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How do public officials provide directionality to breakthrough innovations? The case of the self-driving car policy of the Netherlands.

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How do public officials provide directionality to breakthrough innovations? The case of the self-driving vehicles policy of the Netherlands

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Abstract

As Science, Technology and Innovation (STI) policies incorporate societal challenges in their design, questions have been raised about the role of policymakers therein. It has been suggested that policymakers should provide these novel STI policies with directionality, as the capacity of public authorities in determining the directions of change. This concept remains unexplored empirically. We address this research gap by performing a qualitative case study in which we claim directionality is provided by policymakers: The Dutch self-driving vehicle policy. By interviews with stakeholders engaged in this policy and document analysis, we explore the barriers of and ways in which this directionality is provided.

Keywords: directionality; STI policy; smart mobility; self-driving vehicles; transformative innovation policy; socio-technical transitions.

1 Introduction

Contemporary societal challenges, such as climate change, wellbeing, and sustainability are increasingly becoming central in the design of Science, Technology, and Innovation (STI) policies (Kuhlmann and Rip, 2014; OECD, 2015). This acknowledgment has been reflected in the design of breakthrough approaches in STI policies,

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such as in the establishment of the European Union Horizon 2020 program as well as of the Responsible Research & Innovation and smart specialization frameworks (see European Commission, 2016; OECD, 2011, 2014). This shift in STI policy, which has been labeled as its 'normative turn' to the transformative innovation policy paradigm, suggests that grand challenges can be addressed by introducing and diffusing societally desirable breakthrough innovations (see Daimer et al., 2012; Lindner et al., 2016).

It has been extensively argued that existing intervention rationales and policy instruments to govern a STI policy may be inadequate to govern societal challenge oriented STI policies (Daimer et al., 2012; Lindner et al., 2016; Mazzucato, 2015; Weber and Rohracher, 2012). Particularly, as the two dominant intervention rationales in this policy domain, namely *market failures* and *systemic problems* (Edler and Borrás, 2014b) cannot justify policy interventions that these challenges require. For this reason, Weber and Rohracher (2012) have suggested a new type of policy intervention rationale, the 'transformational system failures'. These failures are based on arguments of sustainability transitions literature mirroring "recent debates in the context of [...] sustainability policy, but [...] yet not been explicitly linked" to the dominant contemporary innovation policy debates (Weber and Rohracher, 2012, p. 1042).

One transformational failure suggested by Weber and Rohracher (2012) is *directionality*. This rationale refers to the necessity of "not just to generate innovations as effectively and efficiently as possible, but also to contribute to a particular direction" of change (Weber and Rohracher, 2012, p. 1042). In other words, directionality indicates that the state should have a leading role in providing a strategic and normative orientation to STI policy (Daimer et al., 2012). Directionality, albeit largely explored on a theoretical level remains unexplored empirically (e.g. Daimer

et al., 2012; Lindner et al., 2016; Steward, 2012). We have limited understanding of how this directionality looks like in contemporary policymaking, including its main barriers for implementation and policy instruments to provide it to the innovation process. This research aims to fill this gap by performing a qualitative case study in which we claim directionality is being addressed by policymakers: The self-driving vehicle policy of the Netherlands.

The self-driving vehicle policy of the Netherlands has emerged in recent years to position the Netherlands as a front-runner in this technological area (Rijksoverheid, 2017). It is part of a broader transition STI policy towards smart mobility established in 2013 by the Dutch Ministry of Infrastructure and Environment (I&M) fostering innovations in the fields of traffic information, traffic management, and in-vehicle technology (see de Mooij, 2013). This policy has lead to the establishment of multiple programs enhancing the development and adoption of automated driving (see Automotive Campus, 2016; Brainport, 2016). We claim that in this policy the transformational failure of directionality is present for at least two reasons: It is a transition policy in which multiple directions of change could be taken, according to policy reports (see Tillema et al., 2015); and self-driving vehicle technologies are still in early phases. Both reasons suggests that policymakers, sooner or later, will need to make decisions about specific directions and routes to take in the development of this technology.

