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Technology and Instrument Constituencies as Agents of Innovation: Sustainability Transitions and the Governance of Urban Transport

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Abstract: Sustainable urban transport is a complex challenge requiring innovation in technologies, culture, and policies. Given the systemic nature of the issues involved, numerous studies have applied the transitions approach to urban transport. However, relatively weak conceptualization of agency in the transitions literature limits the usefulness of this approach for the governance of urban transport. The objective of this study is to contribute to the conceptualization of agency in the multilevel perspective to sustainability transitions. We propose that two types of actors exercise agency to foster innovation: technology constituencies, who promote the adoption of specific technologies by citizens, businesses, or governments; and instrument constituencies, who promote the adoption of specific policy instruments. In focusing predominantly on technological innovation, the transitions literature has generally juxtaposed these constituencies or considered them to be the same. We posit that the two constitute distinct, albeit possibly overlapping, actors and that their relationship(s) help better understand and explain how transitions evolve. We discuss the implications of this distinction for the governance of urban transport and argue that the presence of instrument and technology constituencies, and their relationship(s), should be examined empirically in future research.

Keywords: agency; governance; innovation journey; instrument constituency; multilevel perspective; policy integration; sociotechnical transitions; technology constituency; urban mobility; urban transport

1. Introduction

The existing system of urban transport is not sustainable. The high ownership and use of automobiles have created numerous sustainability issues such as air pollution, energy inefficiency, greenhouse gas emissions, land availability, noise, poor connectivity, public health, road safety, and traffic congestion [1–5]. Although low- and middle-income countries have lower car ownership than high-income countries, they have witnessed rapid motorization, and the trend is likely to continue [6,7]. Moreover, if the status quo is not changed, the problem will worsen further as the share of urban population increases from about 50 percent at present to over 60 percent by 2030 [8]. A *radical*, systemic shift is needed to promote sustainable urban transport.

Earlier research on urban transport, based on engineering, neoclassical economics, and psychological perspectives, resulted in largely incremental, siloed policy advice. Kemp and Rotmans [9], for example, found that initial policies relied on technological solutions such as catalytic converters and unleaded petrol to reduce air pollution, without focusing on the underlying causes of the problem. Further, behavioral and technological interventions, or even private and public transport,

were viewed as alternatives rather than parts of an integrated strategy. Such approaches, however, have gained limited success in addressing sustainability (for example, see [10]). A sustainable mobility paradigm should be based on an appreciation of the socio-economic embeddedness of transportation activity, implementation of innovative alternatives, and high public acceptance, if not, active public participation [11,12]. Subsequent work, therefore, called for engaging more deeply with the social sciences and adopting a systems perspective [13,14].

Given the interdependencies in and of the urban transport system, the transitions perspective has received increasing attention in research on urban transport (for further discussion, see [15]). The transitions literature adopts a systemic approach to analyze how radical innovations develop and diffuse to replace, transform, or reconfigure existing systems over several decades [16,17]. This approach conceives transitions as complex, multi-actor, multi-dimensional, non-linear, path-dependent processes through which technologies, businesses, users, markets, policies, culture, and politics co-evolve [18]. The term 'socio-technical' is often prefixed to transitions in this literature to signify the connectedness of technical and social elements of the system. The application of the transitions approach has been diverse, from examining the innovation journey of a specific innovation in one context [19] to analyzing the potential numerous areas of innovation in multiple socio-technical contexts [20].

While applications of the transitions perspective to study urban transport have enriched analytical and narrative inquiry into the topic [21], translating lessons into practice requires a multi-level, multi-actor view of governance as well. A nuanced understanding of governance is especially important due to the variety of institutional arrangements—across different modes of transport, agencies or departments, tiers of government, and geographically adjacent jurisdictions—that influence policymaking and implementation in the sector [22–25]. Research should, therefore, capture "the full extent of governance processes . . . 'beyond the slightly naive view of policy [as] something the public authorities do' to understand all the actors involved" [26] (see, also, [27]). This entails developing a better understanding of how various actors exercise agency to influence politics, polity, and policy in urban transport.

