Article

Charging for Collaboration: Exploring the Dynamics of Temporal Fit in Interdependent Constellations for Innovation

Wouter P. L. van Galen , Bob Walrave , Sharon A. M. Dolmans and A. Georges L. Romme

ITEM Group, Department of Industrial Engineering & Innovation Sciences, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands; b.walrave@tue.nl (B.W.); s.a.m.dolmans@tue.nl (S.A.M.D.); a.g.l.romme@tue.nl (A.G.L.R.)

* Correspondence: w.p.l.v.galen@tue.nl; Tel.: +31-402-472-170

Abstract: The development of a suitable public charging system for electric vehicles relies on inputs from many complementary organizations that need to synchronize interdependencies across different activities, organizations, and industries. Research on temporal fit has focused on synchronizing activities within or external to the organization, rather than exploring synchronization across multiple organizations with highly interdependent yet colliding temporal structures and multiple time-givers. Drawing on a case study of a collaborative effort to create a national charging infrastructure for electric vehicles, we theorize the interplay between various highly interdependent actors. The resulting theory posits that actors combine and shift between different innovation practices to organize time and explains how multiple, yet interdependent actors engaging in temporal work attempt to accomplish temporal fit. Three entrainment dynamics are identified: (1) temporal tug-of-war through ecosystem configuration; (2) temporal dictating through group politics; and (3) ecosystem navigation through temporal ambivalence. These dynamics arise both between and within groups of actors when they coordinate innovation practices across multiple temporal structures and time-givers. Together, the simultaneous pursuit of synchronization within and across these different coalitions appears to constrain the realization of the collective goal.

Keywords: EV charging infrastructure; electric vehicles; temporal work; entrainment; collaborative innovation setting

Citation: van Galen, W.P.L.; Walrave, B.; Dolmans, S.A.M.; Romme, A.G.L.

Charging for Collaboration:

Exploring the Dynamics of Temporal Fit in Interdependent Constellations

for Innovation. *Energies* **2021**, *14*, 5386.

<https://doi.org/10.3390/en14175386>

Academic Editor: Marcin Polom

Received: 29 June 2021

Accepted: 25 August 2021

Published: 30 August 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

In today's interconnected world, many organizations need to manage interdependencies across different activities, organizations, and industries. These interdependencies imply the need to coordinate efforts among various inter-organizational strategies and processes in order to simultaneously achieve local goals (e.g., sustaining a competitive advantage) and collective goals (e.g., they aim to replace an incumbent technology by a more sustainable technology [1–6]. For example, the development of path-breaking innovations to grand challenges in the area of sustainable energy production and smart mobility systems is characterized by high levels of interdependence between diverse organizations that need to be involved yet also be aligned. Hence, these are system-wide issues that stretch beyond the boundaries of a single organization or industry, involving diverse yet complementary organizations (such as governments, grid operators and technology developers) that have various competing interests (e.g., societal and environmental versus commercial interests) and objectives (e.g., reducing local air pollution versus safeguarding grid stability versus increasing profit) [7,8].

As such, the broader collaborative setting for innovation comes with specific challenges for those organization pioneering a path-breaking value proposition. In particular because concerted efforts are required from the organizations involved, each shaping its strategic choices and actions according to a unique temporal structure and assumptions—that is, temporal work [6,9,10]. In this respect, the various participants in a joint innovation

effort are likely to face different temporal interpretations [9–13] that, as a result, causes for participant misalignment, which then may jeopardize the efficacy of the collaboration [3,6]. Thus, the involved actors have to coordinate their activities across different temporal structures to ensure a so-called state of *temporal fit*, required to materialize the focal value proposition [2].

The temporal fit between two or more interacting systems has also been called *entrainment*, also known as the synchronization of activity cycles of one (organizational) system to those of another [14–16]. The concept of entrainment serves to understand the processes by which organizations cope, or fail to cope, with the key elements of entrainment—that is, matching speed and aligning phases—to accomplish temporal fit between their own time-giving activities (e.g., internal R&D processes) and those of the external environment (such as technology suppliers or customers) [17]. Previous studies have assessed entrainment in various contexts, both within and external to the organization, and its impact on performance [12,16,18–21]. However, little is known about entrainment in a structure of joint path-breaking innovation ([22] is an exception), despite the fact that matters of alignment are of central importance in such settings [1,2,23,24]. Indeed, grand challenges are highly complex, uncertain and without easy solutions; moreover, effective cross-sector collaborations are deemed necessary to solve such challenges e.g., [25–27]. Here, organizations such as technology developers, energy providers, grid operators and local governments are facing competing temporal structures, multiple time-givers, and conflicting local goals and strategies in their innovation efforts [7,8,11] while being nested in a complex system of interdependence.

It is therefore not surprising that scholars have called for research that seeks to understand how organizations interact in their joint efforts to achieve the desired joint value proposition, particularly when temporal structures and activities tend to collide e.g., [12,19–21,28] or when these organizations are nested within larger interconnected systems [18,29,30]. However, still little is known about how various complementary actors make sense of time in complex and highly interdependent constellations for innovation. Therefore, in this study we seek to understand *how multiple organizations engage in temporal work in the context of an ecosystem for a path-breaking innovation*.

By drawing on an in-depth embedded case study of the development of the Dutch charging infrastructure for EVs, we highlight the complex dynamics that interdependent actors face when they collaborate toward a collective goal. Our findings suggest that ecosystem actors give rise to three specific entrainment dynamics: (1) temporal tug-of-war through ecosystem configuration; (2) temporal dictating through group politics; and, (3) ecosystem navigation through temporal ambivalence. These dynamics arise both between and within groups of actors when they coordinate innovation practices across multiple temporal structures and time-givers. More specifically, we observe that actors establish coalitions to seek to synchronize their innovation practices to a single dominant time-giver that is perceived to be most relevant to their interests and challenges of achieving temporal fit. In addition, groups of actors are likely to use such a coalition to gain more influence and power over competing temporal-structures and innovation practices (e.g., to influence value appropriation distribution or the nature of the joint value proposition). However, when actors strategize in the form of such coalitions (called ‘nested-entrainment’), they are likely to jeopardize the interdependency structure at the collective level—which is critical to creating the collective innovation outcome in the first place.

This study contributes to the literature on temporal work and innovation by theorizing how organizations combine and shift between different innovation practices, thereby generating three distinct entrainment dynamics. Hence, our findings offer a new perspective on how multiple yet interdependent actors engage in temporal work and (fail to) accomplish temporal fit. Moreover, while temporal work and entrainment are typically explored within or external to a focal organization, this study is one of the first to shed light on the dynamics underlying the complex relationships between multiple nested systems, that

together represent a multi-level system seeking to achieve temporal fit and thereby aim to materialize a joint value proposition in an innovation ecosystem setting.

2. Theoretical Background

Entrainment involves the process by which two or more interacting systems come into temporal fit [14,15] and provides a lens for developing theoretical perspectives on different interacting systems at multiple levels of analysis [15,16]. In this respect, scholars have addressed the synchronization of organizational activities with an external environment, such as competitors, customers, or governments—referred to as extra-entrainment. Extra-entrainment explains the performance implications that arise as activity cycles of one system entrain to those of a more dominant external system, the so-called *time-giver* [16,17,20]. Time-giving actors “set the tempo (i.e., the speed at which an activity is to be performed) and/or phase (i.e., the starting point) of activity cycles to which the organization must entrain” [20] (p. 106). However, the need to synchronize internal activities, that is, intra-entrainment, has also been emphasized [16,17,31]. Hence, the state of intra-entrainment may reinforce or undermine the positive effects of extra-entrainment [17,20].

Some studies have only focused on intra-entrainment; for instance, Hopp and Greene [32] examined the temporal relationships between business plans and the achievement of new ventures’ viability. However, other studies have considered both intra- and extra-entrainment. For example, several studies show that alliance managers have to assess and manage internal and external rhythms to effectively coordinate alliances [16,21]. While studying the temporal fit between organizations and its external environment, Khavul et al. [20] focused on the intersection of internationalization and the performance of international new ventures, and Reinecke and Ansari [6] explored the interplay between market and development temporalities to explain how organizations entrain to multiple temporal environments. Collectively, the logic in these multidisciplinary studies has remained largely the same over the years: entrainment captures the temporal fit between two interacting systems. Hence, a good fit is likely to enhance firm performance, e.g., [14,16,17,20], while a misfit results in damaging consequences and thereby suboptimal firm performance [14,33,34].

Despite these advancements, entrainment is rarely studied in more complex contexts, notably those that reach beyond a single focal organization (see [12,22] for two exceptions). This is interesting, as organizations are inevitably embedded in larger systems and thereby interconnected with other competing and/or complementary organizations, which on top of an organization’s entrainment strategies might further complicate and potentially destabilize joint efforts [18,29–31]. More specifically, entrainment inevitably occurs in a nesting structure, involving a hierarchical structure of multiple organizations that need to achieve temporal fit to reach an overarching collective goal [18,19,21,30]—such as innovation. Such a nesting structure represents a multilevel system composed of interdependent subsystems (i.e., organizations that embrace different temporal-structures and time-givers) that share common interests and goals while coordinating their activities to a higher-level system goal. Such a structure is likely to bring about a (transient) state of equilibrium among competing time-givers [18] which allows multiple organizations to collaborate, but a powerful organization or alliance of actors can have the leverage to enact or resist temporal change and thereby undermine the collective innovation effort [17].

