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Making Sense of Autonomous Vehicles: U.S. State Policy Advisory Systems

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Abstract

Between 2015 and 2020, the anticipated arrival of autonomous vehicles (AV) created considerable uncertainty for U.S. states in charge of roads. In response, states activated their policy advisory systems. Policy advising at the national level or by scientists is well understood. Much less is known about the sub-national level or advisory systems as a whole. In this study, we seek to understand U.S. state subnational policy advisory systems by analyzing reports written for states to help them make sense of an emerging technology in preparation for governance. We collected 75 reports on autonomous vehicles produced by 33 states between 2014 and 2021. We classified their 2,600 images and 3,100 references, cataloged 1,200 contributors and their affiliations, and identified the main topics discussed. Committees, university researchers, staff at Departments of Transportation, and legislative staff produced different types of reports, for example, more and less academic, focused more or less on topics associated with governance or engineering. Our analysis reveals that state policy advisory systems used two types of processes - convening and expert - and employed three types of expertise - academic, practical, and political - to help prepare to govern this emerging technology.

Keywords/short phrases:

Policy advisory system, expertise and policy making, sensemaking, autonomous vehicles, immutable mobiles

Introduction

In this paper, we explore the policy advisory systems of U.S. states through a case study of state responses to the promised arrival of autonomous vehicles. When challenged to respond to the emerging technology of autonomous vehicles, states activated their advisory systems. Such systems must exist, but their contours and operations are obscure, particularly when challenged with emerging technology. We seek to locate the process of advising states on their response to an emerging technology within theoretical frameworks developed to characterize policy advice systems and to understand the characteristics of advisers and their expertise and how that shapes the content of their advice.

In what follows, we examine the sensemaking style of policy advising at the state level in the United States through the lens of policy reports about autonomous vehicles. We build on the policy advising literature as well as document theory. After introducing the autonomous vehicle hype cycle, we describe how we gathered and processed the reports. We then analyze the reports' varied authorship and how report characteristics and so policy advising differ by type of expertise deployed. This analysis of the polycentric advising capacity at the sub-national level in the transportation policy subsystem sheds light on how the components of this advisory system combine.

Policy advising

Over the past several decades, scholars have developed a sophisticated understanding of policy advising sensitive to differing governing systems. In one prominent literature, authors concerned with Westminster-style governments (U.K., Australia, Canada, and New Zealand) have analyzed the dynamics of advising systems moving from internal provision of advice that strictly separated political and analytical components to more externalized provision of advice that blurred the distinction between political and analytical advising (for example, Craft & Halligan, 2020). This is often described as moving from speaking truth to power to a porous, fluid, and dynamic situation with many competing voices (Craft & Howlett, 2012). Government control has been a central concern. Authors from continental Europe have explored how advisory commissions operate and influence policymaking (Christensen and Hesstvedt, 2023; Krick, 2015). U.S.-focused analysis has been more concerned with how often analytical techniques taught in policy degrees (for example, Weimer & Vining, 2017) are used in practice and prevail over purely political considerations (Howlett, 2009). In this literature, substantive, as opposed to political, policy advice is primarily equated to the use of methods such as cost-

benefit analysis, modeling, statistics, program design, and evaluation (Howlett, 2015; James & Jorgensen, 2009).

Those concerned with the knowledge needed in policy making beyond policy analysis techniques tend to view policy advising as an exercise in knowledge use as opposed to being part of the larger policy process (Craft & Howlett, 2012, p.82). In particular, authors grounded in science studies explore whether and how scientific knowledge is used in policy making (for example, Jasanoff, 1998 & 2005). This tradition often hones in on the need to synthesize knowledge and communicate it well. Often intermediaries are offered as a solution to the difficulties researchers have in doing this job well (Isett and Hicks, 2020; Gluckman et al., 2021).

The need for specialist knowledge in policy making beyond policy analytics has increased with the increasing complexity and technical nature of policy problems. There is broad agreement across literatures that "decision-makers need expertise to make sense of the policy issues they face and to design solutions to these problems" (Christensen, 2021, p. 460). The requirement for expertise, often research-based, is problematic for democratic governance. From the other side of the equation, the need to engage with policy making has created epistemological problems for the technical knowledge base. Expert advisors with specialist knowledge are caught between being close to politicians, which can enhance use of their knowledge but compromise its quality; being close to the knowledge community, which preserves the quality of knowledge but raises questions over democratic legitimacy; or engaging the public which increases legitimacy and acceptance but raises epistemological risks (Head 2023). Responses have included developing participatory processes and setting out evidentiary standards (Christensen et al., 2022; Head, 2023; Krick, 2023).

Although these literatures have generated deep understanding, generalizability is somewhat limited by a narrow focus. From this body of work, we understand a great deal about national governments, intergovernmental bodies, and high-profile issues. Advising in the Westminster system, U.S. Congress, IPCC, and COVID have been thoroughly explored (for example, Craft & Halligan, 2020; Craft & Henderson, 2023; Baumgartner and Jones, 2015; Grundmann, 2022; Hustedt, 2015; Marciano & Craft, 2023). Studies most often examine one type of advisor, that is in-house staff or advisory committees, or even one advisory body, such as the IPCC. Broadening the focus to sub-national governments and comparing the role of different types of advisors could deepen understanding (Connell et al., 2023; Howlett, 2009; May et al., 2016). Beyond this, a call for a second wave of studies recommended centering on advisory systems rather than the public service, contextualizing advisory systems within policy subsystems and examining "why advisory system components combine. . . and with what effect" (Craft & Wilder, 2015).

Methodologically, we suggest that examining U.S. state level policy reports provides a means to explore more dimensions of policy advising. Recognizing the heterogeneity of knowledge required in policymaking and so in the advisory system, we position our study within a comprehensive theoretical framework. Within Craft and Howlett's (2012) model of policy

advice systems, policy reports provide substantive (rather than procedural) and long-term/anticipatory (rather than short-term/reactive) advice. That is, they offer "cold" (as opposed to "hot") advice that is research-based, problem-solving, long-term, strategic, and wide-ranging with a public interest focus and open processes that seek the best solution (Craft and Howlett, 2012 table 3). The style of policy advising combining an open advisory process with a long-term/anticipatory approach to problem-solving was named "sensemaking" by Aubin and Brans (2021).

