A Methodological Approach on Studying Policy-making of Autonomous Driving in Cities

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This commentary proposes a methodological approach about policy analysis on autonomous driving. It focuses on the role of discourse, the multiple actors and technologies involved in the processes of urban policy-making. Autonomous driving is considered a crucial case of policy-making in cities, because of the multitude of established and new actors involved as well as the combination of different digitalisation and automation technologies. Current research outlines the uncertainty planners and policymakers find themselves in regarding how to plan and regulate for autonomous driving, and calls for the need of finding the right forms of governance and policy for the implementation of autonomous driving in urban contexts. Therefore, studying the processes of its policy in the making is vital, as it is these processes that determine if and how any kind of policy will come into place. Subsequently, it is urban policy that will define the ways autonomous driving will be implemented and its implications in cities. Since both socio-political and material factors play a role in policy-making, a suitable methodological approach is needed that can address both. Therefore, this commentary discusses methodological developments drawing inspiration from Argumentative Discourse Analysis (ADA) and combining it with elements from Actor-Network-Theory (ANT). The insights provided by the commentary aim at a more comprehensive and thorough understanding of policy-making processes of autonomous driving and how policy change occurs (or not).

Keywords: autonomous driving, policy-making, argumentative discourse analysis (ADA), actor network theory (ANT)

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Introduction

Autonomous driving is an important element of the discussion about the future of mobility. It is often assumed to radically change the way we move in the future (Fraedrich et al., 2015; Lipson & Kurman, 2016). While applications of autonomous driving on highways are already expected by 2022 (Kellerman, 2018; Freudendal-Pedersen et al., 2019), its implementation in cities is considered much more complex (Kröger, 2016; Kellerman, 2018). This is because cities are complex highly-populated environments with multiple interactions between infrastructure, persistent mobility patterns and humans. In this sense, especially during the transition phase, autonomous vehicles would need to share urban space with vehicles with a driver, and other road users (e.g. cyclists, pedestrians) as well as human activities (e.g. retail). Therefore, there are a lot of debates and questions surrounding the implementation and implications of autonomous driving in cities. To name but a few: will autonomous driving reduce or increase today's car use and ownership, traffic volumes, and transport emissions? How will autonomous driving affect land use in cities? To what extent will it be integrated into public transport, be combined with on-demand services and sharing schemes, and replace private conventional cars? Will autonomous driving actually increase inclusivity in mobility (e.g. for the disabled, children, people who don't drive) or will it be available only to the people who can afford buying autonomous cars? The answers to these questions are to be determined through policy-making.

So far, policy-making for urban mobility has been primarily based on the negotiations between the established automotive industry and the public sector (city planners, politicians). As such, it has been characterised by specific path dependent principles and objectives (e.g. prioritization of highway capacity, parking spaces, etc.). However, autonomous driving brings in new actors and technologies (e.g. ICT industry), challenges the long-established actors, and creates interdependencies between old and new actors. Thus, it can be argued that whether and how it will be implemented depends a lot on how the negotiations between the automotive industry, the ICT industry, and the public sector will play out. At the moment, there is a lot of uncertainty and ambiguity among the actors as well as institutional inertia when it comes to its implementation in cities (Freudendal-Pedersen et al., 2019). This renders autonomous driving a 'messy policy problem' (Fischer & Gottweis, 2012). Therefore, the main scope of policy-making at this initial stage is more about determining who is going to steer the process, and about creating a vision on the role of autonomous driving in urban mobility. It is not yet about actual implementation, as there has not been any formulation of a common understanding of the issue or of any strategic orientation so far. Thus, it makes more sense to talk about *policy of autonomous driving in the making*.

Research on the policy-making processes on autonomous driving has been so far underrepresented. Porter et. al. (2018) and Legacy et.al. (2019) point out the challenges of finding the right forms of governance, policy and regulation that could lead to a 'good' future of autonomous driving. There are also few studies describe governmental legislative initiatives in several countries (see for example Taeihagh & Lim, 2019). In general, most policy analysis approaches in mobility focus on the inputs and the outcomes of policy-making. Most of these studies treat policy-making as a linear and rational process focusing mainly on the formal institutions while neglecting the processes through which policy objects (and subjects) have come to be. They have little to say about the role of diverse actors in making these policies (Schwedes, 2011). Thus, these approaches fail to adequately reveal latent power struggles as well as black-boxed conflicts, uncertainties in policy-making processes, and to offer opportunities for engagement. Especially, in the case of autonomous driving, studying the processes of *policy in the making* is vital, as it is these processes that determine if and how

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any kind of policy will come into place. Subsequently, it is policy that will determine if autonomous driving will be implemented and how. Based on that, autonomous driving represents a crucial case of mobility policy-making in cities, as it combines the uncertainties and conflicts of several new and old actors and technologies.