A key challenge is therefore the need to balance the demands of multiple divergent yet interconnected organizations, without compromising individual and collective performance. In response, several scholars have stressed that forming alliances [21], forming strategic groups [18] and setting up coalitions of organizations [17] are well established approaches to manage inter-organizational relationships. Nevertheless, strong and stable sub-systems representing groups of organizations—such as a coalition or alliance—may also result in internal tensions. That is, organizations active in such a sub-system may prefer a different speed and/or set of rhythms, and these sub-systems may therefore face continuous tensions that emerge from external (competing) demands [18], for instance from

co-innovating organizations [2,35]. While the mutual appreciation of interdependencies can allow organizations to bridge competing temporalities [6], the arenas in which various organizations seek to accomplish temporal fit have become very complex [3,18,36], for example because of temporal complexity [11]. This is likely to result in misfit and may jeopardize the efficacy of the collaboration and its performance.

Thus, while the unique inputs and impulses from co-innovating actors typically serve to enable innovation it also raises important issues in terms of temporal fit [1,2,17,20,28]. That is, the competing temporal structures, multiple time-givers and conflicting local goals make collaborative settings for innovation unstable and thereby a complex endeavor [11]. However, nowadays various organizations increasingly collaborate as partners in joint innovation efforts towards *both* local and collective goals, for instance to compete with established value propositions, aimed to replace the incumbent technology [2]. Moreover, in the context of such a joint innovation setting (often referred to as an innovation ecosystem), the functioning of the system—and with that the potential to realize the system's goal—depends on the functioning of the participating actors, and vice versa [1,2,5,35,37]. This implies that the failure of any key actor to successfully synchronize with the innovation ecosystem negatively impacts the performance of the system as a whole. As such, the entrainment challenges arising from joint innovation are not only situated within the organization, but also in the organization's (external) ecosystem of co-innovating actors.

A key challenge for the actors involved in an innovation ecosystem is therefore to achieve their local goals, while bridging competing temporal perspectives to achieve a temporal fit, without compromising the joint value proposition. In this respect, many authors have called for research that seeks to create a better understanding on how organizations interact in their joint efforts to achieve collective innovation outcomes, particularly when temporal structures and time-giving activities tend to collide, e.g., [12,17,19–21,28] or when these organizations are nested within larger interconnected systems [18,29,30]. In response, Hilbolling et al. [22] provided useful empirical insights by taking a temporal lens on the coordination of innovation ecosystems. More specifically, the authors suggest that a combination of both synchronous as well as asynchronous strategies shape temporal coordination in innovation ecosystems.

Nonetheless, the complex structure of interdependency raises several new questions. For instance, how is entrainment behavior shaped or constrained in a complex system of interdependent actors and how does this influence the success or failure of achieving a path breaking value proposition? How do organizations cope with multiple time-givers? In addition, questions arise regarding how the complexity, dynamism, and uncertainty of an interdependency structure shape organizational practices in achieving fit, or reducing misfit, with the environment. Overall, the extant literature suggests that little is known about how multiple actors organize time in complex and highly interdependent constellations for innovation [12,17–21,28–30]. In this study, we therefore explore *how multiple organizations engage in temporal work in the context of an ecosystem for a path-breaking innovation*.

3. Method

Due to the exploratory nature of the research question, we conducted an in-depth case study that offers an authentic context and allows us to develop a deeper understanding [38]. Our study focuses on an emerging innovation ecosystem in the Netherlands, representing a set of various highly interdependent actors with complementary assets that need to be combined to develop a public charging infrastructure for EVs. At the time, such an infrastructure is considered as a critical prerequisite to enable a successful transition to EVs (e.g., through smart charging [8,39]). This ecosystem is well-suited for studying the behavior of diverse actors attempting to structure time in an innovation ecosystem for a path-breaking innovation. It covers a multiplicity of co-innovating actors creating novel temporal trade-offs that influence the nature of their main innovation practices, while also being connected by their collective value proposition [7,8,40–42].

Furthermore, the development of the national charging infrastructure entails various local parties and large scale (technical) inputs that require inputs from multiple organizations of the same type—such as multiple municipalities, grid operators, and charge point operators [7,8,41]. This allows us to study how (groups of) actors engage in synchronizing their innovation practices in the ecosystem. The simultaneous engagement in both joint innovation and temporal fit makes the Dutch public charging ecosystem an appropriate setting for this study [43,44].

3.1. Data Collection

The data collected consist of interview data, site visits, and archival data. The public and private organizations studied were selected in view of their direct involvement in the development of the public charging infrastructure, including: local governments (representing Dutch municipalities, city regions and provinces), national government (Enterprise Agency and a ministry), grid operators (i.e., Distribution System Operators or DSOs), large (European) energy companies, charging station manufactures, Mobility Service Providers (MSPs), Charge Point Operators (CPOs), European and non-European (electric) vehicle suppliers, and knowledge institutions (i.e., universities, research institutes, and consultancy firms).

3.1.1. Interview Data

A total of 30 semi-structured interviews, which lasted from 45 to 120 min, were conducted with 36 key actors representing managers or policy makers responsible for their organization's public charging infrastructure related innovation activities. We used an interview protocol (Appendix A) to systematically uncover the actors' innovation attitude, strategic behavior, temporal innovation practices, and synchronization efforts in view of the dynamics related to the ecosystem and the joint innovation practices. During the interviews, the interviewees were first invited to elaborate on their role in the organization and were subsequently invited to describe how their organization was involved in the development of the public charging infrastructure. The interview then focused on key topics related to the joint innovation processes, the actors' strategic behavior and innovation practices, and their synchronization efforts with respect to their external environment. When necessary, we also asked for additional information on specific innovation activities and relationships. All interviews were digitally recorded and transcribed.

3.1.2. Site Visits

In addition to the interviews, we conducted 26 site visits to organizations involved with public charging in the Netherlands. We visited grid operators (3 DSOs, and 1 industry organization), 3 local governments (i.e., municipalities), 3 regional governments (i.e., provinces and city regions) and 2 national governments (i.e., Enterprise Agency and a ministry), and multiple technology companies (developers of charging stations, CPOs, MSPs). These visits grounded the findings in the field, helped to identify additional informants (to be interviewed) and enabled access to additional documents (see below).

3.1.3. Archival Data

Throughout the study, various kinds of (publicly available) documents (27 in total) and other secondary data regarding the participating organizations and ecosystem served to triangulate the patterns inferred from the interview data and site visits. By regularly sharing the emerging findings with various actors, we assured that our interpretations of the dynamics in and around the innovation ecosystem were valid.

3.2. Data Analysis

Different steps were used to analyze the data [45,46]. We performed these steps sequentially, but kept iterating as we continued to collect data in the field. Firstly, the data were transformed into a more manageable form, by analyzing and mapping various

relevant characteristics of the actors involved in the ecosystem. Table 1 provides a concise overview of the actors that formed the basis of the ecosystem, including their roles, complementary assets, interests, and general innovation strategies. This step resulted in a general case narrative, constructed from the interviews, observational and archival data. The narrative constituted our initial effort to explore the entrainment dynamics in the ecosystem through open-coding, and to understand how (groups of) actors engaged in synchronizing their innovation practices in the ecosystem. Secondly, we used second-level codes to label distinct characteristics that explain actors' temporal work (Table 2), hence fueling dynamics across the participating actors. Further analysis pointed at three specific entrainment dynamics that may detail how multiple organizations engage in temporal work in this ecosystem (Appendix B).

Table 1. Overview of the public charging ecosystem's actors.

Actor	General Role and Complementary Asset	Local Interests	Expectations	Strategies	Dominant Time-Giver
Local government	Approve location and placement of charging stations. Asset: public space, i.e., charging spot.	Fulfill charging demands of citizens and visitors. Preserve strategic parking spaces and optimal use of parking spaces.	Growing number of EV charging spots may aggravate parking pressure. Public charging market is organized and self-sustaining in the short term.	Variety of supportive policies in cities and surrounding regions. Policies and financial incentives for charging station requests and corresponding permits differ.	Ratio between EVs and public charging points.
Energy company	Provide electricity in order to enable charging. Asset: electricity.	Maintain and increase market share. Flexibility on the wholesale market, balancing electricity supply and customer demand, and prediction of electricity price movements.	EV and charging infrastructure will become an essential and valuable element in the transition to future energy systems. EV may pose a threat to the balance between supply and demand in the long term.	Development of forecast models for dynamic pricing and peak shaving. Establishing public charging networks to learn about EV and charging. Lobby for legislative change to enable balancing.	Consumers of electricity.
Grid operator	Construction of the physical connection between the grid and the charging point. Asset: electricity grid.	Grid stability and safety. Supply security and postpone grid reinforcements and investments. Facilitate the development of the charging infrastructure.	Large scale adoption of EV may pose a threat to the grid stability and cause additional investments. Grid stability requires smart charging.	Development of forecast models for smart charging. Coordinate activities and safeguard interests in different ways.	National government.
Charging station manufacturer	Provide suitable charging stations. Asset: charging station.	Commercial interests. Maintain R&D activities. Market expansion, both national and international.	EV demand will increase and charging market provides opportunities to develop and exploit products internationally.	Partnerships in large scale projects to create economies of scale. Market segmentation.	Customers of charging stations.
Charge point operator	Place, maintain, operate, and thereby provide a reliable pool of charging stations. Asset: provide other actors access to charging stations.	Quickly organized ecosystem. Market expansion, both national and international. Commercial activities in the short term and being part of future energy transition.	EV demand will increase and charging market provides opportunities to develop and exploit products internationally. Competition will increase.	Commercial strategies. Provide themselves a profitable position in future. Collaborate with other actors for interoperability, and technical protocols.	Users of the public charging infrastructure.
Mobility service provider	Provide charging services. Ensure that users can charge anytime, anywhere at different charging providers. Asset: Charging services.	Selling services and making profit. Market expansion, both national and international. Reliable public charging infrastructure.	EV demand will increase and charging market provides opportunities to develop and exploit products internationally. Competition will increase.	Develop new services and increase marketing intensity. Participate in projects. Create agreement on administrative matters, interoperability, and technical protocols.	Users of the public charging infrastructure.
(electric) Vehicle supplier	Provide Electric Vehicles. Asset: electric Vehicles.	Charging infrastructure is necessary for EVs. Maintain market share in the long term through diversification of product portfolio (not necessarily with EVs).	Different expectations about technological- and market developments, and future consumer demands. EV will be part of the future automotive market.	Strategies are focused on EV and differ due to various expectations. Introducing a variety of EVs on the market.	Customers of EVs.

