everyone in the world had the same portion of wealth, then $L(p)=p$, and we end up with straight line representing a perfectly equitable distribution of wealth. Fig. 2 provides a hypothetical Lorenz curve where the total number of jurisdictions within an MPO is plotted by percentile on the x-axis and the total amount of transportation funds allocated to the MPO is plotted by percentile on the y-axis. The 45° line represents a line of perfect equality, where each quintile of the jurisdictions receives an equal 20% allocation of the total transportation funds.

The Lorenz curve is represented by the bottom line in the figure and shows an unequal allocation of funds where the bottom quintile of local jurisdictions receives only 10% of the total funds

[8] The SAFETEA-LU legislation was signed into law in August, 2005. SAFETEA-LU represents the largest surface transportation investment in the history of the U.S. (FHWA, 2005). The study period includes both pre-SAFETEA-LU and post-SAFETEA-LU funding allocations to the state of Vermont.

and 60% of the jurisdictions receive only 30% of the total funds. The Gini coefficient is defined as the ratio of the area that lies between the line of relative equality and a particular Lorenz curve over the total area under the line of relative equality (area A): $G = 2\int_0^1 [p - L(p)]dp$, where the constant 2 is a scaling factor allowing the coefficient to vary between 0 and 1.

5.1. Equity with respect to transportation policy

The broader issue of *equity* is extremely complicated and difficult to directly address, and we do not attempt examine the concept of equity in detail in this paper. However, concerns over the "inequitable" allocation of transportation project funds were explicitly raised in the stakeholder workshops, and a brief discussion of equity related to transportation funding is warranted.

As Altshuler (2013) observes, despite the fact that the word "equity" is featured in the title of recent surface transportation programs in the U.S. such as SAFETEA-LU (the Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users), the concept of transportation equity is very general and can be defined in different ways. For example, in the context of SAFETEA-LU, the equitable allocation of transportation funds means guaranteeing that each state receive at least a 90 percent return of its contribution to the HTF (increased to 92% in 2008). In fact, most claims to equity in U.S. transportation policy follow variants of return-to-source policies, where benefits flow back to those who paid for them (Altshuler, 2013). General examples of transportation return-to-source policies are fee-for-service toll roads and geographically defined financial flows from higher to lower levels of government that are proportional to the revenues that flow from lower levels up to higher levels. This is vastly different from the theme of redistributive equity, which focuses on offsetting "inequality" via transfers from more affluent (have) to less affluent (have not) groups.

Americans are inclined to have very different views on equity depending on whether the focus is on the public or private sector. When it comes to the private sector, Americans tend to view inequality as "a vital incentive on which prosperity depends" (Altshuler, 2013, p. 3). On the other hand, Americans tend to believe that most public services should be provided equally, or should be based on need. These two opposing views of equity: (1) return-to-source, and (2) redistributive, frequently come into conflict when questions of the scope or magnitude of various government policies arise. In the U.S., egalitarian norms are most often applied to personnel and social policies, while return-to-source norms are most often applied to economic policies (Altshuler, 2013). Historically, most transportation policy issues have been framed from the economic perspective, with very little focus on redistribution. Most Americans are therefore relatively comfortable with return-to-source equity concepts when it comes to transportation policy issues.

The concerns over inequity related to project prioritization and funding allocation in Vermont are framed from a redistributive, egalitarian perspective. Hence, we define equity from the redistributive perspective. However, following the logic of the SAFETEA-LU guidelines, the most equitable allocation of transportation funds within a state would follow a return-to-source model, and would involve giving the largest share of project funding back to the localities with the largest tax or population base. Interestingly, in a recent study investigating the distributive equity of philanthropic grants to rural communities in the U.S. state of Georgia, Ashley (2014) concludes that the "inequitable" allocation of funding throughout the state can actually be seen as "equitable", based on certain equity measures. This provides a clear illustration of the dichotomy associated with the concept of equity related to funding allocation.

Research addressing inequity in transportation finance is fairly sparse; however questions related to inequity in transportation funding have addressed transit, congestion management, and tolls (Altshuler, 2013; King, 2009) and more recently, urban versus rural communities (Ashely, 2014; Karner and London,2015). Issues related to inequalities in transportation access and social exclusion have been more widely examined (Lucas, 2012).

6. Results

The development of the MCA tool produced more than a decision support tool – it was a critical component of the entirely new project prioritization decision-making framework, and included input from a wide variety of intergovernmental network actors throughout Vermont. We examine the extent to which the development and implementation of the MCA tool and the corresponding innovative changes in the project prioritization process are viewed as successful based on the performance objectives outlined in the Introduction of this paper: (1) to make the transportation infrastructure project prioritization process more transparent to the critical actors within the intergovernmental network; (2) to improve the project prioritization process by incorporating well-defined, objective evaluation criteria that can be used to compare and contrast projects from different infrastructure asset classifications into the decision-making process; and (3) to reduce inequality in the allocation of transportation project funds to localities and regions throughout the state. It is worthwhile to note that the three objectives are clearly synergistic, but are not mutually dependent. It is possible for the outcome associated with an individual objective to be positive, negative, or undetermined regardless of the outcomes associated with the other two objectives.

The degree to which the innovation accomplished objective 1 is assessed using feedback from the workshops and documentation from the VAOT (VAOT, 2014a; Koliba et al., 2011; Zia, 2010). Based on this information, we confidently state that the innovation accomplished objective 1. The post-innovation project prioritization process offers a clear improvement over the pre innovation

Table 2
Summary Statistics of Total Funding Allocation by Jurisdiction (1998–2010).