Policy-making reflects both struggles of competing interest groups and actors as well as broader governance modes, which can be traced through the study of discursive exchange (Hajer, 2009). Fischer and Forester described policy-making as

> *'a constant discursive struggle over the social classification, the boundaries of problem categories, the intersubjective interpretation of common experiences, the conceptual framing of problems, and the definition of ideas that guide the ways people create the shared meanings which motivate them to act'* (Fischer & Forester, 1993, pp. 2) .

Besides the role of ideas and norms conveyed through discourse (e.g. efficiency and competitiveness as core principles), policy-making of autonomous driving, is also (re)shaped by material aspects, such as infrastructure and technologies. For example, self-learning algorithms and machine learning might influence policy-making in unpredictable ways (Bissell, 2018; Elliott, 2018). These material and discursive aspects are interdependent, in the sense that the availability and readiness of certain technologies over others might lead to specific discursive formulations, and thus specific policies for autonomous driving. For example, 5G technologies are currently ready to be implemented, while there are still many open questions about how artificial intelligence, which is necessary for vehicle autonomy, can deal with ethical dilemmas. This might lead actors to discursively articulate 5G as a prerequisite for autonomous driving, and then develop a policy for 5G connectivity infrastructure to prepare the ground for autonomous driving, instead of developing policies for direct implementation of autonomous vehicles on city streets. At the same time, policy change in urban contexts is influenced by the interaction of multiple administrative levels (national, regional, urban) and industrial sectors (automotive, ICT), which are also interdependent. Thus, the central argument of this commentary is that a methodological approach to studying policy-making of autonomous driving in cities should include both discursive and material elements, in order to achieve a more comprehensive (discursive-material interdependency) and thorough (multi-level and multi-sectoral interdependency) understanding of policy-making and how policy change occurs (or not). As Wagenaar (2011) imparts, policy-making is non-linear and dynamic and a precondition of engaging with policy, of affecting it and of changing it is the ability to grasp these dynamics. The objective of this commentary is to propose a conceptual-methodological approach on policy-making of autonomous driving, which focuses on policy discourse, and the multiple actors and technologies involved. For that, it draws inspiration from Argumentative Discourse Analysis (ADA), combining it with elements from Actor-Network-Theory (ANT). Up to today, there have been few studies that combine ADA with ANT (see Mikus, 2008; Beveridge, 2012).

The commentary discusses conceptual and methodological issues tailored to policy-making of autonomous driving, but its insights can also be considered in the context of policy-making and urban governance in general. Given the fact that an empirical analysis of a case study is not provided, a concrete methodological approach that can be applied in any case study cannot be provided, as interpretive methodologies are also shaped by the data at hand. The intention is rather to provide food for thought for future empirical studies on urban mobility policy-making. Following the conceptual framework in the next session, the methodological approach is proposed, and some insights and concluding remarks will follow.

Conceptual Framework

Autonomous driving as an object of policy-making can be seen in two ways. First, it can be seen as a product of policy discourse, socially constructed by human beings. It can also be seen simply as a product of interaction between human and material actors, who are constitutive of each other's contribution to urban mobility policy-making. However, viewing it simply as the product of interaction between human and material elements does not explain everything about its promotion. There is a need to analyse mentalities and the rationalisations that influence these interactions, and the ways these rationalisations simplify and reduce complexity in governance processes. Therefore, this commentary discusses Argumentative Discourse Analysis as the main analytical approach to study policy-making of autonomous driving supplemented by elements from Actor-Network-Theory (ANT).