Sensemaking is an apt term for the state response to emerging technology. State policy makers need to structure "the unknown so as to be able to act in it" (Ancona, 2012). Decision makers must make sense of what is happening to decide whether action should be taken and, if so, formulate proposals. In these circumstances, officials face a mountain of volatile, uncertain, complex, and ambiguous information that they must organize, integrate, and interpret to identify connections, patterns, and causal relationships (Bennis and Nanus 1985). Through the sensemaking process, people create an understanding of novel circumstances expected with the advent of a new technology. Together, they construct meaning, connecting and contextualizing data to provide a foundation for subsequent decision-making and organizing to adapt to the arrival of new technology.

State-level policy reports provide insight into sub-national policy advice produced by authors both inside and outside government. With their varied authorship, state AV reports provide a vehicle for the "dispersed advisory capacity" characteristic of the current polycentric advice-giving reality (Craft and Howlett, 2012, p. 85). Policy reports synthesize and explain complex knowledge, as the knowledge use approach suggests. Beyond this they are expected to make recommendations, that is to move beyond knowledge to action, a defining feature of expertise (Grundmann, 2017; Turner, 2010). To justify using documents to explore the nuances of policy advice processes, we turn to document theory.

Documents matter

Autonomous vehicles involve two sexy topics: cars and the frontier of information technology, and so have attracted many visions of the future of the technology and projections of the pace of change and societal impact. The fundamental challenge for policymakers, public administrators, and their agents is accessing, understanding, and curating this information abundance. Ironically, state governments wrestle with information abundance by augmenting it, writing yet more reports explaining autonomous vehicle technology, tracking developments in other states, and exploring legal, planning, and infrastructure implications for their state.

To gain insight into the policy response, we examine the policy reports produced in reaction to the advent of autonomous vehicles. Policy reports are ubiquitous in the complex and knowledge intensive endeavor that is modern policy making. As a result, they tend to be taken for granted except as a source to be mined for information on concepts shaping policy making. Our approach differs. Instead of analyzing their contents (for example, Freeman & Maybin,

2011; Schiff, 2023; Ulnicane et al., 2021; Malmborg 2023), we offer a detailed analysis of the characteristics of the documents to explore the state-level policy advising system engaged with an emerging transportation technology. In this, we follow and expand upon the approach advocated by Freeman and Maybin and attempt "to articulate a different way of thinking about documents and their place in policy" (Freeman and Maybin, 2011, p. 159.

Our approach builds on Latour's (1986) focus on "inscriptions," in particular the "file or record," likely a translation of *dossier* a thing as central to French policymaking as reports are to U.S. policymaking. To Latour, the notable characteristic of files, or reports, is that they gather and arrange many heterogeneous elements. Those who can sum up and interpret the multifarious information relating to the issue at hand gain oversight and mobilize the elements to serve their aims. Latour argued that: "some power is given to an average mind just by looking at files: domains which are far apart become literally inches apart; domains which are convoluted and hidden, become flat; thousands of occurrences can be looked at synoptically" Latour, 1986, p. 28). Writing reports means engaging in this mustering of heterogeneous elements with the intent of shaping government programming.

Freeman and Maybin draw attention to the material properties of documents that enable "governments to act over time and space" (2011, p. 160). Once inscribed, a standard message can be communicated to diverse people in distant places now and in the future, able to coordinate their thinking and actions because documents are stable over space and time. In Latour's terms, they are "immutable mobiles." This makes reports ideal vehicles for anticipatory policy advising.

Reports consolidate the varied interests of those who produce them. Document production can bring diverse stakeholders together for the first time and begin to align their approaches to the issue. Documents connect actors and coordinate their actions. "They create groups, providing them with a common language and vocabulary and helping them express to others what they are trying to do." (Freeman, 2006, p. 53). The policy report and the group are mutually constitutive; each is defined in terms of the other (Freeman, 2006, p.53). In other words, to produce a report for a state by reviewing what others have said about autonomous vehicles, authors organize the recent past "so as to establish a shared present that will be the basis for coordinated work in the future" (Bazerman and Paradis, 1991, p. 5). Establishing the sharing in anticipation of future coordination is more important than generating unique information. Thus, report writing by groups involves the kind of consensus building work those who commission advisory groups usually hope to activate.

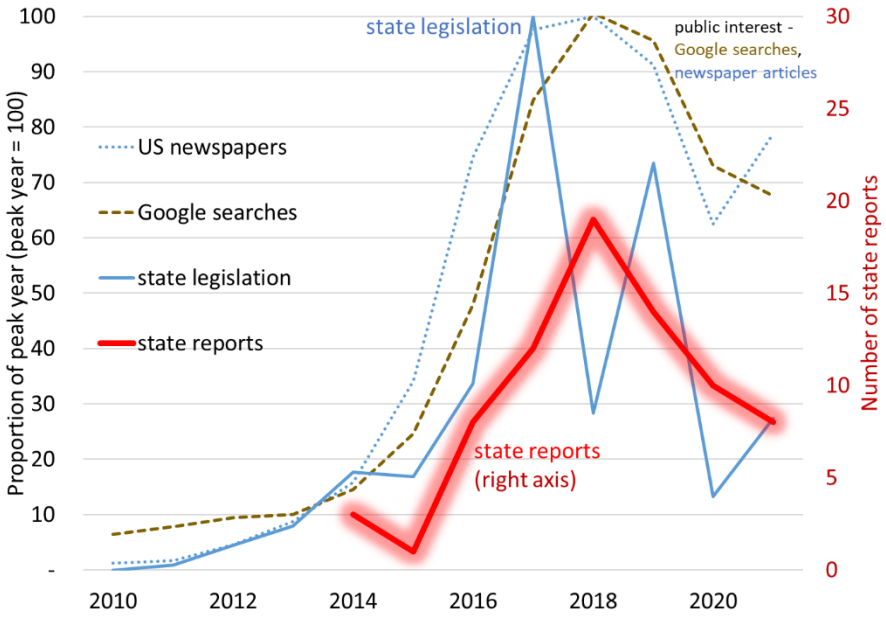
The collective understanding achieved through document production has a purpose - to anticipate governance changes needed to respond to the advent of self-driving cars. Governments have honed collective report production into an advisory tool to achieve a shared understanding of complex situations in order to develop ideas to manage complex problems. Reports exemplify the definition of genre as: "a central nexus of human sensemaking, where

typification meets utterance in pursuit of human action" (Bazerman, 2010, p. xi). Therefore, they are central to policy advice systems, at least in the United States.