Albeit it remains impossible to study the concrete directions of change that policymakers will take in the following years regarding this technology, we can research the challenges that both policymakers and stakeholders have to incorporate this transformative system failure in STI policy. By performing interviews with stakeholders and analyzing policy documents, we aim to answer the research question of

how do policymakers provide directionality to the Dutch self-driving vehicle policy?. In order to answer this question, we focus on the following research inquiries. First, *How do policymakers can provide directionality to STI policy according to the academic literature?*. Second, *what other barriers to directionality are identified by stakeholders in our case study?*. Finally, *what type of policy instruments are used by policymakers to address it?*. This research focuses on policymaking localized in the automotive region of Eindhoven, which is the major industrial cluster for automated driving in the Netherlands (Brainport, 2016).

The paper is structured as follows. In the following section (2) theory is introduced. In section 3 we refer to the method for answering our research question. Preliminary findings are shown in section 4. Finally, we provide general discussion points and conclusions based on this ongoing research in section 5.

2 Theory

Until recent years, the two main rationales to support the design of Science, Technology, and Innovation (STI) policies were their contribution to economic growth (Schot and Steinmuller, 2016). However, we have recently witnessed an increasing acknowledgment in the academic literature about the potential contribution of STI policies to address contemporary grand challenges, such as climate change, aging population, inclusive societies, and wellbeing (Mazzucato, 2016; Schot and Steinmuller, 2016; Steward, 2012; Weber and Rohracher, 2012). This acknowledgment, labeled as the normative turn in STI policies (Daimer et al., 2012), has been reinforced by novel approaches to incorporate societal challenges in the design of STI policies, e.g. in countries of the Organization for Economic Cooperation and Development and the

European Union (European Commission, 2016; OECD, 2014, 2015).

This normative turn has raised several questions about current governance frameworks for STI policies (Christensen et al., 2016). Specially, it has been claimed that current governance frameworks cannot justify the policy interventions in this type of policies (Weber and Rohracher, 2012). Up till now, policy interventions are based on the principles of *market failures* and *systemic problems*. While the former refers to circumstances in which the allocation of resources by market parties is not efficient, the latter is about problems in the performance of innovation systems (Mazzucato, 2015; Wieczorek and Hekkert, 2012). However, societal challenge oriented STI policies require policy intervention beyond these notions, to address issues which have been argued to hinder societal transformations, e.g. in terms of legitimation of policy measures and market creation strategies. For this reason, several scholars have called for creating new intervention rationales for these STI policies, which Weber and Rohracher (2012) labeled as "transformational system failures" (see also Kuhlmann and Rip, 2014; Schot and Steinmuller, 2016). These failures are derived from the emerging field of socio-technical transitions to sustainability, in which the process of governance of socially desirable policies have been extensively studied. Four intervention rationales have been suggested: Directionality, demand articulation, policy coordination, and reflexivity (Weber and Rohracher, 2012).

The field of socio-technical transitions to sustainability, in contrast with previous innovation accounts, bring a new perspective of how we understand the nature of innovation. In particular, it has extensively studied the barriers hindering the fundamental changes that current societies face in order to become more sustainable (Markard et al., 2012). According to this field, societally desirable and sustainable solutions can be achieved by radically transforming the contemporary socio-technical

systems. By socio-technical systems, we refer to the heterogeneous set of elements that allow societal functions (e.g. mobility, health, energy) to be fulfilled via technological developments. These elements include "policy, markets, consumer practices, infrastructure, cultural meaning and scientific knowledge" of given technologies (Geels, 2012, p. 471) reinforcing and determining contemporary technological trajectories (Smith et al., 2005).

In order to clarify the analytical scope of a socio-technical system via STI policy, we present a stylized version of the expected transformations in figure 1. All the elements maintaining the current technological trajectories, as science, industry, policy and user practices need to be changed in order to provide a deep transformation of a socio-technical system. As a result a new configuration of the elements maintaining a socio-technical regime will emerge.