Jurisdiction	Total $	Annual average $	Standard deviation	Percent of grand total (%)
Bolton	–	–	–	0.0
Buels Gore	439,200	33,785	121,812	0.1
Burlington	53,872,931	4,144,072	3,545,572	13.0
Charlotte	1,540,147	118,473	146,030	0.4
Colchester	21,955,601	1,688,892	1,050,884	5.3
Essex	9,054,114	696,470	519,572	2.2
Essex Junction	4,010,162	308,474	597,282	1.0
Hinesburg	3,363,801	258,754	462,768	0.8
Huntington	5,248,095	403,700	521,945	1.3
Jericho	1,215,171	93,475	166,381	0.3
Milton	4,229,809	325,370	772,541	1.0
Richmond	15,625,722	1,201,979	1,890,502	3.8
Shelburne	29,761,041	2,289,311	2,675,444	7.2
South Burlington	42,067,847	3,235,988	4,186,448	10.2
St. George	348,158	26,781	91,799	0.1
Underhill	2,154,654	165,743	239,307	0.5
Westford	386,384	29,722	68,690	0.1
Williston	3,639,610	279,970	294,508	0.9
Winooski	24,329,394	1,871,492	2,459,870	5.9
Total (towns/cities)	**223,241,839**			**53.9**
Interstate	96,392,468	7,414,805	4,187,222	23.3
Transit	81,166,398	6,243,569	2,433,987	19.6
Regional	13,273,971	1,021,075	663,054	3.2
Total (special)	**190,832,838**			**46.1**
Grand Total(all jurisdictions)	**414,074,677**			**100**

Table 3
Aggregate Gini Coefficients for Total Funds Allocated (1998–2010).

Actual funds allocated	Funds normalized by population	Funds normalized by VMT
0.6378	0.8056	0.7652

process by providing a well-defined and well-documented decision-making framework where one did not exist before. The new decision-making framework actively encourages input from actors at different levels of the intergovernmental network and is carried out in a systematic and transparent fashion. Each MPO/RPO provides initial project rankings that are developed using the new objective scoring criteria. These rankings are then shared with the CCMPO TAC with an opportunity to discuss and debate specific rankings and individual projects. Discussion is followed by a project-by-project priority vote by the TAC. The outcome of this vote is then reviewed by the full CCMPO board, and the proposed TAC rankings are voted on. Once the prioritization of the regional projects is finalized by the CCMPO board, the VAOT incorporates the regional priorities into the MCA tool using the regional priority weighting score within each of the asset class-specific criteria. While there has been some dissatisfaction expressed with the priority weighting accorded to the region (20% weight) versus the state (80% weight), and there has been some disagreement regarding the rankings of specific projects, the process itself is consistent and transparent. Although there is well documented evidence that the new process is much more transparent than the old process, it is possible that some of the positive feedback from different actors is synonymous with the Hawthorn effect. That is, some members of the focus group might feel that there was a notable improvement in the project prioritization process simply because they were asked how they felt, or were directly involved in the development of the new process.

We can also confidently conclude that the innovation accomplished objective 2 as illustrated by the development and adoption of a formalized set of qualitative scoring criteria for each project class as shown earlier in Table 1. We next evaluate the degree to which the innovation accomplished objective 3 by analyzing Gini coefficients from both the pre-MCA and post-MCA implementation. The Gini coefficient, G, can be most easily calculated using unordered data via Eq. (1), where $0 \leq G \leq 1$, x_i is the funding allocation in jurisdiction i, and n is the total number of jurisdictions in the sample (Damgaard and Weiner, 2000):

Table 4
Annual Gini coefficients for funds allocated (1998–2010).

Year	Actual funds allocated	Funds normalized by population	Funds normalized by VMT
1998	0.8494	0.9251	0.8976
1999	0.8009	0.8846	0.8108
2000	0.5855	0.8021	0.7366
2001	0.6662	0.8466	0.8100
2002	0.6624	0.7739	0.7633
2003	0.7790	0.8949	0.8165
2004	0.7737	0.8927	0.8351
2005	0.8062	0.8069	0.8548
2006	0.7413	0.8221	0.8054
2007	0.7297	0.7946	0.7909
2008	0.6825	0.8366	0.7810
2009	0.7189	0.8432	0.7976
2010	0.7136	0.8148	0.7800
Overall Mean	0.7253	0.8369	0.7934
Overall Median	0.7243	0.8366	0.7976

Table 5
Gini coefficients for grouped pre and post-MCA implementation.

Years	Actual funds allocated	Funds normalized by population	Funds normalized by VMT
Pre-MCA (1998–2005)	0.6921	0.8469	0.7873
Post-MCA (2006–2010)	0.5889	0.7765	0.7315
Mean of Pre-MCA	0.7404	0.8534	0.8156
Mean of Post-MCA	0.7172	0.8223	0.791
Median of Pre-MCA	0.7764	0.8656	0.8137
Median of Post-MCA	0.7189	0.8221	0.7909

$$G = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left|x_i - x_j\right|}{2n^2\mu} \quad (1)$$

Eq. (1) thus represents the mean of the difference in funding between every possible pair of jurisdictions, divided by the mean funding allocation of the jurisdictions in the sample, μ. Alternatively, the Gini coefficient can be calculated using ordered data via Eq. (2) where x_i' is the funding allocated to jurisdiction i, sorted from smallest to largest $x_1 \leq x_2 \leq \ldots x_n$.

$$G = \frac{\sum_{i=1}^{n}(2i - n - 1)x_i'}{n^2\mu} \quad (2)$$

As a point of reference, the Gini coefficients for individual countries around the world generally range from 0.2 to 0.6, with 0.4 being slightly above the median. Countries that have a Gini coefficient above 0.4 are considered to have a relatively high degree of income inequality, while countries that have a Gini coefficient somewhere between 0.2 and 0.35 are considered to have a relatively equal distribution of income. The Gini coefficient for the world as a whole is about 0.65 (Catalano et al., 2009). Obviously, the coefficient is highly dependent on how the population is selected.

