Identification of a UR5 collaborative robot dynamic parameters

3. Modelling innovations in freight transport: a business ecosystem perspective

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1. INTRODUCTION

Innovations in logistics services revolve around the fundamental challenge of making a step change in service quality towards the customer and reducing the costs to deliver these services. As service improvements involve higher costs, the two challenges are often tackled together. Changes in logistics service quality have mainly been driven by the digitalization of services and the servitization of product offerings (i.e. the addition of service elements to a product). Consumers have gotten used to the possibility to choose among different distribution options, including highly responsive services, like home delivery within the day, or even within hours. From a company perspective, omnichannel distribution – a separate channel for each customer segment – has become standard practice (Buldeo Rai et al., 2019; Taylor et al., 2019). As, by definition, customized services serve smaller segments of consumers, service providers miss out on the earlier benefits of economies of scale, which makes logistics more expensive. In addition, competition between service providers has put prices under pressure – home deliveries as well as returns are still done at low prices, or even for free. This pressure is absorbed by companies through innovations in logistics processes, either within or outside the company, by one or more of the options below:

- new logistics technology and organization (e.g. autonomous warehouses or delivery robots);
- improved yield management (i.e. higher prices for consumers willing to pay more);
- horizontal or vertical collaboration across the supply chain (e.g. co-procurement of services between competing firms; mergers and acquisitions of firms situated in different echelons of the supply chain);
- internalizing external costs of services (e.g. pricing environmental impacts).

The aim of this chapter is to discuss the modelling of transport innovations, with the purpose to predict impacts of innovations and thus support decision making. Our focus is on the multi-company city logistics environment that comprises several practical examples of these innovations such as:

- service providers or manufacturers pooling their transport orders to reduce costs;
- two manufacturers that source goods and services together, producing a similar effect;
- a shared warehouse available for multiple firms as opposed to a single-client warehouse;
- running an urban consolidation center (UCC) with public subsidy, justified by environmental impacts;
- price premiums for environmentally friendly services (e.g. zero emission vehicles).

These examples illustrate how changes can affect multiple actors in the system, and cross the boundaries of several institutions, with regulatory, legal, and even political challenges. Decision making around such innovations can be long-cycled (years or decades) for large-scale innovations, and short-cycled (weeks or months) for smaller, incremental innovations. In these situations, the relationships between stakeholders with different motives and business models are a critical aspect for understanding how to make effective decisions (Anand et al., 2012; Cagliano et al., 2017). Furthermore, decision making can transcend the concerns of private markets if public subsidization, investment, or regulation is involved. Models will help to predict the impacts for all the stakeholders of the city logistics system, public and private, and thereby aid the design and implementation of policies. In the context of co-creation of innovations by different stakeholders of city logistics, the role of modelling is changing – from supporting long-term cycles of policy making and implementation, to supporting short cycles of incremental innovation. These cycles are similar to the policy cycle but faster paced and shared between stakeholders. They include ex post analysis, predictions of upcoming states of the system, and optimization of control and implementation measures. The question for this chapter, then, is how models can help to assess economic, social, and environmental impacts of logistics innovations in the complex multi-actor systems called City Logistics (CL).

Descriptive and predictive freight transport models have come a long way, from the earliest econometric transport system equations to the current transparent agent-based simulation models, which aim to mimic everyday logistics decisions. The first approaches for freight modelling consolidated all logistics decisions into aggregate structures, describing freight production and attraction, trade, mode choice, and routing for an entire city, region, country, or even the world. Throughout the decades these models have evolved by providing further detailing of these structures in behavioral terms (Comi et al., 2014). More and more, logistics decisions were being considered in descriptive models, including decisions on distribution structures, multimodal chains, vehicle types, and routing and scheduling of trips. Also, disaggregate approaches provided empirically valid models at the level of the individual firm. Recent reviews of freight modelling emphasize the need to continue in the direction of a more realistic representation of actual logistics business processes (see e.g. Anand et al., 2015; Meersman and Van de Voorde, 2019; Tavasszy, 2020; Tavasszy et al., 2012). Also, the nature of modelling to support innovations is changing from an arm's length reflective role towards one similar to action research, where the modelling becomes part of the innovation cycle (OECD, 2020). Simulation models and agent-based models help to progress in this direction as they show how individual firm behavior and interactions between firms lead to an aggregate outcome, which is of interest for the policy maker who oversees innovation processes and might decide to intervene if negative externalities ensue. Moreover, these models differ from traditional models because they include many, heterogeneous agents and these agents receive feedbacks from other agents and are therefore better equipped to model the non-linear behaviors of complex innovative ecosystems.

We argue that models of firms and their interactions should preferably be built on a conceptual framework that recognizes the main interests of the model users. In this chapter we propose a framework for analysis, based on business ecosystems, that formally identifies the different actors in the system and their business interrelations, including private and public stakeholders. The main premise is that innovations will affect these actors through their relations and that innovations thus do not affect only one actor, but multiple or all actors. We illustrate how innovations propagate through the system of actors in city logistics through several examples of new public and private initiatives. Also, we explain how these ideas can be operationalized in empirically grounded agent-based models of cities.

The chapter is built up as follows. First, section 2 explores the theoretical background underlying the foundations of the business ecosystem agent-based modelling. Then, the general operationalization of the business ecosystems perspective on transport innovation is outlined in section 3, together with a practical implementation example for urban freight ecosystems in section 4. In section 5 we discuss theoretical and practical implications of this work, and finally we draw the conclusions in section 6.

2. BUSINESS ECOSYSTEM AS LENS: THEORETICAL BACKGROUND

Business Ecosystems Theory

Theoretical and practical frameworks for designing and assessing business models and decisions "assume that the strategic outcome can be defined independently of the reactions of other players" (Tian et al., 2008, p. 102). However, a critical challenge that is not entirely dealt with by the business model concept lies in characterizing the relationships among business entities and understanding how decisions taken by one entity affect other interrelated entities (Tian et al., 2008). In some sectors, companies combine to provide services, thus taking the form of a business ecosystem (or network).