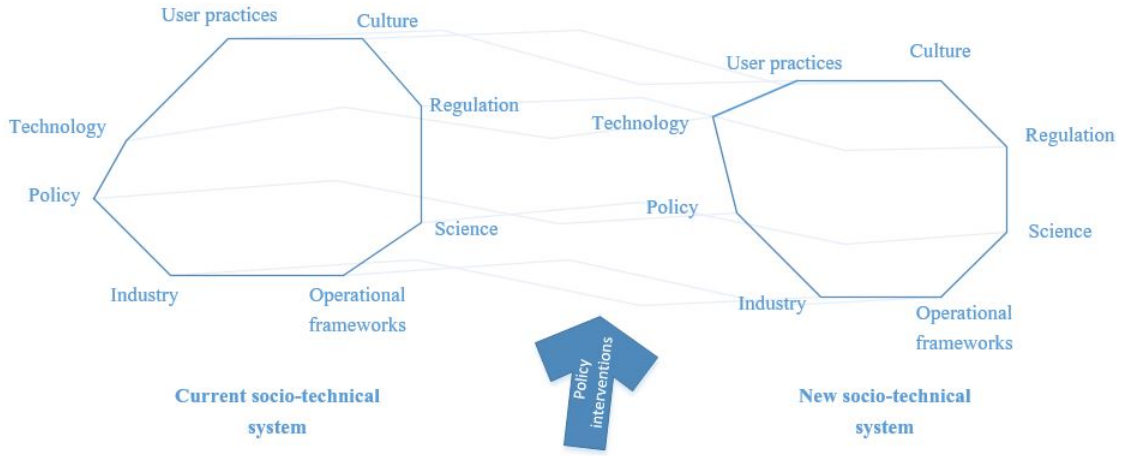

Figure 1: Socio-technical systems change. Source: adapted & extended from Geels (2004).

This view has some policy implications in the way in which STI policies are governed. Particularly, it broadens the scope of policy interventions, such as in the reconfigurations of cultural meanings, user practices, and legal frameworks in which

technologies operate. Nowadays we are seeing that this broadening is reflected in new programs affecting the governance of STI policies, such as in behavioral change programs. Edler and Borrás (2014a) provided an example of how this broadening is occurring in STI policy. According to these authors, the development of electric driving does not only depend on the technical solutions such as "batteries, electric engines, software, and so on", but also on the "infrastructures for charging batteries and other support services [...] and the opportunities offered by new technical knowledge and consumer demands; by the regulations, soft laws and voluntary standards that frame safety, insurance conditions, and so on [...] and by the societal acceptance and [its] ultimate support" (Edler and Borrás, 2014a, pp. 1-2).

2.1 The concept of Directionality in STI policy

The novel intervention rationale of 'directionality' (also discussed as strategic orientation') is one way in which STI policy is broaden towards new areas of governance. In particular, it is suggested that state authorities are able to settle a direction of change in the innovation process to achieve socially desirable outcomes. As indicated by Weber and Rohracher (2012), this concept refers to the "necessity not just to generate innovations as effectively and efficiently as possible, but also to contribute to a particular direction" of socio-technical change (p. 1042).

This direction-related rationale in policy resembles what Mazzucato (2013) considered the *entrepreneurial nature* of state authorities in innovation, suggesting a central and leading role of the state in developing breakthrough innovations in the twentieth century. Her findings suggested that the state took this role as markets were short-sighted and not ale to internalize the long-term uncertainties surround-

ing breakthrough innovations (Mazzucato, 2016). Following her argument, the state was a core player in minimizing the aforementioned incapacities of markets parties by indicating pathways or desired routes of technological developments (Mazzucato, 2015).

The provision of a 'direction function' in STI policy is not something completely new in STI policy. Next to the development of breakthrough innovations, the state also provided it in the era of 'grand missions' STI policies, reflected in the Green Revolution and Space Exploration policies in the United States (Foray et al., 2012; Wright, 2012). However, the direction that the state provided in the twentieth century to sti policies was largely related to specific technologies, and not about direction in a broader socio-technical level (Schot and Steinmuller, 2016), i.e. by neglecting the elements of the socio-technical systems mentioned above.