Argumentative discourse analysis (ADA)

Discourse analysis approaches attempt to understand policy-making processes. A linguistic analysis of policy is not just about what is being said, but also about the deliberation of policy-making and the ways language is used to pursue political and organisational objectives and produce knowledge. When studying socio-technical policy objects, such as autonomous driving, there comes a point when the analysis must move beyond the assessment of language alone and look at the influence of technologies and practices in (re)shaping policy. In this context, Hajer's Argumentative Discourse Analysis (ADA), which rejects a narrower focus on linguistics and includes the practices within which discourse is (re)produced (Hajer, 2003). Thus, Hajer (2006, pp. 66) defines discourse analysis as 'the examination of argumentative structure in documents or other written and spoken statements as well as the practices through which these utterances are made'. ADA adds the performative and practical dimension to the linguistic dimension of discourse analysis by looking at the dynamic processes of meaning production (Hajer, 2005a).

ADA offers a concrete analytical framework of discursive constructions, namely storylines, actor coalitions and practices. As Hajer described, politics is seen as constituted by and constitutive of specific discourse coalitions, who (as actors) come to be organized around a specific policy storyline and a set of practices communicating that given storyline. The key concept here is the storyline, which reflects a specific discursive understanding of a given policy, and thus is communicated by political actors in efforts or struggles to institutionalize their understanding of a given policy in practice. Storylines are short-cut phrases (e.g. autonomous driving as a means of efficiency) that summarise 'narratives on social reality' 'cluster knowledge, position actors and are essential in the formation of coalitions in a given domain' (Hajer, 1995, p. 63). For example, in the case of autonomous driving, a policy storyline could be that autonomous driving provides energy efficiency, which might be co-produced by and within the practice of integrating autonomous driving in the local plan for electric mobility (Freudendal-Pedersen et al., 2019).

Hajer measures the influence of a certain discourse within policy-making processes with the concepts of discourse structuration and discourse institutionalisation. A first level of influence is reached if a discourse establishes the vision of an important discourse coalition. Then if this discursive vision translates into the creation of institutional practices and concrete policy actions, then the discourse is successfully materialised. For Hajer, a discourse is dominant if both criteria are met (Hajer, 2006, pp. 71). However, there are still two main weaknesses with the capacity of this approach to comprehensively study policy change: Firstly, policy change often occurs without its corresponding discourse becoming structured. In other words,

sometimes policy change occurs simply because the people who want it have power and control over material things, such as technology, or have positional power in a network. Secondly, even if structuration does occur, institutionalization might not happen due to material factors and/or routinized practices. For example, Stuttgart's aspiration to be the world leader in autonomous driving might be hindered by a) physical limitations of its hilly landscape and infrastructure networks, b) objections of people to giving up driving their cars, c) institutional inertia. This implies that not everything is a matter of argumentation. Both these weaknesses have to do with materiality. That is why ADA can benefit from ANT, which takes into account material influences.

Actor network theory (ANT)

ANT provides an approach to studying how social order(s) is contingently achieved through the enlistment of human (individual, collective, institutional) and material (technologies, infrastructure, documents, etc.) actors into relationships called actor networks. It assumes that nonhuman entities have agency too, thereafter hybrid forms of agency define our society (Latour, 1996, 2005). Its core point is that whilst technology is a social construction, society is a technological construction as well. In relation to policy-making, ANT explains how the subjects and objects of policy-making come together (Rutland & Aylett, 2008). Despite what its name suggests, ANT is not exactly a theory, but it represents a methodological sensibility that introduces uncertainty concerning the nature of agency as not being exclusively human by reconceptualising it as 'the ability to make a difference' (Sayes, 2014).

ANT's most fundamental assumption is that entities are an effect of their relations with other entities, rather than inherent properties (Law, 1999). Agency here is acquired and relational, rather than inherent and individually possessed. For example, 'software and hardware developments' (material agency) combined with a modification of the traffic law (human agency) might result in allowing autonomous vehicles to be on the streets. In this sense, ANT assumes that the world is multiple, performative and different from a single pre-existing reality (Law, 1992). ANT can also reveal, to a certain extent, how material things can determine power relations (Winner, 1980). For, instance, V2X technologies might dictate the way road infrastructure (e.g. traffic lights and road sensors) are designed, which would give more power to the ICT industry to steer policies (Stilgoe, 2018), instead of city planners planning based on social and environmental equity. Oftentimes, however, ANT approaches conceive human influence in a limited way, since only direct human actions within a system are considered. The influence of the broader socially constructed beliefs, values and ideologies that inform interactions are barely taken into account (Jasanoff, 2004).