A business ecosystem is defined as a network of interrelated business entities, characterized by value transfer and value co-creation mechanisms (Wang et al., 2015), operational transactions, and interdependencies between business entities (Solaimani et al., 2015). This definition of a network of interrelated companies as a business ecosystem stems from the ecology research arena, whereby biological ecosystems are depicted as complex systems of organisms and relationships among them (Battistella et al., 2012). Likewise, within business ecosystems, "firms interact in complex ways, and the health and performance of each firm are dependent on the health and performance of the whole. Firms … are therefore simultaneously influenced by their internal capabilities and by their complex interactions with the rest of the ecosystem" (Iansiti and Levien, 2002, p. 8). Business entities composing a business ecosystem can at the same time cooperate, to improve the growth of the business ecosystem, and compete for market shares (Battistella et al., 2012).

The business ecosystems literature recognizes the existence of roles and actors along the value chain, and draws attention to the necessity of making a clear distinction between roles due to the presence of different functions performed by the ecosystem companies (Pohlen and Farris, 1992). In fact, roles are defined in the pertinent literature as an aggregation of activities performed, as well as of the resources necessary to perform them. In this sense, roles serve as the basic element of a business ecosystem, whereby actors perform specific roles to achieve the overarching objectives of the ecosystem (Story et al., 2011). As a matter of fact, the profitability of the ecosystem is affected by the organizational structure underlying the assignment of actors (i.e. firms) to the role played, taking into consideration that different firms are able to take on the same role. Regarding this notion, most authors argue that, to some extent, it is possible to single out the most efficient firm–role assignment, through either qualitative inquiry or mathematical estimation (Savaskan et al., 2004). However, in order to achieve and maintain the network structure at the efficient frontier it is necessary to understand and develop role-specific competences (Harland and Knight, 2001). Harland and Knight (2001) also argue that organizations can adjust the role played in the network, and thus respond to factors that have an impact on their performance by taking on different roles. Network management is also a very relevant role in a business ecosystem, and covers a wide range of activities, including collating and analyzing information and disseminating it to other actors so as to coordinate physical and information flows and facilitate communication and innovation (Harland and Knight, 2001).

In essence, by assessing through the theoretical lens of the business ecosystem framework how innovations affect changes inside a network of firms it is possible to achieve several objectives. On the one hand, this framework brings forward a perspective shift from the focal firm, typical of the traditional business model concept, to the whole ecosystem of firms. On the other hand, the framework still allows us to highlight all the individual business models of which the ecosystem is composed. Moreover, the business ecosystem framework acknowledges that when innovations are introduced the roles played by the firms change dynamically. Finally, business ecosystem theory provides more leeway for opening up the analysis towards all relevant actors in the ecosystem. In the context of transport innovation this means that public stakeholders, who ought to be included in the assessment as previously mentioned, are also given different roles and an actionable business model to drive their decisions.

These considerations make the business ecosystem framework well suited in our view to study not only business model changes through innovation but also technology transition regimes.

Transition Management in Business Ecosystems

Innovations in sustainable transport are wicked problems: they concern many actors and groups of actors with vested interests, who are not easily amenable to fundamental change (Kemp et al., 2007). Therefore, our view of organizations should consider more factors than those that cause short-term inertia in the system. Theories about change management, system transitions, and institutional economics have created the discipline of transition management to support the realization of major societal, or landscape, innovations (Geels, 2002). Here, the so-called “regimes” or robust structures of institutions prevent individual technological or organizational innovations – however radical they may be – from changing the system landscape. Therefore, the institutional economics of systems (see e.g. Williamson (2000) for a systematic description) – including the institutions themselves, their governance arrangements, and their management practices – should be understood and operationalized. This could provide an understanding of the detailed agenda of measures needed for change, which is directed at the system actors, their powers, and the value systems by which they are driven. We argue that the ecosystem lens is instrumental in this respect, as it recognizes the motivation and capability of actors to identify and create new inter-organizational business arrangements. Simply put, if we can predict how patchworks of regimes change, we may be able to predict system transitions.

The ecosystem approach is particularly useful in innovation contexts focused on both value creation and value capture, because it allows analysis to explicitly tackle not only the challenges faced by the focal firm but also those of the external partners and stakeholders (Adner and Kapoor, 2010). Therefore, the processes of technology substitution or business model innovation are in fact driven by the competition between "old" and "new" business ecosystems, and hindered by bottlenecks somewhere in the ecosystem that constrain the full realization of the new technology's (or business model innovation's) potential performance (Adner and Kapoor, 2016). Rong et al. (2015) argue that the process of new supply chain emergence cannot be explained using traditional supply chain theories. Instead, interoperability between different levels of organizations is necessary to cope with the uncertainties embedded in transition processes. Moreover, during the co-evolution of business ecosystems we see a process of emergence of dominant supply chains.

3. A BUSINESS ECOSYSTEM PERSPECTIVE FOR TRANSPORT INNOVATION: GENERAL OPERATIONALIZATION

In the literature, several tools are available for modelling business ecosystems and analyzing the impacts of different business decisions taken by the business entities operating within the business ecosystem. A suitable implementation of agent-based modelling (ABM) to business ecosystem design and analysis is provided by the role-based modelling approach (Ok et al., 2013; Tian et al., 2008). In this approach, business entities can play multiple roles and make decisions reacting to the changes in the ecosystem over time, and based on their objectives, information, and constraints.

Modelling Business Ecosystems with ABM

As previously mentioned, traditional transport modelling approaches fall short of grasping the complex dynamics of multi-actor economic processes which determine the adoption of innovations. The proposed business ecosystem lens enables on the other hand the capturing of interdependencies and interrelations among firms in dynamic ecosystems where reconfigurations of roles and functions emerge continuously, aiming to create and capture value and generating patterns of competition or cooperation. A good fit for modelling business ecosystems is agent-based modelling, insofar as it is able to model organizational complexities and the interdependencies among organizational design elements and decision making (Rivkin and Siggelkow, 2003) better than other modelling approaches. Moreover, the processes of emergence and self-organization are very important features of agent-based models, and they imply that some properties belong only to the system as a whole and not to its individual components (Grimm et al., 2005).

