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The Missing Link

Business Models Lock-in in Sociotechnical Transitions

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"Truth is ever to be found in simplicity, and not in the multiplicity and confusion of things" – Isaac Newton

Abstract

Societal and environmental challenges present challenges for our current industrial systems. In order to respond to these difficulties, various alternative systems have been suggested, as they promise sustainability and increased societal quality of life enabled by innovative technologies. These future solutions hold the capacity to solve problems by unlocking considerable business potential. However, the journey to the forthcoming era will bring dramatic changes, not only to the success of incumbent industrial stakeholders but also to their very existence. The upcoming changes are impregnated with hazards to current business models of successful organizations. So, one may ask what impact future technologies may have on the realms that industrial actors live in? To disentangle the complexity of these unknowns, multitudes of collaborative efforts in protected spaces have emerged globally to experiment with potential systems on the road to sociotechnical transitions.

The transport sector is undergoing efforts towards transitions to future sustainable systems. This sector has a special focus when it comes to sustainability challenges due to its substantial economic and environmental impact. Bus systems are at the heart of this challenge due to the central role they play in urban mobility. Hence, different fuels and charging technologies for buses have been tested in pilot projects to facilitate the march towards sustainability; electric charging is one of the promising technologies, which achieve this aim. However, current business models of incumbent transport stakeholders seem to be problematic, and changes to facilitate the transitions seem to be complex.

Extant literature indicates a critical role of business models under sociotechnical transitions. Theoretically, there is an underlying need for incumbents to change their business models to reap the benefits of innovative technologies. However, this change is difficult and potential business models are far from clear. With that, the dynamics of business models under transition remains as an underexplored area, and the challenge to incumbent business models poses itself as an interesting area to gauge. Under this

umbrella, a question arises regarding how the pressure on incumbent business models interacts with systemic innovations.

This thesis is a case study of an incumbent bus operator participating in a pilot project on a future bus system. The case study is in-depth in nature and investigates the potential business model of a bus operator in a multiple stakeholder pilot project, which tests an inductive electric hybrid bus. With a strong empirical exploratory nature, this thesis is built on an "insider" single case study that occurred in the year 2016-2017. The focus of the study is on the pressure on bus operator business model in the face of systemic innovation. The findings reveal positive future value proposition, disrupted value creation, and unclear value capture in the potential business model of the operator. Moreover, the findings show lock-in and resource dependence situation of the operator's current business model. The lock-in of the business model hinder the transition to future sociotechnical bus system and makes it difficult to commercialize the new technology.

The outcome of this thesis speaks to a significant influence of history and the regulator, manifested by rules on the future of business models of commercial incumbent stakeholders. This demonstrates that a lock-in situation may prove to be a major impediment, and that unchained and flexible business models of incumbents are critical for further continuation of successful shifts. Given these findings, this thesis suggests applying the business model lens to pilot projects for sustainability. This would aid in better comprehending how current business models may facilitate or hinder favorable transitions. This knowledge informs both managerial decisions and policy making, especially when it comes to resource optimization and investment decisions.

Keywords: Business Models, Sociotechnical Transitions, Lock-in, Resource Dependence.

Sammanfattning

Samhälls- och miljöutmaningar bestrider våra nuvarande industriella system. För att möta dessa svårigheter har olika alternativa system föreslagits, som anses medföra hållbarhet och ökad livskvalitet som möjliggörs av innovativ teknik. Dessa framtida lösningar har kapacitet att lösa problem genom att låsa upp stor affärspotential. Resan till den kommande eran kommer dock att medföra dramatiska förändringar, inte bara för framgångsrika industriella intressenter utan också för deras verklighet. De kommande förändringarna kommer med risker för framgångsrika organisationers nuvarande affärsmodeller. Så man kan fråga sig vilken inverkan framtida teknologier kan ha på de världar som industrins aktörer verkar inom? För att utröna den okända komplexiteten har en mängd samarbetsinsatser i skyddade miljöer uppstått globalt för att experimentera med potentiella system på vägen till socioteknisk förnedringar.

Inom transportsektorn genomförs ansträngningar för övergång till framtida hållbara system. Denna sektor har ett särskilt fokus när det gäller hållbarhetsutmaningar på grund av sektorns stora ekonomiska och miljömässiga konsekvenser. Bussystem är ett av centrala områden i denna utmaning på grund av den centrala roll som de spelar för mobilitet i städerna. Därför har olika bränslen och laddningstekniker för bussar testats i pilotprojekt för att underlätta förändring mot hållbarhet. Elektrisk laddning är en av de lovande teknikerna som uppnår detta mål. De nuvarande affärsmodellerna för befintliga transportintressenter tycks dock vara problematiska, och förändringar för att underlätta övergångarna verkar vara komplexa.

Omfattande litteratur indikerar en kritisk roll för affärsmodellerna under socioteknisk övergångar. Teoretiskt sett finns det ett underliggande behov för etablerade företag att ändra sina affärsmodeller för att dra fördel av innovativ teknik. Denna förändring är dock svår och potentiella affärsmodeller är långt ifrån uppenbara. Med detta sagt utgör dynamiken hos affärsmodeller under övergång ett underforskat område, och utmaningen för befintliga affärsmodeller är i sig självt ett intressant område att analysera.

Under detta paraply uppstår en fråga om hur trycket på befintliga affärsmodeller interagerar med systemiska innovationer.

Denna avhandling är en fallstudie av en bussoperatör som deltar i ett pilotprojekt om ett framtida bussystem. Fallstudien är djupgående och undersöker en bussoperatörs potentiella affärsmodell i ett pilotprojekt med flera intressenter, som testar en induktiv elektrisk hybridbuss. Med en stark empiriskt undersökande karaktär bygger denna avhandling på en "insider" - studie som inträffade under åren 2016–2017. Studiens fokus ligger på trycket på busoperatörsmodellen inför systemisk innovation. Resultaten visar positiva framtida värdeerbjudanden, en disruption av value careation och oklar value capture i operatörens potentiella affärsmodell. Dessutom visar resultaten att inlåsning och resursberoende präglar operatörens nuvarande affärsmodell. Inlåningen i affärsmodellen hindrar övergången till det framtida sociotekniska bussystemet och gör det svårt att kommersialisera den nya tekniken.

Resultatet av denna avhandling vittnar om ett betydande inflytande av historia, som utgörs av regler för framtida affärsmodeller för kommersiellt ansvariga aktörer. Detta visar att flexibla affärsmodeller är kritiska och lock-in kan visa sig vara ett stort hinder för fortsättning på framgångsrika förändringar. Utifrån dessa resultat föreslås i denna avhandling att den teoretiska linsen för affärsmodeller används till pilotprojekt som kan medföra ökad hållbarhet. Detta skulle hjälpa till att bättre förstå hur nuvarande affärsmodeller kan underlätta eller hindra goda övergångar. Denna kunskap informerar både ledningsbeslut och beslutsfattande, särskilt när det gäller resursoptimering och investeringsbeslut.

Nyckelord: *Affärsmodeller, Sociotekniska förnedringar, Inlåsning, Resursberoende.*

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1. Introduction

A definition of ***Missing Link***: An absent member needed to complete a series or resolve a problem ~ *Merriam Webster Online, Retrieved April 2019*.

A long time in the future, in a city that is yet to be born, where the environment is uncontaminated, everyone will be heading home after a hard day at work in noiseless shared automobiles. Everyone will be using buses that are friendly to the environment. In a city that is yet to be born, charging infrastructure is invisible and power cables are history. Everything moves smoothly in this future city that is guarded by consciousness and guided by visionary plans. Nevertheless, the road to this utopia is long and winding; it requires radical transformations and is marked by hard effort. An empirical illustration of such effort is an electric charging pilot project for buses in Södertälje, Sweden where this thesis is anchored. Nevertheless, what motivates such efforts? Where does the need for radical shifts come from?

Industrialization has yielded more stable and prosperous societies over many centuries. However, this progress has not materialized without a heavy price to pay. Global warming is one consequence of our industrial success and by all accounts, it poses an imminent threat to our survival as human race. The operations of industrial sectors including transport have yielded unintended consequences including harmful emissions. To counter these unfavorable outcomes, nations across the world have enacted laws that guide a new industrial march towards a sustainable future. For instance, the governments of Britain and France plan to ban diesel and petrol driven vehicles by 2040. Sweden has also pledged to cut all greenhouse gas emissions by 2045. For the transport sector, the ambition is to be fossil fuel free by 2030.

According to a multiple level perspective on system innovation provided by Geels (2002), the new rules above represent interventions that challenge the current transport socio-technical regimes (buses, cars, trucks, etc.), these regimes encompass not only firms, technology, and activities of engineers, but also other social groups such as users, policy makers, civil society actors, (Geels, 2012, 2002). Such interventions may trigger a shift to a new sociotechnical system which is more environmentally efficient (Geels, 2005; Geels and Kemp, 2007). However, these actions involve challenges and

uncertainties related to potential alternatives to our current systems. This situation has motivated public and private actors to work together to tackle these challenges. Therefore, in order to reduce the uncertainty of the future, R&D programs, demonstrations, and pilot projects have been established around the world to test alternative and sustainable technologies. Such pilots embody the future systems and act as proxies of the unrealized prospect. In the words of socio-technical transition scholars, these pilot projects can be understood as protected spaces where the novelties can be nurtured and tested in in the quiet waters away from the stormy market forces.

The empirical focus of this thesis is in one of these pilot projects, the electric bus project in Södertälje, a town to the south of Stockholm. This project was aimed at testing an electric charging bus system built by multiple bus system actors. In this system, the electric energy supply to the bus takes place during bus circulation, which is called, opportunity charging. The bus in the pilot project was charging through static wireless power transfer (inductive) from a charging station under the ground. This bus pilot project novelty promises a bright potential for bus systems manifested in inductive technology, aesthetic nature, energy efficiency, and reduction of harmful emissions. The logic of the proposed bus system differs from the current models where the bus fuels/charges in depots at nighttime before operations. The expected change would increase the transport operation time due to charging within operations

In this project, the participant bus system actors were: Scania (a manufacturer of trucks and buses), Vattenfall (an energy provider), Bombardier (a Canadian manufacturer of aircrafts and trains), SL (the public transport authority in Stockholm), Nobina (a public transport operator), Södertälje municipality, and ITRL (Integrated transport Research lab), a research center at KTH the royal institute of technology in Stockholm. The actors in the project worked collaboratively during the period December 2014 to December 2017. The installation of charging infrastructure under the ground and development of the bus went hand in hand until March 2017 when the first field-testing of inductive opportunity charging in the Nordics has occurred. This initiative was carried out within the framework of the Swedish Energy Agency's demonstration program for electric vehicles, which aims to identify and solve

barriers to a large-scale introduction of electric vehicles on the Swedish market. This pilot project constitutes a novelty presenting a radical alternative, a micro level technological niche (Geels 2002).

The radical alternatives like the electric charging bus pilot project were introduced as niches and face a strong clash with stable transport regimes. This tension is due to the fact that the alternatives are more expensive as they did not yet benefit from economies of scale and learning curves, and they may require changes to user practices, mismatch current regulations, and lack appropriate infrastructure (Geels, 2002). Therefore, these novelties have uncertainty about price/performance, precise demand, and impact, this triggers complications for future thinking, analysis, calculations, and models, including business models. This might be one of the reasons why the business model construct has been gaining popularity among practitioners and academic scholars (Amit and Zott, 2001; Chesbrough and Rosenbloom, 2002; Magretta, 2002; Teece, 2010; Casadesus-Masanell and Ricart, 2011; Baden-Fuller and Haefliger, 2013; Bolton and Hannon, 2016). The business model explains how an organization works, links the organization to the external world, and revolves around what value is proposed, how it is created and captured so as to take advantage of business opportunities (Amit and Zott, 2001; Magretta, 2002; Johnson *et al.*, 2008).