Although many might argue that ANT could make the empirical analysis of the political processes behind autonomous driving apolitical by neglecting the existence of a central figure whose interests dominate, this is not the case. Rather this commentary argues that it is important that researchers acknowledge that policy-makers have outsourced some of their regulating principles, politics, and moralities. This does not mean that asymmetries of power are to be neglected, but rather that the approach aspires to reduce pre-existing assumptions regarding 'who governs and how', and to avoid establishing a-priori distinctions as much as possible. It is about viewing the policy-making arenas as fields of experimentation, where the unexpected variations and surprises of the policy-making deliberation can be revealed (see Gomart & Hajer, 2003; Hajer, 2005b; Hajer & Versteeg, 2005).

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Complementary approaches

Both ADA and ANT can be said to be concerned with the practical aspects of governing, arguing that political discourses only have effects in the extent to which they become practical. However, there is a tension between the two approaches regarding the means through which they seek to reveal this, even keeping the material issue out of the discussion. The key difference lies in the treatment of discourse. Hajer's ADA begins with the premise that discourses and rationalities are constitutive of social relations and actions, and traces how these discourses are produced and re-produced in different contexts and the effects these processes have. Despite the fact that ANT has influenced Hajer (see Gomart & Hajer, 2003; Hajer & Versteeg, 2005), who drew on ANT to provide an account of the simultaneous knowledge production and power relations as performance, Hajer's approach still has the tendency to explain policy change with reference first to the discourse itself and then to turn to a consideration of interactions between policy actors (Rutland & Aylett, 2008). Besides that, in the case of socio-technical objects of policy-making, such as autonomous driving, Hajer's approach does not suffice to take into account the influence of material technological aspects that (re)shape policy-making. In contrast, ANT starts with the premise that discourses are an outcome of networks and explores the processes through which these networks are assembled; it is bottom-up rather than top-down (Beveridge, 2012).

Therefore, the two approaches can be complementary. The concept of 'translation' coming from ANT can be used to complement the more practical, informal, generative and material aspect of storylines production. ANT scholars Callon (1984, 1986) and Latour (2005) refer to the concept of 'translation' as the means through which different rationalities, interests, programmes, and technologies are aligned. Thus, 'translation' is a way of combining an analysis of broader discourses, local storylines, technological artefacts and practices in the policy-making of autonomous driving. Below the author proposes a methodological approach on how ANT could complement ADA in doing empirical research on policy-making of autonomous driving.

Methodological Approach

Combining different methods

This commentary proposes that a methodology for studying the policy-making of autonomous driving, which is descriptive, exploratory and interpretive, following an abductive process of reasoning. This means that theory and concepts develop in relation to the data material at hand in order to explain it. In other words, theory shapes the empirical analysis and vice versa. The approach suggests the deployment of three different qualitative methods (desk research, expert interviews and field observations) and is operationalised through three steps, which can be conducted simultaneously.

As a first step, a desk research is conducted including the analysis of policy documents and media articles related to autonomous driving and mobility in an urban context. The purpose is to obtain an overview of the socio-political and material circumstances as well as technologies related to urban mobility. Thus, the main events and milestones, the main practices, artefacts and actors involved in the emergence of autonomous driving can be identified. Policy documents might include proposals and decisions formally submitted to, discussed and decided by the City Council and the administration, documentation on funding applications for projects on autonomous driving, as well as relevant planning documents that attempt to integrate autonomous driving (e.g. Urban Transport Plans). An analysis of position papers

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from groups and organisations (e.g. NGOs, Automotive Associations, etc.) can also be insightful and complement policy document analysis. Material from different administrative levels (e.g. regional, national, EU) can also be analysed, so that policy practices or events that influence the policy-making on the local level can be identified. Media articles provide a different perspective on formal policy-making processes, in the sense that they often integrate the public opinion, something often left out of formal policy documents and discussions at this early stage of policy-making of autonomous driving. As the following quote from the author's empirical research in Stuttgart indicates, there have not been substantial discussions between policy-makers and citizens regarding the implementation of autonomous driving so far, with the policy-makers arguing that this is because technology is still in an experimentation phase:

> '*We will only inform the citizens and the local society if we start with some pilots on public streets. A big discussion about autonomous driving, what is changing in our society, what is changing in our city…we will have this later'*(Interview with expert from Department of Economic Development of the City of Stuttgart, 2019: pp. 22).