On this front, the applicability of the transitions perspective for governance has been questioned in the past. Initially, various frameworks and theoretical orientations in the field were criticized for underestimating the 'messiness' of the socio-technical change, neglecting the role of agency, treating policy making as a black box, and ignoring the importance of politics [28–32]. The research agenda on transitions has since delved into such issues; more recent studies have examined agency explicitly and paid further attention to policy making and politics [18,33–38]. However, the field has scope for further conceptualization of agency involved in fostering an innovation (or resisting a competing innovation). This is the task we undertake in this study.

We address two questions: (i) how can the agency involved in fostering innovation in transitions be conceptualized? (ii) what are the implications of our conceptualization of agency of innovation for the governance of urban transport? Although the paper is predominantly conceptual, we use examples from studies on urban transport and energy to illustrate the argument. We draw on recent studies on instrument constituencies in policy analysis [39] and posit that transitions involve two types of actors who push for specific socio-technical alternatives to (a variety of) societal issues. The first, instrument constituency, refers to actors that support the development and diffusion of specific governance arrangements or policy instruments. This constituency is glued together by their shared interest in expanding the use of the policy instrument; the actors in this constituency do not necessarily share an interest in the problem(s) the policy instrument is meant to solve. Similarly, the second, technology constituency, refers to actors that foster technological innovation by positioning the technology as addressing the societal need(s). This constituency is glued together by their shared interest in increasing the penetration of the technology, and not necessarily the societal need(s) it is meant to address. We posit that although the transitions literature has generally assumed the two to be the same or juxtaposed them, they are distinct but possibly possess overlapping actors. Further, their

relationship(s) help understand and explain policymaking in areas of innovation and the evolution of transitions. This is especially important for the governance of urban transport, which witnesses the presence of numerous socio-technical alternatives and, hence, constituencies competing for dominance. Thus, to facilitate the governance of urban transport, the presence, composition, structure, and activities of these constituencies should be examined empirically.

The rest of the paper is structured as follows. Section 2 presents the theoretical framework for the article and the socio-technical system in urban transport. Then, the concepts of instrument constituencies and technology constituencies are introduced (Section 3). Section 4 discusses the possible dynamics between instrument constituencies and technology constituencies. Subsequently, the implications for these dynamics for the governance of urban transport are discussed (Section 5). Section 6 concludes the paper.

2. The Socio-Technical System in Urban Transport

Transitions studies use an interdisciplinary approach, drawing primarily on science and technology studies, evolutionary economics, and neo-institutional theory to explain stability and change in technologies but also non-technological dimensions of a system, such as institutions, policies, and user practices [40]. This research area consists of numerous analytical and prescriptive frameworks or theories, with strategic niche management [41,42], transitions management [43,44], the multilevel perspective [17,18], and technological innovation systems [45,46] arguably being the most central. Regardless of the theoretical orientation, transitions are conceived as complex, multi-actor, multi-dimensional, non-linear processes that are characterized by path dependence and occur over a long period [18]. They involve interactions amongst technologies, businesses, users, markets, policies, culture, and politics.

While our conceptualization can be adapted to the broader transitions literature, we use multilevel perspective as the theoretical framework to illustrate our argument. The multilevel perspective views transitions as non-linear processes that are influenced by development at three levels, each with more stability and structuration than the previous—niches, regimes, and landscapes [17,19]. While niches are protected spaces in which radical innovations emerge, regimes are the locus of established practices and rules and landscape represents the relatively exogenous settings in which processes unfold. Niches include spaces such as research and development laboratories, demonstration or pilot projects, or small markets for users with specific requirements. Through the mutually supporting processes of articulation of expectations and visions, technological and social learning, and building of networks to increase resources [41,47], niche actors aim to 'breakthrough' and reconfigure or replace the existing regimes. However, they face active or passive resistance from regimes, which are characterized by lock-in mechanisms and path dependence. Regimes include various dimensions such as science, technology, industry, markets, policy, and culture. Innovation in regimes is generally believed to be incremental, as regimes are stabilized by interdependence and interactions amongst various actors and activities.