One challenge of studying this concept is that its debate remains largely unstructured. For this reason, we performed a literature review of prominent journal articles in which the concept is discussed. Albeit we found a dozen of articles in which this concept is treated, there are five articles in which the concept of directionality is central in their arguments. These are shown in table 1. In order to structure the literature review we present four main statements indicating general concerns found in the literature review: (1) Providing reflexive governance arrangements to create, adapt and revisit the direction of change; (2) endogenizing the requirements of the socio-technical regimes in the STI policy subsystem; (3) providing stability and increasing returns in areas with high levels of uncertainty; and (4) assessing and evaluating the direction of change. These four statements should be read as analytical categories, which may overlap but reflect different types of arguments developed by STI policy scholars.

Author	Ways to achieve directionality	Barriers for directionality
Daimer et al. (2012)	Orchestrate the STI system, coordinate policy interventions; formulate long-term goals; develop evaluation mechanisms; foresight processes.	Top-down approaches; lack of clear evaluation mechanisms of progress; participatory approaches are time consuming; lack of agreement; impartiality, independence and credibility in evaluation.
Lindner et al. (2016)	Enhance reflexive governance; endogenize process of direction setting in the STI sub-system; self-reflection capacities.	
Mazzucato (2015, 2016)	Make public authorities the lead investor; establish networked organizations; break techno-economic paradigms; smart specialization; develop market landscapes.	State authorities as a passive force; lack of intervention rationales; lack of knowledge about the type of public sector organizations, evaluation, and incentives for transformative policies.
Weber and Rohracher (2012)	Develop cumulative knowledge and learning; translate external requirements of the STI system; negotiate external requirements with STI actors; establish shared future visions; enable reflexive and participatory processes; promote regulations, standards, and targeted funding; foment development and demonstration projects.	Power and agency in the innovation system, lack of coordination between policy instruments.

Table 1: Main barriers & ways to achieve directionality (source: literature review)

1. *Providing reflexive governance arrangements to create, adapt and revisit the direction of change.*

Directionality is directly related to uncertainty. Innovation processes have, by definition, to cope with it. However, this uncertainty is higher in a socio-technical transition, as it does not have to do solely with technological returns (e.g. in terms of efficiency), but also with non-technical elements such as users practices or cultural values regarding technologies. In addition, the incapacity to foresee the long term return of technological investment hinders the possibility of making adequate policy choices. In words of Van Lente (2012): "[T]here are many possible paths while choices have to be made. The optimal direction cannot simply be calculated – there are too

many possibilities and there is too much uncertainty" (p. 774). For this reason, one general concern in providing directionality to the STI process is that the state should have the capacity to self-reflect on the directions taken and, if required, revisit them Daimer et al. (2012). This is expected to be achieve by what Lindner et al. (2016) have discussed as reflexive governance.

As stated by Lindner et al. (2016), the concept of reflexivity in the governance of STI policies connects to the ability of an innovation system "to reflect about a given situation, to deliberately define the goals of innovations and eventually transpose them into a strategy" (p. 3). This is expected to be realized by 'opening-up' the innovation system by democratic means to new players which can influence and impact the overall strategy of the innovation system. The direction of change should be negotiated with a broad range of stakeholders (Weber and Rohracher, 2012). Consequently, we should under the governance of transition oriented STI policies as a complex activiity beyond the 'linear understanding' of instrumentation of governance (Edler and Borrás, 2014b). There are several challenges to create these governance arrangements, including the role of power and agency in STI processes. The power and agency in the governance of transition oriented policies can be materialized by discursive strategies (Späth and Rohracher, 2010).

2. *Endogenizing the external requirements of the socio-technical regimes in the STI policy subsystem.*

A second concern of several STI policy scholars working on the topic of directionality is the how to 'capture' the requirements beyond a STI subsystem. Policymakers should not only think within the boundaries of STI policies, but go beyond and address the use and functionality of technology in society (see Geels, 2004). We

have witnessed in recent years shifts towards new participatory models in STI policy, especially at the EU level reflecting this turn. Consequently, most of the external requirements of the STI policy should also be captured.

According to Weber and Rohracher (2012), the development of future visions allow the internalization of external requirements. In future visions, several stakeholders which have a stand in socio-technical transformations but do not have an access to traditional decision making mechanisms can state their arguments. In addition, Daimer et al. (2012) suggested that one way in which this can be achieved is by linking particular societal challenges with concrete technological innovations. Schot and Steinmuller (2016) took the argument further and suggested that innovation processes may just be successful if they are inclusive. For these reasons, policy instruments addressing this aspect is important.