Autonomous Vehicles

The reports we examine concern state response to the arrival of autonomous vehicles. Though interest in automating the driving of cars dates back to the 1940s (Norton, 2021), the dream seemed to be coming to fruition in the 2010s. In response, Nevada, Florida, and California legalized testing of autonomous vehicles on their roads in 2012. Excitement, or hype, took off in 2014 when Google announced a pilot program to build 100 cars with no driver controls (https://blog.google/alphabet/just-press-go-designing-self-driving/) and Tesla launched its misnamed "autopilot" feature and promised customers access to full self-driving capability. Also in 2014, a canonical classification of levels of driving autonomy was released by SAE International, an automotive standardization body (SAE, 2014). This scheme was subsequently referenced in almost all reports examined here. Public interest in self-driving cars surged, as shown by the growth in newspaper articles published and Google searches for the topic, Figure 1. Figure 1 also shows that the growth in public interest was mirrored in state legislatures, with 113 bills introduced in 2017 alone. State interest also generated the need for policy advice, met with the production of policy reports.

Figure 1 – Public and government interest in autonomous vehicles surged in late 2010s



The seemingly imminent introduction of autonomous vehicles (AV) onto public roads created considerable uncertainty within well-established patterns of governance and administration of state transportation systems. State governments must make long-term plans for infrastructure investments over decades. States authorize their Departments of Transportation to plan,

design, and build infrastructure that can adapt to the evolving fleet of commercial and personal vehicles. Legislatures oversee the rules of the road and vehicle licensing.

To prepare for something whose final form and arrival time are unknown, states needed to understand where this technology was going, how quickly it would appear on their roads, how it would affect the efficient movement of people and freight, and how the rules of the road, vehicle and driver licensing, road planning, construction, maintenance, signage, and signaling systems would need to adapt. To meet this challenge, states activated their advisory systems. Advisory reports were produced by a range of actors in many states. The following section explains how we found and analyzed these reports with the goal of better understanding the functioning of state policy advisory systems.

Methods

Below, we analyze the characteristics of state reports on autonomous vehicles. We began by searching for reports on autonomous vehicles commissioned by states, identifying 75 reports produced by 33 states between 2014 and 2021. Our search strategy was to run five or six combinations of searches for each state. Typically, terms that yield the best results were a combination of the state name, report, DOT, AV, autonomous vehicle, driverless, and CAV. Requiring all the terms did not work, but interchanging them brought good results. Terms such as DOT followed by state name, CAV, and "report" were the most effective at yielding governance studies. Oregon and Minnesota created a database of AV reports, and so have higher report counts.

We included documents produced by or for a state that addressed the implications of AV technology for the state. For many years, state transportation agencies and state transportation research centers (usually located at universities) have reported the results of their AV technology research. However, reports concerning narrow aspects of AV performance do not address governance, so we excluded them. We also excluded reports produced by and for other jurisdictions such as municipalities, corridors, regions, and the Federal government. Also excluded were reports addressing industry trends or local pilot projects.

Transportation research in the U.S. is well funded, many reports are produced, and the National Transportation Library seeks to index them. However, indexing gray literature is challenging, and because we easily found reports that were not indexed, we relied instead on searching for reports in each state. However, our method suffered the same challenges and likely missed some reports because we depend on reports being posted online (Grimmer, Roberts, and Stewart, 2022). We are also vulnerable to the "found data" problem since we sampled without an authoritative list of the population of state reports focused on governance issues and because reports can disappear from the internet at any time.

We found 75 PDFs of state AV reports and analyzed their characteristics, including length, authorship, participants, imagery, and references. We cataloged 1,200 participants, most listed

in the first few pages. However, some listed participants in the middle requiring a search for keywords like acknowledgment, advisor, participant, author, consultant, task force, member, or advisory council. Participant affiliation and job title, when available, were also recorded. Affiliations were classified into eight categories: state government, private sector, academic, NGO, intergovernmental organization, local government, public-private partnership (usually an economic development corporation), and federal government. We counted and classified 2,590 images, finding graphs and tables, pictures of roads, trucks, and cars, artist renderings illustrating the operation of AVs, and headshots of participants. We extracted 3,081 references using the Scholarcy reference extraction API and URL extraction from text. References were classified into seven categories: academic (journal articles and conference papers), reports (including PDFs on university websites with no DOI), media articles, federal, state, and local government documents or reports, and others.

We used topic modeling to characterize the contents of the state reports. The core text of each PDF was extracted for modeling, meaning the introduction through the conclusion. Excluded were title pages, executive summaries, bibliographies, and appendices. We used Wordstat 9.0.8 for text processing and topic modeling using the non-negative matrix factorization (NMF or NNMF) method. Text was preprocessed using snowball stemming and Wordstat's standard English list of common words to exclude. Two thousand words were retained based on TF/IDF. Other settings remained Wordstat defaults. Examining coherence statistics showed a peak at about 50 topics. The final model retained the strongest 40 topics associated with more than one state.

The result was a database of 75 reports and their characteristics, including page length, number and type of references, number and type of images, number of participants and their affiliations, and the topics discussed. This information forms the basis of our analysis of report characteristics by authorship.

Findings

Observers of policy advising have noted that the shift to greater external participation engages a variety of institutions, including universities, think tanks, consultancies, and government-appointed advisory bodies, in addition to the traditional internal sources of advice in government agencies (Christensen et al., 2022; Craft and Howlett, 2012; Head, 2023). Our corpus exemplified this with five types of authors represented: university researchers, Department of Transportation staff, legislative staff, consultants, and committees or task forces. Reports' first pages revealed their attributions through logos, author affiliations, or even the title, in the case of task forces. Table 1 displays the four main types of authors, the number of reports produced by each, and two sample titles for each type.