Although the socio-technical system in urban transport varies across geographies, and the actors in the system are not necessarily homogenous, some elements of the system that are widely applicable can still be identified. The petroleum car is generally the dominant technology around which the present socio-technical system is built. The car 'system' includes: (i) the car and the car industry; (ii) other related industries; (iii) the supporting infrastructure; (iv) culture and the symbolic meaning of the car; (v) consumer preferences and the market; and, (vi) policies and regulations in transport and related policy areas [20,48,49]. The urban transport system also comprises of 'subaltern regimes', such as the train, tram, bus, and cycling, which cannot be considered as niches as they have existed for a long time and are not radically new. Although these subaltern regimes are also maintained and reproduced by specific communities through institutionalized practices, they occupy a relatively small share of total mobility demand [15]. This is the case due to the reinforcing nature of user practices, established rules, and cultural associations that sustain the automobility regime [48].

Urban transport consists of numerous novelties that are at various stages of development and aim to alter different aspects of the socio-technical system. These can be categorized into the following [15,20,50].

- Green propulsion technologies: these novelties include technologies that depart from the internal combustion engine/petroleum car system but still operate within the automobile paradigm, such as battery-electric vehicles and fuel-cell vehicles [51–53].
- Public transport innovations: these include initiatives such as Bus Rapid Transit (BRT) systems, which provide affordable and reliable urban transport service with relatively short implementation time and low capital cost [54], and the introduction of green propulsion technologies in buses.
- Intermodal travel: innovations in intermodal travel include schemes and policies aimed at integrating different systems of transport for the same trip [55], such as park and ride facilities, bike sharing schemes, intermodal ticketing, and smart cards.
- Cultural and socio-spatial innovation: this includes initiatives that challenge the automobility paradigm more fundamentally, such as compact cities, transit-oriented development, bike and car sharing
- Information and communication technologies: this category includes Intelligent Transport Systems (ITS) that integrate smart devices in the transportation network to enable real time management of traffic as well as practices such as tele-working, tele-shopping, tele-conferencing.
- Demand management: initiatives in this category aim to reduce car use through changes in mobility demand and practices, such as public transport information and marketing and urban cycling initiatives.

In addition, 'pathway technologies' help bridge the gap between the current, unsustainable system and a future, more sustainable one [9,20]. These technologies, such as automatic vehicle control, global positioning system, and monitoring for mobility management, can facilitate behavioral and institutional changes that are necessary for a transition.

The landscape changes influencing urban transport are globalization, demographic changes, increased demand for mobility, fuel supply, congestion, air pollution, climate change, and growth in information and communication technologies, among others. While trends such as globalization, individualization, rising standard of living, and population stabilize the car system, concerns such as resource depletion, air pollution, and greenhouse gas emissions exert pressure on the regimes to change and may create windows of opportunity for innovations in niches to breakthrough and diffuse [20,56].

However, who are the actors in this system and how do they exercise agency? As mentioned above, the multilevel perspective has been criticized in the past for emphasizing path dependence and structural determinism, making it less useful for governance [57]. Although recent research has focused extensively on the subject, there is scope for a better conceptualization of actors that participate in these processes. We turn to this task of conceptualizing and distinguishing distinct types of actors in the next section.

3. Constituencies in Transitions

The transitions literature tends to emphasize innovations in which technologies play a key role. However, exceptions do exist (see, also, [15]). Schwanen [50], for example, has argued: " ... there has not been much attention for innovations in which technology plays a very limited role, such as walk/cycle-to-school initiatives or cycling cafes and hubs for cycling training, maintenance and/or storage. Such innovations can nonetheless be of critical importance to low-energy transitions, because they directly seek to reconfigure elements of sociotechnical systems other than technologies and transport infrastructures as conventionally understood, such as cultural values, user practices and maintenance and repair." Similarly, Hodson et al. [58] have argued that "innovation is not with an artifact per se but is in processes of embedding and the reconfiguration or 'diffusion' this necessitates."