In agent-based models, a bottom-up approach is adopted to define and represent a complex system, rather than identifying global variables ruling the system as a whole. Hence, there are three basic elements in each agent-based model:

- a set of agents, together with their attributes and behaviors;
- a set of relationships and rules that drives agents' interaction;
- the agents' environment.

General Theory

The main pillars of this framework are roles and business entities, representing the most important agents in the business ecosystem. These two types of agents operate differently, whereby business entities represent the firms operating in the ecosystem that enter into contractual relationships with each other, and roles are the functional agents of the system carrying out operational activities.

The first pillar of the framework requires a working representation of how to define a role. The definitions available in the literature are however very context-specific and, while pointing to the notion that multiple companies can play the same role, they do not indicate specifically what categories and variables can be used in order to separate roles and companies. To solve this dilemma and achieve more precision, a role is here defined as a bundle of different functions and activities, but since companies can perform similar functions the distinction between the roles can be somewhat blurred, and this could generate problems and conflicts between actors. Hence, a specific role k can be defined as:

$$R_k = \{A_k, D_k, M_k\} \tag{3.1}$$

where A_k, D_k, and M_k are sub-sets of activities, decisions, and metrics available in the ecosystem.

Table 3.1 Elements of the framework

Component	Definition	Properties
Role	A role is a bundle of different activities, decisions, and metrics available in the ecosystem.	Activity(s) Decision(s) Metric(s)
Business Entity	A business entity is an actor of the business ecosystem. A business entity can be associated with a particular type depending on the ecosystem context.	Type Role(s)
Resource	A resource can be a physical (e.g. a vehicle, a warehouse), intangible (e.g. knowledge, intellectual property), or financial asset. Resources are owned by the business entities and are necessary for the roles to be performed.	Owner Unit cost Operational characteristics
Activity	An activity is performed by a business entity while playing a specific role, in order to offer a service. Activities consume resources.	Resource usage
Metric	A metric is a key performance indicator (KPI) measuring a certain business object, namely activities, resources, value proposition exchange, business entity, ecosystem.	Business object Value
Decision	Business entities make operative and economic decisions in the fulfilment of their roles, based on a set of constraints, variables, decision parameters.	Objective Decision variable set Constraint set
Service	A service is an aggregation of activities that use resources and are characteristics of a role.	Service attributes Activity set
Value Proposition	A value proposition is a set of service offerings characterized by different gained benefits that are valued by users.	Provider and user Services Evaluation method

The value proposition represents the component of the system which dictates if a certain role will be taken by a business entity, thus driving a contractual relationship with another business entity. A value proposition has been defined as a bundle of products and services which represents a value for a specific customer (Osterwalder, 2004).

In a business ecosystem, the interrelations between resources, activities, value propositions exchanged, and decisions are fundamental. As anticipated, a business entity performs activities and requires investment in resources to build a sustainable business model. Then, the value proposition exchanged lies at the core of a specific business model configuration, which in turn determines which business entity takes certain decisions as well as the partnership model. These decisions have an impact on activity execution, and metrics are used to assess quantitatively the outcome of activity execution so as to evaluate the role-playing performance (Table 3.1).

Business entities must choose which roles to play in the business ecosystem, thus deciding which of the roles' specific activities, decisions, value propositions, and metrics to inherit. Business entities also have entity-specific attributes and relationships. The most important attribute possessed by a business entity regardless of the roles played is represented by the resources (human, financial, physical etc.) owned. As a matter of fact, the availability of resources has a significant influence on the types of roles a business entity can play in the ecosystem. A depiction of the general workings of the role-based business ecosystem is given in Figure 3.1. It centers around the assignment of roles to business entities. The physical flow of goods relates to the roles in the system, independent of their business owner, as these are the agents executing the physical process. Due to this property, next to the physical flows, the roles can also give rise, together with the contractually determined service and payment agreements that flow between business entities, to other intangible benefits (e.g. process status information, or social involvement). The execution process also provides information and feedback to the business entities that own the role.

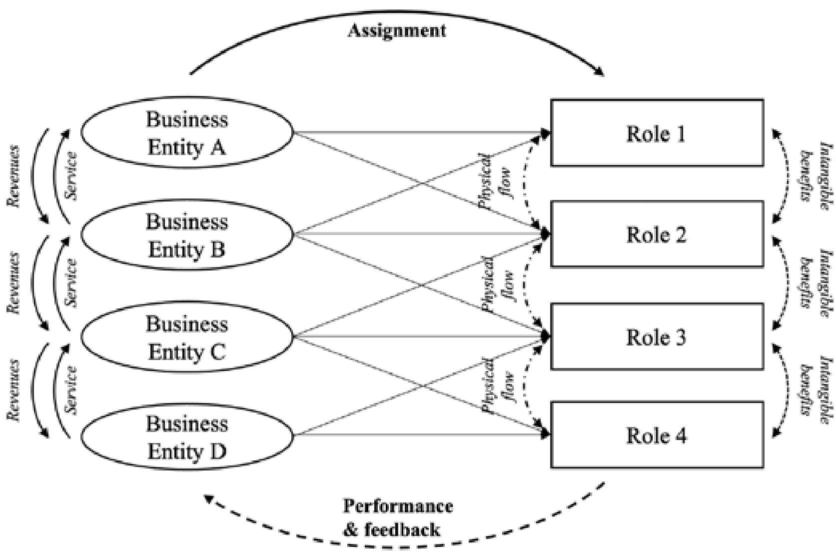


Figure 3.1 Relationships between roles, business entities and their roles

In other words, goods flow between roles and services flow between business entities in return for the exchange of revenues and intangible benefits. Business entities own monetary resources and thus are able to enter into logistics contracts and acquire services from other business entities. In essence, the value exchanges of money, goods, and services, as well as the intangible benefits (e.g. value proposition), are dependent on the role assignment, and are thus created (or co-created) and exchanged during the actual execution of the roles. For this reason, the boundaries between the roles have to be defined in a clear-cut way so as to identify the most basic elements of a business ecosystem that are still capable of providing value to the ecosystem and entice business entities to develop a sustainable business model around them.