Table 1. Cont.

Actor	General Role and Complementary Asset	Local Interests	Expectations	Strategies	Dominant Time-Giver
National government ¹	Orchestrating and optimizing the public charging chain.	Achieve national and international EV economic/sustainability-objectives, as part of this, a suitable public charging infrastructure should be developed.	Development of a public charging infrastructure is a market task. Unambiguous market demand regarding issues and possible legislative changes.	Reactive role during the development of a charging infrastructure. Approving of a variety of supportive and corrective policies and support for research funding.	Ratio between EVs and public charging points.

¹ The national government has no indispensable assets with respect to the public charging infrastructure. However, they inevitably played a role in shaping the overall ecosystem's structure, e.g., through legislation, knowledge sharing, and matching various actors.

Table 2. Concepts and characteristic that drive temporal work in innovation ecosystems.

Concept (Definition)	Characteristic	CPO, MSP, Charging Station Manufacturer	Energy Company, Vehicle Supplier	Grid Operator	Local/Regional Government
1. Joint innovation attitude (i.e., actor's rationale behind joint innovation)	The main reason to engage in joint innovation is:	To be profitable	To learn and to be profitable	To safeguard responsibilities and compliance with legislation	To address societal and environmental issues
	The desired outcome of innovation is:	The exploitation of opportunities	The exploration of opportunities	To address changing setting and regulative tasks	The compliance with societal interests and policies
	Decision making is mainly focused on:	Self-interest	Self-interest	Self-interest and social interest	Self-interest and social interest
	The attitude towards exposing the organization to dangerous, harmful, or failing situations is:	Risk taking	Considering risks	Risk avoiding	Risk avoiding
	The willingness to consider new external initiatives and innovation practices:	High	Medium	Low	Ranging from low to medium
	The mindset to create a desired situation in the ecosystem is driven by:	Pro-active behavior	Ranging from waiting to proactive behavior	Ranging from waiting to proactive behavior	Ranging from waiting to proactive behavior
2. Temporal structure (i.e., actor's temporal characteristics that shape local innovation practices, adapted from: [6,7,9])	The course of action to achieve innovation objectives is to:	Compete for market share and collaborate to develop standards	Participate in (pilot) projects and collaborate to develop standards	Participate in (sizeable) pilot projects and collaborate to develop standards	Support and collaborate to develop generic procedures and guidelines
	The process of putting innovation related decisions or plans into practice can be characterized by:	Efficient and fast implementation	Effective implementation	Coordinated and effective implementation	Coordinated and effective implementation
	The usual period for planning and performing innovation activities is oriented on:	The short-term	The mid-term	The long-term	The mid-term
	The main aspects of how (important) decisions are made, through:	Opportunity based decision making	Opportunity based decision making	Comprehensive and thoughtful decision making	Comprehensive and thoughtful decision making
	The speed of decision taking is:	Rapid	Average	Slow	Slow
	The perceived position of innovation and entrainment challenges is:	Mainly external	Either ranging from internal to external, or both internal and external	Both internal and external	Either ranging from internal to external, or both internal and external
3. Challenges of achieving temporal fit. (i.e., actor's challenges to achieve temporal fit with co-innovation actors)	The capability to entrain internal activities to changes in the ecosystem is:	Highly flexible	Inflexible	Inflexible	Inflexible
	The perceived necessity of a well-arranged ecosystem where actors follow justifiable and obvious innovation patterns and all actors play by the same set of rules is:	High	Ranging from low to medium	Low	Ranging from low to medium

4. Results

This section describes the main findings. First, we introduce the setting of the case by presenting an overview of the actors that formed the basis of the ecosystem. Second, we describe how the actors engage in organizing their practices, according to the actors' characteristics. Here, we show three entrainment dynamics: (1) temporal tug-of-war through ecosystem configuration; (2) temporal dictating through group politics; and (3) ecosystem navigation through temporal ambivalence. Finally, we explain how this simultaneous pursuit of synchronization within and across these different coalitions constrains joint innovation at the system level. Figure 1 provides a conceptual overview of the innovation ecosystem setting and the three different entrainment dynamics.

Figure 1. Overview of the innovation ecosystem setting and the three different entrainment dynamics.

Figure 1 shows different complementary actors (represented by the different symbols) in the development of a joint value proposition (JVP). The ecosystem setting in this study focuses on the JVP of developing a national public charging infrastructure for EV. The complementary actors are local governments, energy companies, grid operators, charging station manufacturers, charge point operators, mobility service providers, and (electric) vehicle suppliers. The location of each entrainment dynamic is visualized by the grey dashed arrows. More specifically, temporal tug-of-war is observed across complementary actors, temporal dictating is observed within groups of actors, and temporal ambivalence is observed both across as well as within the ecosystem's actors.

4.1. Setting the Stage: Exploring Temporal Work in an Innovation Ecosystem Setting

Innovation ecosystems can be characterized by complementary actors that interactively seek to achieve a collective goal. In the case of the national ecosystem the collective goal is to develop a suitable public charging infrastructure for EVs. Table 1 portrays the various actors that are involved in the development of the charging infrastructure and shape the dynamics in how they collaborate toward that collective goal.

A first key finding centers on the observation that each actor has a particular position in the ecosystem. The empirical analysis shows each of the multidisciplinary actors has a particular motive to engage in the development of the charging ecosystem. In general, the actors have positive expectations regarding the success of EV and acknowledge for various reasons the necessity of a suitable public charging infrastructure. Despite actors' distinct interests, expectations and strategies, Table 1 demonstrates that the strategies are not purely aimed at either hindering or supporting the development of the collective innovation outcome.

Instead, the strategies are directed at influencing the ecosystem's configuration in order to align it to local interests, informed by their distinct dominant time-giver. As such, the different actors seek to establish an innovation ecosystem configuration that maximizes the fulfillment of their own interests. A key actor reflected on this configuration as follows:

"It is obvious, the charging infrastructure is vital. Without a charging infrastructure no EVs. That's the reason why we started so long ago with the development of the charging infrastructure. Our position was and still is that the public charging infrastructure is a matter of public concern. Like other supportive infrastructure that is generally made available to enable driving. This is something that is not achieved by the private organizations. Like parking spots or the road infrastructure itself, traffic lights, public lighting . . . These are all indispensable matters to support mobility. And we feel that the charging infrastructure also belongs here. And that's the point where we [grid operators] started with. In addition, an EV requires a completely different provision than petrol, gas or fluid energy system. This means that you have to develop and integrate the [infrastructure for EVs] differently. And that is smart charging, electric charging requires smart charging. And combining these two [to enable public charging], that's where we started with already back in 2008." (Innovation manager, grid operator #1).

However, as these local interests do not necessary align, a setting characterized by multiple misfits arises, including those among interests and strategies which may hinder the establishment, speed, and outcomes of the joint effort. On the other hand, the actors share positive expectations and ambitions toward accomplishing the collective goal, which may mitigate the adverse effects. Hence, these shared expectations enable actors to join the collective effort and engage others in the ecosystem:

"We are frontrunners in The Netherlands. That did not happen because either the private sector or the government that stick to national laws and regulations started. Instead, that is because there was an enthusiastic group of policy makers and business managers who decided: "we're going to start and make it work together". But this is key, there should be a government that actively looks for industry partners to jointly invest and promote the development. [Governments] should not begin with designing new policy first, and after that looking whether there is still money available and only then start the development. No, you have to go beyond this and do it together with the industry." (Regional policy maker #1).

Moreover, in their efforts to collaborate and achieve temporal fit, many actors are exposed to each other's innovation attitudes, temporal structures, and alignment challenges. Table 2 serves to map the interrelated concepts and distinct characteristics that underlie actors'

efforts to organize time in the innovation setting (i.e., temporal work), and hence fuel the interplay between the participating actors.

As Table 2 illustrates, major contrasts exist across the actors. The intended fit toward the desired collective goals thus entails the coordination across a complexity of interrelated characteristics. In the remainder of this section, we will elaborate on this interrelatedness and outline the entrainment dynamics between and within actors in more detail, including how these dynamics affect each other.