They have posited that innovations may, thus, represent governance arrangements, socio-technical configurations, and conceptions of sustainability.

We agree with these authors about the need to adopt a broader view of innovation in transitions. We posit that the two different types of actors promote specific governance arrangements and socio-technical configurations by using conceptions of sustainability to galvanize support for their innovations.

3.1. Instrument Constituencies

While much of the research in transitions has focused on expectations, strategies, and activities of individual actors or a small group of actors, actors in transitions derive agency not only through individual action but also through collective action [34]. The notion of 'running in packs' or 'institutional entrepreneurship' has been invoked to denote the idea that actors in coalitions or networks benefit from system level externalities more than actors 'going it alone' [59,60]. The interdependencies amongst various actors, such as businesses and governments, are likely to result in the formation of 'close alliances' amongst actors [61].

One such close alliance has been examined in recent literature on policy analysis: the instrument constituency. Voß and Simons [39] have posited that the creation of a policy instrument may accompany the formation of an instrument constituency. The term may refer to "heterogeneous practices," or the actors supporting these practices, "involved in the making of instruments: scientific theory building, data production, and publishing, political issue framing, agenda setting, coalition building, business development, marketing and lobbying, management of innovation networks, professional organization." However, the authors do not necessarily ascribe reflexivity to instrument constituencies.

Voß and Simons [39] have argued that instrument constituencies are distinct from other actor networks identified in the policy analysis literature (that have been borrowed in the transitions literature). Instrument constituencies differ from discourse coalitions, for example, as the former are identified by their shared interest in a policy instrument or in a technology (regardless of the problem to which it is applied) while the latter are glued by shared language, metaphors, and storylines [62]. Advocacy coalitions are also different from instrument constituencies as the former are formed around shared normative or causal beliefs around policy priorities and implementation preferences [63]. However, the boundaries between these networks may not be fixed and rigid in practice. Further, it is possible that the same actors are present in more than one actor network. For example, Weible [64] has posited that instrument constituencies, or their members, might work with advocacy coalitions to promote their policy instruments.

How does an instrument constituency form and operate? Support for the constituency is recruited through the articulation of the instrument's ability to meet the societal need(s) (functional promises) but also its ability to further the interests of the actors nurturing it (structural promises) [39,65]. The constituency then manages the interface between the policy instrument as an abstract model and the policy instrument as an implemented governance arrangement. The actors or practices in the constituency actively promote the instrument as a solution for various policy problems, creating a supply push for it; these actors and practices are, in turn, sustained by the development of the instrument. These constituencies expand through connections across geographically dispersed sites (trans-local linkages), facilitating the diffusion of policy instruments to other policy jurisdictions when windows of opportunity open.

Such constituencies have been shown to be present in various policy areas, including emissions trading [39], conservation trading [66], social insurance and pension privatization [67], and public participation and deliberative democracy [68,69]. Recently, Perl and Burke [70] have found that instrument constituencies played a role in creating and maintaining support for motor fuel taxation as a key mechanism for funding road transport infrastructure in Australia and the United States. The authors argued that the instrument constituencies' intervention in policy making in both countries

influenced their relationships with advocacy coalitions in transportation and affected the scope for subsequent policy change.

3.2. Technology Constituencies

Apart from the instrument constituencies, we propose that another type of actor in transitions is technology constituency. Just as the instrument constituencies facilitate the expansion of their policy instruments, technology constituencies foster technological innovation and promote its diffusion amongst citizens, businesses, and governments. Our idea of a technology constituency is similar to that of a 'technology advocate' proposed by Raven et al. [71]. Raven et al. have posited that technology advocates—consisting not only of technology developers, but also of lobby groups, political actors, civil society organizations, and users—tied socio-technical narratives to socio-political agendas to create, maintain, and expand protective spaces for technological innovation. However, we use the term constituencies rather than advocates to indicate the similarity with the concept of instrument constituencies.