The second step is to study how local actor coalitions are formed, and how they position themselves in the local discourses on autonomous driving through the construction of storylines. This step is also about how the knowledge, values and norms of the actors are mobilized and coordinated, in order to perform practices. For that it is suggested that semi-structured in-depth expert interviews with the relevant actors be conducted. According to Hajer,

> '*the real challenge for argumentative analysis is to find ways of combining the analysis of the discursive production of reality with the analysis of the (extra-discursive) social practices from which social constructs emerge and in which the actors that make these statements engage. This is the function of the concept of "discourse coalition"'* (Hajer, 1993, p. 45).

In order to deal with this challenge, it is necessary to put the subject of the policy actors and their interactions in the centre of the analysis. It is the policy actors in their particular context that articulate statements and make the link between a policy and the outcome of the policy process (Zittoun, 2009, p. 67). That is why this step is the most crucial step for studying *policy in the making* in-depth, as it reintegrates the subject in the analysis. This is the distinctive difference to more teleological approaches to policy analysis, which consider policy in terms of input, output and their causal relations. Especially in the case of autonomous driving, which still lacks a policy framework and there are so many ambiguities about its implementation, the emphasis on the processes of policy-making is crucial. For example, Blyth (2019) shows that the argument 'safety of the driver' might contradict itself, if it practically fails to regulate loss of privacy issues due to big data functions, as people might lose part of their autonomy to being safer. Therefore, while conducting expert interviews, the researcher ought to put emphasis on specific events, practices, ongoing local debates and any form of argumentative exchange between actors.

Autonomous driving in many ways changes the existing policy-making constellation of actors by bringing in new actors (e.g. technology companies, start-ups, etc.), while destabilizing the role of established actors, such as the automotive industry and the public sector. Furthermore, it might change the role of the different administrative levels (i.e. local, regional, national) in the urban governance processes, as it creates new regulatory and legislative requirements (e.g. regarding safety, responsibility, etc.). Therefore, the exact number and kind of interviewees cannot be precisely defined a priori, as it is not clear who acts and how. In this

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context, Hajer's Argumentative Discourse Analysis in line with ANT limits relevant context to actors that can be identified in those settings, circumstances and elements that have a concrete and observable impact on discursive struggles and/or result in any form of action. In other words, an actor is not an actor if they do not act in some way within the observed policy-making processes, even if they traditionally have an official position in institutional settings. For example, the Department of Road Construction of a City might not be a relevant actor to interview, if its role is executive and the policy-making of autonomous driving is still on a decision-making level. Thus, the extent of the research object, cannot be defined ex ante, but constitutes one result of the empirical analysis. Practically, this means that the empirical research starts with a list of 'visible' actors identified in the desk research. These actors could be planners, local politicians, public transport companies, automotive industry manufacturers and suppliers, actors from civil society, and engineers that develop autonomous driving technologies.

The third step is conducting field observations through participation in preparatory meetings of dialogue labs and/or platforms, where diverse actors gather to discuss and exchange opinions on the potential implementation of autonomous driving and also identify 'invisible' actors that were not identified from the desk research and the interviews. The purpose of this is to better capture the conflicts, power struggles, and interactive practices among the actors, which might not be adequately captured through the interviews. This way the discursive exchanges and their relations to infrastructure and technologies can be further analysed and elaborated. This is a further step to focus on the subject of the actor as unit of analysis and to methodologically address it thoroughly. It also allows to better contextualise the data obtained from interviews by observing the actors interacting in their specific social and spatio-temporal contexts. In this case, the researcher has a more passive role by being just an observer who keeps notes without actively influencing or shaping the ways actors articulate arguments. Actor-Network-Theory offers a methodological framing for the observation of production and creation of argumentative exchanges and policy processes in general. Combined with argumentative analysis, it supports the 'understanding of the dynamics of policy-making today through a contextually situated, ethnographically rich analysis of policy constellations' (Fischer & Gottweis, 2012, p. 6).