Table 1 Sample report titles by type of author

Author	Title
Task Force (21)	• Final report of the advisory council on connected and autonomous vehicles • Governor's Advisory Council On Connected And Automated Vehicles: Executive Report
University (21)	• Preparing for a Driverless Future • Envisioning Florida's Future: Transportation and Land Use in an Automated Vehicle World
DoT (13)	• Connected & Automated Vehicle (CAV) Strategic Action Plan: A Strategic and Operational Outlook on the Impacts of CAV • Planning for Connected & Automated Vehicle Readiness
Legislative (5)	• Automated Driving Systems (ADS): A Snapshot Of State And Federal Policies • The Future Is Now: The Technology And Policy Of Self-Driving Cars

Most of the research into the use of expertise in policymaking has focused on the use of knowledge derived from academic research. Three of the six literatures identified in Christensen's review of expert knowledge in policymaking explores the use of knowledge deriving from academic research (Christensen, 2021). University researchers were indeed leading authors of AV reports, accounting for 21 reports. However, Head proposed that in addition to rigorous scientific and technical analysis, two more types of expertise are particularly relevant in policy development: political know-how and practical and professional field experience (Head, 2008). We see the practical and professional approach of DoT transportation engineers deployed in the 13 DoT authored reports and political know-how engaged in the five reports written by legislative staff. Thus, the three kinds of expertise identified by Head were deployed in producing these AV reports. As might be expected, the reports authored by different kinds of expert differed in their characteristics.

University reports were notable for markers of academic expertise. They were positioned as research and analysis presenting the state of knowledge as found in the academic literature. Even when tasked with strategic planning, one university report was framed as a study of strategic planning for AV University reports were commissioned by state Departments of Transportation. Although we excluded purely technical reports, these reports contain a form required by Federal Acquisition Regulations (FAR) 35.010 for scientific and technical reports. This indicates that state Departments of Transportation paid for these reports as research using federal pass-through research funds. As we might expect of research reports, the majority of participants on university reports were affiliated with universities, and university and Department of Transportation people together comprised 85% of participants. The reports were lengthy, averaging 97 pages compared to 55 on all other reports, consistent with an

emphasis on thorough treatment of a topic, as opposed to accessible communication. Signaling a concern with credibility, the reports were heavily referenced, averaging 79 references compared to 19 on all other reports.[1] University reports also drew more heavily on academic sources; 41% of their references were to journal articles or university reports compared to 14% on all other reports.

University-authored reports were distinct in their greater emphasis on urban environments, pedestrian and bike safety, and street parking. They also discussed the implications for Uber and Lyft. As these are not technical reports, modeling was not a prominent topic, but when modeling or simulation was mentioned in our collection of reports, it was in university reports. Also, topics that can be simulated or modeled were most closely associated with university reports, such as willingness to pay and intersection management. University-authored reports also displayed an analytical emphasis in their heavier use of tables and graphs, averaging 16 per report compared to 8 per task force report.

The practical and professional engineering expertise deployed in the 13 DoT reports was visible in their unique characteristics. Eight of the DoT reports were produced by a single author, so on average, DoT reports had less than half the participants of either task force or university reports. DoT reports were shorter than university and task force reports and carried fewer references. When normalized by the number of pages, DoT media support was visible in the use of imagery that was in between university and task force reports. Engineering analytical tendencies were visible in use of tables and graphs exceeding both university and task force use. DoT reports most often were a DoT initiative but sometimes were undertaken at the direction of the governor or legislature.

DoT reports made plans. Over 75% of their titles contained the word plan; see examples in table 1. Their purposes included recommending short-term next steps, developing visions, and meeting goals and objectives. DoT and university reports shared an interest in engineering topics. Foremost among these is analyzing crashes, scenarios, and cost reduction. Also discussed were pavement conditions and markings; platooning[2] and freight; smooth traffic flow; blind spot monitoring and automatic lane departure warnings; sensors and fiber optics.

DoT reports were distinct in their heavy discussion of connected vehicles, including DSRC, a technology for vehicle-to-vehicle communication. Connected vehicles began as a vision in which cars would communicate with other cars, pedestrian devices, traffic lights, and the rest of the infrastructure. Attempts to realize this vision involved a lot of engineering and coordination on things like spectrum allocation and protocols. The DoT transportation engineers who wrote reports were heavily engaged with this vision, others less so. So far, things have turned out

[1] These averages were calculated excluding two reports from University of Texas at Austin that were extremely long and contained a very large number of references. Including these outliers would exaggerate the difference between university and other types of reports.

[2] In transportation, platooning is a method for driving a group of vehicles together. Platoons decrease the distances between cars or trucks using electronic coupling.

differently. Cars communicate with their owners' phones and with their manufacturers over mobile phone networks, sending data and being monitored[3]. Special networks are not needed. Even collision and blind spot monitoring, once seen as use cases for vehicle-to-vehicle communication, are implemented instead using a car's own sensors.

Legislative experts authored five reports. These reports averaged 3 participants, much less than the others, and were much shorter at 20 pages on average. Their referencing was limited, but compared to others, legislative reports drew more heavily on prior reports and federal and state documents. They did not use academic journal articles. Legislative reports also contain relatively few images, though they do contain tables and graphs. Legislative reports focused heavily on Federal motor vehicle standards and law enforcement. Not surprisingly, they were also attentive to policy, see table 1. Legislative reports highlighted legislation, liability, damage, and insurance. Car control – steering wheels, brakes, etc. – as well as driver assistance – blind spot and lane departure warnings – were discussed more in legislative reports than in others.

When DoTs wanted to make sense of AV technology, they wrote a report or commissioned a university researcher to write one. Legislatures would ask their staff to make sense of the landscape for them. However, these expert approaches were also supplemented by reports commissioned by governors who directed groups of stakeholders to write a report on the implications of autonomous vehicles for their state.

The two task force titles in Table 1 exemplify this approach. Such task forces authored 21 reports. These reports often mention intentions to foster collaboration, coordination, and partnerships. Many people were brought together in the process of producing these reports. Task force reports averaged 37 participants, compared to 11 on all other reports. All task force reports included representatives of the state Department of Transportation (DoT), almost all included legislative staff or legislators, and most included university researchers. Together, these groups accounted for 32% of the 777 participants on task force reports.