We do not presume reflexivity on the part of technology constituencies and posit that their activities can also result from the distributed agency rather than coordination [34]. Garud and Karnøe [72] have found such dynamic in technology entrepreneurship, wherein the independent and uncoordinated involvement of various actors resulted in the emergence of a path for technological development. This path than not only enabled but also constrained the activities of the actors involved. Further, these constituencies are not limited to niches, as regime actors also offer active support or resistance to novelties and play a role in fostering innovation [71,73].

Other studies have also found the presence of such constituencies. Lovell [74], for example, has characterized the actors responsible for the discursive reframing of sustainable housing first to low energy housing and subsequently, to low carbon housing in the United Kingdom as discourse coalitions. She argued that "discourse unites the often disparate organizations involved in innovation, and thereby gives structure and direction to the innovation journey . . . discourse has the power to retrospectively 'reframe' the course of an innovation journey, leaving out inconsistent parts and ignoring twists and turns, so past innovation journeys are in effect reconstructed in the present" [74]. Similarly, Pesch [75] has argued that discursive analysis led to insight on agency and change in transitions. However, discourses may be used 'performatively' by actors to seek or maintain cultural legitimacy to acquire resources, protection, or external support [76,77]. Thus, these actors were technology constituencies promoting the adoption of their technological innovation by (re-)framing it as a solution to diverse issues, such as unsustainability, energy inefficiency, and climate change.

The transitions literature has at times juxtaposed various types of actors or assumed them to be the same. However, distinguishing between these actors and understanding their activities are analytically important for understanding how the transitions unfold. In the next section, we discuss the relationship(s) between instrument constituencies and technology constituencies.

4. The Relationship between Instrument and Technology Constituencies

In the transitions literature, policies are generally studied in relation to technologies. Strategic niche management and the multilevel perspective, for example, posit that new technologies need to be shielded, nurtured, and empowered. Nurturing is an inward-oriented activity that involves articulation of expectations, learning processes, and creation of networks [41]. On the other hand, shielding and empowerment are outward-oriented activities involving the creation or mobilization of a protective space to seed the innovation and the change in the mainstream environment to suit the development of the technology, respectively [77]. Governance arrangements or policy instruments are, thus, viewed as tools to shield or empower new technologies [78,79]. This premise leads to a misconception that policy activities of actors involved in innovation center exclusively around technologies (or socio-technical configurations).

Consequently, the literature generally assumes that only technology constituencies exist or that instrument constituencies and technology constituencies are the same, at least as far as analytical inquiry is concerned. Such an assumption may hold true in certain circumstances. For example, when a technology constituency uses an existing governance arrangement (passive protection) to shield an innovation [77], an instrument constituency may not develop around the policy instrument. Illustratively, Harborne et al. [80] found that fuel cell bus demonstration projects in North America, Europe, and Japan were facilitated by a network comprising "active lobby groups or 'prime movers' supporting the adoption of an innovation." Here, a technology constituency exercised agency to promote fuel cell buses, and not demonstration projects *per se*. An instrument constituency is not likely to have developed around demonstration projects as a generic policy instrument unless it served the interest of a variety of actors.

Instrument constituencies and technology constituencies are likely to be the same or have significant overlap when policy innovation and technology innovation complement one another over a period. This was arguably the case for solar photovoltaic (PV) technology and the feed-in-tariff policy in Germany around the beginning of this century. Hoppmann, Huenteler and Girod [79], for example, have found that both the technology and the policy co-evolved over time, resulting in lower cost of generation and higher deployment of solar PV in the German electricity market. Thus, a learning dynamic was created wherein the policy change facilitated technological learning and change, which in turn resulted in policy learning and change. Such an 'alignment' and co-evolution of instrument and technology constituencies stabilizes policy and technological development.