3. *Providing stability and increasing returns in areas with high levels of uncertainty.*

Socio-technical transitions assumes that any radical transformation in socio-technical systems require decades to unfold (Geels and Schot, 2007; Turnheim et al., 2015). However, this long-term is completely opposed to the short-term gains that are expected from technological developments, e.g. due to lack of economies of scales or path-dependence of dominant technologies. For this reason, STI policy actors would tend to look into technologies generating incremental gains and dismiss long-term investments. It has been argued the central responsibility of the state in providing stability and accelerating transitions (Weber and Rohracher, 2012).

In this respect, STI policy scholars have suggested a central role of policymakers in accelerating market development. This is a strategy that can reduce

financial constrains in STI policy. This idea of market creation is not new, and resembles what Mazzucato (2013) indicated as the entrepreneurial role of state authorities. This market development can also be achieved by developing path dependencies to fasten technological development (Weber and Rohracher, 2012), as well as targeted funding under situations of 'market failures'. In addition, it has been suggested that policymaking should support the development of emerging technology by 'forcing through regulation', in which requirements of new technologies are met (Kuhlmann and Rip, 2014), e.g. reduction of CO_2 emissions, without clear guidelines, letting market parties to decide with strategy to follow.

4. *Assessing and evaluating the direction of change.*

A final concern for STI policy scholars is how to evaluate the impacts of a given direction. Up till now, policymakers remain assessing the impacts of STI policies in terms of technological and scientific output (e.g. in terms of patents, journals, etc.). Up till now, measures for evaluation in innovation systems remains largely static (Kuhlmann and Rip, 2014). However, these indicators may not capture the required transformations of contemporary STI policies (Mazzucato, 2015). For instance, there are no indicators to assess "transformations of technological landscapes [...] [or] behavioral changes" in STI policies (Christensen et al., 2016).

It has been suggested, therefore, that directionality should incorporate new ways to capture the added value of experiments in STI policies. In particular, as transition oriented policies (including contemporary transformative STI policies) have a contested processes (Loorbach, 2010). It becomes necessary to assess how 'well' a direction is taken. This could be achieved in multiple ways. For example, by fomenting experiments which can be later evaluated by stakeholders.

3 Method

In order to answer the research questions of *How do public officials provide directionality to the self-driving vehicle policy in the Netherlands?*, we pursued a qualitative approach. We aimed for this approach as both the concept of directionality and the self-driving vehicles remain as emerging concepts. Qualitative studies allow, via exploration, getting meaningful insights that can be used to refine emerging theories. For this reason, we performed an exploratory case study. This research is developed by interviewing stakeholders participating in this policy. We focused primarily on actors participating in the Brainport region (in the south of the Netherlands, with Eindhoven as its main city), in which the Dutch automotive and IT clusters are located. Interviewees are representatives of stakeholders in networked organizations to foster self-driving vehicle technologies in this area. They come from multiple expertises and represent companies collaborating in the self-driving car policy. Their background and positions differ greatly, in order to provide a representative sample, e.g. working as consultants, policy advisors, or representatives of high-tech companies. As an ongoing research, we expect to continue the interviews with more stakeholders in the following months.

We performed semi-structured interviews with these stakeholders to get their opinions in different areas related to the directionality of the innovation process, including target funding, policy instruments, governance arrangements, and visions regarding the self-driving vehicle technological developments. In order to guarantee anonymity, we present the findings at an aggregate level. This interviews were analyzed using a qualitative analysis software and by the notes taken during the interviews.

4 Findings

The smart mobility policy of the Netherlands started in 2013, when the Minister of Infrastructure and Environment communicated to the parliament her intention to foster the development of emerging technological fields, namely in the field of traffic management, traffic information, and in-vehicle technology (de Mooij, 2013). Albeit in 2013, the technologies of self-driving vehicles where at their stage, technological developments in the following two years (including projects related to autonomous driving made by companies such as Google and Tesla) initiated a path which became materialized in several policy documents stating that self-driving vehicles were a possible innovation in the short and medium term (Rijksoverheid, 2017). The Netherlands does not have any 'big name' car manufacturer (in comparison to Germany, Japan, or United States), but it has a strong automotive industry, mostly formed from Small and Medium Enterprises (AutomotiveNL, 2016; Tweede Kamer der Staten-Generaal, 2012).