4.2. Entrainment Dynamic I: Temporal Tug-of-War through Ecosystem Configuration

The central point for understanding the interplay between highly interdependent actors is that our results show that the contrasting characteristics between typical actors exist (cf. Tables 1 and 2), which in turn underlie entrainment tensions that emerge across actors. We label this temporal tug-of-war through ecosystem configuration. More specifically, our findings show that actor's strategies and innovation practices are directed at influencing the ecosystem's configuration in order to align it to specific local (temporal) characteristics, and hence cause tensions (i.e., tug-of-war) that emerge across actors who embrace different temporal innovation practices. The following example serves to highlight how differences in actor's innovation activities and time-giver feed misalignment.

"We use specific guidelines to process an application for a public charging point. Here we make agreements with the municipality about what we expect from them. For instance, whether there should be a parking spot reserved, whether or not we need a sign and if yes who takes care of this, whether or not we need a civil servant to check the engineering activities on site, what is a good spot for a charging point . . . And we need this to be clear far in advance. And then, if we receive an application, we can check whether the application is entitled to receive a public charging point. If so, then we make a further application for a license. And this is a very long time-consuming process, which differs by municipality. And then step 2: the grid operator. Here we face significant differences among grid operators. Again we do a location check [for the grid connection] upfront, otherwise the application is for nothing. It then goes to the grid operator, and depending on their internal agreements it requires one simple working process [. . .] or multiple working processes. The latter is really frustrating for us because it cost us really much time and it is according to us pointless." (Business manager, CPO #1).

The governmental attitude, the duration of their implementation and decision-making processes, in turn, provide a stumbling block for the CPO. In other words, the CPO's process of putting innovations into practice can be characterized by efficient activities and rapid decision-making. A CPO has to deal with external innovation challenges. In this respect, the CPOs would like the municipalities to speed up their (internal) processes and switch to a generic applicable application guideline, so that they, as a private organization, can be more efficient and more profitable in the short term.

Decision making speed and innovation planning can be interpreted in various ways. For instance, when a grid operator is willing to discuss critical issues regarding public charging, it typically means one has to schedule a series of appointments across the entire upcoming year which, in turn, frustrates the representatives of a commercially driven company. An innovation manager reflected on these differences as follows:

"CPOs or those decisive organizations versus a grid operator. The entire culture of a grid operator is totally different, 100% different I would say. A grid operator may be willing to collaborate, but this means that I as a grid operator schedule meetings every two weeks for the upcoming two years. And such a decisive organization then says: WHAT, I have to do something else, but you know what, let's settle it next Friday within just 1 h, preferably with a Skype call, and then it should be done. Of course, this is an extremely different approach. And the

same goes for CPOs toward local governments [. . .]. No, these are two different worlds in terms of culture and thereby in terms of time interpretations, time they could invest [in public charging related matters] and the way they talk [about public charging].” (Innovation manager, grid operator #2).

From yet another perspective, the public organizations involved attach less importance to decision-making speed. They attach value to comprehensive and thoughtful decisions that comply with societal interests and policies, and consequently, efficiency is less important. Despite the fact that public organizations are willing to support innovation to address societal issues, the innovation implementation process of public actors is typically characterized by high coordination costs, strong risk considerations, and compliance with an unequivocal policy. Whether the tasks or activities are completed on time, or how (efficient) individuals perform, or what the final (measurable) results are, are less important to public organizations and therefore barely emphasized. As one of the respondents mentioned:

“Generally speaking, everyone agreed that the government is slow, and this will always be the case. We [government] think that we’re much faster than in the past, in my opinion this is the case. But since technological developments occur rapidly we as a government will always lag behind. Moreover, as a government you always have multiple interests to serve.” (Policy maker, national government #1).

In addition to the different innovation practices, many actors appeared to struggle with understanding each other’s practices, time-givers, and associated efforts. For instance, the empirical data demonstrates that private actors, such as a CPO or a, MSP, do not speak the language of a public organization, and vice versa. A private organization is mainly focused on synchronizing its activities and for them it is difficult to think about the interests of others. For example, during a project with a municipal organization and a CPO targeted at the allocation of charging spots a consultant reflected:

“It is difficult for them [CPO] to think about local activities such as the nearby residents, the road authorities, legal affairs and spatial planning. Of course, from a CPO’s perspective it would be favorable and commercially attractive if all the green spaces in the public environment could be adapted slightly in their favor, so that a charging station could be allocated everywhere and always. But there are many more issues than the CPO can effectively overlook, and its proposed solutions are rarely acceptable across all local (i.e., municipal) and regional (i.e., provincial) policy areas.” (Innovation advisor, consultancy firm #1).

On the contrary, the same applies for a civil servant who wants to trust private actors, but rarely understands private actors’ underlying interests and impact of the dominant time-giver. For example:

“As a local government I don’t want to worry about the trustworthiness of a market player. How should I judge a market player, by his annual sales or number of sold charging stations? [. . .] We don’t have the expertise to do so. What are the minimal quality requirements of the charging stations, do we have to determine this? We don’t have this knowledge, and we are therefore not looking to attain formulation on these points.” (Regional policy maker #2).

This is confirmed by an independent advisor:

“Regarding public charging it is difficult for local governments to figure out what commercially driven organizations really consider as important. For instance, what is more important: the charging tariff or the location of the charging spot? In other words, what to do if the charging tariff per kilowatt-hour increases with 1 Euro cent when one can charge directly in front of the door instead of 100 m at the end of the parking space? This is something that a local government does not understand.” (Innovation advisor, consultancy firm #1).

4.3. Entrainment Dynamic II: Temporal Dictating through Group Politics

We now turn to a distinct group of actors as level of analysis. Our data shows that actors establish distinct groups of actors (i.e., coalitions) in which they seek to safeguard their main local goals and thereby synchronize their innovation practices to a single dominant time-giver that is perceived to be most relevant to their interests. We identified this entrainment dynamic as temporal dictating through group politics. For this dynamic, actors establish distinct groups (e.g., through exploiting existing interest groups or setting up new forms of coalitions). As such, actors somehow try to dictate the configuration of the innovation ecosystem.

In addition to the first entrainment dynamic and accompanied tensions that are between the actors, actors pursue different ways of safeguarding interests, while engaging in an innovation ecosystem setting and being guided by a dominant time-giver:

“We initially entered into a cooperation with parties that adopted the same mindset. Those who also thought that the [public charging] infrastructure should be a public matter. [. . .] So we combined these parties in [The grid operators’ load coalition]. And we then establish [The grid operators’ load coalition] with the aim to develop and install a public charging infrastructure. However we are currently not allowed to expand this infrastructure. The national government [dominant time-giver] doesn’t want that anymore, they prohibit us from doing so. In view of this, we have stopped with installing . . . but what we’ve installed has to be maintained and kept operational.” (Innovation manager, grid operator #1).

A second example shows how commercially driven private-actors synchronize their innovation practices toward their dominant time-giver (i.e., users of the public charging infrastructure) through a coalition called eProtocol:

“We started eProtocol a couple of years ago to send out a common message: it is very important for [EV] drivers that they can drive around with cards [that allow for charging anywhere and anytime]. We [MSPs and CPOs] take care of the payments later, let’s ensure that [EV] drivers reach their destination first. Because it is the interoperability [among MSPs and CPOs] that has been established in this way. In the Netherlands we did this very well with multiple parties, it is just important that we do not bother the [EV] driver.” (Business manager, MSP #1).

In addition, our data shows that a group of actors simultaneously acknowledges the importance of the interdependency structure, yet also perceives the temporal differences and tensions across the complementary actors. As such, a group of actors seeks to enhance the joint innovation process and development of the collective goal—the development of a public charging infrastructure. In other words, the interdependency structure and collective goal appears to trigger subgroups of actors to organize their efforts in ways that also meet the temporal and strategic demands from actors outside their subgroup, hence acknowledging the need to achieve a collective fit at the ecosystem level. A representative of the coalition for grid operators illustrated this as follows:

“The connection [to the electricity grid] has to comply with certain requirements, and I believe that we attempt to promote creativity among market participants. And this is where [The grid operators’ load coalition] provides the platform through which various grid operators can collectively agree upon a solution that we accept.” (Coalition representative #1, grid operators).

Despite the mutual tensions existing across grid operators and other actors, the latter appreciate the grid operators’ joint efforts to address these challenges. For example, a business manager of an energy company stated:

“But a difficulty I do have is in the collaboration with the grid operator. And that is something that the grid operator knows, so this is something I can easily say. The difficulties involve the large bureaucratic organization. And not in a negative sense, bureaucracy has also its advantages: standard processes and well

designed. But, these processes are not designed for this [realizing public charging points] processes but for realizing household connections. [. . .]. What I do know is that [The grid operators' load coalition] has been working on this issue. [. . .]. [The grid operators' load coalition] envisages to launch a website dedicated for public charging points for which we run a different process than we have for a household connection. This enables us to make agreements with the grid operator about, for instance, the steps [in this process] and how to design these. I regard this as a smart approach, at least to organize this process differently from a grid operator's perspective. Thus [The grid operators' load coalition] performs this on behalf of the grid operator, but it is not ready yet." (Innovation manager, energy company #1).

Despite these efforts, the data also demonstrates that such groups of actors are likely to remain loyal to their dominant time-giver and organize their actions following the characteristics of their own temporal innovation practices, and still organized around local interests (see Tables 1 and 2). In response, actors tend to challenge their own group of actors as they prefer different speeds and actions that they consider as necessary to meet demands from complementary actors.