This thesis is a case study of a bus operator incumbent participating in a pilot project whose business model is hindering the transition to future bus systems. Incumbent business models may be problematic as the current practices are challenged by sustainable technologies (Bohnsack *et al.*, 2014). Therefore, incumbents may be required to change their business models to unlock economic value in new innovations (Chesbrough and Rosenbloom, 2002). However, incumbents are challenged when changing their business models in practice (Frishammar and Parida, 2019). Several challenges to business model alteration and redesign such as internal hurdles. Some of these hurdles are: balancing coaching new units without interfering with exploration, competition over resources among current and potential business models, resistance to change, and lack of sufficient data to analyze the future business models (Chesbrough, 2010; Chesbrough and Rosenbloom, 2002; Sund et al., 2016; Teece, 2010; Zott and Amit, 2010).

Finally, future business models are unclear under transitions (Tongur and Engwall, 2014).

While extant literature on business models in transition sheds light on this problem, further research is needed on business models to advance knowledge on management of sustainable transitions. More specifically, the understanding of business models dynamics under transition leading to industry transformation is underexplored (Schaltegger *et al.,* 2016). Might lack of awareness in such a critical area lead to ill-informed decisions about pilot projects? Could this lead to waste in critical investment resources? Further research has also been called in order to understand whether commercialization of technological innovations via an existing or novel business models matters (Bidmon and Knab, 2018). Without such knowledge, might organizations derail from tracks while managing their development activities towards the future? One may argue that awareness in this area would help in clarifying future roles of the incumbent and new actors, the potential future interactions in value networks, as well as guiding policy makers in their upcoming decisions.

This study shows how the adjustment that the innovative bus system posed (stopping during operations for few minutes) have strong impact on the potential business model of the operator. More specifically, while positive value proposition is envisaged, future value creation may be disrupted and value capture is vague. This thesis shows that the shift to opportunity charging electric bud systems places pressure on bus operator incumbent. This shift may be hindered by incumbent's path dependency, which is a rigid action pattern resulting from non-deliberate consequences of past decisions and positive feedback processes leading to persistency with current systems and lock-in (Sydow et al., 2009). By that, the missing flexibility of incumbent business models and missing viability of potential business models is counterproductive to fostering sustainability transitions.

This thesis revolves around the interaction between business models and sociotechnical change to understand the implications of systemic innovation on an incumbent business model. It focuses on how the business model of the bus operator in the pilot project in Södertälje acts as a threshold, hindering

the breakthrough of a future bus system. While exploring the test of the wireless opportunity electric charging technology for a bus system, this thesis addresses the tensions on incumbent business models and their impact on sociotechnical transitions. Finally, this work is delimited by its focus on one incumbent actor in urban public transport context, which may demonstrate a higher influence of city authorities and commons on business in comparison to other industrial contexts like logistics for example. Moreover, this thesis is anchored in one project, namely the opportunity-charging pilot in Södertälje. In that, the study did not cover the user aspect but rather the current and potential future bus operations utilizing a business models lens. Furthermore, this thesis did not span to other projects of similar nature nor to historical projects.

1.1 Structure of the thesis

This thesis is organized in eight chapters. Following the introduction, chapter 2 presents the literature review, which provides the theoretical background of this thesis. In particular, it starts by discussing the sociotechnical transition literature. This part of the work starts by discussing multi-level perspective and transition pathways; it highlights niche innovations and challenges to incumbents' business models, and ends by discussing path dependency and the role of business models in transitions. Afterwards, the second lens is introduced which is the business models. This subsection, starts by introducing the rational and external influence views on business models, this is followed by discussing challenges of changing business models, and ends with presenting a business model framework. Chapter 3 discusses the overall research design of the thesis and describes the data collection and analysis. This chapter ends with presenting the empirical settings of the electric bus pilot project. Chapter 4 discusses and analyses the current and envisaged business models, and ends by presenting the findings of the thesis. In Chapter 5, the thesis findings meet the theory, and then the findings are put in a broader context by discussing the theoretical, policy, and managerial implications. Chapter 6 reiterates the thesis, its contributions, and concluding remarks. Finally, the references and some details about the interview are provided in the last two chapters.

2. Literature Review

This section represents the theoretical background, which presents two lenses utilized in this thesis. The first lens is socio-technical transition, which introduces the transition mechanisms. This is intended to help lay theoretical understandings for the problem of the study. The second lens is the business models, through which the focus on business model reviewing two streams in the literature.

2.1 Sociotechnical transitions

A transition process is a shift from one sociotechnical system to another, not reorienting the current trajectory but rather shifting to a new one. This translates to changes in socio-technical system elements: knowledge base, technologies, infrastructures, regulations, user practices (Geels and Kemp, 2007). This approach relies on the notion that a technological change on its own is not sufficient to drive large-scale changes leading to a transition process. Therefore, the transition is viewed as a process resulting from interactive processes occurring on multiple levels (Geels and Schot, 2007). Geels (2002) introduced a dynamic multi-level perspective (MLP) on system innovation which distinguishes between three levels, (macro) landscape, (meso) sociotechnical regime, and (micro) technological niches, figure (1) visualizes this perspective.

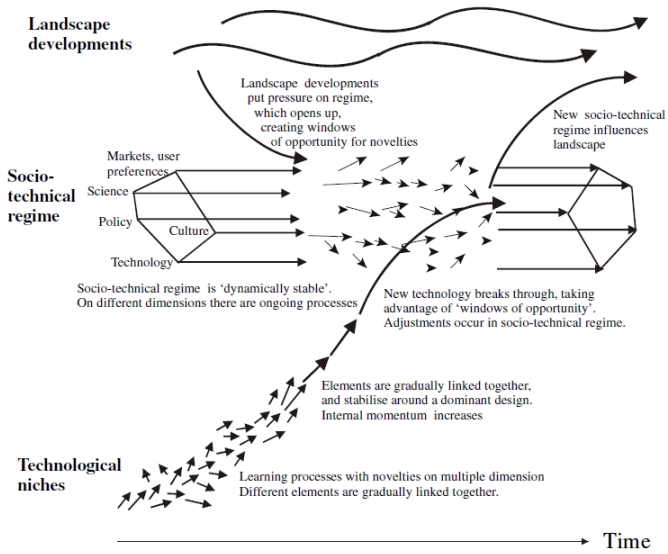


Figure (1) MLP A dynamic multi-level perspective on system innovations (Geels, 2002,p. 1263)

Sociotechnical regimes and change

Geels (2002) suggests the term sociotechnical regimes referring to the set of rules set up and followed by different social groups. This term is a merger between the technological regime concept and the social aspect manifested in rules. Technological regimes are built on harmonization as an outcome of routines built from both organizations and cognition as the actions of organizations and engineers lead to routines which make the technological regimes (Nelson and Winter, 1982). These routines reside in the minds of engineers and developers. Furthermore, the technological regime can be viewed as a set of rules residing in complicated practices of engineers, technologies, products, skills, procedures, ways of handling artefacts and people. The sum of these rules is embedded in institutions and infrastructures (Rip and Kemp, 1998, p. 340). Social commitments on multiple levels – legal (contracts), organizational (producers, users, financiers), and political (state associated actors) – are strong mechanisms to develop large technological systems (Walker, 2000).

Existing regimes are stable (like bus regime), locked in and have path dependence going on predictable trajectories utilizing incremental changes (like the technological advances to develop the combustion engine) (Geels, 2002). Lock in mechanism are shared beliefs which bind the actors to stay within their scope, regulations creating market barriers, consumer beliefs, investments in machines, people and infrastructure, resistance from vested interests, economies of scale (Unruh, 2000; Walker, 2000). This stability is related to the set of rules being deeply seated in practices, structures, manufacturing processes, and product characteristics. Therefore, the trajectories are not only influenced by professionals working on technicalities, but transcend it to all relevant stakeholders: societal groups, scientists, policy makers, the direct users. These groups' activities are guided by a set of rules, therefore. These stable rules and practices may face radical change leading to transition, building on innovative initiatives.

According to Rotmans et al. (2001) the sociotechnical transition has four different phases, see figure (2). First, pre-development phase, occurring in technological niches within the current system. Second, the takeoff phase, where the technology develops within a trajectory and is deployed in small markets. Third, the acceleration phase, where technologies spread and compete with current technologies. Finally, the stabilization phase, where the regime shifts to a new technological system, where the new technology is on mass market level (Geels, 2005). The focus of this study is the future business model of one key actor and the potential changes to a sociotechnical system.

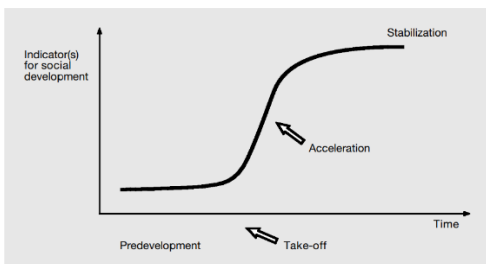


Figure (2), four phases of transition (Rotmans et al., 2001)

According to Geels and Schot (2007), sociotechnical transitions have four possible pathways emerging as a function of two criteria: first, the timing of

the interactions between the landscape pressure on regimes and the state of niche innovations developments, second: the nature of those interactions: whether niche innovations are symbiotic or competitive to the current regime The suggested pathways are the following:

- *P1 Transforming*: This path develops when disruptive change comes at a moment when niches are not sufficiently developed. Then actors within the regime modify the directions of their R&D paths accordingly.

- *P2 De-alignment and re-alignment:* This occurs when landscape disruptive change is abrupt, deviating, and strong. Afterwards, regime actors lose faith and the regime erodes. If niches are not developed at this time, then multiple innovations flourish in the empty space, coexisting and fighting for survival and resources until one niche becomes dominant, forming the core of a new regime.

- *P3 Technological substitution:* This pathway unravels as the sudden strong landscape shock occurs when niche innovations are ready and well-developed. Then those niches break through and replace the eroded regime.

- *P4 Reconfiguration:* This path is created when innovations developed in niches are adopted by the regime to solve local problems, they act as a symbiotic force in the core architecture of the regime. This results in a new order that is built on combinations of new and old elements, leaving most of the rules of the old regime unchanged.

Niche innovations, challenges of radical alternatives to incumbents

Novelties, developing in small niches to satisfy particular use, are held in protected spaces like pilot projects and experimentation in order to allow real-life conditions for better learning. Innovations in niches focus on the geographical area, new technology, or special government intervention where the developments in niches are formed by external developments. The developments shape the expectations and strategies of companies and governance (Geels and Kemp, 2012). Within niche innovations, three social

processes are recognized. First, the articulation and adjustment of expectations or visions serving two roles: giving direction and guidance to internal innovation activities and attracting funding attention from external actors. Second, building social networks enrolling more actors in order to expand the social and resource base of the niche innovations. Third, learning processes on various dimensions, about imperfection of technology and how they may be overcome, issues of organization, market demand, user behavior, infrastructure requirements, policy instruments, and symbolic meanings (Kemp *et al.,* 1998; Schot and Geels, 2008).

Within niches, novel technologies are tested. One important pattern with novel technologies is the hybridization – add-on of new technology with the current technologies. Under this pattern, "*niche innovations do not necessarily compete with existing technologies also entering new combinations with them and in the reconfiguration path. As the technologies are improved and actors gain more experience they may gain prominence leading to a more hybrid form*" then, the new technology might win and dominate the old technology which will either become marginalized or vanish (Geels and Kemp, 2012, p. 61). Therefore, incumbents indulged in transitional periods find themselves working with mixes of the new technology with the old one and potentially expected win of a new innovation. The mechanisms of the potential transition reveal noncompetition between the new technology and the current technology. However, the hybridization between the new technology and the current technology may be a temporary period on the way to a potential full transition.

The innovations brought in niches are intended to be radical: innovation which comprises certain technical knowledge about how to do things better than the status quo (Teece, 1986). Moreover, innovation is about change involving new alternatives (products or processes), deviating from the present in one or more aspects. The nature of such change can be of either a continuous or a discontinuous nature. While the continuous does not incur dramatic changes, the discontinuous entails an irreversible new order (Watzlawick *et al.,* 1974; Burt, 2007). Discontinuity is the unexpected that will disrupt the trends of the present and in this way form the future; a future that is very different from today. A discontinuity can be attributed to a change of

a great degree and can be described by its scale, results, and irreversibility (Ayres, 2000; Drucker, 1968).