The business model of a business entity is thus identified with the set of roles the business entity is playing and its relationship with other business entities, which are substantiated through formal or informal contractual obligations. This will lead to the coexistence of different business models in the system, such as the case of global players (e.g. Logistics Service Providers (LSPs)) offering a wide array of services for different market segments. Hence, each business ecosystem consists of a set of business entities and roles, together with the assignment of business entities to the roles. A business ecosystem then represents just one of the possible configurations of the system stakeholders and interactions.

Innovation in transport ecosystems brings forward a transition, either radical or incremental, from one configuration to another. For example, new business entities enter the ecosystem to provide value added services to other business entities and can enhance the overall profitability of the ecosystem in two ways. First, they can marginally improve the performance of the status quo role assignment through technological advancements that increase operational efficiency, without changing the underlying structure of the system. Second, they can create new logistics value and business relationships by either aggregating or separating the existing roles, thus contributing to a potential shift from one regime to another. In such a way, existing business entities are able to change some of the roles they play, moving towards a specialization (i.e. playing fewer roles) or a vertical integration (i.e. aggregating roles). The former case may be exemplified by a business entity outsourcing a purely operational role to a more specialized business entity, such as is the case with freight transportation tasks, which are usually carried out by haulers on behalf of large LSP organizations. The latter case instead involves business entities deciding to internalize more roles if synergies arise from the aggregation and bundling of services and products.

By the same token, changes in the role configuration of a business ecosystem may be fostered by the repositioning of existing business entities not necessarily driven by the entrance of new players. One could think for example of the breadth of roles being played by the online retailing giant Amazon, which goes beyond the traditional role of retailer to include those of logistics service provider (i.e. through the separate entity Amazon Logistics) and cloud computing platform offering Internet-as-a-service (Iaas) services to small and large businesses. These role changes were enabled by the availability of resources and by the fact that other business entities evaluated positively the benefits being generated through the service delivery.

The general description of the theoretical framework presented in this section is expanded upon in the next section via an application to urban freight transportation (UFT) systems.

4. AN APPLICATION TO URBAN FREIGHT TRANSPORTATION[1] SYSTEMS

UFT systems are characterized by a multitude of stakeholders with different and often conflicting objectives (Anand et al., 2014; Macharis et al., 2014). Moreover, urban freight has been center stage for the introduction of several logistics and transport innovations that cooperate or compete with incumbent players, such as cargo-bike delivery (Arnold et al., 2018; Gruber et al., 2014; Melo and Baptista, 2017), delivery through crowd-sourcing (Buldeo Rai et al., 2018; Devari et al., 2017; Guo et al., 2019; Le et al., 2019), or urban consolidation centers (Browne et al., 2005; Johansson and Björklund, 2017; Morganti and Gonzalez-Feliu, 2015; Paddeu et al., 2017).

The general role-based business ecosystem theoretical framework has been applied to UFT systems by Zenezini (2018; Zenezini et al., 2017, 2019). First of all, a practical implementation of the general theory must begin with the identification of the ecosystem boundaries. For urban freight systems, these are represented by the logistics process entailed in the last mile of freight transportation from a local source to the final recipients of the goods, which comprise retailers and final customers. For instance, this could be represented by the last leg of the physical distribution journey from the reception of goods at the distribution center located in the outskirts of an urban area to the final customer.

Then, agents must be defined, including business entities and roles. In particular, the roles are identified and classified:

1. Receiver. This role generates the demand for freight but is not in charge of any decision regarding the delivery process and only acts as recipient of the goods. This role is usually covered by final customers and local retailers.
2. User of logistics and city delivery services. These two roles also generate the demand for freight but actively decide to use one or more logistics or transportation services. Users of logistics service providers often require a wider array of services including warehousing and cross-docking, while users of city delivery services only need to outsource the transportation

of goods in the last mile. Usually shippers take on the role of users of logistics service providers, while express couriers often use local freight carriers for the city delivery.

3. Logistics service provider and city delivery operator. These two roles are taken by business entities that are appointed by the two previous roles to deliver parcels and other goods. These roles comprise the functions of goods consolidation as well as last-mile planning and delivery. City delivery operators offer only the transportation service. Usually express couriers such as DHL or small city transport companies take on these roles.
4. Network coordinator. While the previous roles are centered on the physical flow of goods downstream along the last-mile chain, this role covers those necessary activities and competences required for a smooth and transparent flow of information between users and providers. In other words, they provide the interface between the service providers and the users. Usually transport providers provide coordination services but, in some cases, intermediary platforms or public authorities can take on this role.
5. Logistics space planner and policy maker. These roles comprise the functions of land-use planning, in both public and private areas – for instance, facility managers who decide to offer a logistics concierge service for their employees or a public authority that wishes to add more loading/unloading bays for transport companies. The major interest of policy making is to evaluate the aggregate outcome of the ecosystem and intervene when necessary to steer it towards more sustainable goals (e.g. by limiting fossil fuel vehicles).

In addition to the UFT roles, nine business entity types are identified ranging from large global players such as express couriers to facility managers and local freight transportation companies. A more thorough and encompassing definition of CL business entities, roles, activities, resources, decisions, and value propositions is available in Zenezini (2018, pp. 20, 42).

The next step of an ABM implementation is the assignment of roles to business entities. In this regard, entities can only perform a handful of roles due to their inherent constraints or internal objectives. Nevertheless, most entities have significant leeway to change their status quo situation and move towards new roles, thus triggering the value creation process and ultimately the generation of a new business ecosystem. In any case, CL systems need to comprise all the roles identified in the matrix (Table 3.2), but, since business entities can take up more than one role, they can consist of only a sub-set of business entities.

Table 3.2 *Role assignment matrix*

Business entity	Role							
	Receiver	User of logistics services	User of city delivery services	Logistics service provider	City delivery operator	Network coordinator	Logistics space planner	Policy maker
Express courier		X	X	X	X	X	X	
City freight carrier					X		X	
Last-mile operator				X	X	X	X	
UCC operator	X			X	X	X	X	
Parcel locker operator	X		X	X	X	X	X	
Shipper		X	X		X			
Large retailer	X	X	X		X		X	
Local retailer	X	X	X				X	
Local authority	X	X				X	X	X
ICT-platform operator						X		
Facility manager	X	X				X	X	
Final customer	X	X	X					

Note: X marks a potential role–entity assignment.