4.4. Entrainment Dynamic III: Ecosystem Navigation through Temporal Ambivalence

While safeguarding their main local goals and synchronizing their activities to a single dominant time-giver (entrainment dynamic II), actors tend to deviate from the group of actors. That is, actors pursue specific efforts to simultaneously navigate through the temporal differences and similarities within the innovation ecosystem. We label this entrainment dynamic: ecosystem navigation through temporal ambivalence. The following example illustrates this entrainment dynamic and points to the differences among the group of grid operators, who have teamed-up to defend their position and interests in the public charging system. Two interviewees:

"The national government prohibits us [to develop a public charging infrastructure], we are not allowed to do that. You see that [name grid operator #3] has a creative solution for this issue [. . .]. But then organized under a pseudo split-off [a CPO, called X]. We didn't choose for this, if the national government doesn't want it [grid operators developing the charging infrastructure] then we won't do it. It is all or nothing. [. . .]. The national government should support it. But [CPO-X] is a market player, with a market model, an 'odd man out'. The legitimacy of [CPO-X] is being contested, because [CPO-X] is still part of [grid operator #3]. And that is the legal grey zone between a grid operator and commercial activities, and they are in the middle of this grey zone. Is this allowed, or not? But we [grid operator #1] didn't decide to do this." (Innovation manager, grid operator #1).

Likewise:

"Our mission is always energy, whether it is for a traffic light or a charging point, it should be managed properly. A quick and inexpensive realization of a connection to the grid, preferably also sustainable. This does not mean that we also participate in the charging station business, like [grid operator #3]. But we do participate in pilot projects, for instance in our service area. Imagine if [public charging] become a big deal, it will have an impact on the electricity grid. If we cooperate in a pilot-project, we cannot run away from a little investment in some hardware [charging points]. So in our service area one can find some charging points here and there, which we have used to contribute. And we do this for testing purposes, not because we see a business opportunity. And that's a significant difference between us and other grid operators. We consider [activities grid-operator #3] as market-distorting, and that's the reason why we don't do such activities." (Account manager, grid operator #2).

While doing so, however, inconsistencies arise between the espoused collective efforts, based upon what they as a group of actors think they do and have identified as to be important, and the actual efforts of a single actor to influence, sustain and/or redirect other actor's temporal innovation practices and strategies. In particular, tensions within a distinct group of actors tend to arise. For example, from the perspective of fellow grid operators:

"I have mixed feelings in this matter. It has a strange effect on our position. But on the other hand, if there was a functioning [public charging] market, there was no room for [CPO-X]. What I mean, in essence they are a grid operator. As a market party you are capable to do exactly the same thing and you can respond more quickly. But, apparently, there is room [in the public charging market]. It has a distorting effect, and then they [CPO-X] also claim a position in the arena that belongs to market parties." (Coalition representative #1, grid operators).

Furthermore:

"In the short-term, nobody is taking the lead but they do [grid operator #3 with CPO-X]. This is quite opportunistic in the short-term. If there is a demand and nobody stick their necks out for this. On the other hand, in the longer-term this does not favor the [public charging] market for EV, because it does . . . it could have a distorting effect. My opinion is that we as grid operators and also [CPO-X] should not act like this." (Coalition representative #2, grid operators).

A second example demonstrates the tensions within the group of (electric) vehicle suppliers, representing the car manufacturers. More specifically, the coalition that voices the needs and interests of vehicle suppliers sought to establish a financial fund for developing the public charging infrastructure. However, they failed to do so, due to disagreement among these (electric) vehicle suppliers. One of the associated managers noticed:

"This [fund] captured the [financial] contribution of the car manufactures. But there was just a lack of agreement, and I understand this. It does make sense. If we [as a brand] do financially contribute to the fund, and for instance, Toyota does not but suddenly introduces a new plug-in hybrid vehicle [. . .] they do profit with their vehicles [from our investment]. Unless we decide that different brands [vehicle suppliers that do not contribute] are not allowed to request charging stations. But in this case you are still not able to manage that users [from a different brand] are not going to charge [at our station]. This is what played a part in the decision of car manufactures. Why should I invest financial resources in the fund if we don't do this together? It was our view, we join if all EV and plug-in hybrid brands join. And if then only a couple of them are willing to do so, we decided to withdraw from the fund." (E-mobility manager, (electric) vehicle supplier #1).

Or, as a coalition representative observed:

"Look, they [car manufactures] know a bit from each other what is going to happen, who has which types of vehicles in the pipeline . . . And that brings us to the issue that one says: I'm currently the only one [who has chargeable vehicles] . . . I introduce the most to the market so I'm the one who has to invest the most. But in 1.5 years another one has 15 new [chargeable vehicles] while I've developed a charging infrastructure. So there was a significant difference in terms of speed. [. . .] [Car manufacturer Y] does not want to have any to do with the traditional sector, and seek to deviate in different manners. I understand this because it is part of the strategy. They took active part in the discussion about the fund, but eventually decided to not invest, also because they are developing their own charging infrastructure. This is unfortunate but considering their position I do understand it." (Coalition representative #1, (electric) vehicle suppliers).

Moreover, besides defending main local interests, several actors are also likely to navigate differently to achieve fit with other actors embracing other temporal structures. In this

respect, the previous examples demonstrate how like-minded actors establish a distinct group of actors with its own temporal structure. However, such a subgroup is also likely to attempt to meet competing temporal structures and transcend the group members' temporal structures. Thus, actors tend to ignore established timing norms and/or challenge its dominant time-giver, either to accomplish fit with complementary actors or to gain more power in the ecosystem.

Notably, our findings also suggest that ecosystem navigation through temporal ambivalence, may reinforce tensions across actors and complicate the innovation ecosystem. This effect occurs when actors, as part of a distinct group of actors, juggle between ambivalent forms of achieving temporal fit, even if this conflicts with their typical temporal structure. For example:

“But we [co-innovating actors] make things very complex, also because we want to organize it [the innovation ecosystem] very well. On the contrary, if you don't [organize] it, like we [CPOs and MSPs] did with eProtocol, then we wouldn't have the momentum that we [co-innovating actors] have at this moment. I find it very difficult, the aspect that complicates [the innovation ecosystem] the most is the interference by government and industry. This collaboration should be good, the role of the grid operator, if this role becomes clear lots of things are going to change. These are actually the only things that currently stand in the way. One can see the grid operator in general, with [The grid operators' load coalition] or without [The grid operators' load coalition], actually aims to play a key role in this setting. The question is: why actually? And this hinders the development [of the public charging infrastructure] extremely.” (Business manager, CPO #2).

In this respect, a regional policy maker experienced the following:

“I blame the grid operators that they structurally feel they must exercise the control over the charging point. Initially, they aimed to do everything: selling electricity and providing charging services and developing and connecting charging stations. There was just one single party that was knowledgeable and that was the grid operator. I found these charging stations quite expensive. These were structurally more expensive than we had in our tenders. And I'm starting to think, our charging stations performed quite well, they provided power and everything went well. But then cheaper, that I think it is something that the market could do. But we lack the confidence that you do something together and thereby agree upon [mutual issues]. So, the grid operator wants to control [the innovation ecosystem] and that's the issue. First, via [load coalition] and they aim to do it now with [CPO-X, grid operator #3].” (Regional policy maker #1).

These examples demonstrate that actors' different approaches to engage in temporal work create group tensions, but also provide an equivocal signal toward other co-innovating actors. As a consequence, actors may be reluctant to entrain (aspects of) their innovation practices to competitive temporal practices or even tend to redirect the entrainment of their internal practices to a new dominant time-giver located outside the ecosystem. In addition, one of the respondents observed how tensions within a group of actors give rise to a negative image of a specific group of actors:

“The goodwill among a large part of the CPOs is very poor. Currently, there are parties that put lots of effort into hindering others, instead of enhancing their own business case. That is a waste of energy and not in the interest of EV.” (Regional policy maker #2).

One of the CPO's business managers mentioned the collaboration issues with the grid operators and explained their efforts to curb their power by avoiding collaboration:

“We have to jointly express what we want with electric driving and, in fact, it results in an expansion of the current electricity grid, but how to address this from a social perspective? What do we want with [public charging], and how

to organize this together? And if we don't [organize] this, I've a commercial opportunity, because my opportunity is: how to avoid the grid connection? That's the only question that market parties are asking themselves. How can we achieve that we don't fill the pockets of grid operators. [. . .] Thus, the money that we together invest in the [public charging] infrastructure goes directly to the grid operators' pockets. And they just reinvest this, in the past with [The grid operators' load coalition] and now with [CPO-X, grid operator #3], in the [public charging] market to operate as an organization. In a certain sense, this market is a sick [collaborative] system." (Business manager, CPO #3).

Moreover, while actors themselves may think they are balancing between achieving temporal fit within groups of actors and across actors, other actors in the ecosystem are likely to judge these efforts predominantly in a black and white manner. Hence, the empirical results imply that actors on the one hand have difficulties to act according a clear and univocal role. While on the other hand, the co-innovating actors tend to experience the actions of complementary actors as confusing or illegitimate:

"In order to enable [the potential of joint innovation] it should be simple and there should be a normal market functioning. [. . .] Nobody has entered the market yet, that's the whole issue. There is nobody that can solve these issues properly. One can say that [CPO-X] has entered the market. But they also depend on laws and regulations. And people also question what [CPO-X] actually is. Is it a stated owned company or what kind of party is it? This is confusing, there should be a clear level playing field, with laws and regulations, and then there should be market mechanisms in place to unlock the potential of [the innovation ecosystem]." (Business manager, MSP #1).