However, task force reports not only bring together the three types of policy expertise, they include a much wider group of stakeholders. Task forces involved people from 28 different organizations on average, compared to 5 organizations on all other reports. Task forces included representatives from many types of organizations not invited to join reports produced by universities, Departments of Transportation, or legislatures. These organizations included parts of state government: governors' offices, law enforcement, attorneys general, and agencies overseeing labor, insurance, health, and commerce. Invited to join from outside government were car manufacturers, trucking and insurance companies, manufacturers associations, general lobbying firms and focused transportation advocacy organizations, unions,

[3] The press has discussed connected vehicles for many years. However, the meaning of the term has changed. Originally articles explaining connected vehicles discussed the vehicle-infrastructure communication vision. In recent years, they discuss the advantages of infotainment and navigation systems and repair reminders from dealerships.

and more. Thus, task force reports provide evidence of convening inclusive conversations among concerned stakeholders with varied knowledge of and interest in the issue.

In contrast to technically oriented university and DoT reports, Task force reports emphasized engaging communication and took full advantage of the opportunity for imagery offered by cars, trucks, and roads. Task force reports averaged 15 images per report compared with 10 for universities. Task forces probably also benefitted from staff and media support, enabling their use of a glossier, more image-heavy format.

The topic model also highlights the convening nature of the task force reports. The strongest association in the model between topic and authorship (measured by topic words per thousand words of text) is the association between the topic "committee activities" and task force reports. This topic comprises words such as meeting, subcommittee, member, vote, and recommendation. This points to the administrative apparatus needed to manage a conversation between representatives of a wide range of organizations. This topic was over three times as strong in task force reports as in any other type of report. Task force reports were also notable for their concern with motor vehicle standards, a topic involving discussion of Federal motor vehicle safety standards, highly automated vehicles, law, regulation, and law enforcement.

Finally, consultants wrote eleven reports, which ressembled both task force and expert reports. Consultants were hired by DoTs to research or develop AV strategic plans and by task forces to run their meetings and write their reports. Three consultant reports had more than 30 participants; another was 350 pages long with 158 tables and graphs, and another listed 108 references. The references in consultants' reports relied heavily on prior reports and more heavily than others on news media. Overall, the consultant reports tended to look like DoT reports and favor similar engineering topics along with strategic planning.

Discussion

The authors of state AV reports work at universities, Departments of Transportation, legislatures, and consultancies. University reports signaled the depth of specialist knowledge in long reports containing many references exhibiting a preference for tables and graphs over pictures. Departments of Transportation reports, like university reports, had fewer participants and slightly favored graphs and tables over pictures. Although they did not share the academic characteristics of length and heavy referencing, they did favor academic references. DoT reports shared with university reports a concern with analytical and engineering issues. Legislative reports were short and focused on legislative issues, if not legislation. These three types of expert reports interpreted AV from the point of view of a single knowledge framework.

In contrast, task force reports pooled the three types of expertise and augmented them with the perspectives of other stakeholders. Task force reports and workshop proceedings resulted from conversations among over 30 participants. These reports took full advantage of the

pictures available to those writing about cars, trucks, and roads, perhaps because they were more likely to benefit from the support of professional media staff and more concerned with communicating to non-specialists. Task force reports were often discussed governance issues The voices of DoTs, university researchers, and legislatures were well represented in most task force reports.

Our results suggest policy advising on challenges that are novel and knowledge-intensive deploys expertise in two modes. One is expert-driven, with academic, practitioner, or governance experts authoring reports. The other engages these three types of expertise in dialog with each other and with a broader group of knowledgeable stakeholders. These two processes have emerged in prior research on the use of knowledge in policy and management (Baumgartner and Jones, 2015; Lester and Piore, 2004; Weiss, 1979). The first process, deployment of expertise, was called problem-solving by Weiss, who noted that research helps identify and select the means to reach agreed-upon goals, which can mean commissioning research and analysis. Baumgartner and Jones noted that expert information search focused on a single well-defined problem, often using analytics to break down a problem and simplify it, and was most relevant in a search for solutions. In innovative firms, Lester and Piore found an analytical approach involving problem-solving and rational choice conducted by engineers, economists, and MBAs. These characteristics describe an expert-led process of making sense of knowledge-intensive, uncertain situations. We label this process "expert."

Reports in the expert mode deploy one of Head's three types of policy knowledge: rigorous scientific and technical analysis, practical and professional experience, or governance know-how. The university reports align well with Head's identification of scientific and technical analysis as one type of knowledge used in policy. University reports inherit characteristics of the scholarly genre – long with many references, often to scholarly articles, and a preference for tables and graphs. DoT reports deploy practical and professional experience in developing policy, and legislative reports deploy governance know-how. This is visible not only in the authors' writing preferences but also in their preferred topics. DoT experts balance their use of pictures, tables, and graphs; they do not like to write as much as academics do. Their reports are shorter and have fewer references, though they emphasize academic sources more than convening reports. Legislative reports tend to focus more on legislative issues and legislation.

The second process Weiss called the interactive model, meaning a process in which "all kinds of people involved in an issue area pool their talents, beliefs, and understandings in an effort to make sense of a problem" (Weiss, 1979, p. 428). Baumgartner and Jones (2015) labeled this "entropic" search, meaning disordered. It brought many perspectives to bear to explore problems and solutions, incorporating diverse viewpoints into decision-making. Lester and Piore saw an open-ended, unpredictable, ongoing interpretative approach. People of different backgrounds and perspectives talked about ambiguous situations, identifying and clarifying problems to the point that a solution could be identified.

In the policymaking context, meetings and documents frame the interactions central to the interpretive process. A policymaker wanting to activate an interpretive process convenes stakeholders who interact in the format of meetings or workshops. The stakeholders will likely include the practitioner, governance, and academic experts who also write expert reports. However, in the interactive context, many other domain experts will be included. Documents would inform the meetings or workshops, and be produced as output from them so that in the future, a wider group of as yet unknown membership can benefit from the knowledge generated. The authors of these documents would be more like scribes and the knowledge brought in, developed, and recorded would be contributed by others. We label this process "convening" to emphasize the bringing together of perspectives it entails.