Table 3.3 Business and operative decisions of CL roles

<table>
<tr><th>Role</th><th>Strategic decisions</th><th>Operational decisions</th></tr>
<tr><td>Receiver</td><td>Choice of logistics services
Evaluation of level of service
Evaluation of intangible benefits</td><td>Decide stock levels
Inventory policy: economic order quantity (EOQ), frequency of delivery, time of delivery</td></tr>
<tr><td>User of logistics services</td><td>Choice of logistics services
Demand allocation (long term)
Evaluation of level of service
Evaluation of intangible benefits</td><td>Demand allocation (short term)</td></tr>
<tr><td>User of city delivery services</td><td>Suppliers selection
Evaluation of level of service
Evaluation of intangible benefits</td><td>Demand allocation (short term)</td></tr>
<tr><td>Logistics service provider</td><td rowspan="3">Value proposition setting
Level of service provided
Pricing scheme
Budget allocation
Resource acquisition</td><td>Fleet allocation
Vehicle routing
Demand allocation</td></tr>
<tr><td>City delivery operator</td><td>Fleet allocation
Vehicle routing</td></tr>
<tr><td>Network coordinator</td><td>Data quality control
Computational capacity allocation</td></tr>
</table>

Each role–entity assignment configuration implies an allocation of decisions to business entities. Therefore, a business entity makes different decisions based on the roles played, and thus adopts different decision-making attributes. In the CL business ecosystem, decisions are related to both business and operational aspects of role execution (Table 3.3).

In the next two sub-sections we show a working example of how the theoretical framework is used by comparing and contrasting a traditional business ecosystem with an innovative one.

Traditional Urban Freight

A traditional urban freight business ecosystem focused on home delivery is usually composed of four entities taking on eight different roles, as shown in Table 3.4. Generally speaking, online retailers outsource the physical distribution to express couriers, who in turn consolidate different flows at their cross-docking centers as well as sorting the final delivery to delivery vans which are mostly operated by small local carriers. Final customers pay for the delivery but usually do not get to choose the LSP in charge of the delivery. Finally, local authorities are responsible for setting local regulations for freight vehicles.

Table 3.4 Traditional last-mile delivery role–business entity assignment

Business entity	Role							
	Receiver	User of logistics services	User of city delivery services	Logistics service provider	City delivery operator	Network coordinator	Logistics space planner	Policy maker
Express courier			X	X	X	X	X	
City freight carrier					X			
Online retailer		X						
Local authority								X
Final customer	X	X						

The value propositions offered by providers to users are often centered on speed, reliability, flexibility, visibility, and total cost of ownership (Ghodsypour and O'Brien, 2001; Dulmin and Mininno, 2003; Awasthi et al., 2016; Hwang et al., 2016), as shown in Figure 3.2. Local authorities are seemingly outside of the picture in traditional city logistics ecosystems because they do not offer logistics services directly. However, their actions, aimed at increasing the sustainability of transport operations, have an impact on providers. For instance, restrictions on polluting vehicles reduce the overall emissions level but increase the cost of transport providers (Broaddus et al., 2015; Dablanc and Montenon, 2015). On the other hand, a congestion charge might reduce the number of vehicles and thus increase the commercial speed.

By comparing Tables 3.2 and 3.4, we see that in Table 3.4 (i.e. the traditional UFT business ecosystem) fewer Xs are marked and thus there is some untapped potential for innovation due to several missing assignments between business entities and roles.

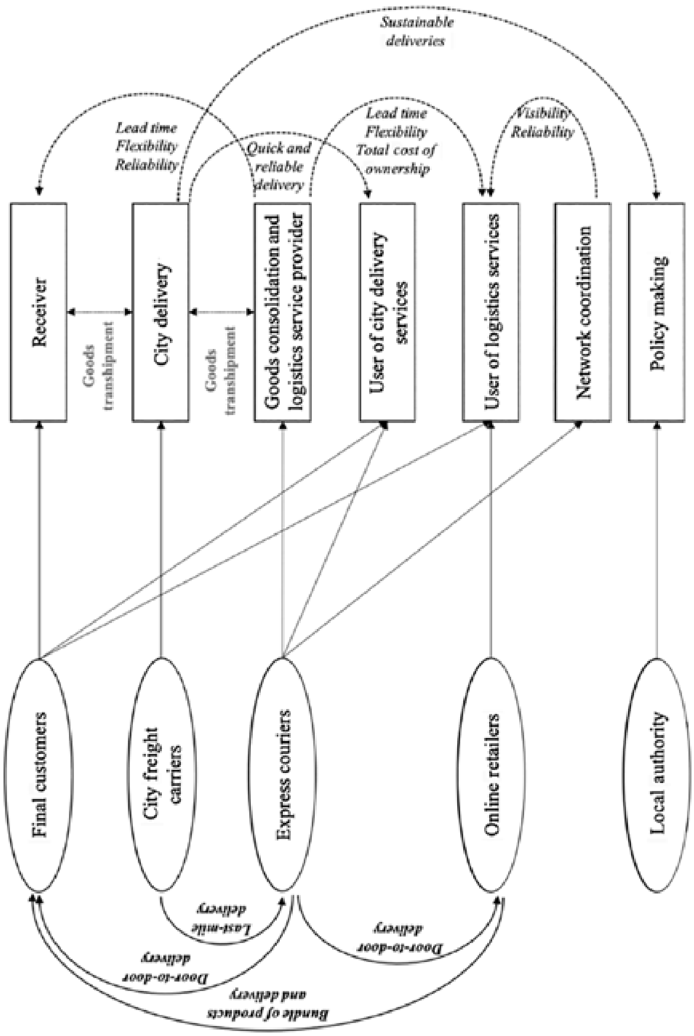
Innovative Urban Freight

As mentioned above, previous literature has explored a variety of innovative urban freight innovations that have attempted to alter the ecosystem by changing the traditional assignments of business entities to roles.