Table 2 provides summary statistics for total funding over the sample period 1998–2010. For 20 of 391 projects (5.1% of the total) more than one jurisdiction was listed for a single project. In these cases, the obligated funds were split evenly between the jurisdictions. Jurisdictions are broken down into 19 local/municipal jurisdictions and three “special purpose” jurisdictions: (1) interstate projects, (2) transit projects, and (3) regional projects. The special purpose jurisdictions include projects that extend beyond the scope and geographical boundaries of individual town and city jurisdictions, serve multiple jurisdictions, the county, and/or the entire population of the state of Vermont as a whole, may be larger in scope, and may be more capital intensive. These projects are not associated with any particular town, city, or municipality jurisdictional boundaries. We include the special

Table 6
Mann–Whitney test comparing pre and post-MCA Gini coefficient distributions ($\alpha = 0.05$).

	Actual funds	Normalized by population	Normalized by VMT
Median rank	$n_A = 10$, $n_B = 6$	$n_A = 10$, $n_B = 6$	$n_A = 10$, $n_B = 5$
Mean rank	$n_A = 7.63$, $n_B = 6.0$	$n_A = 7.88$, $n_B = 5.6$	$n_A = 8.25$, $n_B = 5.0$
Critical values ($w_{\alpha/2}$, $w_{1-\alpha/2}$)	7, 33	7, 33	7, 33
U	15	13	10
p-Value	0.50926	0.34212	0.16452
z-Score	0.6587	0.9515	1.3907

Table 7
Mann–Whitney test comparing different Gini coefficient distributions ($\alpha = 0.05$).

	Actual vs normalized by population	Actual vs normalized by VMT	Normalized by population vs normalized by VMT
Median Rank	$n_A=7$, $n_B=19$	$n_A=7$, $n_B=18$	$n_A=18$, $n_B=10$
Mean Rank	$n_A=8.15$, $n_B=18.85$	$n_A=9.23$, $n_B=17.77$	$n_A=16.31$, $n_B=10.69$
Critical values ($w_{\alpha/2}$, $w_{1-\alpha/2}$)	46, 123	46, 123	46, 123
U	15	29	48
p-Value	0.0004	0.0048	0.06432
z-Score	−3.5385	−2.8205	1.8462

jurisdictions in the summary information, but do not include them in the Gini coefficient analyses, as the Gini analyses center on equity issues related to the allocation of funding between the local jurisdictions in Chittenden County. The special purpose projects account for just over 46% of the total funding allocation and projects associated with specific towns, cities, and/or municipalities account for approximately 54% of the total funding allocation.

Within the 19 municipal jurisdictions in the CCMPO, the cities of Burlington, South Burlington, Shelburne, and Winooski are the four jurisdictions with both the largest total and largest average funding allocation. The towns of Bolton, St. George, Westford, and Buels Gore are the four jurisdictions with both the smallest total and smallest average funding allocations. Bolton received no funding allocations at all during the time period examined.

Table 3, presents the aggregate Gini coefficients associated with the total funds allocated to each of the 19 municipal jurisdictions for the entire sample period. The table includes aggregated Gini coefficients for funding allocation normalized by both population and by VMT. It is important to note that there are many different techniques that can be used to scale or normalize data. We normalized the funding allocation by population using the ratio of the population of each jurisdiction to the maximum population for all 19 jurisdictions and then multiplying this ratio by the base funding allocation for each jurisdication. We normlize funding by VMT in a similar manner.

The aggregate Gini coefficient for the entire sample period calculated from all actual funding allocations is 0.6378, which is indicative of a highly inequitable funding allocation. The aggregate normalized Gini coefficient values are 0.8056 and 0.7652 when the funding allocations are normalized by population and VMT respectively. Annual Gini coefficients are presented in Table 4.

The annual Gini coefficients also indicate a high degree of inequality in the allocation of funds between the jurisdictions for each year of the 13 year sample period and the Gini coefficient values increase when the funding amounts are normalized by population and VMT.

The Gini coefficients for the grouped pre and post-MCA implementation are shown in Table 5. The years 1998–2005 are considered pre-treatment and coefficients from years 2006–2010 are considered post-treatment.

Based on the mean and median values, the Gini coefficients associated with the pre-MCA implementation appear to be slightly higher than those associated with post-MCA implementation. We use a non-parametric Mann–Whitney test for unequal sample sizes to statistically compare the annualized Gini coefficient values pre and post-MCA. We conduct a two-sided test at the 95% confidence level ($\alpha = 0.05$) for each of the three Gini coefficient samples (actual funds, funds normalized by population, and funds normalized by VMT). The data consist of a sample of observations $A_1, A_2..., A_{n1}$ from population 1 with unknown median M_A and a sample of observations $B_1, B_2,..., B_{n2}$ from population 2 with unknown median, M_B. The sample sizes are n_A=8 for pretreatment and n_B=5 for post-treatment. The two samples are independent and the variables are continuous random variables. The measurement scale employed in the test is ordinal.