The radical alternatives introduced as niches face a strong clash with stable systems as they are more expensive since they did not benefit yet from economies of scale and learning curves, and may require changes to user practices and mismatch current regulations, and lack appropriate infrastructure (Geels, 2002). Therefore, the alternatives carry uncertainty about price/performance, precise demand, and impact and trigger complications for future thinking, analysis, calculations, and models including business models.

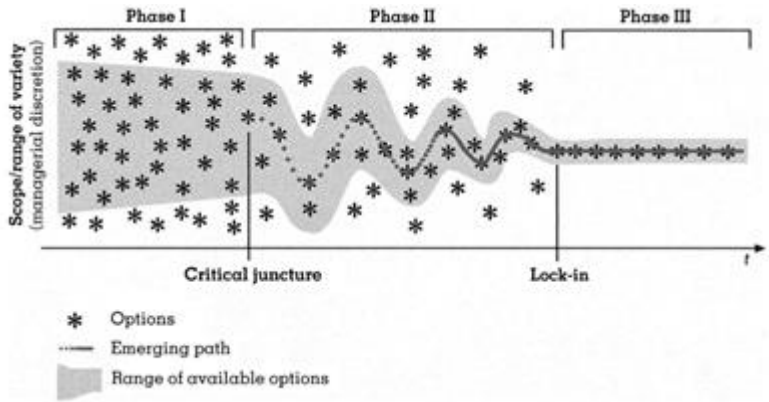
The role of business models in transition

Transition to sustainable technologies provides potential to meet environmental targets. However, such technologies are not commercially viable under the current business models of incumbents (Bohnsack et al., 2014). Thus, changes are needed to existing business models to translate some aspects of the sustainable technologies into new economic value, however, incumbents are cognitively constrained by their existing business models in contrast to new entrants (Chesbrough and Rosenbloom, 2002). Furthermore, future business models are vague under transitions (Tongur and Engwall, 2014). Thus, business models play an important role in transitions with special importance to uncertainties coming when they are changed during transitions.

The transition implies a significant change. This change is difficult for incumbents who have an embedded dominant design and logic (Prahalad, 2004). While this is important to keep the progress going ahead, it blinds the organization to threats and opportunities and keeps its focus within certain boundaries. Discontinuous changes pose pressure on the incumbents leading to potential disruptions to the way business is done at the present. Such challenges defy the current way of doing the work, which often does not appeal to incumbent organizations (Bessant *et al.*, 2014). Within this context, many organizations face a puzzling situation, when signs of an external change are impending, as the majority of organizations are hesitant to change their "business as usual". Prahalad (2004) describes this phenomenon as the

'blinders of dominant logic', which hinder the organization from receiving new signals and allocating resources to prepare for the uncertain future. These dynamics translate to many attributes of the incumbent firms. Specifically, the business models of the incumbents come under subtle challenge with systemic innovations looming on the horizon.

Transitions may be hindered by path dependency of incumbents, the transition such as that of electric vehicles maybe obstructed by the path dependency of current actors. Path dependency is a rigid action pattern resulting from involuntary consequences past decisions and positive feedback processes, this means that history matters and that past events guide future action with persistence in decision making over time, relating to persistency and lock-in (Sydow *et al.,* 2009). It belongs to a natural process marked by two conditions, contingency and self-reinforcement, which causes lock-in in the absence of an exogenous shock (Vergne and Durand 2010). This distinguishes the process of path dependency from the outcome which is lock-in. Incumbents tend to get locked-in to their path due to self-reinforcing mechanisms contributing to development of such paths. Such a pattern is usually accompanied by immediate or potential inefficiencies. Lock-in occurs under three phases, where in phase 1 starting with contingency, there is a critical event or a decision that favors a solution leading to a critical stage. If this triggers a regime of positive self-reinforcing feedback, then the solution becomes persistent and we enter phase 2, this path is likely to be replicated, becoming persistent phasing out of other alternatives to an extent, arriving at a lock-in situation phase 3 (Sydow *et al.,* 2009). Figure (3) presents the three phases that construct the path to lock-ins.



Figure(3) the construction of organizational path

The role of business models under transitions (such as the case studied here, the bus operator business model under potential transition to electric based bus systems) could be three-fold, manifesting as part of the regime or the niche innovations (Bidmon and Knab, 2018). First, the business model as stabilizer could be part of the sociotechnical regime, and thereby, the business models act as industry recipe stabilizing the current systems and hindering the transitions. The second is the business model as a mediator between the niche and the sociotechnical regime, thereby driving the transition for the technological innovation from niche to regime level by linking the technology with actors in the current value network. The third role is the business model as a non-technological niche innovation and as a part of a new regime supporting different types of innovations. Here, the business model acts as a driver for the transition by building up a significant part of the new regime and is independent of technological innovations.

2.2 Business Models

Nature of business models

The business model construct has gained importance both among practitioners and academic scholars reflected in a growing body of literature (Amit and Zott, 2001; Chesbrough and Rosenbloom, 2002; Magretta, 2002; Shafer *et al.*, 2005; Teece, 2010; Casadesus-Masanell and Ricart, 2011; Baden-

Fuller and Haefliger, 2013; Bolton and Hannon, 2016; Kortmann and Piller, 2016). The growth of business models research is reflected in the increasing number of articles which started in the mid-nineties with the advent of the internet (Massa et al., 2017). Moreover, the business model is considered as a unit of analysis spanning the limits of organization (Zott *et al.*, 2011). However, this rising interest came along with a debate on what exactly a business models is as there is no agreement on its nature with no theoretical grounding for the construct in economics or business studies (Teece, 2010; Zott *et al.*, 2011).

Business models are narratives that explain how enterprises work (Magretta, 2002). Moreover, the business model construct is entangled with securing and enhancing the competitive advantage for organizations and revolves around the transactions built to create value in order to take advantage of business opportunities (Amit and Zott, 2001; Johnson *et al*, 2008). It links the organization to the external world, through the exchange of creating and capturing value. It also entails how a company systematizes itself for the purpose of creating and distributing the value ensuring economic viability (Baden-Fuller and Morgan, 2010). The business model has roots in strategy as the construct is a realization reflecting the firm's strategy (Casadesus-Masanell and Ricart, 2010), and provides a vital connection between strategy and processes of a firm (Veit et al., 2014). This aspect of the business model reveals a potential significance for managers working on the business logic and story to create a competitive advantage in relevant markets; this occurs by handling interconnected decision variables in strategic, economic, and architectural contexts (Magretta, 2002; Morris *et al.*, 2005). Hence, the business model is about exploiting a business opportunity for the firm and its business partners (customers, suppliers, etc..) (Johnson *et al.*, 2008; Zott and Amit, 2010). Furthermore, the business model transcends organizing the value chain to figuring the value proposition for customers as well as mechanisms to capture value by mechanisms to turn payments into profits (Teece, 2010). A business model is defined by its function as it coins value proposition, classifies market segment, defines the value chain structure, identifies the revenue generation mechanism, estimates cost details, and describes the firm's position in the value network among suppliers and

customers (Chesbrough, 2010). In the following, the business model design will be discussed considering the different views in literature.

The rational view on business models

In previous literature, the prevalent underlying assumption is that the business model design is guided by a rational management decision of a focal firm (Chesbrough and Rosenbloom, 2002; Teece, 2010; Wirtz et al., 2016; Zott et al., 2011). The business model design creates, according to this literature, value for the firm and its partners, while simultaneously appropriating sufficient value back to the firm (Markides, 2006; Zott and Amit, 2010). Thus, business models are recipes for creative managers as they provide means to describe and classify the business (Baden-Fuller and Morgan, 2010). Furthermore, the managers define the structure of the value chain, which is required to create and distribute the offering, incurring the determination of complementary assets to support the organization's chain position. This process is finalized by estimating the cost structure and profit potential of making the offering and describing the firm's position in the value network (linkages between customers and suppliers) including identification of potential complementors and competitors (Chesbrough & Rosenbloom 2002).

Prominent business model design concepts and frameworks provided in the literature reveal the guidance by managerial choices. First, drawing on Amit & Zott (2001) the design of a business model depicts an activity system that encapsulates interdependent activities, and can be structured into two main areas; the architecture consisting of content, structure and governance; and the value creation sources, including key aspects such as novelty, lock-in complementarities, and efficiency. Another famous approach is the one set by Osterwalder (2004, p. 22) as he portray the business model in his thesis as a canvas with 9 building blocks, suggesting a (Lego brick box) tool given to the business model designer to create new business models.

The role of executive management decisions in business model design is stressed in the literature. Johnson *et al.* (2008) demonstrate the need for executives to understand the business model by identifying its essential parts. Furthermore, they also highlight that executives need to understand what is

needed to construct new business models, which aim at capturing emerging opportunities. In addition, Teece (2010) stresses that business pioneers need not only to be great at product development and innovation, but also in designing their business models in order to create value. Finally, (Zott and Amit, 2010) depict the business model as a deliberately designed activity system considering the designing of the business model as a key decision for entrepreneurs, managers, and corporate leaders, keeping in mind that the activity system may span the organizational boundaries.

The business model design incurs choices on complementary vertical and horizontal activities to perform, and evaluates whether such activities can be done at an appropriate cost to generate sufficient profits (Teece, 2010). In other words, the heart of these design activities is management choices connected to orchestrating the interdependent activities to a common overarching purpose.

The rational view on business models is the major line in the business models' literature and provides important views to practitioners and managers. Moreover, it provides the decision makers with guidance into managerial choices of the design and redesign choices of their business. Furthermore, it informs how the company can utilize its own abilities to capture business opportunities by tailoring their business model design. However, this view falls short on the influence of external environment on business models. Another descriptive stream of the business models describes the external limitations that bounds the business model activities.

External influence on business models

There is a stream of literature that highlights the contextual aspects and external influence on business models, For example, the importance of value network is highlighted, which is the context where the firm identifies and responds to customer needs (Christensen and Rosenbloom, 1995) and by that creating and appropriating value involves third parties. Furthermore, the value network forms the role that suppliers, customers, and third parties play in commercializing innovations. Therefore, aligning with the value network and non-alignment with the value network can dispel value (Chesbrough and Rosenbloom, 2002). Some literature approached business models from

network perspectives which elevates the importance of external stakeholders in the business model design (Coombes and Nicholson, 2013; Mason and Spring, 2011; Palo and Tähtinen, 2013).

Moreover, Pateli & Giaglis (2005) show how the development of business models is affected by contextual factors such as industry structure and balance between transaction costs and costs for internal development, while Björkdahl (2009) revealed how the business model of a firm is highly dependent on market competition. Consequently, the evolution of a company's business model is fundamentally affected by the dynamics of the company's context (Demil and Lecocq, 2010). While Amit and Zott (2010) initiate their views on business models focusing on the choices within the organization. This view is developed when advising managers and entrepreneurs to consider the four antecedents in the design of complex activity systems: goals, templates, activities performed by stakeholders, and environmental constraints (Amit and Zott, 2015). The latter two are related to external influence. First, stakeholder activities connected to collaboration, bringing expertise and talent to the table. This would inform the business model design process. second, the environment constraint gave the example of the uncertainty of building the interaction with other partners. They suggest that entrepreneurs should become novel to counter this challenge. Finally, the stakeholders' role is discussed in terms of expertise and collaboration brought to the table for the design process and suggest that the constraints hold more in emerging markets and start-ups rather than established ones.

While this of thinking acknowledges external influence on business model design, it also shows the importance of industry structure, stakeholders' role in collaborations, as well as environment constraint. However, this thinking still reinforces and assumes the decision is in the hands of the focal firm deciding which activities and functions to undertake, which ones to outsource, and how to govern business models and underestimates the external restrictions and limitations set by external actors. Moreover, while this literature acknowledges the importance of external factors, it does not explain how the business model activities are affected by external

environment. These aspects may prove to be important in the pursuit of understanding why changing business models is challenging for incumbents.