However, instrument constituencies and technology constituencies can comprise distinct but intersect set of actors. First, technology constituencies may precede instrument constituencies. While passive protection shields an innovation, expansion in the market share of technology often requires a push for additional, often dedicated, resources [80]. Here, technology constituencies promote specific policy instruments (active protection) to promote or sustain their technologies [77]. Buehler, Pucher and Dümmler [55], for example, have examined the case of a regional public transport association, the 'Verkehrsverbund.' Verkehrsverbund involved a collaboration between (previously competing) public transport constituencies and local governments to provide integrated services, fares, and ticketing to passengers. Thus, the key innovation was not in the technology but in the governance arrangement that facilitated a new socio-technical configuration of existing technologies. This governance arrangement allowed the public transport owners to retain or increase their modal share, and the modal share of cars decreased in the metropolitan areas where Verkehrsverbund was present. The instrument, subsequently, acquired 'a life of their own' and spread to over 70 metropolitan areas in Germany, Austria, and Switzerland over the past five decades.

Unlike in the previous case, the current instrument constituencies and technology constituencies move independently and may diverge when expectations change, interests become misaligned, or landscape developments exert pressure on the constituencies. Illustratively, Ulmanen, Verbong and Raven [78] have described such dynamic in their study on the development of biofuels in Sweden. There, a group of actors who were interested in promoting a specific biofuel of ethanol, setup an agency for this explicit purpose. When technological development was not satisfactory, interest in ethanol declined while interest in a potential substitute, methanol, grew. The agency then changed its name and scope to promote, more broadly, the development of alcohol. As Ulmanen et al. have argued, the presence and activities of this agency influenced the subsequent development of methanol in Sweden. This should, however, not be dismissed as a case of path dependence as the outcome resulted from the choices made by the actors involved. Further, the resulting socio-technical configuration of the system, which is the transition pathway would likely have been different if the instrument constituency and the technology constituency had been the same.

Second, instrument constituencies may lead, while the technology constituencies may follow. Such a situation occurs when a new policy instrument, adopted to address a governance challenge faced by the system, spurs technological innovation directly or indirectly. This dynamic has been

observed in a case of congestion charging. Siemiatycki [81], for example, has argued that although the policy instrument was initially adopted by the city of London to reduce road congestion, the interests of various actors associated with its deployment played a key role in its diffusion. The employee credited with implementing congestion charging launched his private consultancy to raise awareness about the scheme and the consulting organization that provided services for the implementation of the policy touted it as a successful scheme ready for deployment elsewhere, despite lacking conclusive evidence. Further, the policy received international interest because it was "attractive to a broad range of special interest constituencies," including economists, business associations, environmental groups, community organizations, and social justice activists.

Once the instrument is in place, it may require technological development for its sustenance or expansion but also provide passive protection to shield a new technology. The availability of alternative transport technologies for commuters, for example, is critical to the success of congestion charging [20]. Similarly, expansion or redesign of congestion charging has, itself, been facilitated by the innovation in electronic road pricing technologies in Singapore, the first city in the world to implement electronic road toll [82]. However, the instrument has also been used by actors to promote further socio-technical innovation. Some of these, such as car club coalitions, formed around the idea of car sharing and reduced private vehicle ownership and use [83], thus addressing the original policy objectives of congestion charging. Others such as electric vehicles, however, derived a competitive advantage from an exemption to pay the congestion charge while meeting the objectives of low air pollution but not reducing traffic congestion. Thus, we see that when technology constituencies follow instrument constituencies, they do not necessarily reinforce either the development of the policy instrument or its initial objectives; instead, they may prioritize some policy objectives over others and change the notion of sustainability in the transition pathway.

Third, it is also possible that technology constituencies and instrument constituencies either do not exist in a policy area or operate independently, with little synergy. When technology constituencies exist but lack the financial support or 'legislative' space provided by the instrument constituencies, niche networks do not develop fully and technological development is hindered [84]. Verhees et al. [85], for example, have found that although the offshore wind industry in the Netherlands mobilized active policy protection for its growth initially, flaws in the policy design resulted in a rollback of supportive policies and, instead, resulted in the formulation of constraining policies. The authors have, thus, described the absence of an instrument constituency not only to sustain and ensure co-evolution of a supporting instrument but also to resist the implementation of an encumbering policy. On the other hand, when instrument constituencies receive little support from technology constituencies, policy implementation failures are likely to occur. Penna and Geels [86], for example, have found that though the state of California adopted a Zero-Emission Vehicle mandate in 1990 itself, the only technology which could meet the mandate at that time was the battery-electric vehicle. The lack of support from technology constituencies—in fact, active lobbying against the legislation by Chrysler, Ford, and General Motors—resulted in a rollback of the mandate. Thus, when the activities of instrument constituencies and technology constituencies are not synergistic, a 'failed' transition is likely to result.