In this sub-section, we will focus on a sub-set of innovations which relate to the concept of the UCC. A UCC is a logistics facility that bundles consignments coming from multiple carriers and aims to consolidate deliveries to local retailers and final customers in order to reduce the number of vehicles required, the distance travelled, and the CO_2 emissions (Browne et al., 2011; Heeswijk et al., 2017; Johansson and Björklund, 2017). In particular, the four cases of UCC-based UFT business ecosystems presented here show that very similar innovations can shape the ecosystem in radically different ways.

Case 1: Targeting new customer segments and consolidating last-mile deliveries

The first case of innovation depicts a new business entity operating a last-mile delivery service through a distribution center and a network of parcel lockers located inside the office buildings of large employers (Table 3.5). This new company is opening up a new market in the traditional urban freight ecosystem by offering a dual value proposition: for employers the value proposition consists in the fact that the additional workload at the reception desk of the employer will be relieved if employees ship their items to an unmanned automated locker; for employees the service reduces the risk of missed deliveries without bearing additional cost.



Note: Ovals are for business entities, blocks are for roles.

Figure 3.2 Traditional last-mile delivery business ecosystem

Table 3.5 *First case of urban freight innovation – business ecosystem configuration**

Business entity	Role						
	Receiver	User of logistics services	User of city delivery services	Logistics service provider	City delivery operator	Network coordinator	Logistics space planner
Express courier						X	X
City freight carrier				X	X		
UCC operator	X		X	X	X	X	X
Online retailer		X					
Facility manager		X					X
Final customer		X					

Note: * Local authorities play the role of policy maker.

After signing up to the service, employees make their online purchase and enter the company's distribution center as a delivery address while receiving a code to open the parcel locker which will contain their parcel. Express couriers then deliver goods to the company's distribution center on behalf of the shippers. Finally, the company receives the parcels from the couriers and sorts them onto the delivery vans operated by a city freight carrier for the final leg. The value proposition then rests upon good coordination between the company and the express couriers, who are required to deliver at the distribution center early in the day in order to comply with the delivery service levels.

Case 2: A UCC subsidized by a local authority

The second case shows a typical example of a UCC implemented by a local administration and operated by an LSP (Table 3.6). The value proposition for this UCC operator is again dual. First, express couriers outsource the city delivery to a city freight carrier, a situation akin to a business-as-usual configuration. Second, local retailers pay the last-mile delivery service in a bundle with the extra storage service provided by the UCC, which in turn increases delivery service flexibility and speed (i.e. local retailers can have their parcels delivered on very short notice from the close-by UCC). Local retailers are thus asked to be more proactive in their logistics choices in comparison to the traditional urban freight.

The UCC consolidates goods destined to retailers in the Central Business District (CBD) of the city, and then operates a fleet of electric vehicles for the delivery. Besides subsidies provided by the local city council, which account for 45 percent of operation costs, the revenue streams derive from usage fees paid by both local retailers and express couriers. The value proposition in this case is sustained largely with very low and competitive fees, which could put the UCC's financial stability in jeopardy once subsidies are terminated.

Case 3: A privately owned UCC

This case represents a company operating a network of urban consolidation centers in Dutch cities (Table 3.7). It focuses on offering goods consolidation and other logistics services (e.g. delayed cross-docking, home deliveries, waste returns) to small local retailers. The major value proposition for the company is aimed at local retailers, who can take advantage of a decreased number of deliveries and a lower inventory, which are typical benefits of a receiver. Hence, the UCC operator receives monetary remuneration from local retailers, who need to be proactive and shift towards the role of logistics services users.

The UCC operator acts as a logistics service provider and organizes the last-mile delivery process, as in the previous cases. Moreover, as in the previous cases, there is an overlapping of logistics service provider and network coordinator roles between the new business entity and incumbents (i.e. express

Table 3.6 Second case of urban freight innovation – business ecosystem configuration

Business entity	Role							
	Receiver	User of logistics services	User of city delivery services	Logistics service provider	City delivery operator	Network coordinator	Logistics space planner	Policy maker
Express courier			X	X		X	X	
UCC operator				X	X	X	X	
Local retailer	X	X	X					
Shipper		X						
Local authority		X					X	X

Table 3.7 *Third case of urban freight innovation – business ecosystem configuration*

Business entity	Role						
	Receiver	User of logistics services	User of city delivery services	Logistics service provider	City delivery operator	Network coordinator	Logistics space planner
Express courier				X		X	X
City freight carrier					X		
UCC operator			X	X		X	X
Local retailer	X	X					
Shipper		X					

couriers). Retailers in fact pay a monthly membership fee plus an additional fee for the extra logistics services. The last-mile delivery is outsourced to city freight carriers. Contrary to the previous UCC case, this UCC operator does not target express couriers specifically and instead hopes to target shippers by offering them an ICT system integration package that provides a single interface to receive real time Proof of Delivery (POD) for all their shipments and enables them to combine shipments for geographical areas. As a consequence, network coordinator is a role where the UCC operator is putting in considerable effort in order to offer a valuable service and provide intangible benefits to shippers.

Case 4: A pickup point for employees

This case hinges on an internal pickup point and consolidation center located within a university (Table 3.8). The main value proposition in this case is to provide a service to employees. Moreover, intangible benefits are also reaped by the express couriers, who can be certain that their deliveries will not fail and can optimize their routing by consolidating deliveries in a single stop. In some regards, this case study is akin to Case 1. However, in this particular case the delivery process is not automated as in Case 1, where parcel lockers were installed and no interaction between the driver and the personnel occurs.

Daily operations include receiving deliveries for all employees (about 2000 people) and sorting them by university department, and are subcontracted to a third-party company by the university. Thus, for the employees this center operates as a pickup point for their online purchases, whereby delivery receipt is notified via electronic exchange and employees can pick their purchases up within office hours. Express couriers retain their business-as-usual business and operational model. Again, network coordinator is a role of paramount importance for the success of the service, even though the pickup point operator does not guarantee any level of service for the delivery.

From the cases presented in this section we can draw some implications for CL business ecosystems, as well as make insightful linkages between CL practice and the business entity theoretical lens and its application to transport innovations.