The null hypothesis tested is $H_0 : M_A = M_B$ and the alternative is: $H_A : M_A \neq M_B$. The null hypothesis can be stated as *the pre and post-MCA populations have the same distribution of Gini coefficient values*. In other words, any inequity in the annual funding allocations between jurisdictions essentially remained the same after the introduction of the innovative MCA tool. The alternative hypothesis can be stated as: *the distributions of the pre and post-MCA populations are different in some way*. Results of the tests are shown in Table 6.

In all three cases we fail to reject H_0 and must conclude that the distributions of the pre and post-MCA Gini coefficient populations are statistically the same. The adoption of the innovative MCA tool appears to have no statistically significant impact on the allocation of transportation project funds to the various jurisdictions. We next compare the annualized Gini coefficient values associated with the actual funds to the normalized funds in Table 7.

In both cases where the Gini coefficients associated with the actual funding amounts are compared to the Gini coefficients associated with the normalized funding amounts, we reject H_0 and conclude that the distributions of the Gini coefficients of the two samples are statistically different (the normalized Gini coefficient values are different from the actual Gini coefficient values) and that the normalized Gini coefficients are larger than the actual Gini coefficients. When the normalized populations are compared to one another, we fail to reject H_0 and conclude that the distributions of the Gini coefficients are the same.

All Gini coefficient analyses point to considerable inequity in the allocation of transportation funds between the various jurisdictions over the entire 13-year sample time period. This inequity persists despite the adoption of the innovative MCA tool in 2006. The inequity in the allocation of funds between the various jurisdictions is more pronounced when funding allocations are normalized by population and VMT. We discuss these results in Section 6.1.

6.1. Discussion of results

The results of the Gini coefficient analyses point to considerable inequity in the pre-MCA project funding allocations. It is interesting to note that these inequities do not appear to be explained in a way that is consistent with the way federal funds are allocated to the states under the SAFETEA-LU guidelines, as federal funds are generally allocated to the states based on criteria such as contributions to the HTF, population, and well known, volume-based engineering metrics such as VMT and lane miles. If project funds were being allocated to the local jurisdictions throughout the state in a manner consistent with the SAFETEA-LU criteria, we would expect the normalized Gini coefficient values to be lower than the actual Gini coefficient values. Clearly this is not the case. Instead, we see that the normalized Gini coefficients are larger, and inequity actually becomes more pronounced when funding amounts are normalized both by population and VMT. Not only is there inequity in the allocation of project funds between the various jurisdictions, the inequity of the allocation appears to be even greater for higher population, higher VMT jurisdictions.[9] This is counterintuitive to well-established federal funding criteria, as one would logically expect localities with larger populations and/or higher VMT to receive larger transportation funding allocations.

Post-MCA, we see the exact same pattern – there is considerable inequity in the allocation of project funds between the local

[9] The funding allocation data were also normalized by total lane miles within each jurisdiction. We did not explicitly present these results in the paper for sake of brevity. The results of the statistical tests were identical to the population and VMT tests, and the lane miles normalized Gini coefficient values were nearly identical to the VMT normalized Gini coefficient values.

jurisdictions, which again is unexplained when funding allocations are normalized by population and VMT. Although the raw values are lower for all three post-MCA Gini coefficients (actual, normalized by VMT, normalized by population), there are no statistically significant changes in any of the pre-MCA versus post-MCA Gini coefficient values. In this sense, the adoption of the MCA tool and the innovative project prioritization process appears to be unsuccessful in terms of leading to a more equitable allocation of project funds to the different local jurisdictions. For opponents of SAFETEA-LU based funding criteria, these results are interesting, but only lead to more questions. While it does not appear that project funding allocations to the local jurisdictions are systematically based on population or VMT – as the normalized Gini coefficients are larger than the actual Gini coefficients – funding inequities persist post-MCA, and there is no clear explanation for these inequities.

It is important to point out that the federal SAFETEA-LU guidelines did not change as a result of the development and adoption of the MCA tool, and that the corresponding changes in the project prioritization process did not address the development of non-traditional project evaluation measures that might place a higher priority on local needs, or on measures that specifically focused on a more "equitable" allocation of funds throughout the state. While the development and adoption of the MCA tool resulted in a more transparent decision-making process, the values of the post-MCA Gini coefficients remain high, and concerns over inequity persist among some stakeholders. Although post-MCA funding allocations in Vermont do not appear to be driven by federal funding criteria, the development of the innovative MCA tool and the new project prioritization process did not necessarily address the funding priorities of the individual jurisdictions, or provide a more equitable distribution of resources to less densely populated, lower traveled areas throughout the state.

7. Conclusion

State governments within the U.S. are highly dependent on federal programs to fund transportation infrastructure projects at the state and local levels. These funding programs are largely driven by federal evaluation criteria and priorities as opposed to specific state-level priorities. The criteria the federal government uses to determine funding allocations to the individual states is strongly tied to the states' contributions to the HTF, federally defined TAM infrastructure assets, population, and to well established, volume-based engineering metrics such as VMT and lane miles. Consequently, federal funding programs disproportionately steer funding to states and regions with more total lane miles, more NHS interstate lane miles, higher VMT, larger populations, and larger HTF contributions. These funding criteria are not inherently "good" or "bad", but may create discrepancies between the criteria the federal government uses to determine how funds are allocated to the states, and the infrastructure priorities at the state and local levels within the states.