Challenges of changing business models

Firms frequently struggle to change their business models (Frishammar and Parida, 2019). Business model design and innovation incur changes that are difficult for organizations (Chesbrough, 2010; Sund et al., 2016; Teece, 2010). Some challenge to changing the business model in incumbents has been looked at in the literature with an internal organizational focus (Johnson *et al.*, 2008; Sund *et al.*, 2016). This internal focus has manifested itself in internal resistance and competition with the current business model as it is ruled (Chesbrough, 2010; Teece, 2010; Zott and Amit, 2010).

Changing an existing business model, or even refining its current components, will usually encounter organizational hurdles manifested in uncertainties over multiple aspects (Teece, 2010). This situation is often manifested in a resource competition between the existing and the new business models, settling quickly on structure before comprehending the best fit, and balancing coaching new units without interfering with exploration (Sund et al., 2016). Moreover, lack of understanding of the current business model makes it hard to make decisions on altering it (Johnson *et al.,* 2008). Another root to the problem of changing business models extends to the lack of understanding the process of successful transformation of business models, Frishammar and Parida (2019) provided a step-by-step model to counter the difficulty of transforming incumbent business models to circular business models to meet environmental, social and financial goals.

The challenge of exploring new business models has financial, cognitive and managerial aspects. Sund et al. (2016) revealed what incumbents face with such exploration and found three main problems. First, when incumbents attempt to design new business models they face settling quickly on organizational structure for the new business model before maturing and knowing what works best. Second, balancing top management support and experimentation, to protect and coach the new unit but not to steer it and to allow it to explore. Third, a potential power struggle between resources arises between the new and the current business model, hindering the emergence of

the upcoming. Moreover, uncertainty about what the new business model looks like is likely to arise when designing and innovating a new business model. This can be countered through learning (Chesbrough, 2007; Teece, 2010).

Designing a new business model for incumbents incurs three processes: experimentation, effectuation, and leading the change in the organization. However, each of these processes entails inherent difficulties. With experimentation: costs to mimic the real market conditions. With effectuation: cognitive bias of lack of sufficient data to analyze towards a new business model. With leadership, premade challenges are expected: the lack of authority to reconcile conflicts, the feeling of a threat to leadership, a challenge from rotation of management (Chesbrough, 2010).

Altering current business models has its own complications. Rather than creating new business models to be fit for the future, the organizations tends to alter the current business models. Chesbrough (2010) argues that the root of the conflict is between current business models tailored for current technology and the business model required to exploit new opportunities. This means that the information sourced to make corporate decisions supports the old logic. Moreover, when incumbents try to rethink their old business models, cognitive inertia and resistance to change stands out (Teece, 2010; Zott and Amit, 2010). This hurdle stems from the fact that the managers, charged with the mentality related to current business models, are the ones responsible for the reconfiguration of the business model or due to influence of existing dominant business model logic (Chesbrough and Rosenbloom, 2002). Another prominent issue is managerial, including the lack of understanding of the premises, interdependencies, and strengths and limitations of the current business model. This understanding is vital in order to make decisions on when and how to change the business model (Johnson et al., 2008).

A business model framework

In their literature review (Massa et al., 2017) found that the literature treats and interprets the business model in one of three ways. The first is as an attribute of the firm (Zott & Amit 2010; Johnson 2010; Casadesus-Masanell

& Ricart 2011). The second view treats the business model as a cognitive scheme (Baden-Fuller and Morgan, 2010; Chesbrough and Rosenbloom, 2002; Magretta, 2002), and finally the business model is seen as a formal conceptual representation of the firm (Osterwalder *et al.*, 2005; Teece, 2010). In this thesis, the business model is treated as an attribute of the firm, under this notion, "*The attributes are empirically determined classifying real-world manifestations of organizations as a function of their measured similarity on observed variables*" (Massa *et al.*, 2017). This supports identifying business model architypes with terms like, razor and blades, freemium, and subscription etc.

To maintain the simplicity needed in order to trace changes within the business model before and after applying the new technology change, the business model is limited to three key recurring components in the literature, see table (1): value proposition, value creation, and value capture. These dimensions are derived from existing frameworks (Chesbrough and Rosenbloom, 2002; Johnson et al., 2008; Osterwalder et al., 2005; Teece, 2010; Tongur and Engwall, 2014). These elements of business model revolve around the value notion. First the customer value proposition, which articulates the value created for users by the offering based on the technology. Under this notion the company helps the customer to get a job done, which is a fundamental problem in a given situation, therefore organizations need to understand this job and all its dimensions including the process of how it gets done in order to design the offering (Chesbrough and Rosenbloom, 2002; Johnson *et al.*, 2008). Under value proposition the organization promises content (a product and/or a service) to a specific targeted segment of customers (Bohnsack *et al.*, 2014). Second, value creation. This dimension refers to key activities and processes that specify the structure of the value chain for the firm, value creation has sources like novelty, efficiency, complementarities and lock-in (Amit and Zott, 2001; Zott et al., 2011). The subcomponents of value creation may include key activities, resources, partners, and technology required to create and distribute the offering (Chesbrough, 2007; Johnson, *et al.*, 2008). Finally, value capture refers to a business model function showing how the company creates value for itself while it delivers value to its customers. This consists of aspects connected to seizing value throughout some activities leading to earning profits. The subcomponents of value capture are the cost structure (driven usually by main

cost driver(s)), the revenue model (specifying how business generates revenue streams from its products and services), and resource velocity (connected to how quickly resources are needed to support operations) (Johnson *et al.*, 2008).

Table (1) Business model components

Value proposition *Content and segment*	Value Creation *Production\Sales and Governance*	Value capture
Product Service Segment	Key activities Technology Partners Resources	Cost structure Revenue model Resource velocity

3. Methodology

This section discusses the methodology of this thesis including the research design, the data collection process, data analysis, as well as the validity and reliability. Finally, a description of the empirical setting with regards to the project is provided.

3.1 Research Design

This thesis explores the pressure on the incumbent's business model and the challenges of changing business models under sociotechnical transitions. This has been operationalized by studying the pressure on bus operator business model in experimental stage of transition to a future bus system utilizing a pilot project. This pilot project is acting as an agent of a potential sustainable future bus system. To address this aim, a case study approach was adopted. This choice enabled inspiration for new ideas by immersion in rich data, and helped pursue an in-depth understanding of a complex social phenomena (Eisenhardt, 1989; Siggelkow, 2007; Yin, 2009). The data was not used for statistical generalization but rather for in-depth understanding and theory building (Eisenhardt and Graebner, 2007; Flyvbjerg, 2006; Yin, 2009).

The case study was conducted with an in-depth, exploration of the nature of the opportunity charging pilot project, with the purpose of generating abundant knowledge about the challenges that the bus operator face in attempting to change its business model. The pilot project represent an early phase of transition to a future sustainable bus system. The rationale behind this methodological choice is that the case is an up-to-date example of electric bus systems which multiple actors including the operator are participating in. Therefore, the case helped to capture the circumstances and conditions surrounding the business model within a contemporary case (Yin 2009, P48) and enabled knowledge of the incumbent business model's role in the niche phase in the course of potential sociotechnical transition. Finally, the unit of analysis in this thesis is the tension on the incumbent business model of a key actor in a system facing a change presented in a pilot project.

3.2 Data collection

The data collection was done alongside project activities, which included attending project meetings, going on field visits, attending seminars. Moreover, interviews with representatives of project partners and responsible personnel in the organizations were conducted, covering electricity provider, technology supplier, public transport authority, bus manufacturer and bus operator in order to understand the nature of the technological change this potential transition could bring. Further interviews focused on understanding the public bus business, which comprised in-depth interviews with SL (Stockholm Transport Authority) strategists and business specialists. The business model of the operator is explored through in-depth interviews with the operator professionals.

Through the study, the data concerning the pilot project, the technology presented, current bus system, and the bus operator's business model was collected. The focus of the data collection was on the offerings, the value capture logic of the operator, the relationships among the operator, manufacturer, and the transport authority, the inner workings of the business model of the operator, the rules and policies, such as the subsidy polices and different contracting themes. Moreover, to understand the pressure, data was collected on the business models changes needed to facilitate the new bus system. Furthermore, in order to obtain a comprehensive understanding of the subject and to enhance the validity of the study (Yin, 2009), several data collection methods were used, namely, semi-structured interviews, document analysis, and participant observations. The data collected during the study is summarized in table (2).

The study incorporated participant observations of the technical development of the bus system and business perceptions surrounding its future by the operator and the actors/partners. The participant observation comprised 23 project meetings lasting between 2 to 3 hours, and two field work meetings for the development facility of the bus and the charging station. Introductory meetings with the engineers and managers where the scope of research activities was discussed provided additional data to this work.

Semi-structured interviews represented one of the most important sources of data. The set of interviewees was identified together with the project actors' representatives in the project, ensuring representation of a wide range of technical, business, strategic, operational perspectives. Later on in the process, the interviewees were asked to provide further contacts to reduce the initial selection bias. In total, 24 semi-structured interviews were conducted with business strategists, market strategists, engineers, project managers, and other actors. The interviews lasted on one hour or more.

The interviews were complemented with the analysis of project reports, annual report(s) of the operator and business partners in order to understand the workings of the business model. Moreover, technical project documents were reviewed. These documents were chosen with the guidance of the project manager in order to understand the technology aspects of this potential future bus system.

Table (2) A summary for the case study data sources

Data Source	Actors	Respondents/ Sources	Documentation
25 Interviews	-Bus manufacturer (Scania)	- Project manager 1 (1 interview) - Project manager 2 (1 interview) - Bus business development manager (2 interviews) - Business roadmap manager (1 interview) Chief engineer Electromobility at manufacturer (2 interviews)	-Audio recordings -Notes
	-Bus operator (Nobina)	Traffic planner (2 interviews) - Operations engineer (2 interviews) - Bus fleet manager (2 interviews) - Marketing strategy manager (2 interviews)	
	-Public transport authority (SL)	- Senior business strategist (2 interviews) - Bus strategist (2 interviews) Bus and Depot Specialist (1 interviews)	
	-Technical solution supplier (Bombardier)	- Sales manager (1 interview)	

	-Electric energy supplier (Vattenfall) -Municipality (Södertälje) -Transport Research lab (ITRL)	- Head of R&D for E-mobility (1 interview) - Municipality representative (1) - Project board member (2 interviews)	
Participant observation: - 23 Project meetings - 2 Field visits	- Bus operator - Bus manufacturer - Electric Equipment provider -Municipality	- Project meetings attendance - Bus development facility visit - Charging infrastructure site visit	Field notes
Document analysis	- Operator - Solution supplier - Bus manufacturer	- Technology - Project detail - Operational - Financial	- Project documents (meeting notes) Bombardier technical descriptions - Nobina Annual report (2015/2016) - Scania Annual report (2015/2016) -Web material regarding other pilots
2 Industry conferences participation	- ITRL conference - ERS conference	Organizations working on future charging technologies initiatives	Notes

3.3 Data analysis

The data analysis in this thesis occurred simultaneously with the data collection due to its ethnographic nature (Fetterman, 1989, p. 13) of the research. The business model framework in table (2) was applied to the data collected in relation to the bus operator business under the current bus system and the same approach was applied to the operator potential business model under the envisioned bus system. This helped in better visualization of the different dimensions of the current business model, and future required changes. This approach proved to be powerful by sorting and grouping the data in an organized way in preparation for comparison.

The second step was conducting a comparative analysis between the current and envisaged business model to trace the potential changes to the bus system and the business model of the operator as well as the significance of these changes. The comparison tracked the changes to the dimensions of the business model framework manifested in offering, value creation and value capture. The comparison led to concluding results on the business model dependence and lock-in hindering the transition.