We observe overall that autonomous driving became an emerging technological field which was taken by the smart mobility policy by 2014-2015. Up till now, the technological developments are leading towards two potential areas in which self-driving technologies are palpable: (1) Automated driving in automobiles, (2) automated driving in public transportation services, and (3) automated driving in the truck industry. Each of these areas entails different challenges for its process in implementation in society. In automobiles, general concerns have been raised primarily over issues of privacy, security, and liability. In public transportation, one of the main questions are how to integrate data services that would allow a certain level of autonomy to operate. In this area, it is particularly present the lack of integration of

Barriers to directionality.	**Approaches to overcome directionality barriers**.
1. Providing reflexive governance arrangements to create, adapt and revisit the direction of change	
Reflexive and adaptive governance comes at the expense of concrete policy goals; lack of harmonized strategic agendas; structuration of an emerging policy domain	Structuration activity; creation of roadmaps, strategic agendas, & transitions pathways; clustering activities.
2. Endogenizing the requirements of the socio-technical regimes in the STI policy subsystem	
Lack of business models and operational frameworks of mobility services; internalize demands beyond STI subsystems; lack of system-thinking by policymakers and technical experts; consideration of major trends regarding smart technologies (e.g. privacy and security.)	Experimentation of business models and operational frameworks; consultation with several stakeholders (beyond STI policy) to internalize requirements; consultants as main providers of ideas.
3. Providing stability and increasing returns in areas with high levels of uncertainty	
Lack of markets and business ecosystems; reduced investment climate; policymakers are not used to 'think' in terms of business models; lack of system integration to upscale already existing technologies.	Promoting regulatory frameworks; accelerate market development; increase incentives for R&D; improve the climate of investment; increase targeted funding to the innovation system.
4. Assessing and evaluating the direction of change.	
Experiments have clear guidelines for evaluation; experiments results are overlooked by policymakers	Lack of clear ways to assess and evaluate the transition policy.

Table 2: Findings of barriers and approaches of policymakers regarding directionality failure according to inteviewees.

automated driving technologies due to lack of business models and proofs of concepts which local, regional, and national authorities should take into account in order to operate. Finally, automated driving in the truck industry has been proven technically feasible and operational, with experiments at a European level such as the Platooning Challenge lead by the Dutch presidency of the European Union in 2016 (see Janssen et al., 2015).

In order to present our findings, we follow the four statements which were provided in section 2.1 regarding the concerns of directionality according to STI policy scholars.

1. *Providing reflexive governance arrangements to create, adapt and revisit the direction of change.*

The literature suggested that reflexive governance is necessary to adapt and

reflect on the direction of change. Overall, we observe that this type of governance is present in the smart mobility policy. The Dutch authorities promoted in between the years 2011 and 2013 several policy instruments to achieve it, including strategic roadmaps (Amsterdam Group, 2013; AutomotiveNL et al., 2014; de Mooij, 2013). These roadmaps established concrete technological choices and transition pathways. According to some interviewees, a particular challenge in these roadmaps is that current innovation processes are highly dynamic, and particular technologies develop in just a couple of years. These roadmaps have been revisited constantly by policymakers together with stakeholders.

However, interviewees suggested that a particular challenge in creating common visions and pathways regarding roadmaps is that policymakers neglect concrete policy choices. For instance, they contrast what public authorities are doing regarding the self-driving vehicle with the hydrogen car policy. According to interviewees, policymakers are less reflexive on

In addition, we see that policymakers, in the process of providing directionality to the self-driving car policy, have also to deal with what we call here a 'structuration activity'. The transition towards the self-driving vehicle in the Netherlands implies new policy actors, which are expected to replace existing one in the mobility subsystem. Thus, one role of policymakers is to articulate new policy subsystem. For instance, this is done by dedicated organizations which bring together a triple-helix collaboration or generate 'momentum' and public attention to the self-driving vehicle (*Connekt* and *Connecting mobility*, respectively). In addition at a national level the organization *AutomotiveNL* works as the cluster organization of the automotive industry (AutomotiveNL, 2016; Connekt, 2016). We also see, that in the process of structuration of a new policy domain, policymakers aim to cluster the industry as a

way to generate synergies between the disruptive technology stakeholders (e.g. the *Automotive Campus* in the Brainport region).