While a stated benefit of the MAP-21 and SAFETEA-LU legislation is to give states more flexibility in deciding how transportation funds should be allocated among the various localities within the state, states do not necessarily have clearly defined criteria for distributing transportation funds to different localities throughout the state[10]. In this paper we examine the outcomes associated with the development and implementation of an innovative transportation project prioritization and funding allocation process in the state of Vermont. The innovation is championed by Vermont's state-level transportation agency, the VAOT, and occurs within an intergovernmental transportation planning network that includes a variety of federal, state, regional, and local stakeholder groups. The objective of the study is framed in the context of empirically evaluating the outcomes associated with a specific public sector innovation. In this case, the innovation is not a product per se, but a radical change in the state's project prioritization and funding allocation process that centers on the development and adoption of a MCA decision-support tool.

We evaluate the effectiveness of the innovation with respect to three objectives. We demonstrate that the adoption of the MCA tool did result in a more transparent decision-making process (objective 1), and did introduce well-defined, objective evaluation criteria into the project prioritization process (objective 2). However, the adoption of the MCA tool did not appear to substantially reduced inequality in the allocation of transportation project funds to the local jurisdictions throughout the state (objective 3), as measured by the Gini coefficient. Our results show that there is considerable inequity in the allocation of transportation project funds throughout the study area both pre and post-innovation. There is no statistically significant difference in the pre-MCA Gini coefficient values and the post-MCA Gini coefficient values for any of the three funding samples examined in the study (actual, normalized by population, normalized by VMT).

The observed pattern of inequity is at least partially attributed to the decision-making dynamics that occur at the level of regional priority-setting and project ranking, and by the manner in which local priorities are aggregated into the regional priorities. While the MCA tool is key component of the new project prioritization process, the tool does not stipulate how local project priorities should be aggregated into the RTIPs by the respective MPOs and RPOs. The new project prioritization process simply requires that the regional priorities set forth in the RTIPs receive explicit consideration at the state level. Within the MCA framework, regional project priorities are weighted at 20% (with the exception of bridges) compared to 80% for state project priorities. Furthermore, local priorities are aggregated into regional priorities. Projects that are "highly important" at the local level receive a maximum weight of 20% at the state level. Furthermore, the weighting does not eliminate the possibility that MPO/RPOs could minimize or even exclude certain local priorities from the RTIP.

The fact that the VAOT plays the lead role in the transportation planning and project prioritization process is paramount in this discussion, as the MCA approach weights state priorities much more heavily than regional priorities. If local and regional needs are to be more heavily factored into the project prioritization process, then weighting regional and local priorities more heavily in the MCA tool, and then allowing for more direct administration of funds at the regional level may be a better approach. Zia and Koliba (2013) experiment with some of the weighting parameters in the MCA decision-making framework to generate different project prioritization scenarios using an agent-based model (ABM). Scenarios could range from business as usual (emphasizing system preservation in lines with the MAP-21 and SAFETEA-LU guidelines), to improved redistributive equity across local jurisdictions, to an increased focus on environmental sustainability or the economic development needs of a particular region. An equity category could be directly added to the MPO Criteria in the MCA tool (see Table 1), which would result in 10 evaluation criteria instead of the current nine, and all 10 criteria could be equally weighted at 0.1 or 10% of the total. The state could also adopt a scenario-based approach to project prioritization that would allow decision-makers to clearly see how different local priorities, conveyed via different project selection scenarios, might directly

[10] There was a substantial gap in federal transportation funding/planning in the U.S. between 2009, when SAFETEA-LU expired (a variety of temporary SAFETEA-LU program extensions were passed between 2009 and 2012), and 2012 when MAP21 was signed into law. This gap certainly impacted state-level transportation planning to some degree, as there were limited (or even mixed) strategic directives coming from the federal government during this time.

impact state-wide project prioritization and funding decisions. Further development of the ABM could be useful in supporting the state's efforts in this area.

Overall, the development and implementation of the MCA tool and the new project prioritization process was viewed as a much needed, positive step forward by the majority of stakeholder groups involved in the workshops (Zia, 2010). However, there were some stakeholder groups that felt the tool should have accomplished much more with respect to improving the equitable distribution of project funds throughout the state. We believe that this perception highlights a number of the potential shortcoming associated with the MCA approach in the context of this particular research study, as well as highlighting the importance of how the concept of "equity" is defined.

First, MCA is not a "magical" technique that will clearly reconcile different perceptions and priorities, or automatically solve a myriad of complex problems. MCA is designed to identify different decision alternatives, clearly and objectively articulate the expected contribution of each of those alternatives, and allow decision-makers to make informed decisions regarding which alternative they prefer. We believe that in this respect, the innovative MCA tool was largely successful in the state of Vermont, as the pre-MCA prioritization process clearly lacked consistency and transparency, which was dramatically improved via adoption of the MCA tool.

Second, MCA is an iterative, subjective, and time consuming process that involves extensive negotiation and judgment calls. It is a technique that facilitates decision-making. MCA does not make decisions, change stakeholder priorities, or generate perfect information. To this end, we are not sure to what degree all of the stakeholders involved in the process fully understand what MCA is, and how it might be best employed to enhance decision-making in the context of transportation project prioritization decisions. For example, if different actors do not all agree on an overall objective, then problems can arise. In this study, there are three stated objectives as opposed to a single objective. This is clearly problematic with respect to evaluating the overall success of the innovation, as the three objectives are not mutually dependent – the outcome associated with one objective does not necessarily impact the outcomes associated with the other two objectives.