From another perspective, the policy advisor perceived the same confusion about the lack of efforts by car manufacturers:

"Initially and from our perspective, we thought that: okay, hundreds of millions have been spent on tax benefits available for EV drivers, the least car manufacturers can do is something in return [for the charging infrastructure]. But apparently this is too simplistic, because the interest of the [coalition of vehicle suppliers] is not to enable electric driving. Instead, the interest of [this coalition] is to sell as much vehicles as possible." (Policy maker, national government #1).

4.5. Entrainment Dynamics Undermine Joint Innovation

Our findings demonstrate that the actors' attempts to shift between the pursuit of synchronization within groups of actors and across all actors gave rise to multiple entrainment dynamics and associated tensions. These tensions, in turn, fueled unintended outcomes and shaped a collaborative setting in which collaborations within groups of actors were generally superficially and rarely transparent, while collaborations across actors were characterized by fragmented attempts to achieve fit and self-interest. In turn, the interplay between various highly interdependent actors attempting to coordinate different temporal structures and time-givers constrained the realization of the collective goal at the ecosystem level. As one of the independent consultants reflected:

"Instead of struggling for an unattractive dry tea biscuit, organizations should collaborate to change the tea biscuit into a much more valuable cream cake." (Innovation advisor, consultancy firm #1).

Moreover, various actors acknowledged that the creation of a well-functioning and viable joint innovation setting requires strong commitment and univocal signals from both the co-innovating actors as well the groups of actors. When several complementary actors reflected on the functioning of the innovation ecosystem and the collective outcome in terms of a suitable public charging infrastructure, they observed that self-interest and misalignment across complementary actors still prevailed and thus undermined the joint

innovation process. As a result, the magnitude and the development speed of the charging infrastructure was considered to be suboptimal. Hence, many actors emphasize the importance of a clear level playing field and legislative changes. However, from the perspective of the national government, which can be assumed to be responsible for (creating a) level playing field, this is not as simple as it appears to be:

“All [co-innovating] actors are different, and all of them also have different needs because they are continuously developing. Again, it is our [governmental] task to remove barriers and to identify where the system does not work. But the story of ‘we want a level playing field and then everything will work’ . . . The level playing field that suits you, that is for [someone else] desperately bumpy.” (Policy maker, national government #1).

5. Discussion

This study set out to explore and understand how interdependent actors collaborate toward a collective goal, thereby drawing on the temporal work literature [6,9,10,17,20]. An in-depth case study of an innovation ecosystem served to describe and explain the interplay between interdependent actors centered on a collective innovation goal. As such, these actors attempt to coordinate different temporal structures and time-givers, when these actors seek to optimize their position vis-a-vis other complementary ecosystem actors through various forms of temporal work. We identified three specific entrainment dynamics: (1) temporal tug-of-war through ecosystem configuration; (2) temporal dictating through group politics; and (3) ecosystem navigation through temporal ambivalence. More specifically, our findings show how actors, in their efforts to combine and shift between innovation practices, give rise to entrainment tensions across as well as within subgroups in the ecosystem. Moreover, these tensions manifest themselves simultaneously and tend to reinforce each other, ultimately constraining the realization of the joint goal. Our study serves to advance extant theories of temporal work and innovation in four ways.

First, our study responds to various calls to study the complex interplay underlying collectives of organizational actors that (fail to) accomplish temporal work [12,17–21,28–30]. In this respect, previous studies on temporal work have focused on organizational efforts to influence temporal structures and assumptions shaping strategic action (e.g., [6,9,12,13]), and the importance of entraining these actions to ensure a state of temporal fit and enhance firm performance [14,17,18,20]. However, few studies have considered temporal work and entrainment in more complex systems of interdependence [12,22] or the dynamic forces facilitating or inhibiting the interplay between interdependent innovation activities of multiple organizations [12,17,19–21]—despite the growing importance of such systems for innovation [2,3,5,35]. In this study, we moved beyond these conventional units of analysis and unraveled the interplay of multiple organizations in their joint innovation efforts toward the development of a path breaking innovation. Here, our study offers a detailed understanding of the dynamics of temporal work and demonstrates how the interplay between complementary actors produces tensions that may undermine the joint effort. As such, this study sheds new light on the complexity in the context of an innovation ecosystem, and especially how complementary actors drive and impact the large-scale yet collective innovation system’s efficacy and outcomes.

Second, our study illustrates the richness of tensions that actors face when they cope with competing temporal perspectives, while being nested in a system of interdependence. Consistent with previous research, our results show that these tensions are inherent to the juxtaposition of multiple demands and strategic decisions on innovation in temporally complex domains [3,11,17,19,20]. We also extend the literature by demonstrating that a system of interdependence, specifically one that is characterized by high levels of uncertainty arising from joint innovation, fuels particular tensions across (groups of) actors [22]. These tensions are grounded in different temporal innovation practices, variation in and elusiveness of time-givers, and different positions in the system. In particular, our results explain that such tensions entail temporal work that is not focused on bridging, transcend-

ing or reshaping competing temporal structures in the first place [6,17,19–21]. Instead, each actor's temporal work mainly aims at influencing the ecosystem's configuration, in order to safeguard individual interests aligned to their familiar temporal structures and time-giver (i.e., which we labeled temporal tug-of-war through ecosystem configuration). Our results demonstrate that the misfit across actors' innovation practices constrains the realization of the collective goal and thereby reduces individual performance benefits. We thus theorize that, in settings where an actor constrains the benefits of their co-innovating actors, temporal work is perceived as detrimental, fueling tensions across actors and thereby undermining the joint innovation goal. As such, our study serves to identify particular tensions arising in joint innovation [11,18,21,28] and demonstrates how these tensions can achieve (mis)fit.

Third, various tensions arising across actors may cause these actors to engage differently in temporal work, that is, give rise to competing temporal structures for achieving fit or reducing misfit with other actors in the system [6,12,13,17,19,20]. In particular, our findings illustrate the existence of within-actor tensions and how these undermine the interdependence structure. Within-actor tensions, that is, tensions within groups of actors, emerge from differences between coalitions of actors' efforts to engage in temporal work, seeking to achieve fit with other groups in the system (i.e., which we label ecosystem navigation through temporal ambivalence). In line with previous studies [17,18], we demonstrate that (such coalitions of) actors tend to safeguard their own main interests, entrain their activities to a single dominant time-giver, and thereby optimize their power to enact or resist temporal change from other groups of actors, notably through so-called nested systems (i.e., which we label temporal dictating through group politics).

The theoretical rationale that drives actors to establish a nested system of like-minded actors is as follows. While the rise of a nested system initially allows for shared temporal work by a subpopulation of actors, it inherently impedes the overall interdependency structure needed to collectively achieve fit between all actors. Moreover, actors comprising a subpopulation (or group of actors) are likely to prefer different speeds and/or sets of rhythms [18], but they also differ in their temporal approach to achieve fit with competing temporal structures [22]. In this respect, our findings demonstrate how like-minded actors engage in shared temporal work and are likely to use particular temporal innovation practices to bridge competing temporal structures and transcend their own temporal structures. Moreover, actors tend to systematically ignore established timing norms or challenge the dominant time-giver, in order to entrain to and accomplish fit with complementary actors' specific innovation practices. The dynamic interplay between actors explains how within-actor tensions emerge, yet also demonstrates how these actors address complex interdependencies to facilitate the realization of the joint innovation goal.

Fourth, while the mutual appreciation of interdependencies may serve as a mechanism to organize temporally complex domains and bridge competing perspectives [6], any major mismatches in approaches to temporal work may cause tensions within groups of actors, which, in turn, fuel tensions across (those groups of) actors that further undermine the interdependency structure. Hence, the nested structure and actors' differentiated approaches to accomplish a temporal fit provide an equivocal signal toward other complementary actors, and thereby fuel the temporal complexity of the ecosystem [11]. That is, when actors juggle between ambivalent forms of achieving temporal fit, they may give rise to skepticism among other actors. As a consequence, the latter actors are likely to be reluctant to entrain their innovation practices to the ecosystem's time-giver or may even redirect the entrainment of their internal practices to a new dominant time-giver located outside the ecosystem. Therefore, our findings suggest that actors engaging in a complex constellation for joint innovation need to address the emergence of multiple temporal approaches, because these may give rise to tensions within and across actors.

Our findings also have important implications for the innovation ecosystem literature [2,5]. Innovation research has emphasized the ecosystem's alignment structure—the mutual agreement among the actors regarding the reciprocal positions and activity flows—

as being key for an ecosystem's efficacy to materialize the focal value proposition [1,2,35,37]. Despite the key importance of ecosystem alignment, little is known about the complexity of an ecosystem's alignment structure and how differentiated actors' behavior impacts this structure. By analyzing the interplay across actors with distinct temporal structures, we offer a new view on the complexity of an ecosystem's alignment structure, and as such contribute to emerging research on innovation ecosystems [2,5,47]. More specifically, we unravel the alignment structure and show how a nested structure, which inevitably involves multiple time-givers and temporal structures, complicates the actors' alignment efforts. In other words, we demonstrate that complementary actors that are all critical to creating the collective innovation outcome in the first place shape distinct entrainment dynamic, which are likely to jeopardize the overall alignment structure.