The data that was collected was not be used for statistical generalization but rather for building in-depth comprehension (Eisenhardt and Graebner, 2007; Flyvbjerg, 2006). One limitation related to data analysis is manifested in the subjective personal influence of the researcher on data collection and conclusions. However, the awareness of this influence helped interpretation of the data in a better way in order to reach sound conclusions (Alvesson and Sköldberg, 2009). The data collected allowed for triangulation as the data could be verified using various sources and data collection techniques like asking interviewees from different organization, validating data from reports, etc. (Yin, 2009).

3.4 Research Quality

This study examines the challenges on the business model of a key incumbent actor facing transition to a future bus system. While the business model concept has been subject to debate on its nature (Zott *et al.,* 2011; Teece

2010), its potential contribution to the understanding of social technical transitions seems submitted. Furthermore, the author acknowledges that other perspectives could be relevant and may give different interpretations (like policy research, project management, and organization studies). However, the purpose of this thesis was to focus on the potential changes to the business model and the future system rather than on individuals, group dynamics, and organizational focus.

The validity and reliability of the thesis were substantiated by several means. First, the multiplicity of data sources increased the validity of the study (Yin, 2009). Second, preliminary findings were validated through seminars, workshops and presentations, where the project actors discussed and commented on the findings. Third, the researcher tried to remain neutral when conducting interviews, participating in project meetings, field visits as well as analysis and interpretation of the data. Fourth, the reliability was enhanced by providing information on data collection, quotes citing directly from transcribed interviews and comparing the data with findings from the literature (Eisenhardt, 1989).

On the other hand, generalizability is limited in this thesis. As this study has an empirical focus and single case study nature, there are some obvious limitations when it comes to generalizability (Yin, 2009). While the findings of this thesis could be applicable to studies handling future transport systems, it would be difficult to apply these findings to other areas that have a different nature. Furthermore, a multiple case study may be needed to test the findings of this study, as well as to validate the generalizability of the conclusions.

3.5 Empirical Setting

The hybrid-electric bus Pilot project

The research process started as the researcher undertook a role as a project member in a pilot project to study business models considerations in the hybrid–electric bus project utilizing static wireless charging. The project aimed at testing an inductive electric hybrid bus in real traffic with the installation of charging infrastructure on roads located in Södertälje, (a town to the south of Stockholm). The project utilized Bus line 755 for the testing

purposes in Södertälje between Astrabacken and Södertälje Syd (about 4.9 Kms). The overall value of this pilot project was to test and evaluate potential of this system which represents a bus transportation system that could lead to an alternative bus solution that reduces noise, cuts CO2 emissions, improves energy efficiency and decreases fossil-fuel dependency through electrification.

The actors participating in the project were:

- *Scania:* A global leader that provides transport solutions including trucks and buses coupled with services related to them. Scania's responsibility was to lead the project and provide the bus adapted to the new charging technology.

- *Vattenfall:* A Swedish owned uitility company in the energy sector. In this project, the company was responsible for procuring, managing, and installing the charging station.

- *SL:* The public transport authority in Stockholm region responsible for city transportation, mainly: Buses, subway, commuter trains, trams, and ferries. In this project, SL evaluated the potential of the new charging technology and how it may affect the transport system and environment.

- *KTH ITRL:* (Integrated transport Research lab) a research center at the Royal Institute of Technology in Stockholm, ITRL focuses its research on future transport solutions.

- *Södertälje Kommun*: The municipality of Södertälje to the south of Stockholm hosted the project activities and provided support for the installation and operations.

- *Nobina:* A public transport operator that is the largest in the Nordics, Nobina were the winners of the procurement of bus public contract in Södertälje region at the time of the project. Therefore, the responsibility of Nobina was to operate the bus within field tests.

- *Bombardier:* A Canadian manufacturer of aircraft and trains. In this project, Bombardier were responsible for suppling the charging technology equipment.

The funding for this pilot project was provided by *Scania* and the *Swedish Energy Agency* which comes under the Ministry of the Environment and Energy, and which oversees the overall picture of the supply and use of energy in society. Other funding contributions were provided by other partners in the project.

The pilot project started in December 2014 and ended in December 2017. The project consisted of two main phases: the first phase consisting of installation and development lasted from the beginning of the project until March 2017, through which the project actors were engaged in bus development, installing the charging infrastructure, and all work connected to preparation for execution. The second phase of the project, the field test phase, which occurred in the timeline between March 2017 and December 2017. During this phase, the bus operated in real traffic, after the charging infrastructure was in place and the bus was ready for operation. The researcher joined the project in the winter of 2015 when the installation phase was still in progress. The pilot project provided an important venue where the actors could oversee their future roles and how they would change within the future bus system. Furthermore, the project gave insights to the actors on practical problems which occurred while installing the charging systems as well as operational problems and opinions of passengers that evolved during the field test phase.

The two main components of the new bus system were the bus and the electric charging infrastructure. First, the bus to be developed for the purpose of this project was a hybrid-electric bus, as the bus had a combustion engine as well as an electric motor. It had the ability to switch from the electric motor to the combustion engine when necessary, for example when there was a need for high energy such as when ascending a hill. Second, the charging infrastructure technology used in this project was stop inductive electric charging, where the charging unit was installed under the ground. Utilizing this infrastructure, the bus was charged inductively while stationary for a few

minutes at a bus stop. The charging unit consisted of three main parts 1- the primary winding, which transmits energy to the bus, 2- the wayside box, which consisted of energy supply units, 3- a cooling unit. The first two parts located underground while the third part was above ground as shown in figure (4). The innovative aspect of this technology was the fast, wireless charging during bus operation, taking about 6-7 minutes for the battery to charge sufficiently for the route followed.

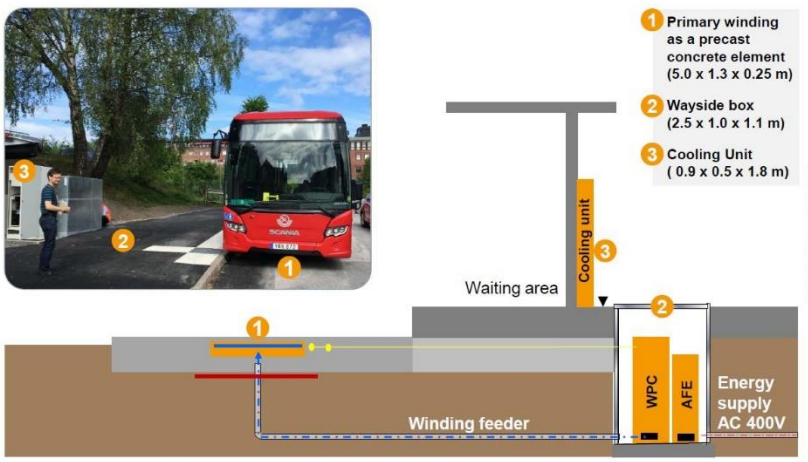


Figure (4) Street cross section of the inductive charging unit

The project results provided learnings for the different actors within the project on multiple levels. These results were the output of surveys, interviews, and field observation by researchers including three researchers. One researcher focus was on the energy aspects, the author of this thesis focus was on business models, and another researcher focused on acceptance of users and drivers for the new system. The research results on energy[1] show a potential positive energy consumption performance was reported had such a charging system been applied on a large scale. The energy consumption was reduced with this technology in comparison with diesel and gas buses,

[1] Towards electrified public bus transport: The case of Stockholm, *PhD Thesis by Maria Xylia,* The Royal Institute of Technology, Stockholm, Sweden.

especially with higher utilization of electric power rather than the hybrid mode. Moreover, the inductive (wireless) charging has an advantage in comparison to conductive charging, by reducing equipment visibility and maintenance cost. Furthermore, there was a positive impression on passengers who rode the bus, as the bus was perceived to be more modern and environmentally friendly. From a user perspective, the survey show a majority of passengers reported a significant noise reduction when the bus was running in electric mode. Bus drivers expressed similar experiences when they reported a quiet and comfortable experience. Finally, the drivers reported a positive experience with electric charging as it happened while people were boarding the bus.

On the other hand, the project output revealed some complications that faced the actors within the pilot project. First, the bus manufacturer reported increasing technical complexity with integrating the electric parts in the bus. Second, the manufacturer's revenue model is largely dependent on after sales maintenance, which may be hampered by electric solutions. This aspect is highlighted by robustness of electric motors and the lower need of the bus for maintenance compared to internal combustion engine buses. One driver reported a charging problem, once when the electric charging did not start due to some technical problems. Furthermore, the infrastructure has received special focus with a conundrum on how the current business models can fit into the new infrastructure and who should be responsible for its cost and ownership, even in a protected environment. In the following chapter, the findings with regards to the challenges of the business model of the operator will be demonstrated.

4. Findings

In the findings section, the operator's current business model will be described according to the theoretical framework dimensions which was presented in section 2.2. Afterwards, the future business model will be shown after applying the opportunity charging. Finally, analytical considerations with regards to transition and business models, where theory meets empirical findings, will be discussed.

4.1 The Bus Operator

Nobina, the bus operator in this pilot project, is a private company which is one of the leading operators in the Nordic bus transportation market. It delivers a service of management and operation of bus traffic. To conduct its operations, the bus operator owns and operates over three thousand buses in Sweden, Norway, Denmark and Finland, which makes up 16% of the total Nordic share of buses making it the market leader. This fleet of buses transports well over 3,000,000 passengers every year. The bus operator operates is in two markets. The first is public bus transport, which is a regional transport operation run under contracts from city transport authorities; the second is express coach travel, which is an interregional operation run under the company's sole management.

The company is comprised of a group of fully-owned subsidiaries, which are organized according to the country and type of business operations. For example, there is a subsidiary that operates public transport in Denmark, and another one operates regional express routes in the same country. According to the operator's annual report, the first market (public bus transport) is significantly larger than the second market (express coach travel). The regional buses constituted approximately 98% of the total number of buses and 96% of the company revenue. The Swedish public bus operation alone comprises 68% of the overall revenue, while the rest covers the other Nordic countries. This study focuses on the public transport market, which reflects the study context and has shown high significance in the total revenues and operations. In order to explain the business aspect of this market, the public transport contracts will now be explained.

In the public transport market, these routes are operated in the public transport market under contracts. The bus operator holds more than 100 contracts for regional traffic covering more than 30 traffic areas. These contracts are managed through tendering or by allocating routes. The former way is becoming the trend and direct assignment has faded as the company owns no contract concessions anymore. The operations are run through contracts with transport buyers who are cities/transport authorities. These contracts are managed on a regional basis where the transport operator promises to deliver bus operations with an average contract length varying from 6 to 8 years. These business conditions are comparable in all Nordics whereas the transport authorities are responsible for supplying the regional public routes.

The core of the business of the bus operator is public bus contracts, where such agreements are set between the transport authority and the operators. These contracts include rules set by the local transport authority to manage the transport in the region in a way to reach their goals. In Stockholm, there are two types of contracts, "production-based contracts", and "passenger-based contracts". In the first logic, the bus operator is compensated based on the mileage that the bus operation has completed. While in the second logic, which is a more recent one, the bus operator is assessed depending on the number of passengers rather than driven distance. In practice, most contracts are a mix of the two logics, and include a revenue model, which typically consists of a fixed share and a variable share, depending on the number of tickets sold to passengers boarding the buses. The contracts are run on regional bases and vary in terms of how the bus operator performance is evaluated and financially compensated. Therefore, the success of the operator's business relies on the successful management of a portfolio of more than one hundred contracts for public bus transport in specified regional areas.

4.2 The operator's public transport business model

The business model of the operator is shaped to match the bus public transport market need, through which the operator can search for potential contracts, manage tendering processes and implement the contracts. This

model is influenced by the fact that the business in the public transport market relies on the contracting with the transport authority. In the following the value proposition, value creation, and value capture aspects will be analyzed.

Value proposition

The value proposition that the bus operator promises is to deliver daily bus services by planning and operating bus traffic in regions. A manager at the operator mentions:

"We try to deliver transport that allows people to move by bus quickly and conveniently to move smoothly like going to work and to entertainments. To meet this challenge, we aim at providing optimized bus solutions".