Prior literature emphasized the diversity of participant backgrounds and perspectives as a core characteristic of the convening approach. We found that task force reports were distinguished not only by many participants but also by their breadth of backgrounds. The convening consultant reports were even more diverse in their participants' backgrounds, with no single sector accounting for the majority. In contrast, the expert reports not only had fewer participants, but also those participants were primarily academics (on university reports), state government and industry people (on DoT reports), and legislative staff or legislators (on legislative reports).

Task force reports are often disparaged as lacking substance, particularly by the authors of expert reports. Analogously, Piore and Lester found that firms did not know they used the interpretative (i.e., convening) approach. Critics miss the value of the process that produced those reports, which engaged a wide range of people in discussion of autonomous vehicles, creating a community of interest around the issue in the state. Producing a report sets the narrative for how the policy space will move forward as participants churn through information and perspectives, arriving at some shared meaning and potentially consensus.

The documents produced by the convening process share the report form with the expert-authored reports, but the emphasis will differ somewhat. Convening reports can be said to construct shared perceptions of possibilities. They address issues as matters of public concern open to administrative intervention appropriate for a particular jurisdiction. This shapes shared perceptions of responsibilities and possibilities. Convening reports construct tractable objects of governance. They marshal research and expertise to define, analyze, and bound manageable policy problems across law, economics, ethics, technology, etc. They organize institutional processes, clarifying limitations, risks, stakeholders, and decision parameters. They project outcomes, advocating for particular solutions in an attempt to tangibly shape governmental programming. Finally, they formulate detailed policy recommendations to activate legislation, resource allocation, monitoring procedures and implementation plans.

The prior literature contrasted this sensemaking, problem-clarifying process of convening with the analytical approach of experts. Research provides empirical evidence and conclusions (Weiss, p. 427); thus, seeing more tables and graphs in expert reports is unsurprising. Analytical

approaches can also mean program evaluation, policy analysis (Baumgartner and Jones, p. 54), and techniques drawn from economics and engineering (Piore & Lester). In AV reports, modeling and simulation techniques were used primarily by university authors who also were most concerned with concepts such as travel times and travel demand, reaction times and freeway capacity and fatal crash scenarios.

Both Baumgartner & Jones and Piore & Lester placed the two approaches at different stages of the problem-solving process. Convening processes are better for "detecting and prioritizing problems" (Baumgartner & Jones, p. 68) or for identifying and clarifying problems to the point a solution can be developed (Lester & Piore). Expert processes are "most relevant to search for solutions" (Baumgartner & Jones, p. 61) and are problem-solving (Lester & Piore). Solution orientation was most apparent in DoT reports' association with the strategic planning topic. In report titles, the words "plan" and "strategy" only appear on DoT reports. As a second type of expert approach, university reports might also be expected to develop solutions. However, these were some of the earliest reports produced suggesting that contrary to expectations, states called upon university researchers to help frame sensemaking processes, provide vocabulary, raise scoping issues, and identify topics that don't fit neatly within the jurisdiction of agencies. Their early engagement may also have to do with an innovation orientation. University report titles refer to the future more often than others, see table 1.

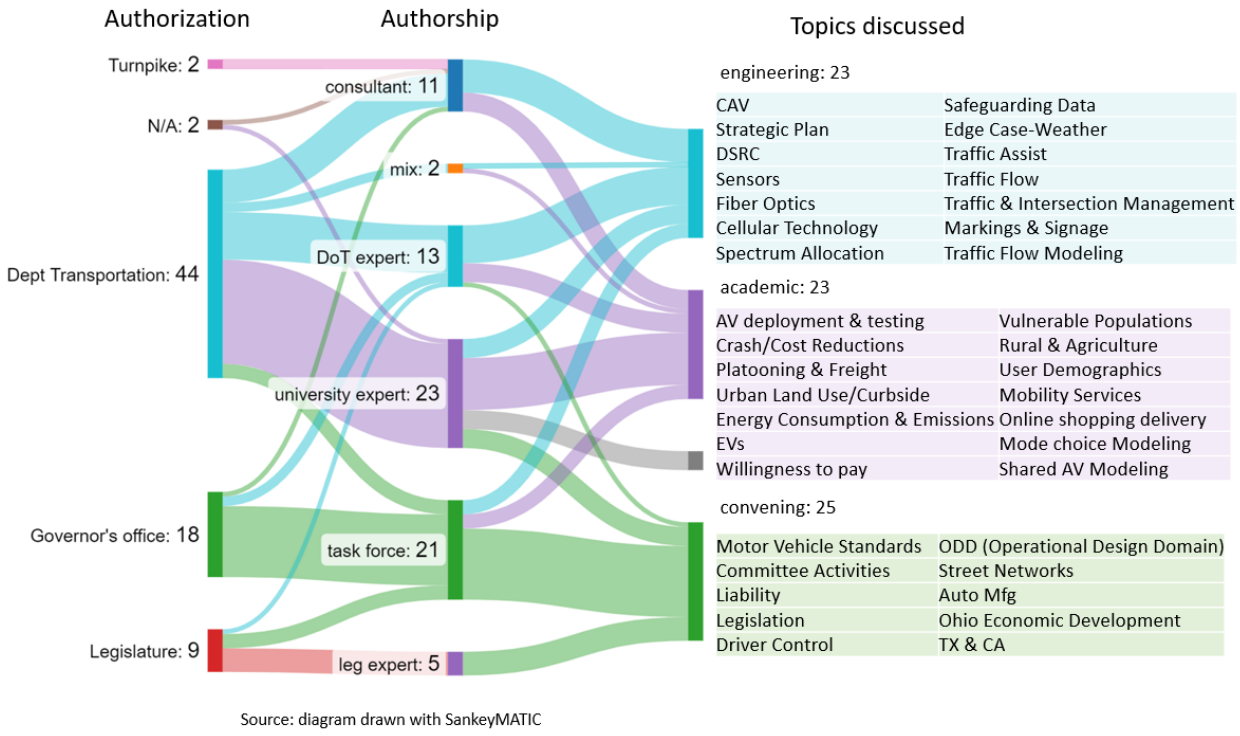
Baumgartner and Jones noticed that different types of organizations search for knowledge differently. In AV, state Departments of Transportation were responsible for expert reports, either writing reports themselves or commissioning them from university transportation research institutes using federal pass-through transportation research funds. In contrast, governors' offices authorized task forces.