5.1. Boundary Conditions and Future Research

The generalizability of the results should be interpreted with caution. Firstly, this research project was conducted in the context of a single ecosystem involving particular actors. This study, while strong in internal validity, is thus unable to establish a high level of external validity. In this respect, our study can inform future work that tests and refines our theoretical explanations to further establish their generalizability. Similar case studies in different settings (e.g., in other countries with other characteristics) could serve to explore whether our findings also hold in other settings.

Secondly, we explored the dynamic interplay between co-innovating actors that attempt to coordinate various temporal structures and time-givers. While we uncovered various complex relationships and tensions across actors, it would be interesting to explore how it temporarily unfolds in ecosystem settings, and how these relationships and tensions change over time. A process study could serve to uncover when and how time-givers become dominant and how time-givers erode in joint innovation settings, for instance as the path-breaking technology becomes more established and widely accepted.

Thirdly, our study suggests that the failure of the transition to EV will also cause the failure of the development of the public charging ecosystem, and vice versa. It will be of interest to consider whether our empirical results can be replicated in other emerging (ecosystem) contexts and what boundary conditions are required to extend the generalizability of the research findings. Other joint innovation formats, for example involving actors that have to maneuver their innovation practices and entrainment efforts across joint innovation settings, may give rise to additional insights to temporal work in such settings. For instance, why do certain timing norms become time-givers, and how do other time-givers take over in joint innovation settings?

Finally, an innovation ecosystem comprises multiple actors that often cross various sectors, however drawing the precise boundaries of an ecosystem is virtually impossible. While we carefully selected the actors involved, shifting the boundaries of the ecosystem and researching ecosystems with more (groups of) actors or with less (groups of) actors may provide useful insights to extend our findings. In this respect, it would be interesting in what ways and/or forms other nested systems show clear similarities and/or differences in the way the larger system of interest functions.

5.2. Managerial Implications

Innovation ecosystems raise many new challenges for the managers of the participating organizations, especially when they attempt to bridge competing temporal perspectives and cope with potentially diverging local goals. Our empirical findings suggest a number of practical recommendations to business practitioners, policy makers and other actors seeking to reach temporal fit engaging in innovation ecosystems.

First, business practitioners and policy makers have to become aware of major differences in temporal innovation activities and need to develop an open mindset toward learning how to achieve temporal fit and effective collaboration. In this respect, any com-

plex constellation for innovation requires actors to dynamically balance between meeting competing temporal structures and safeguarding their local goals and temporal structure.

That is, a major challenge for business practitioners and policy makers is to achieve temporal fit with complementary organizations that embrace conflicting interests, temporal structures, and time-givers. However, the elusive and competitive nature of co-innovating collective innovation outcomes may create a vulnerable collaborative setting prone to sub-optimal performance. To enhance the overall efficacy of the collaborative setting, the co-innovating organizations should make every effort to avoid one solely complying with its own interest and temporal structure. Hence, it is vital that managers try to understand the role of their organization within the ecosystem, the impact of local actions on the viability of the entire system, and how their complementary assets enhance the overall functioning of the system (see e.g., [37] for a hands-on tool).

6. Conclusions

In this article, we argue that a more complete understanding of an innovation ecosystem's functioning arises from considering how actors coordinate their innovation practices across multiple temporal structures and time-givers. By drawing on an in-depth case study of the development of the Dutch charging infrastructure for electric vehicles, we highlight the complex dynamics that the various actors face when they collaborate toward a collective goal. Our findings suggest that ecosystem actors generate three kinds of entrainment dynamics: (1) temporal tug-of-war through ecosystem configuration; (2) temporal dictating through group politics; and (3) ecosystem navigation through temporal ambivalence. Notably, these dynamics manifest themselves simultaneously and tend to reinforce each other, ultimately constraining the realization of the joint goal.

This study serves to advance extant theories of temporal work and innovation in several ways, as previously outlined. These insights are highly relevant in today's interconnected world in which many organizations need to coordinate interdependencies across different activities, organizations, and industries—for example in rapidly evolving energy ecosystems. Future work should test and refine these dynamics in other cases, to further establish the validity and generalizability of the main findings and also explore other collaborative mechanisms for leveraging technology development in emerging innovation ecosystems.

Author Contributions: Conceptualization, W.P.L.v.G., B.W. and S.A.M.D.; methodology, W.P.L.v.G. and S.A.M.D.; formal analysis, W.P.L.v.G., B.W. and S.A.M.D.; investigation, W.P.L.v.G.; resources, W.P.L.v.G., B.W. and S.A.M.D.; data curation, W.P.L.v.G.; writing—original draft preparation, W.P.L.v.G.; writing—review and editing, W.P.L.v.G., B.W., S.A.M.D. and A.G.L.R.; visualization, W.P.L.v.G.; supervision, B.W., S.A.M.D. and A.G.L.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

CPO	Charge Point Operator
DSO	Distribution System Operator
EV	Electric Vehicle
JVP	Joint Value Proposition
MSP	Mobility Service Provider
R&D	Research & Development

Appendix A. Interview Protocol

- A. Introduction
- B. Interviewee background

1. Can you tell me about yourself? Ask about:
 - a. Personal (professional) background
 - b. Present function and role in the organization
 - c. Main (daily) tasks and objectives of these tasks
- C. **Organization**
 2. Can you tell me about the organization? Ask about:
 - a. Organization's vision, mission, strategy (incl. objectives) and organizational structure
 - b. Organization's core capabilities, performance and recent (major) developments
 - c. The importance and definition of innovation and ecosystems
 - d. Innovation strategy/policy, innovation processes, and joint innovation approach
 - e. Organization's interest, perspective and strategy/policy regarding energy transition and electric mobility
 - f. Temporal innovation practices, planning horizon, decision making processes/speed
 - g. Attitude/approach to new external initiatives and (joint) innovation practices
 - h. Organization's capabilities/attitude to achieve (external/internal) fit in joint innovation
- D. **Innovation ecosystem and characteristics**
 3. Can you tell me about the development of the public charging infrastructure? Ask about:
 - a. Organization's involvement and complementary asset(s)
 - b. Public charging infrastructure related innovation activities and approach
 - c. Ecosystem mapping: joint value proposition/shared goal, actors, roles, interests, complementary assets of perceived ecosystem members
 - d. Impression of the ecosystem's functioning, incl. organization's desired configuration
 - e. General enablers/barriers to develop the public charging infrastructure
 4. Can you tell me about the interaction/dynamics between the ecosystem members? Ask about:
 - a. Joint innovation process
 - b. Perceived strategic behavior/innovation practices of co-innovating organizations
 - c. Dynamics between ecosystem members/how members reinforced or counteracted each other (incl. examples how dynamics are reflected)
 - d. Organization's mindset/efforts to accept differences and characteristics
 - e. Organization's synchronization opportunities/strategies (ask about coalitions)
 - f. Barriers/enablers to achieve fit with co-innovation organizations
 - g. Anticipated/implemented innovation strategies and practices to address (mis)fit
 - h. Consequences of (mis)fit and strategic reactions
 - i. Perception/expectations of future innovation initiatives/actions on organization as well as ecosystem level
 - j. Next steps, view on required actions to create a viable ecosystem
- E. **Completion and further remarks**

Appendix B. Coding Scheme

Concept	Definition	Illustrative Quotes
Temporal tug-of-war through ecosystem configuration	Tensions that emerge across actors who embrace different temporal innovation practices and strategies. Practices and strategies aimed at influencing the ecosystem's configuration to safeguard individual interests synchronized to their familiar temporal structures and time-giver.	(I) (II) (III) (...)
Temporal dictating through group politics	Dynamics that emerge when ecosystem actors seek to establish coalitions aimed to dictate the configuration of the ecosystem. Coalitions in which actors seek to safeguard their main local goals and thereby synchronize their innovation practices to a single (for the coalition) dominant time-giver.	(I) (II) (III) (...)
Ecosystem navigation through temporal ambivalence	Tensions that emerge when actors of dominant coalitions tend to deviate from the group of actors. That is, coalition actors pursue ambivalent practices to bridge co-innovating actors' temporal structures.	(I) (II) (III) (...)