### Identifying storylines and working with the empirical material

Storylines are considered as the main analytical category to be identified in the empirical material. Here storylines are understood as a means or resources that actors produce and deploy to convey facts and evidence, and exchange meaning in debates among them. By deploying storylines, actors reduce complexity of the problem of implementation of autonomous driving, gain acceptance, credibility and trust in their narratives. Actors might reproduce a (dominant) storyline to retain and strengthen a given set of institutions, or they might construct an alternative or counter-storyline in an attempt to transform a policy. Thinking in terms of dominant-versus counter-storyline helps to highlight how storylines are produced in relation to each other, and how a counter-storyline only gains its meaning through its relation, or contrast of a dominant storyline (Hajer, 2006).

Storylines are the intermediaries of policy-making processes. As such, they have the capacity to transform, translate, distort, and modify the meaning or the elements they are supposed to carry (Latour, 2005). In the same vain, Hajer claims that all discourse-oriented policy analyses must be based on three interrelated elements: discourse, practices and meaning. While meaning is produced within certain discursive structures, discourses are produced within the context of particular practices. Thus, practices represent the performative dimension of policy-

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making (informed by ANT) and discourse and meaning represent the discursive dimension of policy-making (informed by ADA). However, this does not mean that each of these elements is to be studied separately. In order to analyse policy in the making it is rather necessary to study the three elements as an entity. In other words, discourses, underlying meanings and practices/materialities should be examined together in a creative construction process. Once again it is the storylines shared by the actor coalitions that connect all these elements and enable their comprehensive studying (Figure 1). Therefore, studying how storylines are produced is key to understudying policy-making of autonomous driving.
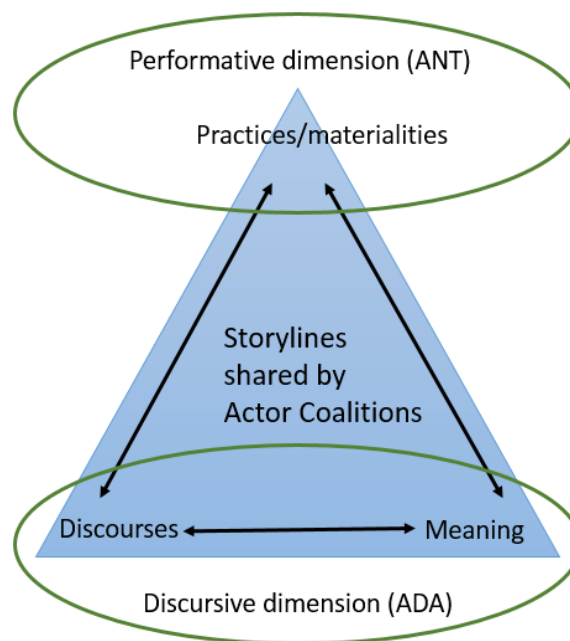
Figure 1. *ADA supplemented by ANT. Source: Author.*

In the case of autonomous driving, the production of storylines is considered as an interplay of local arguments (e.g. last mile solutions), broader discourses (e.g. smart city, competitiveness), actors (new and established), practices (e.g. pilots, tests, decisions) and technologies (automotive and ICT) (Figure 2). For example, investigating how the storyline 'autonomous driving will improve traffic efficiency' is produced and shared by an actor coalition between the automotive industry and a City emerges in a two-fold process: On the one hand, what triggers the collaboration between the actors (performative dimension) is identified in the data. This could be, for example, a new technology for vehicle platooning and/or a pilot programme for developing scenarios of the efficiency potential of autonomous driving. On the other hand, the specific arguments the actors articulate (discursive dimension) are identified. For example, reduction of congestion might be an important argument for the City, and for the industry that they can be a better mobility provider than public transit. Then, by combining the arguments and the practices, the storyline that the actor coalition articulates is revealed.