This offering is provided to municipalities and cities represented by transport authorities in the Nordics, Sweden, Denmark, Finland, and Norway. This promise is delivered under transport contracts in order to efficiently transport passengers utilizing more than 3000 buses and tens of thousands of employees, almost 90% of whom are bus drivers. The transport authority starts tenders for bus transport in regions so the bus operators can deliver their proposals as a business strategist at the transport authority clarifies:

"We procure transport from operators in different regions through a tendering process. However, we don't specify which technology buses should utilize, when we procure the traffic. We need to set some sort of details in the contract, while we stay away from setting certain details".

The public transport authority used to own the buses and to operate them. However, in the last decade, bus public transport has faced deregulation. The new changes opened the market to the bus operator to run any operations in any part of Stockholm without coming back to the transport authority.

While the bus operator is free to choose the offering, it finds this freedom is limited. The bus solutions from bus manufacturers vary in price, performance, and fuel consumption. However, this choice is delimited by environmental guidelines set by the transport authority. Such guidelines are tailored to control the environmental output of the bus operations in the city as a bus strategist at the transport authority specifies:

"*The transport operations have three major impacts on the environment: The emissions, mainly CO2, and then there is noise and energy efficiency usage, for which we provide guidelines to the operators in order to reduce this impact".*

Value creation

In order to deliver the promise, the operator conducts several activities. First, *tendering* which includes all the business activities before the contract and commencement of traffic operations. These activities include prospecting for new business. Within this process, the bus operator searches for contracts and analyses the tenders received from cities, regions, and transport authorities. Afterwards, the operator selects the most attractive tenders depending on margins and risks as the risk assessment is being done through this phase, for the potential tenders to quote contracts. At the end of this phase, the operator submits the tenders and waits to find out the contracts that are won, which marks the beginning of the next step.

The third step is *contract execution* starts in order to ensure the successful execution of operations. This phase incurs traffic planning which is a systemic centralized process that includes scheduling bus routes, timetables, vehicle plans, driver daily and monthly schedules. Traffic planning aims to help use resources efficiently to manage daily bus operations. Traffic planning is followed by traffic management in order to increase cost efficiencies and thereby overall profitability. A traffic planner explains the purpose of this activity:

"*Traffic planning and management ensures the right number of buses with the right specifications are on the right route. This is important to reduce parts of routes with empty seats, to expand the use of renewable fuels, and to increase the number of passengers per bus, thus ensuring the cost efficiency and profitability of contracts*".

This phase incurs procurement of new buses and/or utilizing existing buses which meet the contract demands, as well as building/rental of depots. As the bus fleet manager in the operator states:

"*After winning the contract, we ask for quotes from different manufacturers for a number of buses to fulfil a 10 to 12 year contract, in order to pick the best solution that fits us.*

Which buses to buy and how to utilize them among our different contracts is a key. We also rent or build depots with transport authorities to facilitate the operation".

Traffic is managed in the areas where the operator wins contracts. This is done under a system that can be used by different buses with different fuels available at the depots. This management ensures smooth flow and meeting demands which requires flexibility. The traffic planning activity for the bus operations is highly influenced by certain thresholds set by the transport authority. One traffic planner reflects:

"*The planning regarding bus schedules occur in order to operate for a certain level of frequency demanded by the transport authority. We need to meet specific objectives in terms of operations, timespans, and frequencies. We have some extra margins, but if we exceed these margins then we face penalties*".

The reasoning for these thresholds and penalties is that the transport authority views bus operation in not only the business and financial sense but also for the part it plays in the bigger picture of society as a whole. A transport authority bus development manager speaks to the control over the operations:

"*The operators are private companies that run for profit so they have an incentive to close down the bus lines that are not profitable. Therefore, the freedom that is given to the operator to plan and operate the traffic is limited by a threshold, which is a lowest level of traffic. The bus operator is obliged not to operate below this floor".*

It is important to mention that traffic planning does not stop when traffic management kicks off as traffic management and traffic planning interact to respond to different needs as they emerge (like the need to change drivers, for example).

The operator has more than ten thousand employees, with around 90 percent bus drivers and driver administration, about 8 percent mechanics, and two percent making up the management, sales, HR, and marketing functions. Moreover, the traffic planners, fleet managers, bus drivers, and depot managers are key to the business model of the operator. The involvement of the traffic planners in the first phase is to carry out estimates during the tender

pricing (which requires planning timetable schedules for routes, and planning resources required like number of drivers and buses needed to deliver this promise). The fleet manager is responsible for directing and coordinating the daily activities of the bus operations in order to plan the operations in traffic regions overlooking the contracts execution, which involves bus drivers and depot managers.

The current bus operations rely on overnight energy refueling logic. By that, the bus operator purchases or rents buses, which are fueled in bus depots overnight. Moreover, the operator usually rents bus depots and garages from the transport authority, to facilitate the overnight fueling of buses (diesel/bio diesel fueling). A bus fleet manager at the bus operator clarifies:

"*Today we are utilizing overnight fueling, that is fueling when you are the depot, so the bus stays around five hours in the nighttime, where they fuel and then they operate like a normal bus without stop during operations. There is also overnight electric charging where the bus is charged in the depot but then we need bigger batteries on the bus to sustain operations, the big batteries may lead to less passenger capacity in the bus*".

A key actor that co-create the value with the operator is the public transport authority. The authority is engaged in setting rules and organizing the traffic through demanding certain frequencies of buses in certain areas. Moreover, the bus manufacturer delivers the buses as a supplier to the operator in a way that enhances the uptime and non-stop nature of the operation.

To fulfil the targets and deliver the service, the bus operator relies on several resources. The bus is the keystone of this business; therefore, the operator needs to look for buses that deliver the required needs. Bus fleet manager mentions: "*The current buses with combustion engines deliver great uptime as we can fuel them anywhere and deliver with high performance*". Moreover, in order to optimize the operations and deliver the traffic according the schedules, the role of careful traffic planners is very important in order to utilize the assets and optimize the operations. This entails prospecting the right tenders and conducting efficient timetable planning and operations in order to minimize the costs incurred within operations, which are key in this low margin industry. Furthermore, the role of smart fleet managers is key in the utilization

of buses, as they have a view overlooking the contracts and thus need to make important decisions in terms of rotation of buses among the contracts, or regions. Moreover, these mangers work on whether to procure new buses and/or utilizing existing buses, which meet the contract requirements. As the bus fleet manager states, "*Which buses to buy and how to utilize them among our different contracts is key in order to compete in a low margin market*". Finally, the transport authority provides tickets under public bus contracts, therefore, the operator doesn't sell tickets in this context.

Value capture

The cost structure for the operator varies with the geographical location of operations. When considering the cost structure, the driver's salary in northern Europe is the most significant element of the cost. The other costs vary from fuel, cost of bus procurement, etc. This shows the importance of optimization and efficiencies for the operator of the contracts. As most of the contract costs are variable, reducing costs becomes strategic for operators. A bus fleet manager demonstrates the significance of this cost aspect:

"*The drivers' salaries are about 60% of our costs; this is the highest cost we have here, while in other continents like Asia, the energy cost is the most significant*".

The revenue model of the operator reveals control of the revenue stream by the transport authority. The contract terms are is based on type of contract and passenger tickets. If the contract is production-based then the operator's revenue comes in fixed installments, whereas under the passenger-based contracts the earnings of the operator are tied to the number of passengers validating their tickets, as one marketing strategy manager at the operator clarifies:

"The payment occurs depending on the contract terms, so we get paid either by fixed installments if the contract is based on production, or by number of passenger tickets' validated called blips, if it is based on passenger number or a mix of both"

The bus contract payment method ranges from the old way based on production, meaning that the bus operators are charged per vehicle\kilometer (common until around 2007), to a new way where the bus operators are

charged per passenger\kilometer. Most contracts are a mix of the two logics, and include a revenue model, which typically consists of a fixed share and variable share, depending on the number of tickets sold to passengers boarding the buses. A bus strategist in the transport authority clarifies the rationale of the new logic:

"*The new contracts create financial motivation for operators to get more passengers in the operations. I think they provide a great way to motivate operators to get more passengers. This means more people using public transport. We would like to see more people leaving their cars at home and going by bus*".

When it comes to selling tickets, the operator does not sell the passenger tickets under the contracts; instead, it utilizes the ticketing system of the transport authority. Thus, the ticket revenues do not go to the operator directly. Therefore, the transport authority through contracting terms controls the revenue flow of the operators. A business specialist at the operator explains this process:

"*We don't sell the ticket, the transport authority has the system that manages the ticket selling. We just validate the ticketing. We do not see revenue from operations, as it does not pass through our books. It goes directly to the transport authority.*"

Moreover, regardless of the earning logic, under public transport contracts the tickets are subsidized. The bus operator manager explains:

"The ticket prices are subsidized by regional taxes by up to 50% of their value, by the procuring transport authority"

As mentioned in the offering above, while operators have the freedom to run bus operations on their own without public contracts, the solo operations are much costlier. Therefore, most operators opt for public contracts, which implies tax subsidies that have positive impact on the cost structure of the bus operations, A business strategist at the transport authority confirms:

"*Operators may run the operations, but they discovered that it is not profitable, so they came back to contracts to access subsidies. In public transport, bus operation in itself is not self-financing, so there are tax subsidies in some way in all systems. Typically, it is the same all*

over Europe. There are very few lines or operations that can actually function as fully commercial operations on local public transport. In Britain they have tried, the British system is quite liberalized – deregulated, but they are also coming back to subsidizing because they don't get the service that they want".

The resource velocity aspect of the business model of the bus operator is illustrated in its utilization of the buses. This utilization is handled under uptime, rotation across regions, and rotation across contracts. The first aspect, uptime is important in order to fulfil the contracts and the commuting targets without escalating driver costs. Therefore, overnight charging facilitates nonstop service during operations. Second, the operator may need to rotate some of its buses, which are already running in operations in other areas, among different regions. A bus fleet manager explains:

"*On a fleet level, when you have a large number of buses, the total demand is constantly changing, and typically can say that we rotate 10 to 15% of the total fleet for operations with new challenges every year. Varying demand leads to the need to constantly optimize and monitor the needs in different areas. This could be you need a bigger bus in one place, or a smaller bus in another place and so on, meeting varying frequencies. Urgent needs could come from peaks in demand in certain areas, technical problems, or driver related issues, if we can't rotate*".

Third, this rotation is also important from contract to contract, meaning that the operator may utilize buses already bought for a previous contract. This could be the case only if the buses are already in their technological life span. A business manager at the operator mentions:

"*In a low margin industry, we need to utilize our buses to the full extent, whether by uptime which is keeping our buses running as much as possible non-stop, across contracts, or across regions during execution*"

In summary, the bus operator proposed value is to plan and operate efficient and sustainable bus operations for the public transport authority. In order to deliver this promise, the operator relies on creating this value on efficient bus contract selection and operation management. Efficient operation management and contract selection is also essential in a low margin industry in order to capture enough value to keep the viability of operator's business

model. These activities are critical in order to compensate for the main cost of the operation which is drivers' salary, making up to 60% of the total cost structure. This is not possible without revenue installments from tax subsidy making up to 50% of each bus ticket, therefore the rotation of the main assets namely buses among different regions is critical in this formula. In table (3), the operator's business model dimensions are explained.

Table (3) The current business model of the bus operator with current technologies

Value Proposition Content and Segment	Value creation Production \ Sales and Governance	Value capture
Service Plan and operate efficient bus traffic Meeting environmental targets (provided to municipalities and cities)	**Activities** *Tendering* Prospecting tenders Selecting tenders Evaluating tenders and quoting *Execution* Bus Procurement Traffic planning Traffic management **People** Drivers, depot management staff, fleet management and traffic planning **Technology** Overnight charging **Partners** Transport authority, Manufacturer **Key resources** Buses, subsidy of tickets 50% of ticket price, planners, and fleet managers	**Cost Structure** Driver salary around 60% of cost **Revenue model** 50% Subsidized Tickets generate revenue Revenue instalments are either fixed or payed in percentages depending on the passenger numbers **Resource velocity** High volume of operations High bus utilization, ability to rotate the bus among different regions

4.3 Changes to the Operator's business model

In this part, the changes, the bus operator's business models had the hybrid inductive bus system been deployed are shown. Finally, the main changes will be visualized through the business model framework dimensions.