Competition between old and new ecosystems, and related challenges

The new company entering the market in Case 1 becomes a logistics service provider, thus competing with larger firms. The decisive success factor for the new player here is to improve the goods consolidation and logistics service provider role performance, and find a coordination mechanism with the express couriers in the absence of a contractual agreement. Challenges arise when competition ensues between ecosystems. The UCC operator of Case 2 for instance acts as an additional decoupling point, bearing operational costs

Table 3.8 *Fourth case of urban freight innovation – business ecosystem configuration*

Business entity	Role						
	Receiver	User of logistics services	User of city delivery services	Logistics service provider	City delivery operator	Network coordinator	Logistics space planner
Express courier			X	X		X	X
City freight carrier					X		
Pickup point operator	X			X		X	X
Online retailer		X					
Facility manager		X					X
Final customer		X					

without creating additional value to exchange for higher revenues. Moreover, the UCC operator performs the role of city delivery operator and offers the service to the local retailers, who have already paid for a part of the delivery process and are not always able to negotiate a reduction of delivery fees with shippers and couriers. Hence, acting as both logistics service provider and city delivery operator might not yield economic and financial sustainability for the business entity aggregating those roles. Finally, a very important role that each of the previous new business entities had to perform is that of network coordinator. To perform such a role, the business entities had to develop skills and acquire resources. As previously mentioned, when the complexity and number of linkages among business entities and roles increases, the network coordinator ensures that the delivery goes as smoothly as possible and different supply chains integrate seamlessly. On the operational side, it is often required that new business entities develop an integrated ICT platform from scratch. As a matter of fact, an ICT platform is a required asset for the network coordinator role, which can be performed by new business entities in a more effective and efficient way than other business entities.

Value creation mechanisms

Creating and providing value for existing and new customer segments is key for ecosystem innovation. For instance, the network coordinator does not only help stakeholders switch to the new business model, but could also provide additional value and constitute a profitable service, as in Case 3 for shippers. The new company in Case 1 must compete in performing the same role as the express couriers but by adding an additional consolidation point hopes to gain revenues by providing value to a new customer in the network, namely the employer. In turn, express couriers might benefit from disengaging from the last leg of the delivery process, which accounts for a large share of the total logistics cost. Similar intangible benefits are achieved by express couriers in the case of the university pickup point operator in Case 4. Ideally, monetary flows should be generated in exchange from all stakeholders who benefit from value creation. Unfortunately, this is not always possible due to the ecosystem's inertia and the bargaining power of large incumbent players. Gaining a critical mass of users must then be achieved in order to shift part of the power from incumbents to entrants.

Role improvement

The new business entity in Case 1 takes advantage of the fact that it is not profitable for employers to act as receiver, since it is not rewarding for them and it generates hidden costs of inbound operations. The key to becoming profitable and attractive to employers is to evaluate correctly the value of the solution from the employers' point of view and propose a service fee lower than that value. Reducing the cost entailed in playing a certain role in the ecosystem is thus an efficient way to improve the overall profitability and the ecosystem and to thrive in it.

5. IMPLICATIONS FOR RESEARCH AND PRACTICE

This work generates several research and practical implications for researchers, practitioners, public bodies, and transport innovators.

Implications for Research

This work opens up a variety of potential implications for business ecosystem modelling, by pivoting on the linkages between the strategic decisions taken at the firm level in the face of innovation and the intrinsic operational processes of a transport ecosystem. These linkages work both ways, since the decision from a firm to take on a role and enter into contractual relationships is ultimately driven by the operational aspects entailed by that specific role. Hence, more strategic decisions should be added at the role level to investigate endogeneity in the model. For example, the decision to change a role might be triggered by the failure of an entity to make profit, or by other conditions such as an entity not maximizing other objectives.

In order to release the full capability of the business ecosystem framework and turn its underlying tenets into actionable and useful bottom-up simulation models, it is however necessary to gain more understanding of the behaviors of firms when innovation occurs, bearing implications at different levels of decision making. Bottom-up modelling requires a lot of trial-and-error due to the fact that acquiring behavioral data is a complicated enterprise as it requires abstracting complex behaviors from real life. In this context, the rules that govern decision-making processes can be set up in various ways. Strictly logical, deterministic rules would assign only one possible behavior to an individual in a particular circumstance (Grimm and Railsback, 2005). Alternatively, a rule may be probabilistic, with a different probability for each choice in an array of possible actions in response to some stimulus. Rules may furthermore be a combination of probabilistic and deterministic.

We thus point out some of the thornier issues that researchers need to address while implementing the business ecosystem perspective in a full-fledged agent-based model.

First, while the identification of roles metrics is quite straightforward when they are concerned with tangible objects such as services and resources, it is much more complex when intangible benefits are exchanged between roles and business entities. Second, the decision to take a certain role is binary, meaning that behaviors change abruptly after certain thresholds are achieved. Are these thresholds only represented by the effectiveness of a value proposition offering or by a better cost–benefit analysis, or else are there other aspects to be considered, such as conforming with others or long-term goal-seeking behaviors? Firms for instance might look beyond their immediate payoff and maximize their long-term profits. It is worthwhile in this sense to explore reinforcement learning mechanisms for firm agents (Kara and Dogan, 2018; Teo et al., 2012).

Third, innovation in the ecosystem may trigger various reactions from incumbents. Incumbents can either:

- keep on playing the same roles and cooperate by complementing some innovators' activities or markets;
- imitate the business model, if the innovation is incremental and requires only minor changes in competences and resources (Casadesus-Masanell and Zhu, 2013);
- create new market needs, leveraging the innovation to change their products and service offering (Bucherer et al., 2012).

The agent-based model could then incorporate separate behavioral foundations in the agents' code in order to simulate the effects of these different strategic decisions taken by incumbents of the ecosystem. In this regard, the ABM implementation is not the focus but rather the means through which researchers are able to address the multi-faceted complexities of transport innovation business ecosystems and achieve quantitative evaluations for all stakeholders involved. Hence, the ABM implementation would involve using the most consolidated software available (see Borshchev and Filippov, 2004; Macal and North, 2010; for a more comprehensive review of ABM implementation tools and softwares). Nevertheless, researchers should deal with more manageable applications of the theoretical framework by focusing on a sub-set of activities, decisions, and metrics among the ones included in the business ecosystem roles. The goal of the ABM implementation is thus to describe the business entities as agents that are able to adapt by taking proactive or reactive decisions based on the level of metrics. Zenezini (2018, p. 42) provides an example of such a line of thinking based on Case 1 outlined in section 4.