Finally, the MCA tool was championed and implemented at the state-level by the VAOT. It is not exactly clear to what extent the VAOT is truly willing to share decision-making power, or to what extent the VAOT feels that a more egalitarian allocation of transportation project funds throughout the state is an effective or desirable state-level transportation planning objective. Nor is it clear to what extent local stakeholders understand or appreciate the state's long-term transportation planning priorities, and how local project priorities might conflict with state planning priorities. It is not clear to what extent equity considerations, which are not explicitly accounted for in the MCA tool, may be sacrificed or traded off against other considerations such as environmental or economic considerations, which are explicitly accounted for in the project prioritization process (see Table 1). In our opinion, the MCA tool was not explicitly designed to produce a "more equitable" redistribution of project funds throughout the state, and consequently does not do so.

In a study that draws on some of the same data used in this paper, Tucker (2011) found that the capacity of cities and towns to plan and advocate for specific projects at the regional level was a significant driver of project funding patterns. Localities with more experienced personnel and more planning and lobbying expertize were able to attract more funds than towns with less experienced personnel and limited expertize. This is consistent with previous findings by Rich (1989), who observed that political influence, well-articulated community needs, and prior program experience were important factors in explaining how local governments influence the distribution of funds for federal-aid programs. These findings suggest that localities and MPO/RPOs with more political and economic clout, and who have more infrastructure management experience are better suited to compete against less experienced localities. While it is beyond the scope of this particular paper, socio-economic factors such as education and income may also play some role in transportation funding allocation decisions (Lucas, 2012).

It is relevant to note that the CCMPO TAC is comprised of technical representatives from the cities and towns with the resources available to employ trained and dedicated planning and engineering professionals. Not all local jurisdictions employ planning and engineering professionals. Consequently, these jurisdictions are not directly represented on the TAC. The presence or absence of planning personnel may be a key factor in the ability and willingness to fund projects in certain jurisdictions compared to others. For practical purposes, jurisdictions that are not represented on the TAC have no direct voice in the project prioritization process. Clearly the MCA tool (and the entire project prioritization process) cannot capture the preferences of stakeholders who do not have the opportunity to express their preferences through the current decision-making process. It is also worthwhile to note that some stakeholders may inherently feel disenfranchised, regardless of changes in the funding allocation process.

Additional research focused directly on the dynamics of the intergovernmental transportation planning network, and the roles and expectations of the various stakeholder groups is needed. Future work related to project prioritization and funding allocation would greatly benefit from more detailed, project-specific data and a clear assessment of how feedback from various stakeholder groups is incorporated into the decision-making process. It would also be interesting to investigate whether funding allocation inequity related to project prioritization can be statistically captured using some type of normalized variables that have not explored to date – for example, socio-economic variables such as income or educational attainment. This would go a long way in providing a clear explanation into the allocation of funds between the various local jurisdictions. As of now, there does not appear to be a clear answer as to why the funds are so unevenly distributed between the different jurisdictions from year to year, and why population and VMT are not key criteria in funding allocation decisions. Finally, the basic question of how equity should be defined with respect to transportation policy, and to what degree the objectives and perspectives of the agencies allocating funds may be incompatible with the objectives and perspectives of the jurisdictions requesting funds are open research questions.

References

Altshuler, A., 2013. Equity as a factor in surface transportation politics. Access 42, 1–8.
Aschhoff, B., Sofka, W., 2009. Innovation on demand – can public procurement drive market success of innovations? Res. Policy 38, 1235–1247.
Ashley, S.R., 2014. Is the inequality equitable? An examination of the distributive equity of philanthropic grants to rural communities. Admin. Soc. 46 (6), 684–706.
Baumann, C., White, S., 2012. Making better choices: a systematic comparison of adversarial and collaborative approaches to the transport policy process. Transp. Policy 24, 83–90.
Belton, V., Stewart, T.J., 2002. Multiple Criteria Decision Analysis: An Integrated Approach, 2nd edition. Kluwer Academic Publishers Group.
Benington, J., 2011. From private choice to public value?. In: Benington, J., Moore, M. (Eds.), Public Value: Theory and Practice. Macmillan, Basingstoke, pp. 31–51.
Berechman, J., Paaswell, R.E., 2005. Evaluation, prioritization and selection of transportation investment projects in New York City. Transportation 32, 233–249.
Berry, F.S., 1994. Explaining managerial acceptance of expert systems. Publ. Prod. Manag. Rev. 20, 323–335.