References

- Adner, R. Match Your Innovation Strategy to Your Innovation Ecosystem. *Harv. Bus. Rev.* **2006**, *84*, 98–107.
- Adner, R. Ecosystem as Structure: An Actionable Construct for Strategy. *J. Manag.* **2017**, *43*, 39–58. [\[CrossRef\]](#)
- Barkema, H.G.; Baum, J.A.C.; Mannix, E.A. Management Challenges in a New Time. *Acad. Manag. J.* **2002**, *45*, 916–930.
- Barney, J. Special Theory Forum the Resource-Based Model of the Firm: Origins, Implications, and Prospects. *J. Manag.* **1991**, *17*, 97–98. [\[CrossRef\]](#)
- Jacobides, M.G.; Cennamo, C.; Gawer, A. Towards a Theory of Ecosystems. *Strat. Manag. J.* **2018**, *39*, 2255–2276. [\[CrossRef\]](#)
- Reinecke, J.; Ansari, S. When Times Collide: Temporal Brokerage at the Intersection of Markets and Developments. *Acad. Manag. J.* **2015**, *58*, 618–648. [\[CrossRef\]](#)
- Bakker, S.; Maat, K.; Van Wee, B. Stakeholders Interests, Expectations, and Strategies Regarding the Development and Implementation of Electric Vehicles: The Case of the Netherlands. *Transp. Res. Part A Policy Pract.* **2014**, *66*, 52–64. [\[CrossRef\]](#)
- Wolbertus, R.; Jansen, S.; Kroesen, M. Stakeholders' Perspectives on Future Electric Vehicle Charging Infrastructure Developments. *Futures* **2020**, *123*, 102610. [\[CrossRef\]](#)
- Kaplan, S.; Orlikowski, W.J. Temporal Work in Strategy Making. *Organ. Sci.* **2013**, *24*, 965–995. [\[CrossRef\]](#)
- Orlikowski, W.J.; Yates, J. It's about Time: Temporal Structuring in Organizations. *Organ. Sci.* **2002**, *13*, 684–700. [\[CrossRef\]](#)
- Garud, R.; Tuertscher, P.; Van de Ven, A.H. Perspectives on Innovation Processes. *Acad. Manag. Ann.* **2013**, *7*, 775–819. [\[CrossRef\]](#)
- Granqvist, N.; Gustafsson, R. Temporal Institutional Work. *Acad. Manag. J.* **2016**, *59*, 1009–1035. [\[CrossRef\]](#)
- McGivern, G.; Dopson, S.; Ferlie, E.; Fischer, M.; Fitzgerald, L.; Ledger, J.; Bennett, C. The Silent Politics of Temporal Work: A Case Study of a Management Consultancy Project to Redesign Public Health Care. *Organ. Stud.* **2018**, *39*, 1007–1030. [\[CrossRef\]](#)
- Ancona, D.; Chong, C. Entrainment: Pace, Cycle, and Rhythm in Organizational Behavior. *Res. Organ. Behav.* **1996**, *18*, 251–284.
- McGrath, J.E.; Kelly, J.R. *Time and Human Interaction: Toward a Social Psychology of Time*; Guilford Press: New York, NY, USA, 1986.
- Standifer, R.; Bluedorn, A.C. Alliance Management Teams and Entrainment: Sharing Temporal Mental Models. *Hum. Relat.* **2006**, *59*, 903–927. [\[CrossRef\]](#)
- Pérez-Nordtvedt, L.; Payne, G.T.; Short, J.C.; Kedia, B.L. An Entrainment-Based Model of Temporal Organizational Fit, Misfit, and Performance. *Organ. Sci.* **2008**, *19*, 785–801. [\[CrossRef\]](#)
- Bluedorn, A.C.; Jaussi, K.S. Organizationally Relevant Dimensions of Time across Levels of Analysis. In *Multi-Level Issues in Organizations and Time*; Emerald Group Publishing Limited: Bingley, UK, 2007; pp. 187–223. [\[CrossRef\]](#)
- Dibrell, C.; Fairclough, S.; Davis, P.S. The Impact of External and Internal Entrainment on Firm Innovativeness: A Test of Moderation. *J. Bus. Res.* **2015**, *68*, 19–26. [\[CrossRef\]](#)
- Khavul, S.; Pérez-Nordtvedt, L.; Wood, E. Organizational Entrainment and International New Ventures from Emerging Markets. *J. Bus. Ventur.* **2010**, *25*, 104–119. [\[CrossRef\]](#)
- Shi, W.; Prescott, J.E. Rhythm and Entrainment of Acquisition and Alliance Initiatives and Firm Performance: A Temporal Perspective. *Organ. Stud.* **2012**, *33*, 1281–1310. [\[CrossRef\]](#)
- Hilbolling, S.; Berends, H.; Deken, F.; Tuertscher, P. In and out of Sync: Temporal Coordination in Digital Innovation Ecosystems. In Proceedings of the 11th International Process Symposium: Organising in the Digital Age: Understanding the Dynamics of Work, Innovation, and Collective Action, Chania, Grækenland, 19–22 June 2019.
- Autio, E.; Thomas, L. Innovation Ecosystems. In *The Oxford Handbook of Innovation Management*; OUP: Oxford, UK, 2014; pp. 204–288.
- Walrave, B.; Talmar, M.; Podoyntsyna, K.S.; Romme, L.G.A.; Verbong, G.P.J. A Multi-Level Perspective on Innovation Ecosystems for Path-Breaking Innovation. *Technol. Forecast. Soc. Change* **2018**, *136*, 103–113. [\[CrossRef\]](#)
- Eisenhardt, K.M.; Graebner, M.E.; Sonenshein, S. Grand Challenges and Inductive Methods: Rigor without Rigor Mortis. *Acad. Manag. J.* **2016**, *59*, 1113–1123. [\[CrossRef\]](#)
- Ferraro, F.; Etzion, D.; Gehman, J. Tackling Grand Challenges Pragmatically: Robust Action Revisited. *Organ. Stud.* **2015**, *36*, 363–390. [\[CrossRef\]](#)

27. George, G.; Howard-Grenville, J.; Joshi, A.; Tihanyi, L. Howard-Grenville, Aparna Joshi, and Laszlo Tihanyi. Understanding and Tackling Societal Grand Challenges through Management Research. *Acad. Manag. J.* **2017**, *59*, 1880–1895. [\[CrossRef\]](#)
28. Dykes, B.J.; Hughes-Morgan, M.; Kolev, K.D.; Ferrier, W.J. Organizational Speed as a Dynamic Capability: Toward a Holistic Perspective. *Strateg. Organ.* **2019**, *17*, 266–278. [\[CrossRef\]](#)
29. Bansal, P.; DesJardine, M.R. Business Sustainability: It Is about Time. *Strateg. Organ.* **2014**, *12*, 70–78. [\[CrossRef\]](#)
30. Holm, P. The Dynamics of Institutionalization: Transformation Processes in Norwegian Fisheries. *Adm. Sci. Q.* **1995**, *40*, 398–422. [\[CrossRef\]](#)
31. Eisenhardt, K.M.; Brown, S.L. Time Pacing: Competing in Markets That Won't Stand Still. *Harv. Bus. Rev.* **1998**, *76*, 59–70. [\[PubMed\]](#)
32. Hopp, C.; Greene, F.J. In pursuit of time: Business plan sequencing, duration and intraentrainment effects on new venture viability. *J. Manag. Stud.* **2018**, *55*, 320–351. [\[CrossRef\]](#)
33. Crossan, M.; Cunha, M.P.; Vera, D.; Cunha, J. Time and Organizational Improvisation. *Acad. Manag. Rev.* **2005**, *30*, 129–145. [\[CrossRef\]](#)
34. Gersick, C.J.G. Pacing Strategic Change: The Case of a New Venture. *Acad. Manag. J.* **1994**, *37*, 9–45.
35. Adner, R.; Kapoor, R. Value Creation in Innovation Ecosystems: How the Structure of Technological Interdependence Affects Firm Performance in New Technology Generations. *Strateg. Manag. J.* **2010**, *31*, 306–333. [\[CrossRef\]](#)
36. Kim, A.; Bansal, P.; Haugh, H. No Time like the Present: How a Present Time Perspective Can Foster Sustainable Development. *Acad. Manag. J.* **2019**, *62*, 607–634. [\[CrossRef\]](#)
37. Talmar, M.; Walrave, B.; Podoyntsyna, K.; Holmström, J.; Romme, A.G.L. Mapping, analyzing and designing innovation ecosystems: The Ecosystem Pie Model. *Long Range Plan.* **2020**, *53*, 101850. [\[CrossRef\]](#)
38. Gibbert, M.; Ruigrok, W.; Wicki, B. What Passes as a Rigorous Case Study? *Strateg. Manag. J.* **2008**, *29*, 1465–1474. [\[CrossRef\]](#)
39. Zweistra, M.; Janssen, S.; Geerts, F. Large Scale Smart Charging of Electric Vehicles in Practice. *Energies* **2020**, *13*, 298. [\[CrossRef\]](#)
40. Helmus, J.; Spoelstra, J.; Refa, N.; Lees, M.; Hoed, R.V.D. Assessment of public charging infrastructure push and pull rollout strategies: The case of the Netherlands. *Energy Policy* **2018**, *121*, 35–47. [\[CrossRef\]](#)
41. van der Kam, M.; van Sark, W.; Alkemade, F. Multiple roads ahead: How charging behavior can guide charging infrastructure roll-out policy. *Transp. Res. Part D Transp. Environ.* **2020**, *85*, 102452. [\[CrossRef\]](#)
42. Madina, C.; Zamora, I.; Zabala, E. Methodology for Assessing Electric Vehicle Charging Infrastructure Business Models. *Energy Policy* **2016**, *89*, 284–293. [\[CrossRef\]](#)
43. Locke, K. *Grounded Theory in Management Research*; SAGE Publications Ltd.: London, UK, 2001.
44. Shah, S.K.; Corley, K.G. Building Better Theory by Bridging the Quantitative–Qualitative Divide. *J. Manag. Stud.* **2006**, *43*, 1821–1835. [\[CrossRef\]](#)
45. Eisenhardt, K.M. Building Theories from Case Study Research. *Acad. Manag. Rev.* **1989**, *14*, 532. [\[CrossRef\]](#)
46. Miles, M.B.; Huberman, A.M.; Saldana, J. Fundamentals of Qualitative Data Analysis. In *Qualitative Data Analysis: A Methods Sourcebook*; SAGE Publishing: Thousand Oaks, CA, USA, 2014; pp. 69–104.
47. Clarysse, B.; Wright, D.; Bruneel, J.; Mahajan, A. Creating value in ecosystems: Crossing the chasm between knowledge and business ecosystems. *Res. Policy* **2014**, *43*, 1164–1176. [\[CrossRef\]](#)