Value proposition

While the bus operator will keep on delivering bus transport, with the onset of the electric hybrid, this will be altered. The potential offering will be more attractive and environmentally friendly; therefore, the bus operator will be able to better meet the environmental targets set by the transport authority, especially for noise and emissions. This is due to the hybrid inductive making buses create less noise and less emissions. The bus fleet manager explains:

"We are excited about the new technologies and are looking forward to deploying them. We see an opportunity with less noisy buses. This will enhance our offering to authorities and passengers as well".

Disrupted value creation

The activities that are challenged under the opportunity charging based change are contract selection and traffic planning and management. The first of these activities is the selection of the contracts by the operator. While choosing the right mix of contracts relies on the flexibility of buses, the dependence on infrastructure poses a significant hurdle to the selection process, as the bus fleet manager at the operator explains:

"*Selection of the right contracts relies on the turnover of buses within regions as well as utility of buses from contract to contract, so if two regions are attractive to operate in but they don't have the same opportunity charging infrastructure, we will face a difficult situation".*

The traffic planning and management have been built on rotation of buses, flexible buses and efficiencies. Thus, challenges arise to planning and managing bus operations when the inductive hybrid solution is introduced, since the operator will have less flexibility in utilizing the buses during operations. However, opportunity charging challenges this basis as the fleet manager clarifies:

"The less inflexibility, the fewer limitations we have, the more risk we are prepared to take. However, if we have opportunity charged buses, we have substantial infrastructure dependency and less flexibility".

Therefore, planning and managing the traffic will face difficulties in meeting the traffic targets agreed with the transport authorities as a traffic planner clarifies:

"*The scheduling logic will change due to the time added up, we depend for our estimates on a flexible vehicle, buses are made to be flexible, and stopping during operations will increase the likelihood of not meeting thresholds".*

The technology discussed in this future model is the opportunity charging electric hybrid. Under this solution, the charging infrastructure needs to be located on the street. Thus, one consideration in this case is a change to the way the buses are charged. An engineer at the operator clarifies:

"*With opportunity charging, due to limited battery capacity, the bus will stop during traffic operations for a few minutes to charge the battery, usually at end of the line, in contrast to overnight charging when the bus was charged at the depot*".

While the transport authority does not specify to the operator which technology to choose to run the bus operations, the upcoming environmental targets usually limit the room for choice. A fleet manager at the bus operator explains:

"*When the authority tells us the energy efficiency, noise levels, and other criteria to meet in operations, this already leads us to one technology or the other. Stopping during the operations definitely makes us worse off. We don't believe that any charging during operations will fly, we need to keep on charging overnight*".

The main change in the partnerships for the bus operator is the entrance of a new energy provider, namely the electricity provider that supplies electricity and takes charge of the infrastructure. While this was the case in the pilot project, it is still unclear how this constellation will be managed.

Nonviable value capture

The value capture of the operator is affected by the new logic of charging the buses. The new technology leads to the need for the bus to stop to charge for 6 to 7 minutes during operations. Although this is considered a quick span of time to charge an electric vehicle, it challenges the financial performance of the bus operator. The bus operator business relies on the time factor for its operations. Therefore, any change in the system that will cause an increase in the time of the operations will negatively affect the financial performance of the bus operator.

The opportunity charging solution leads to significantly escalating costs to the operator as a result of the rigidities. These costs are related to the number of buses needed, and the main cost, bus driver salaries. A business specialist at the operator clarifies:

"*Any extra time added during the bus operation, translates to significant increase in costs. The extra time during operation means more hours for drivers' higher salary or need for more buses to run the same operations. This is a big cost difference compared to current business".*

This is not the only aspect that will be affected from a cost perspective. The opportunity charging based operations will increase the probability of not meeting the transport thresholds set by the authorities. Consequently, the operator may be penalized for delays that transcend the thresholds, a traffic planner explains:

"The new solutions with new charging infrastructure, make our drivers stop during operations. We need every minute, and this lower uptime translates into penalties because we didn't meet the thresholds".

Under traffic contracts, these escalating costs mean higher risk for operators. The bus fleet manager demonstrates how this cost may be dealt with:

"*We will need to charge extra for these costs to cover these risks, which of course means more cost to the taxpayers in the end*".

The silent, clean buses provide the operators with enhanced opportunities to operate in neighborhoods and regions that are restricted today due to the current noise levels. This is foreseen as a potential revenue generator. The opportunity charging will provide opportunity for more lines to operate, translating to more revenue potential. A traffic planner clarifies:

"A less noisy and environmentally friendly bus will allow us to operate in areas and at times that we may not be able to operate in today, like near hospitals, or in late night hours".

Future technology may hinder the post contracting operation with regards to utilization of specific infrastructure dependent buses. As the bus operator has 12-year contract duration with the transport authority, the operator can only use these buses in areas that have this specific infrastructure, which may represent a large restriction. As a fleet operations manager explains:

"*We usually roll some of our buses from contract to contract. However, a bus that works on a specific infrastructure will hinder this, and affect our planning*".

This dependency will hinder the ability to alternate the buses according to needs, which is a core activity under the management of the operation:

"*if we have to invest in a bus that is heavily infrastructure dependent, for example if we have inductive charging, a number of inductive charging buses in Södertälje, and we run conventional diesel buses in Nortälje, then there is no opportunity to rotate buses*".

Finally, the overall effect of the opportunity charging on the value capture of the bus operator is significant. This is demonstrated in financial terms by the bus fleet manager:

"*Stopping for 6-7 minutes to charge poses a significant challenge to u during the operations, reducing current transport efficiencies and that will lead to escalating costs. We estimate a decrease in efficiency of 15%, which is an approximate decrease of 7% in the operator's net earnings*".

In summary, stop inductive electric charging provides a great potential to enhance the value by the bus operator. This is manifested in more silent buses, higher energy efficiency, and meeting environmental targets. However, this

positive effect on the value proposition is mitigated by the rigidities brought by this new technology. This is translated into disruptions to the value creation dimension, specifically to the extra costs, making the operator less competitive in contract management and by that same effect in the quoting and tendering process. A positive effect on the revenue is foreseen with new routes available thanks to the silence of the bus and its environmentally friendly capability. However, this would be mitigated as the cost structure will be imbalanced by the escalation of the main cost namely is the drivers salaries and/or an increased cost of assets, which is number of buses needed for the same operation. Moreover, a hindered resource velocity (manifested in lower ability to rotate buses among regions) also leads to a negative impact on the value capture. Table (4) summarizes and categorizes these potential changes to the business model of the operator when adopting the new technology.

Table (4) The business model for the operator adopting inductive bus technology

Value Proposition Content and Segment	Value creation Production \ Sales and Governance	Value capture
Service Enhanced offering sustainable, environmentally friendly and attractive Offering, and energy efficient, potential new routes	**Activities** *Tendering* Less competitive tendering due to costs *Executing* Disruptions to traffic planning and management Schedule differences due to opportunity charge time Need for extra bus procurement **People** Potential increased number of drivers **Technology** Opportunity charging **Partners** Electric energy provider is added to the value network **Key Resources** Not applicable	**Cost Structure** Increased cost of operations (increased time for drivers\or increased number of buses) increased bus costs Cut energy costs **Revenue model** Increased revenue due to availability of new routes **Resource velocity** Increased rigidity in bus rotation (less flexibility and rotation of buses in overall operations)

4.4 Analysis

The Impact on business model

The effects of the change to electric charging on the business model of the operator have both positive and negative aspects. On the positive side, this change makes the operator value proposition manifested in the bus offering more sustainable and attractive with a more silent, less polluting and more energy efficient bus. The lower emissions meet the sustainability demands of cities and help in reducing the negative impact of bus operations in cities. Moreover, the less noisy bus solution would allow the bus operator to be able to operate in areas where noise levels are regulated such as near hospitals, or at times when noise levels are regulated such as night operations close to residential areas.

However, the potential positive considerations above are mitigated by certain complexities to value creation incurred by the potential future system leading to non-viable business models. The suggested future solution (stop inductive) to a sustainable bus system makes the buses heavily dependent on infrastructure. Thereby, the traffic management operations will become less flexible and less able to rotate among regions and other contracts that do not have the same infrastructure. Moreover, due to the need to stop for several minutes during operations, this technology will deprive the buses from a vital feature, which is flexibility. This will hinder the resource velocity by putting the operator in a position where it is less able to rotate buses among regions, and less able to meet its targets. This has a big impact on future business models by disrupting value creation. This disruption spans contract selection and traffic planning and management, which are built on flexible rotation of buses.

The future value capture is far from clear. While the value capture would be positively affected by the new technology in terms of cutting energy costs and generating more revenue from the ability of the operator to operate new routes, however, these positive effects are mitigated by the disruptions to value creation driven by increased time of operations and lower ability to rotate the buses. This would lead to a need for more buses to deliver the same

operational targets. Such disruption would be translated into significant operational costs linked to a potential increase in the number of buses needed, or increasing man-hours: escalation of the main cost (bus driver salaries) as well as rigid resource velocity manifested in lower ability to rotate the buses among regions. In other words, there will be a necessity for more man-hours core either more drivers, or more operational hours by current drivers. This makes the operator uncertain on price performance, and challenges the business models of the future.

In summary, the future technology brings positive impact to the value proposition with a promising offering from an environmental perspective, which would translate into a positive impact on the value capture. However, these positive effects are mitigated by operational disruption to the value creation dimension translating to negative impact on the cost and resource velocity. The following table summarizes and contrasts the dimensions of the current and future business models of the bus operator.

Table (5) Comparison between current and potential business model of the bus operator

Operator business model	Value proposition	Value creation	Value capture
Current Business Model	**Service** Plan and operate efficient bus traffic meeting environmental targets	**Activities** *Tendering* Prospecting and selecting tenders *Execution* Procurement utilize buses utilization Traffic planning Traffic management **Technology** Overnight charging **People** Drivers	**Cost structure** Driver salaries around 60% of cost **Revenue model** Subsidized tickets Revenue instalments fixed or dependent on number of passengers **Resource velocity** High ability to rotate and utilize buses
Potential Business Model	(+) **Service** (+) Enhanced offering sustainable, environmentally friendly and attractive offering, and energy efficient, potential new routes	(-)**Activities** (-) *Tendering* Less competitive in tenders due to costs Rigidities in contract selection (-) *Execution* Disrupted traffic planning and management Schedule differences due to charge time, lower operational efficiency, and lower ability to rotate buses **Technology** Opportunity charging **(-)People** Increased need for extra drivers	**(- +) Cost structure** (-) Costlier buses, increase in man hours, or increase in number of buses needed (+) Lower energy costs (+) **Revenue model** New routes potentially generate more revenue **(-) Resource velocity** Lower ability for bus utilization and rotation

The lock-in of bus operator business model

The transport authority externally controls the business model of the operator. This manifests itself by influence of authority on value creation of the operator, namely the transport authority management of the ticketing system ticketing system. Moreover, this control transcends to the value capture of the operator. This is due to the fact that the operator's revenue model relies on external subsidy. This dependency manifests itself in the authority controlling the revenue stream by deciding the payment terms to the operator, holding leverage with environmental targets, and influencing how the revenue stream design is in the operator business model. This external control shapes the business model of the operator.

The freedom to change the business model of the operator is limited by the operator's dependence on external resources, i.e. the transport authority subsidies. Therefore, the business model of the operator is dependent on an external resource, which is the subsidy provided by the authority due to lock-in. While the operators are free to undergo operations and make their bus solution choices and pursue a business model away from transport authority contracts, nevertheless the operator is locked-in due to high transaction costs for the operators. The bus operators are tied to the subsidy in ticket prices, which is 50%, provided by the authority with the contracts.