Berry, F.S., Berry, W.D., Foster, S.K., 1998. The determinants of success in implementing an expert system in state government. Public Admin. Rev. 58, 293–305.
Bloch, C., Bugge, M.M., 2013. Public sector innovation – from theory to measurement. Struct. Change Econ. Dyn. 27, 133–145.
Bommert, B., 2010. Collaborative innovation in the public sector. Int. Publ. Manag. Rev. 11 (1), 15–33.
Catalano, M.T., Leise, T.L., Pfaff, T.J., 2009. Measuring resource inequality: the Gini coefficient. Numeracy 2 (2) (article 4).
Cohen, J.P., 2010. The broader effects of transportation infrastructure: spatial econometrics and productivity approaches. Transp. Res. Part E: Logist. Transp. Rev. 46, 317–326.
Communities and Local Government Publications (CLGP), 2009. Multi-Criteria Analysis: A Manual, Crown copyright 2009. 〈https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7612/1132618.pdf〉.
Damgaard, J., Weiner, J., 2000. Describing inequality in plant size or fedundity. Ecology 81 (4), 1139–1142.
Dhanaraj, C., Parkhe, A., 2006. Orchestration innovation networks. Acad. Manag. Rev. 31 (3), 659–669.
Duncan, D., Graham, J., 2013. Road user fees instead of fuel taxes: the quest for political acceptability. Public Admin. Rev. 73 (3), 415–426.
Edquist, C., Zabala-Iturriagagoitia, J.M., 2012. Public procurement for innovation as mission-oriented innovation policy. Res. Policy 41, 1757–1769.
Farris, F.A., 2010. The Gini Index and measures of inequality. Am. Math. Mon. 117 (10), 851–864.
FHWA, 2005. A summary of highway provisions in SAFETEA-LU Federal Highway Administration Legislative Summary. 〈https://www.fhwa.dot.gov/safetealu/summary.htm〉.
FHWA, 2012. Moving Ahead for Progress in the 21st Century Act (MAP-21): Summary of Highway Provisions Federal Highway Administration Legislative Summary. 〈https://www.fhwa.dot.gov/map21/summaryinfo.cfm〉.
FHWA, 2014. Transportation Asset Management Plans. Federal Highway Administration. 〈http://www.fhwa.dot.gov/asset/plans.cfm〉.
Frederickson, D., Frederickson, H.G., 2006. Measuring the Performance of the Hollow State. Georgetown University Press, Washington, DC.
Gokey, J., Klein, N., Mackey, C., Santos, J., Pillutla, A., Tucker, S., 2009. Development of a prioritization methodology for maintaining Virginia's Bridge infrastructure systems. In: Systems and Information EngineeRING Design Symposium 2009. SIEDS '09.
Goldman, T., Deakin, E., 2000. Regionalism through partnerships? metropolitan planning since ISTEA. Berkeley Plan. J. *14*, 46–75.
Hierro, L.A., Atienza, P., Patiño, D., 2007. Inequity and Progressiveness in the Distribution of Revenues of the States in Federal Countries: A Comparative Study. Georgia State University International Studies Program, Working Paper 07-03.
Hoppe, E.I., Schmitz, P.W., 2013. Public–private partnerships versus traditional procurement: innovation incentives and information gathering. RAND J. Econ. 44 (1), 56–74.
Karner, A., London, J., 2015. Rural communities and transportation equity in California's San Joaquin Valley. Transp. Res. Rec. 2452, 90–97, ISSN: 0361-1981 10.3141/2452-11http://humanecology.ucdavis.edu/docs/faculty_docs/crd_london_jonathan/journal_in_press_1_rural_ccommunities_transportation_equity.pdf.
Kenis, P., Provan, K., 2009. Toward an exogenous theory of public network performance. Public Admin. 87 (3), 440–456.
Kiker, G.A., Bridges, T.S., Varghese, A., Seger, T.P., Linkov, I., 2005. Application of multicriteria decision analysis in environmental decision making. Int. Environ. Assess. Manag. 1 (2), 95–108.
King, D.A., 2009. Remediating Inequality in Transportation Finance. Transportation Research Board Special Report 303: Equity of Evolving Transportation Finance Mechanisms.
Koliba, C., Meek, J., Zia, A., 2010. Governance Networks in Public Administration and Public Policy. CRC Press/Taylor & Francis, Boca Raton, FL.
Koliba, C., Zia, A., Lee, B.H.Y., 2011. Governance Informatics: managing the performance of inter-organizational governance networks. Innov. J.: Public Sector Innov. J. 16 (1) (article 3).
Kulkarni, R.B., miller, D., Ingram, R.M., Wong, C.-W., Lorenz, J., 2004. Need-based project prioritization: alternative to cost-benefit analysis. J. Transp. Eng. 130 (2), 150–159.
Lee, S.M., Hwang, T., Choi, D., 2012. Open innovation in the public sector of leading countries. Manag. Decision 50 (1), 147–162.
Levinson, D., 2002. Identifying winners and losers in transportation. Transp. Res. Rec. 1812, 179–185 (Paper no. 02-2014).
Lucas, K., 2012. Transport and social exclusion: where are we now? Transp. Policy 20, 105–113.
Lupo, T., 2013. Handling stakeholder uncertain judgments in strategic transport service analyses. Transp. Policy 29, 54–63.
Maruyama, T., Sumalee, A., 2007. Efficiency and equity comparison of cordon- and area-based road pricing schemes using a trip–chain equilibrium model. Transp. Res. Part A 41, 655–671.
Mazzucato, M., 2014. .The Entrepreneurial State: Debunking Public vs. Private Sector Myths. Anthem Press, New York, NY, ISBN: 978-0-85728-252-1.
Moore, M., Hartley, J., 2008. Innovations in governance. Public Manag. Rev. 10 (1), 3–20.