2. *Endogenizing the requirements of the socio-technical regimes in the STI policy subsystem.*

The second concern we identified in the academic literature is the internalization or endogeneization of external requirements of the STI policy. In addition to the barriers identified in the theoretical discussions, some interviewed stakeholder pointed out to some interesting perspectives. In particular, we see a big role of consultant and other non-industrial players as inputs for current mobility trends that are used as guidelines for socio-technical innovation. Thus, policymakers do not define the elements to be internalized in a STI subsystem, but rather third-parties. In this respect intermediary organizations such as the Dutch Royal Cycling Club (AWNB) play a central role.

Moreover, there were other barriers identified by stakeholders. The barriers include the lack of expertise of policy in terms of technologies and business models. As an interviewee suggested "creating business models is not the core business of policymakers". This represent a particular challenge as the lack of expertise hinders the internalization of aspects beyond the STI poicy subsystem.

3. *Providing stability and increasing returns in areas with high levels of uncertainty.*

The third category related to long-term stability and increasing returns of radical technologies. In this respect, interviewees argued that, in contrast with the literature review, the uncertainty is not technological, but rather operational. Almost

all interviewees recognized that the technology for self-driving vehicles is already out there, and the aspect that hinder stability is non-technical. This also affects negatively as companies reduce their long-term investments.

Overall, it has been commented by some interviewees working in the private sector that these lack of stability and increasing returns affect this aspect. For example, by accelerating market developments and ecosystems, increasing incentives for private Research and Development, and improve the overall climate of investment in new technologies.

4. *Assessing and evaluating the direction of change.*

The final category is how to assess and evaluate the direction of change. Most interviewees in the private sector commented that it was one of the weakest points in this policy. Namely, as policymakers cannot generate adequate ways in which to evaluate projects and experiments. In the traditional way, policymakers would allocate funding to a given experiment, and the expected results are related directly to the potential application of this experiment. However, these results may differ and could be interpreted in different ways. As transitions are a open-search process, a experiment that would be consider as a failure by policymakers can leave a strong legacy to other players. For example, by allowing market parties to know each other, cooperate in highly uncertain domains, and reflect upon strengths and weaknesses of the innovation system.

5 Discussion & conclusions

Returning to the main research question of *how do policymakers provide directionality to the Dutch self-driving vehicle policy?*, our preliminary findings show some interesting insights that should be refined on later versions of this paper. We have found, performing the literature review, a clear interest in four main areas of directionality: (1) Providing reflexive governance arrangements to create, adapt and revisit the direction of change; (2) endogenizing the requirements of the socio-technical regimes in the STI policy subsystem; (3) providing stability and increasing returns in areas with high levels of uncertainty; and (4) assessing and evaluating the direction of change.

This areas resonates with what we have found in our case study at the time their interviews were made. However, we found other aspects which are as relevant for providing directionality in STI policies and are not considered so far in the academic literature. We refer to the lack of expertise from public authorities to assess the policy interventions in transition oriented policies, regarding technological developments, and about business models. Moreover, we also found that most of the barriers identified by interviewees are not related to the process of knowledge creation, but rather what we may call an 'implementation failure'.

A really interesting and core activity of policymakers in this new type of policies if what we described as a 'structuration function'. In the case study, the breakthrough nature of the innovation of selfr-driving vehicles forces policymakers to structure the field: Bring stakeholders together, generate momentum, and develop institutions which can be used by stakeholders to develop their innovations. For the aforementioned reasons, and considering the classical distinction between Schumpeterian and Weberian bureaucracies, we may infere that the Schumpeterian approach

dominates in practice policymaking, bu also the Weberian approach of knowledgeable and expert bureaucracies should also be considered.

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