In the next section, we discuss the implications of instrument and technology constituencies for the governance of urban transport.

5. Analyzing Constituencies to Govern Urban Transport

The relationship between the state and society has changed over time, and the role of the state in governing has become more complex and nuanced [87]. The ensuing changes have often been summarized as 'a shift from government to governance,' implying that the state has become less hierarchical and more networked and modes of governance have become less authoritative and more facilitative. Treib et al. [88] have argued that a more accurate depiction of such changes can be presented by analyzing governance across the dimensions of politics, polity, and policy. As actors play a key role

in each dimension of governance, a better understanding of actor networks and their activities can make the governance of urban transport more effective.

The political dimension of governance draws attention to actor constellations and power relations in a sector. Schwanen [21] has highlighted that in urban transport "not only public authorities, urban planners, transport agencies, vehicle manufacturers and consumers are important, so are venture capital suppliers, insurance companies, designers, material and machine suppliers, lobby organizations, social movements, the media and research institutes." However, existing research has indicated that agency is generally exercised by distinct actor networks, either in a distributed or coordinated fashion, than by individual actors. The identification of various instrument and technology constituencies and their members, then, can shed more light on the politics of urban transport in a jurisdiction or even in an area of innovation.

Polity is associated with institutional settings of policymaking. The urban transport system is embedded in numerous institutional settings across different modes of transport, agencies or departments, tiers of government, and geographically adjacent jurisdictions. As stated earlier, policymaking should not be viewed as an activity in which only the public authorities engage. Non-state actors are involved in the policy process, amongst other reasons, to promote their policy or socio-technical innovations. Critical analysis of instrument and technology constituencies and their relationships can help to understand the strategies and influence of non-state actors in the policy process. This is especially important for policy integration across various institutional settings, which is not only a technical exercise but also a political one [89].

Governance is also about the instruments and mechanisms, or the modes of governance, that help attain policy objectives. 'Soft' governance arrangements that facilitate policy coordination have gained prominence of late due to the increasingly networked structure within urban transport [24]. An awareness of various actor networks present in a specific context is important for policy coordination. Consequently, Givoni, Macmillen, Banister and Feitelson [27], for example, have called for a "deep and holistic appreciation" of the policy networks as a prerequisite for effective implementation of soft policy instruments. The dynamic between instrument and technology constituencies is likely to affect the success of various policy instruments in achieving coordination and, thus, the implementation of transport policies.

Further, the governance of urban transport also depends on the presence and scope of instrument and technology constituencies. Where constituencies do not exist, or are narrowly defined, higher order learning occurs, if at all, only within a limited set of actors [90]. Such a situation can create bottlenecks to policy or technology change and stymie innovation. It has been observed, for example, that learning between technological experiments in transport has been inadequate despite the existence of numerous solutions [91]. Even when technology specific learning has occurred, learning between technologies has remained weak [41]. Similarly, policy learning has been posited to occur within instrument constituencies rather than between instrument constituencies [64]. In these cases, government agencies, universities, or 'networked bridging organizations' can play a role in facilitating communication and learning across diverse actors [90,92].

In addition, the distribution of resources within and between constituencies influences policymaking. For example, when resources are unevenly spread, members of constituencies with greater resources are likely to participate in more advocacy coalitions, across several geographies, to promote their technology and policy alternatives. In contrast, members of constituencies with fewer resources are likely to be more selective in their participation in the policy process. As a result, alternatives with no constituencies or weaker constituencies may receive less consideration during the policy design. This does not imply that a more even distribution of resources is necessarily beneficial. Even when the resources are distributed more evenly, the presence of several constituencies in the policy process can lead to contestation and conflict, generating 'more heat than light'. A professional forum that facilitates the exchange of information and ideas about various alternatives can be useful in such a situation.