Mulgan, G., Albury, D., 2003. Innovation in the Public Sector, London: The Prime Minister's Strategic Unit. 〈http://www.sba.oakland.edu/faculty/mathieson/mis524/resources/readings/innovation/innovation_in_the_public_sector.pdf〉.
Naphade, M., Banavar, G., Harrison, C., Paraszczak, J., Morris, R., 2011. Smarter cities and their innovation challenges. Computer 44 (6), 32–39.
Novak, D.C., Sullivan, J.L., Scott, D.M., 2012. A network-based approach for evaluating and ranking transportation roadway projects. Appl. Geogr. 34, 498–506.
OECD (Organization for Economic Cooperation and Development), 2010. Ministerial Report on the OECD Innovation Strategy. 〈http://www.oecd.org/sti/45326349.pdf〉.
Ongkittikul, S., Geerlings, H., 2006. Opportunities for innovation in public transport: effects of regulatory reforms on innovative capabilities. Transp. Policy 13, 283–293.
Osbourne, S.P., 2006. The New Public Governance?: Emerging Perspectives on the Theory and Practice of Public Governance. Routledge, New York.
O'Toole Jr., L.J., 1997. Implementing Public Innovations in Network Settings. Admin. Soc. 29 (2), 115–138.
Piantanakulchai, M., Saengkhao, N., 2003. Evaluation of alternatives in transportation planning using multi-stakeholders multi-objectives AHP modeling. Proc. East. Asia Soc. Transp. Stud. 4, 1613–1628.
Provan, K.G., Kenis, P., 2008. Modes of network governance: structure, management and effectiveness. J. Public Admin. Res. Theory 18 (2), 229–252.
Radin, B.A., 2006. Challenging the Performance Movement: Accountability, Complexity, and Democratic Values. Georgetown University Press, Washington, DC.
Rich, M.T., 1989. Distributive politics and the allocation of federal grants. Am. Political Sci. Rev. 83 (1), 193–213.
Salamon, L. (Ed.). 2002. The Tools of Government: A Guide to the New Governance. Oxford, New York.
Scott, D.M., Horner, M.W., 2008. The role of urban form in shaping access to opportunities'. J. Transp. Land Use 1 (2), 89–119.
Scott, D.M., Novak, D.C., Aultman-Hall, L., Guo, F., 2006. Network robustness index: A new method for identifying critical links and evaluating the performance of transportation networks. Journal of Transport Geography 14, 215–227.
Sinha, K.C., Labi, S., 2011. Transportation Decision making; Principles of Project Evaluation and Programming. John Wiley & Sons, Inc..
Sørensen, E., Torfing, J., 2011. Enhancing collaborative innovation in the public sector. Admin. Soc. 43 (8), 842–868.
Tucker, M., 2011. Intergovernmental Dynamics and Equity Considerations in Transportation Planning and the Allocation of Funds (Masters thesis). University of Vermont, Burlington, VT.
VAOT (Vermont Agency of Transportation), 2002. VTrans Asset Management Vision and Work Plan: Final Report. Prepared by Cambridge Systematics, Inc., January, 15, 2002. 〈http://vtransplanning.vermont.gov/sites/aot_policy/files/documents/planning/VTrans_Asset_Mgmnt_VW.pdf〉.
VAOT (Vermont Agency of Transportation), 2014a. Transportation Project Prioritization and Project Selection at the Vermont Agency of Transportation. 〈http://54.172.27.91/transportation/VTrans/ProjectPrioritizationAbstract2014.pdf〉.
VAOT (Vermont Agency of Transportation), 2014b. VTrans Transportation Asset Management Implementation Plan: Final Implementation Plan. 〈http://www.fhwa.dot.gov/asset/gap/vtgap.pdf〉.
Wagner, S.M., 2008. Innovation management in the german transportation industry. J. Bus. Logis. 29 (2), 215–231.
Walker, R.M., 2006. Innovation type and diffusion: an empirical analysis of local government. Public Admin. 84 (2), 311–335.
Walker, R.M., 2007. An empirical evaluation of innovation types and organizational and environmental characteristics: towards a configuration framework'. J. Public Admin. Res. Theory 18, 591–615.
Weber, M.K., Heller-Schuh, B., Godoe, H., Roeste, R., 2014. ICT-Enabled System Innovations in Public Services: Experiences from Intelligent Transportation Systems. Telecommun. Policy 38 (5-6), 539–557. http://dx.doi.org/10.1016/j.telpol.2013.12.004, online.
Williams, I., Shearer, H., 2011. Appraising public value: past, present, and futures. Public Admin. 89 (4), 1367–1384.
World Bank, 2011. Measuring Inequality. 〈http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTPOVERTY/EXTPA/0,,contentMDK:20238991~menuPK:492138~pagePK:148956~piPK:216618~theSitePK:430367,00.html〉. Permanent URL for this page: 〈http://go.worldbank.org/3SLYUTVY00〉.
Zia, A., 2010. Navigating Trade-offs in Complex Systems: Deliberative Multi Criteria Decision Analysis of the CCMPO Metropolitan Transportation Plan. 2010–2035. University of Vermont's Transportation Research Center Report #11-005, July, 2011. 〈http://www.uvm.edu/~transctr/research/trc_reports/11-005_navigating-trade-offs-in-complex-systems.pdf〉.
Zia, A., Koliba, C., 2013. The Emergence of Attractors Under multi-level Institutional Designs: agent-based Modeling of Intergovernmental Decision Making for Funding Transportation Projects. Artificial Intelligence and Societyhttp://dx.doi.org/10.1007/s00146-013-0527-2 http://download.springer.com/static/pdf/748/art%253A10.1007%252Fs00146-013-0527-2.pdf?auth66=1421165959_4194d01100ca940540eb173f80f33b89&ext=.pdf.