Implications for Practice

The business ecosystem approach marks a major change in modelling from the current methods, which rarely describe the business models of actors, let alone the distinction between the institutional and the business levels. It introduces several innovations in the way we describe actors and processes, for example:

- From a practical standpoint, the business ecosystem agent-based framework enables the assessment of the operational and economic feasibility of innovative solutions in the transport sector, by assigning a business model to all the stakeholders involved. Hence, it allows us to pinpoint the benefits, the responsibilities, and the related challenges for each actor of the ecosystem. As a by-product of this capability, scholars and practitioners may use the framework to identify "winners" and "losers" of a transport innovation.
- Then, several outcomes can unfold. Should transport innovation convey the benefits for other entities in the ecosystem effectively, we would see the positive effects on the ecosystem as a whole already in the short term. Otherwise, other actors might fail to recognize the value of the innovation, thus hindering the long-term sustainability of the innovation itself. The framework in this context may be used to highlight where the discrepancies between the global potential benefits and such barriers to the diffusion of innovation reside.
- Moreover, it is possible to evaluate winners and losers using different scales of evaluation. Innovation in the transport sector can be implemented as a means to achieve environmental sustainability rather than pure economic sustainability. Hence, the business ecosystem agent-based framework already envisions that public authorities become part of the business cycle of the transport innovation. Therefore, when tensions arise between environmental sustainability and financial remuneration of investments by private operators, devising a business model for the local authority supports its entry in the ecosystem as a proactive agent able to smooth those tensions with incentives or regulation.

In the past decades, the history of innovations in city logistics has shown that step-by-step innovations, based on a minimum viable product perspective, are often more effective than radical innovations and large-scale investments. Radical innovations may fail because they only focus on long-term impacts while underestimating the strains and barriers inherent to the change of roles required from the actors in the short term. This is the case of innovation processes, including those in transport, that are positioned in a context of Living Labs (this can be a factory, a consumer group, or an entire city) (Quak et al., 2016). Here, innovations are not presented as big-bang scenarios but in an incremental fashion, where the lab context provides feedback about what works and what does not and allows incremental design and implementation of change. Models in this context have also been named "digital twins" of cities, and form the instrumentation of these labs, where they are fed by sensors that measure all activities, and supply decision makers with scenarios for the future. The business ecosystem lens and the ABM approach allow a dynamic simulation of the interactions among the stakeholders, and allow the evaluation of the implications of multiple, simultaneous or sequential decisions by actors in the system. They could be the backbone for a digital twin of a city's logistics community, which helps to predict and visualize how existing regimes will respond to changes. The effects of radical versus incremental innovations can also be explored with this approach.

6. CONCLUSIONS

Market pressures from customers and competition forces companies to innovate their logistics processes, either within or outside the company. Innovations in the transport and logistics sectors can affect multiple actors in the system, and entail various decision-making processes ranging from long-cycled (years or decades) for large-scale innovations, and short-cycled (weeks or months) for smaller, incremental innovations.

In these contexts, transport innovation modelling should consider the relationships that take place between stakeholders with different motives and business models. In this chapter, we aimed to fill this gap by introducing a new modelling paradigm that depicts transport systems as business ecosystems. To this end, we explained the antecedents of the paradigm, operationalized its theoretical concepts with a practical application in the area of urban freight transport, and proposed several implications for practice and theory.

Four cases of application to the UFT context of our framework were presented. These cases are based on the innovative concept of a UCC, but differ significantly in terms of business entities involved and reconfiguration of the ecosystem. In Case 1 a new business entity enters the market, aggregating the roles being traditionally played by larger incumbents, and thus hopes to improve the performance of those roles as well as involve more business entities in the ecosystem in order to be successful. In Case 2 the innovator provides the same service without a reconfiguration of the system, and thus simply replicates the same business relationships without providing added value. Case 3 is very similar to Case 2 but aims at providing added value to another business entity, hoping therefore to compete with the larger incumbents. Case 4, finally, is focused on including more business entities in the ecosystem by specializing in a specific role and not by overlapping with the roles being played by the traditional business entities.

The proposed framework may be used in other transport ecosystem contexts where innovations occur, beyond the geographical scope underlying the cases presented in this chapter. The business ecosystem framework may be used for instance to evaluate the transition towards the Physical Internet (PI). PI is a revolutionary concept that aims to coordinate different actors situated in different geographical areas and at different functional levels for a more transparent, smooth, efficient, and sustainable supply chain (Pan et al., 2017). This new paradigm forces us to rethink the traditional roles of global supply chain actors and add new ones such as open warehouses and distribution centers (Crainic and Montreuil, 2016; Oktaei et al., 2014).

This work unveils several opportunities for further research. In fact, researchers can make use of the proposed framework to model the uptake process of transport innovations. In order to do so, however, it is necessary to delve into the links between operational and strategic decisions of the role-based framework. For instance, it could be possible to investigate endogeneity in the model by integrating strategic decisions at the role level. Further exploration is also required in terms of understanding the behaviors of the ecosystem firms in the face of incremental or radical innovation.

This work also engenders several implications for practice. First, the business ecosystem agent-based framework allows pinpointing the benefits, the responsibilities, and the related challenges for each actor of the ecosystem, including the public authorities (e.g. by including environmental benefits as well). Second, it allows shedding a light on barriers that exist in the ecosystem and hinder the success of transport innovations, potentially preventing global benefits being achieved in the long term.

Finally, the business ecosystem lens integrated with the ABM approach could provide a backbone for a digital twin of a transport and logistics environment, providing feedback to ecosystem actors about what works and what does not, thus allowing for an incremental design of innovation and further implementation of change.

NOTE

1. As a synonym for City Logistics.

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