Finally, the density of different types of constituencies also have implications for governance. When too few instruments (or instrument constituencies) support numerous technology constituencies, radically new technologies do not receive adequate protection. Numerous technologies, then, compete for resources and their development is more prone to hype cycles and changes in expectations. Bakker et al. [93], for example, found that the battery electric car competed with hydrogen car for research and development funding, regulation, and appropriate infrastructure; only one option received adequate support at any given point of time, resulting in lack of stability in technological development. Similarly, Sierzchula, Bakker, Maat and van Wee [52] identified over 880 alternate fuel vehicle designs, across flex-fuel, liquified petroleum gas (LPG), compressed natural gas (CNG), hydrogen, and electricity, sharing resources from the 15 largest automobile manufacturers. At the same time, as mentioned earlier, the presence of numerous instrument constituencies without adequate support from technology constituencies is likely to result in implementation failure. Governance of urban transport, thus, requires a balance between policy and socio-technical innovation and, thereby, instrument and technology constituencies.

6. Conclusions

The problems posed by urban transport necessitate a systemic approach to move away from the dominant petroleum car-based system to a more sustainable mobility paradigm. Such a move will require concomitant changes in technologies, behavior, and policies. This makes the transitions approach a useful tool to describe and analyze the urban transport system. However, governance of urban transport requires an understanding of the role of agency and, on this front, various frameworks in the transitions literature have been criticized for neglecting agency, politics, and policymaking. Although this criticism has since spawned an active research agenda, there is a scope for further conceptualization of agency.

This paper contributes to the literature by theorizing the form and characteristics of the agency innovation in sustainability transitions. The relationship between technology development and policy change is co-evolutionary or 'compulsive'—while complexities and uncertainties in technological innovation necessitate appropriate policy intervention, policy change itself results in unanticipated technological development [79]. As a corollary, innovation in transitions may occur, not only in the technological configuration of the system but also in its governance arrangements or policy instruments. Therefore, we posit that two distinct types of actors promote innovations in sociotechnical transitions: instrument constituencies and technology constituencies. While instrument constituencies create a 'supply push' for their policy instrument(s), technology constituencies facilitate the development and diffusion of new technologies amongst the citizens, businesses, and governments.

Although both types of actors are primarily interested in promoting their (policy or technological) innovations, their interests and motivations in participating in transitions processes differ. Moreover, their presence, composition, structure, activities, and dynamics are likely to influence transitions pathways. The distinction between the two is, therefore, of theoretical relevance as well as practical significance. This is especially true in the case of urban transport, which is to a large extent coordinated, financed, and/or regulated by governments and consists of numerous behavioral, technological, and policy alternatives. While a large number of technological and policy alternatives do not imply a comparable number of constituencies, given that the future role of actors is closely tied to the diffusion of their innovations, several alternatives would be expected to be propped up by respective instrument and technology constituencies.

Future research should, then, examine the presence of instrument and technology constituencies. This would lead to further understanding of the conditions that enable creation, expansion, and contraction of these constituencies. It is important that such investigation is not restricted to niche actors only [61]. In fact, an advantage of the conceptualization we put forward is that it does not presuppose the behavior of actors involved in different dimensions or 'levels' of the system. Further, the composition, structure, and activities of these constituencies need to be better understood.

For example, do both constituencies consist of same or similar members? (When) Are the constituencies reflexive? Do brokers, such as government agencies or universities, link different constituencies? Or, (when) does learning occur within and between constituencies? Finally, the relationships between instrument and technology constituencies and the effects of dynamics on transitions pathways merit attention. For instance, when do technology constituencies spawn instrument constituencies? Similarly, when do instrument constituencies lead to the creation of new technology constituencies? And, to what extent do these dynamics explain various outcomes, such as the ability of regime actors to resist pressures or the success of innovations in replacing unsustainable socio-technical configurations?

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