However, reports vary and partake of these stylized characteristics to varying degrees. This is most clear with reports written by consultants presumably swayed by the preferences of the commissioning agency. Three of the eleven consultant reports exhibited characteristics of a convening approach. Others mirrored the expert approach. Similarly, most reports discuss most topics to some degree. However, preferences do appear when we count how often topics appear in reports.

Figure 2 provides an overview of state autonomous vehicle transportation advisory systems in a Sankey diagram. The diagram shows the number of reports authorized by different government agencies, who authored those reports, and how authorship connects to the topics discussed. To create this diagram, the topics were clustered using VosViewer. Three clusters were found. One grouped engineering topics that appeared most often in DoT authored reports, we label that engineering. Another set of topics appeared most often in university-authored reports, we label that academic. The third set of topics appeared most often in task force reports, we label that convening. In this way, we are able to trace the threads that constitute the advisory system, making visible both the main lines and the extent of divergence. The three types of expert reports are represented by three types of authorship: Department of Transportation

(DoT), university and legislative (leg), as well as by the the engineering and academic clusters of topics. The convening approach is the Task Force authored reports and the convening cluster of topics, which is quite similar to the topics discussed in legislative expert reports. In the state advisory system, agency activations, authors and report contents often align.

Figure 2 State AV advisory system



Source: diagram drawn with SankeyMATIC

One further characteristic of the state AV advisory system deserves comment, namely its monotony. An AV policy report typically reviews:

- Federal transportation agency programs, recommendations, and guidance;
- other states' legislative, DoT, and pilot program activity;
- AV technology, including:
  - a representation of the five levels of automation defined by the Society of Automotive Engineers
  - and projection of the year technology will be in widespread use;
- and thoughts on how traffic behavior will change.

Observations of federal and other states' actions, technological developments, and forecasts relate to the broader environment and do not differ by state. The reports conclude with recommendations for the state and its DoT, broadly similar across states. Thus, the AV sub-genre of policy reports is highly typified rhetorical action (Miller, 1984). Although the ostensible purpose of a state AV report is to inform about the future of AV, people in a state could learn

about the future of AV by reading earlier reports produced by other states. Nevertheless, each state writes more reports.

Prior comparative studies of policy advising compared advice across countries. Because national governments, even those within the same tradition, differ quite a bit, the repetition of advice escapes attention. In comparison, U.S. state governments are quite similar. Therefore, one report should work for all. Indeed, one of the reports' key components is looking at other states' legislation and pilot programs. Think tanks produce reports meant to advise all state governments, such as the RAND report: *Autonomous vehicle technology: A guide for policymakers* (Anderson et al., 2014), one of the documents most frequently referenced in AV state reports.

Why wasn't the RAND report sufficient to guide state policymaking? The production of documents containing very similar information by multiple states at about the same time seems like a waste of effort if documents simply synthesize information. If sensemaking is viewed as simply map-making (Ancona, 2012), then duplication is wasteful. However, intrinsic to the sensemaking style of advising is not simply the understanding acquired, but also the purpose for which understanding is sought which is to be able to act upon the unknown. The reports aim to understand autonomous vehicles in order to propose government action. The multiplicity of similar AV reports does make sense if particular people need other particular people to go through the process of producing such a document. Because each state has its own set of stakeholders and because reports motivate recommendations intended to guide the actions of particular agencies and legislatures within a particular jurisdiction, each state writes its own reports. It is the connection to action that entails the particularity justifying production of many very similar AV policy reports.

Conclusion

Innovative technology presents governance challenges. A series of emerging technologies, not only AV but also social media and AI, are forcing governments at all levels to respond to challenges that transcend existing governance routines. State governments repeatedly find themselves needing to make sense of an emerging technology with ambiguous implications. Because such situations recur, states are adept at activating the sensemaking style of policy advising to produce reports. Policy reports are typified rhetorical actions based in recurrent situations, or a genre (Miller, 1984). The genre exists to provide a means of synthesizing knowledge in order to devise possible policy responses. Thus the purpose of the genre is to connect knowledge to policy action.

Head pointed out that handling knowledge and evidence in such policy processes is not straightforward. Tracing the advisory system in state transportation policy subsystems revealed that there are a variety of ways to handle knowledge through report writing. Three types of experts wrote reports, tweaking the report form to best deploy their knowledge and set up their perspective on autonomous vehicles. In addition, governors brought together the three

types of expertise in conversations that included a broad range of stakeholders. Thus, choosing between types of expertise or forcing agreement was unnecessary. The report genre is capacious enough to accommodate different forms of knowledge that combine into a policy advice system. Out of the work done to produce the reports and the conversation between reports emerged recommendations providing states with guidance on moving forward with the governance of autonomous vehicles.

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References

Amara, N., Ouimet, M., Landry, R. (2004). 'New evidence on instrumental, conceptual, and symbolic utilization of university research in government agencies', *Science Communication*, *26*(1): 75-106.

Ancona, D. (2012). Framing and Acting in the Unknown. Chapter 1 in S. Snook, N. Nohria, & R. Khurana (eds), T*he Hhandbook for Teaching Leadership*, Sage, pp. *3*-19.

Anderson, J. M., Nidhi, K., Stanley, K. D., Sorensen, P., Samaras, C., & Oluwatola, O. A. (2014). *Autonomous vehicle technology: A guide for policymakers*. Rand Corporation.

Aubin, D., & Brans, M. (2021). Styles of policy advice: A typology for comparing the standard operating procedures for the provision of policy advice. In *The Routledge Handbook of Policy Styles* (pp. 286-299). Routledge.

Baumgartner, F. R., Jones, B. D. (2015). *The politics of information: Problem definition and the course of public policy in America*, Chicago: University of Chicago Press.

Bazerman C., Paradis, J.G. (1991). 'Introduction' in C. Bazerman and J.G. Paradis (eds), *Textual dynamics of the professions: Historical and contemporary studies of writing in professional communities*, Madison: University of Wisconsin Press. pp 3-10.

Bazerman, C. (2010). 'Series editor's preface' in Bawarshi, A. S., Reiff, M. J. *Genre: An introduction to history, theory, research, and pedagogy*, Anderson: Parlor Press LLC.