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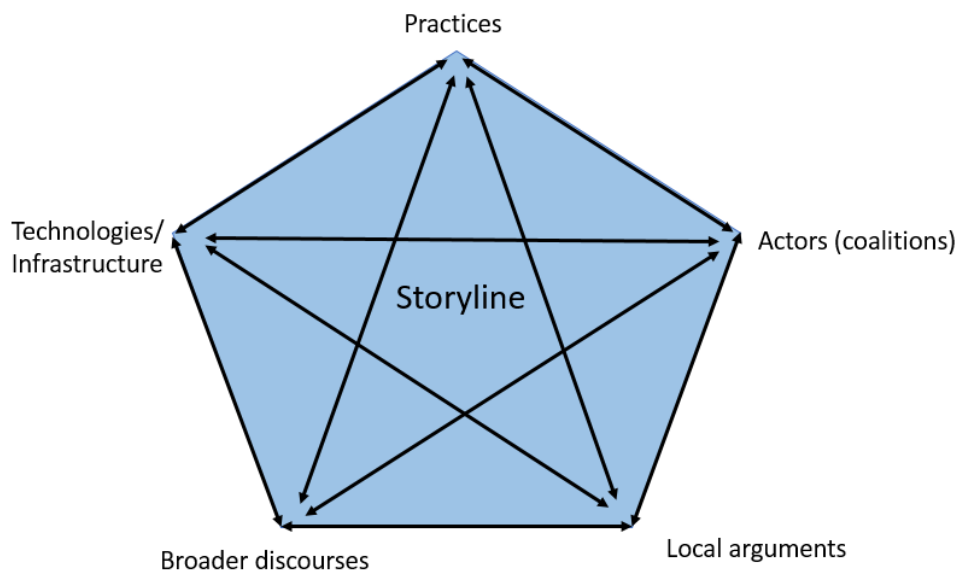
Figure 2. Combination ADA and ANT for autonomous driving. Source: Author.

In the data, policy storylines are considered as rather metaphors and/or short-cut phrases that are deployed and shared by actors in an attempt to connect concepts and material aspects that were previously unconnected, in order to develop a common understanding of the topic at hand. In order to categorise and structure the empirical material, six analytical elements, arising from a combination of ADA with ANT, are identified, which constitute and are constitutive of storylines:

- A set of practices or actions they engage in to literally 'do' or produce a storyline. This includes rules, legislation, initiatives, agreements, economic practices, studies, projects.
- The set of material aspects that influence the production of a storyline. These material aspects include infrastructure, technological developments (e.g. hardware and software) and business models.
- A set of events and tipping points that (re)shape the storylines.
- A set of synergies and conflicts between the actors that facilitate or impede the policy-making process.
- The actor coalitions as those specific actors who share a policy storyline in relation to the larger discourse they (re)produce.
- A set of arguments they form to articulate a policy storyline.

Storylines reflect the agency of actors within and in relation to a complex system of governance. It is not assumed that actors are the agents of change, but that they have the capacity to change the conditions and framework through which policy-making takes place. It furthermore seems that policy actors 'act' to not only change policy, but furthermore to 'resist' to change (Tschoerner-Budde, 2019). Furthermore, there are limitations to this capacity of actor coalitions to induce change or not. There is a certain limit to their capacity to navigate into regimes, institutional structures and norms. For instance, there are certain physical structures, technological capacities, already established infrastructure and path-dependencies that interact with, limit or enable the agents' capacity to transform policy through discourse. It

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is about how actors interact with existing policy regimes, how they engage in debates, how they attempt to attach meaning to new technologies. In this sense, the identification of storylines and the analytical elements that are made of can analyse not only policy change, but also policy inertia.

Broader discourses might inform and inspire policy-making, but might just as easily become transformed in processes of translation - come to mean different things in different settings at different times - and/or get rejected because of material and practical factors (Beveridge, 2012). Subsequently, policy-making is context-oriented and takes place in specific socio-material, spatial and discursive arenas. That is why the storylines and all discursive elements identified in a specific context are a product of particular interactions of socio-material elements during a specific period of time, which might be distinct from other socio-temporal and spatial settings. This is illustrated by the following quote from one of the author's expert interviews, which summarises the distinct processes of policy-making of autonomous driving in German and American cities. It shows how the notion of safety is contextualised and translated differently in urban contexts of two countries due to different mentalities, cultures and landscapes.