The transport authority subsidy has a considerable impact on the behaviour of the operator when it comes to its persistence of the business model and relentlessness in reconfiguring its business model and adopting future alternatives. Therefore, the subsidy creates a self-reinforcing mechanism making the operators' bus business model only viable under public contracts. Therefore, the subsidy leads to a lock-in of the operator's business model and thereby stabilizes the current bus system and hinders further transition to stop inductive charging.

5. Discussion

This thesis aims at investigating the pressure on incumbent business model of a key incumbent actor in the face of change under transition to future bus system. The findings in this thesis show how the lock-in of incumbent a business model can hinder sociotechnical transitions. In this case, the incumbent business model functions as part of the sociotechnical regime, a stabilizer of the current system (Bidmon and Knab, 2018). While the sustainable technology potentially delivers a positive effect on the value proposition, significant disruption to value creation and value capture effects are more uncertain. This negative impact hinders the unlocking of the value from the sustainable technology. Moreover, the nature of the business model of the operator played an important role in obstructing the system transition to stop inductive electric charging. As shown above, the business model of the operator is dependent on external resources, namely the transport authority subsidy. This dependence is due to a lock-in situation (Sydow *et al.*, 2009; Vergne and Durand, 2010) as an outcome of a subsidy associated with public contracts leading to a high transaction cost for other alternatives. These outcomes speak to the underexplored understanding of business model dynamics under transition leading to industry transformation (Schaltegger *et al.*, 2016). The findings indicate the influence of incumbent current business models on transition, and partially informs the commercialization of new technologies with current or novel business models.

The extant literature suggests three roles for business models in sociotechnical transitions. First the business models implying a dominant logic representing an established understanding of how an organization works (Bohnsack *et al.*, 2014) as a part of the sociotechnical regime, the second as mediators between the niche and the sociotechnical regime, the third role as a non- technological niche innovation (Bidmon and Knab, 2018). The first role acts to hinder sociotechnical transitions and the latter two drive such transitions. The findings in this thesis speak to the first role of the business model in transitions and extends this understanding by revealing that the lock-in of one incumbent actor (the bus operator) business model could be stabilizing of the whole sociotechnical bus regime and may hinder transition

to future electrified bus system. This means that the lock-in of the business model of one key actor enforces the dominant regime logic.

Furthermore, the findings of this thesis illuminate the significant influence of a regulator, in this case the transport authority, in shaping the role of the bus operator by means of business models. This effect greatly influenced the transition from the niche phase to mass market. Moreover, the dependent and locked-in business model of the operator helped in understanding the interaction between the two actors and revealed the influence of the regulator on shaping the role of the bus operator. This understanding informs the call for future exploration of the role of business model in understanding actors and organizations under transition as well as what influence actors have in shaping roles (Bidmon and Knab, 2018).

This thesis sheds light on how business models influence the impact of technological innovation on transitions (Bidmon and Knab, 2018). The findings show the difficulty of commercializing innovations within current business models. While a further study is necessary to evaluate the impact of novel business models on commercialization of the innovation, the dependence and lock-in of the operator's current business model indicate that the commercialization within current business models may be more difficult than tailoring new business models to commercialize innovations. In this case, the incumbent business model may act as a selective mechanism among innovative technologies, filtering the ones that defy the dominant logic and established rules within the sociotechnical system.

The findings in this thesis highlight the context role in shaping the business model. This is manifested in the dependence of the business model on external resource as a source of influence on shaping business models which extend the external view of business model (Christensen and Rosenbloom 1995; Pateli and Giaglis 2005). The dependence on external resource is manifested in the externally controlled value capture mechanism, mainly the revenue stream, as well as externally controlled value creation manifested in the ticketing system.

Finally, it might be reasonable to argue that the transition to electrification of bus systems corresponds to *P1 transforming* transition pathway (Geels and Schot, 2007), due to moderate disruption coupled with underdeveloped niche innovations. The landscape pressure manifested by global warming and government target goals poses a potential disruption to incumbents. However, this shock seems to be moderate, as the deadlines to obtain sustainable transport solutions given by industrial state governments are more than a decade ahead, which gives the incumbents in the transport industry the space to shift their R&D paths to meet these goals. So, the moderate disruption in this case excludes *P2 De-alignment and re-alignment:* and *P3 Technological substitution* pathways as they entail an abrupt disruptive shock. Furthermore, the novelties represented in niche innovations, electrification in this case, are not developed enough to take off. This excludes *P4 Reconfiguration* pathway, which speaks to well-developed novelties at the time of disruption.

Implications

The lock-in and dependence of the business model may imply that the business model autonomy is connected to the level of coupling to a system. If this relationship materializes then the independence of a business model is pertinent to its context and how one actor is connected to a system. The coupling may prove to be an important factor to gauge when it comes to the reshaping of business models. Therefore, we may need to encourage the designer to think beforehand on the context where the organization is considering shaping or reshaping business models. If the organization is coupled to a strongly rigid system like a transportation case, where a high level of coordination and harmony is utilized by high flow of information among the different actors, then collaboration is a key to success. On the other hand, if the organization is on a loosely coupled system, the degree of autonomy is probably higher and less collaboration is therefore needed and solving business problems can be done with more freedom for the organization. Finally, a layer of coupling could be suggested to contribute to business models and this would give guidance on when business models need to be addressed as autonomous and when they need to be addressed as an integral part of the system.

For managers, the findings demonstrate the benefits of mapping their business model dependencies and identifying sources of lock-in. This would aid them in making decisions and considering the viability of business model innovations or other decisions that imply changes to value proposition, creation, and capture. This knowledge would guide the managers' choices when it comes to the impact of technological changes as well as relationships with other actors in the value chain. With that clarity, managerial decisions would be better informed.

When it comes to policy implications, this thesis revealed a pivotal role of the transport authority in the bus transportation system in shaping the business model of focal organization. The dependence of the business model design of the bus operator on external resource. The findings reveal the critical role of authority rules. The authority acts as a system owner that holds a significant influence on other actors by controlling the contract that defines the terms in the bus transportation system. Especially, as in the present study, where the contract represented a complex public-private market setup, changes in the contract were viewed as both powerful and difficult to comprehend. Therefore, findings suggest that system owners need to build well-functioning relations to other actors in the system and develop a sound understanding of the other actor's business models in order to manage the overall system functionality and effectiveness.

This vital role of the external actor in shaping a focal organization business model reveals that co-design is needed and encouraged in complexity, taking into account that the relative power position of the actors needs to be comprehended. The criticality of the system owner role emanates from the significant changes that the other actors will face had the owner manipulated the terms. The repercussions that the system owner can cause in the system not only reach the direct actors but also transcends to the shores of unexpected other actors in the system endangering their survival. Therefore, a strong need arises to comprehend how slight alterations could send shockwaves through the system. Therefore, co-design becomes a necessity as it may hold an important piece of the answer to difficult transitions. Therefore, an advice to political actors is to apply the business model lens on their current and future systems. This would add clarity to the impacts of

current rules on system actors as well as guide the financial impact of future changes.

Appling the business model lens within niche innovations unpacks the complexity of uncertain transitions and gives the system designers a clearer picture of the future required changes on different levels, for example: Policy, business, resources, infrastructure, etc. The mappings of the business models may reveal that the current business models would facilitate the transition. Otherwise, such mapping may guide the transition by revealing the needed changes/new business models. Therefore, mapping the current and future business models for actors in pilot projects proves to be a powerful tool to aid sociotechnical transition management. The understandings emanating from such analysis may aid the deployment of certain innovations within the business model situation.

6. Conclusion

This study focused on the pressure on the current business model of an incumbent in the face of systemic innovation of electric bus system. This has been done utilizing an in-depth case study approach. The investigation shows mixed effects on the future business model dimensions of the bus operator: positive value proposition, negative on value creation, and mixed effect on value capture. This represents the potential implications that the opportunity charging technology would have on the bus system. This demonstrates the need for a clear and viable envisaged business models to further progress with future bus systems. Moreover, the investigation revealed the lock-in of the business model of a key incumbent actor, where the lock-in hindered the transition. This outcome signifies that unchained incumbent's business model acts as a missing link needed to provide the continuity to achieve successful transition.

The findings of this thesis come with some limitations. Based on a single case, this study has limitations as to the extent of generalizability of its findings. Thus, this study does not claim generalizability in a statistical sense. However, it aims to reach analytical generalizability (not to enumerate frequencies but to expand and generalize theories) (Yin 2009, P15). Another limitation is that the case followed an ongoing project following a potential transition, which does not allow for future follow up on the upcoming outcomes of the transition. This is a prominent methodological challenge. One limitation to this thesis is the ongoing nature of a process that is already evolving rather than a historical transition that as already completed such as the introduction of early steam engines to ships (Geels, 2002). It can be argued that although it is uncertain whether we will arrive at full electrification of buses, incumbent organizations have already embarked both mentally, technologically, and operationally by engaging their R&D, production/sales department including different levels of hierarchies within the organizations in the pilots. Therefore, the pilot projects are manifestations of this embarkation with many expected learnings from the pilot project that will affect the path ahead without putting much focus on the destination, which is beyond the scope of this study.

For future studies, a single case study was applied in this thesis. While this helped to gain rich data and follow the case, the researcher acknowledges the need to conduct a multiple case study approach in order to validate the findings and explore the contingencies that may be revealed in different contexts. Moreover, this study was conducted in a Swedish context, in Stockholm, which is representative of a sustainable city as it has achieved above 90% sustainability and aims for more. On the other hand, studying other contexts with different conditions in cities like Madrid or Mexico City may reveal further important findings. Finally, this study focused on one actor, therefore, conducting research analyzing multiple actors would enhance the understanding of the transition process.

Finally, the potential of sustainable systems represents something that it is not yet real, yet the transport system stakeholders act as if it is real. In order to reach the future desirable goals of sustainability, interactions with the real world in terms of business, technology, social and regulation are needed. These interactions breed information that helps navigate through uncertain future developments. Pilot projects are manifestations of these actions and interactions. Within such protected environments, the business model analysis provides a way to expose the incumbents to the future cognitively. This thesis unravels the lock-in, dependence of a key actor's business model on external resources, and how this situation hinders the transition. These finding may suggest that the ending result of sociotechnical transition may be a function of the current state of key incumbent business models under certain conditions that may need to be explored. Therefore, the success of favorable shifts may rely on how embedded or locked-in the current business models are. This understanding helps to reveal the dynamics of business models within transitions to the targeted potential. Knowing this helps to build the necessary societal knowledge needed for better design and management of future pilots and driving the societal collective aiming to better drive to sustainability goals.

7. References

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8. Appendix1: Interview dates

Actor	Interviews	dates
Bus Manufacturer (Scania)	- Project manager 1 (1 interview)	24 Mar, 2016
	- Project manager 2 (1 interview)	29 May 2017
	- Bus business development manager (2 interviews)	11 Jan 2017 10 April 2017
	- Business roadmap manager (1 interview)	11 Jan 2017
	-Chief engineer Electromobility (2 interviews)	1 Feb 2017 26 May 2017
Bus Operator (Nobina)	- Traffic planner (2 interviews)	11 Jan 2017 20 May 2017
	- Operations engineer (2 interviews)	13 Jan 2017 24 May 2017
	- Bus fleet manager (2 interviews)	2 April 2016 24 April 2017
	- Marketing strategy manager (2 interviews)	22 April 2016

Public transport authority (SL)	Senior Business strategist (2 interviews) Bus Strategist (2 interview) Bus and Depot Specialist (1 interview)	2 May, 2016 21 October 2016 1 May 2016 14 October 2016 3 Feb 2017
Technical solution supplier (Bombardier)	Sales Manager (1 interview)	13 Sept 2016
Electric energy supplier (Vattenfall)	Head of R&D for E-mobility (1 interview)	11 May 2016
Municipality (Södertälje)	Municipality representative (1 interview)	21 June 2016
Transport Research lab (ITRL)	Project board member (2 interviews)	10 April 2016 12 June 2016