Bennis, W., and Nanus, B. (1985). "The strategies for taking charge." *Leaders,* New York: Harper. Row 41 .

Christensen, J. (2021). Expert knowledge and policymaking: a multi-disciplinary research agenda. *Policy & Politics*, 49(3), 455-471.

Christensen, J., Holst, C., & Molander, A. (2022). *Expertise, Policymaking and Democracy*. Routledge.

Christensen, J., & Hesstvedt, S. (2023). The influence of expert groups: a citation analysis. *Journal of European Public Policy*, 31:5, 1259-1294. DOI:10.1080/13501763.2023.2174168

Connell, A., Downe, J., Durrant, H., MacKillop, E., & Martin, S. (2023). Externalising policy advice within subnational governments. *Policy & Politics*, 51(4), 628-646.

Craft, J., & Halligan, J. (2020). *Advising governments in the Westminster tradition: Policy advisory systems in Australia, Britain, Canada and New Zealand*. Cambridge University Press.

Craft, J., & Henderson, S. (2023). Policy staff and the evolving nature of policy analytical capacity in Australia, Britain, Canada, and New Zealand. *Policy Studies*, 1-25.

Craft, J., & Howlett, M. (2012). Policy formulation, governance shifts and policy influence: Location and content in policy advisory systems. *Journal of Public Policy*, *32*(2), 79-98.

Craft, J., & Wilder, M. (2017). Catching a second wave: Context and compatibility in advisory system dynamics. *Policy Studies Journal*, 45(1), 215-239.

Freeman, R. (2006). 'The work the document does: research, policy, and equity in health', *Journal of Health Politics, Policy and Law*, 31(1): 51-70.

Freeman, R., Maybin, J. (2011). 'Documents, practices and policy', *Evidence & Policy: A Journal of Research, Debate and Practice*, 7(2): 155-170.

Freeman, R. (2019). 'Meeting, talk and text: policy and politics in practice', *Policy & Politics*, 47(2), 371-387.

Gluckman, P. D., Bardsley, A., & Kaiser, M. (2021). Brokerage at the science–policy interface: from conceptual framework to practical guidance. *Humanities and Social Sciences Communications,* 8(1), 1-10.

Grimmer, J., Roberts, M. E., & Stewart, B. M. (2022). *Text as data: A new framework for machine learning and the social sciences*, Princeton: Princeton University Press.

Grundmann, R. (2017). The problem of expertise in knowledge societies. *Minerva*, 55(1), 25-48.

Grundmann, R. (2022). *Making Sense of Expertise: Cases from Law, Medicine, Journalism, COVID-19, and Climate Change*. Routledge.

Head, B. W. (2008). 'Three lenses of evidence-based policy', *Australian Journal of Public Administration,* 67(1), 1-11.

Head, B. W. (2023). Reconsidering expertise for public policymaking: the challenges of contestability. *Australian Journal of Public Administration*, 1-17. DOI: 10.1111/1467-8500.12613

Howlett, M. (2009). Policy advice in multi-level governance systems: Sub-national policy analysts and analysis. *International Review of Public Administration*, 13(3), 1-16.

Howlett, M. (2015). Policy analytical capacity: The supply and demand for policy analysis in government. *Policy and Society*, *34*(3-4), 173-182.

Hustedt, T. (2019). Studying policy advisory systems: Beyond the Westminster-bias? *Policy Studies*.

Isett, K. R., & Hicks, D. (2020). Pathways from research into public decision making: Intermediaries as the third community. *Perspectives on Public Management and Governance*, 3(1), 45-58.

James, T. E., & Jorgensen, P. D. (2009). Policy knowledge, policy formulation, and change: Revisiting a foundational question. *Policy Studies Journal*, 37(1), 141-162.

Jasanoff, S. (1998). *The Fifth Branch: Science Advisers as Policymakers*. Harvard University Press.

Jasanoff, S. (2005). Judgment under siege: The three-body problem of expert legitimacy. In *Democratization of expertise? Exploring novel forms of scientific advice in political decision-making* (pp. 209-224). Dordrecht: Springer Netherlands.

Krick, E. (2015). Negotiated expertise in policymaking: How governments use hybrid advisory committees. *Science and Public Policy*, 42(4), 487-500.

Krick, E. (2021). *Expertise and Participation: Institutional Designs for Policy Development in Europe*. Springer Nature.

Latour, B. (1986). Visualization and cognition. *Knowledge and Society*, 6(6), 1-40.

Lester, R. K., & Piore, M. J. (2004). 'Innovation—The missing dimension', In *Innovation—The Missing Dimension*, Boston: Harvard University Press.

Malmborg, F. af (2023). Narrative dynamics in European Commission A.I. policy—Sensemaking, agency construction, and anchoring. *Review of Policy Research*, 40(5), 757-780.

Marciano, R., & Craft, J. (2023). Theorising policy advisory system management: approaches and practice. *Journal of Public Policy*, 43(3), 490-511.

May, P. J., Koski, C., & Stramp, N. (2016). Issue expertise in policymaking. *Journal of Public Policy*, 36(2), 195-218.

Miller, C. R. (1984). 'Genre as social action', *Quarterly Journal of Speech*, 70(2), 151-167.

Norton, P. (2021). *Autonorama: the illusory promise of high-tech driving*. Island Press.

SAE On-Road Automated Vehicle Standards Committee. (2014). Taxonomy and definitions for terms related to on-road motor vehicle automated driving systems. SAE Standard J, 3016, 1.

Schiff, D. S. (2023). Looking through a policy window with tinted glasses: Setting the agenda for US AI policy. *Review of Policy Research*, *40*(5), 729-756.

Turner, S. P. (2010). Normal accidents of expertise. *Minerva*, 48, 239-258.

Ulnicane, I., Knight, W., Leach, T., Stahl, B. C., & Wanjiku, W. G. (2021). Framing governance for a contested emerging technology: insights from A.I. policy. *Policy and Society*, *40*(2), 158-177.

Weimer, D., & Vining, A. (2017). *Policy analysis: Concepts and practice*. Routledge.

Weiss, C.H. (1979). 'The many meanings of research utilization', *Public Administration Review*, 39(5), 426-4.