> '*It is interesting that American cities were really open at the beginning, but after the accidents they are starting to watch it carefully. So, maybe the approach is a little bit different in Germany…we are slow at the beginning, but later we will be maybe more active (…) That is not only for autonomous driving, but for the whole thing about urban mobility services in Germany. It is maybe a little more open in America, while here we are more critical and concerned always about safety (…) Especially in California the topography is different and cities are different, so…culture is different.*'(Interview with expert from BMW, 2018: pp. 23)

Insights and Concluding Remarks

This commentary proposed a methodological approach for investigating the policy-making processes behind the promotion of autonomous driving in cities. Combining ADA and ANT as complementary approaches, it was argued that both discursive and performative (practical and material) aspects are crucial to understanding policy-making for autonomous driving. On the one hand, the weakness of ADA to take into account material aspects that influence policy-making can be 'cured' by the hybrid actor-network analysis of ANT. On the other hand, the failure of ANT to capture broader mentalities and discourses in a comprehensive way and provide a thorough understanding of precisely how actors influence each other can be dealt with by the concepts of storylines and actor coalitions of ADA. Overall, the goal was to provide insights on the translation of broader discourses and local storylines, technologies, infrastructure, interests and actors, in order to contribute to a better understanding of the indeterminate, ambiguous and contested aspects of policy-making.

By re-materialising the concept of discourse, the concept of agency opens up to being attentive to the ways in which human actors and material aspects interact. This way ANT could add to ADA by opening up the conceptualization of actors to include the role of technologies, so that the complex relation between technology and policy can be further elaborated. By doing so, researchers can be open to the uncertainties and the peculiarities of policy-making processes.

For example, automation technologies have already been available since 1921, when the U.S army introduced the first remote-controlled vehicles. Later on, automatic transmission in 1939

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and automated guided vehicles in 1954 became available in the US. However, the first tipping point for the beginning of the computerization of the car was in the 1960s and in the 1970s when electronic cruise control (US), emission control technologies and anti-lock braking systems (Germany) were introduced, following the general development of computers and IT (Kröger, 2016; Kellerman, 2018). This was the tipping point, when the automotive industry and the ICT industry started converging. According to Johnson (2016), what triggered this convergence was the environmental and safety awareness regarding emissions and accidents caused by cars in the 1970s. For this reason, the engineers of that time used computer applications in cars to reach environmental and safety regulatory standards. No one back in the 1970s anticipated the computerization of the car as an outcome of emissions and safety regulations (i.e. Clean Air Act in the U.S.). In other words, the automobile's changes towards increasing computerisation since the 1970s are significantly driven by the regulation of technologies emerging in the 1960s and 1970s (e.g. the combustion engine was regulated because of the emissions). Ever since, there has been increasing convergence of the two industries further accelerated by artificial intelligence (1980s), GPS navigation systems, etc. that are targeting mainly safety, connectivity as well as convenience. The role of policy in the computerization of the car in the 1970s was vital to the development of autonomous driving today. This highlights the unpredictability of policies and the uncertainties of policy-making.

Table 1. Timeline of the main developments in autonomous driving. Source: Author.

1921	Remote-controlled vehicles
1939-1954	Early automation: automatic transmission, automated guided vehicles
1960s-1970s	Convergence of ICT and automotive industry for complying with environmental and safety regulation: Electronic cruise control, anti-lock braking, emission control technologies
1980s-1990s	Accelerating convergence due to artificial intelligence, GPS systems, etc.
2000s-2010s	Integration of computers, sensors, artificial intelligence and communications technologies for AVs

Therefore, policy goals should not be assumed as being flat and given. Thus, they must be studied relationally in how they are co-produced and used by heterogeneous actors in policy-making processes. After all, the institutional inertia, mentioned in the introduction, that the city governments find themselves into can only be thoroughly investigated in parallel with the informal politics and lobbying of the private sector, as well as the particular materialities that allow or impede the implementation of autonomous driving in cities.

Investigating socio-technical objects of policy-making, such as autonomous driving, by using a combined approach of language and materiality, can contribute to acknowledging the political nature, normativity and specific values of the promotion of technologies, and eventually democratizing them. Because that is exactly the problem with both technology and policy. On the one hand, popularizing technology and denouncing its politics usually leads to disconnection of everyday social realities and missed potential for actual change and problem solving. On the other hand, policy often tends to be a means of promoting efficiency and effectiveness, while the political nature of policy-making is hidden by the use of technical language. Techno-centric think-tanks supply public policy-makers with both broad mentalities and specific policy arguments. Therefore, it would be unfair to reduce policy-making to the

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formal decision-making without taking into account the role of infrastructure, technologies and technocrats, just as it would be wrong not to see it as a dynamic product of constant political action and hybrid interaction.

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