CAN GOVERNANCE PRINCIPLES AND BUSINESS MODELS OF DIGITAL INTERNET BE TRANSLATED TO PHYSICAL INTERNET?

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Abstract

The Physical Internet (PI) is envisaged as a new approach to cooperation in logistics, aimed to increase efficiency and reduce impact through increased interoperability, inspired in how data is transferred via the Digital Internet (DI). Therefore, many of the elements of the Physical Internet network can be translated to their Digital Internet counterparts. Most of the research until now has focused on standardisation of packaging or the digitalizing of different documents exchanged between logistic partners. With regards to governance and business models in the Physical Internet network the current research is relatively limited. As the concept of Physical Internet was inspired by the Digital Internet, it makes sense to look at the concepts applied there and see if and how they can be translated to the Physical Internet. As a proof of concept, this paper will show that some of these concepts are indeed transferable and could be of importance for the future development of PI. To that end, the paper investigates an important governance issue: Net Neutrality and two well known business models the auction and the subscription model.

1. Introduction

Logistics today have difficulty keeping up with the ever increasing demand for transport, while shipments size decreases and frequency of delivery increases. These trends lead to less efficient systems, while the importance of reaching the zero emission targets becomes more and more clear. Therefore, it is relevant modify logistic systems to cope with these new challenges. Traditionally, from a business point of view, logistic operations can be improved by either expanding a company by acquiring competitors or complementary services, contracting or subcontracting specific tasks to other companies, or forming alliances between independent companies (Ballot, 2021).

The concept of the Physical Internet (PI), as first formulated by Montreuil (2011), adds a novel fourth option to improve logistic operations. Looking at the Digital Internet (DI) for inspiration, this concept looks at ways to send cargo through a network of networks, as if it were packages of data on the internet. This implies smooth cooperation between independent companies operating different smaller networks within the larger whole.

Most 'real world' steps taken towards Physical Internet at this point look to either standardisation of containers or the digitalizing of different documents exchanged between logistic partners. Although this facilitates cooperation and decreases the cost of interoperability, this doesn't fundamentally change the way the logistic chain functions. Although some authors have referred to the potential of Physical Internet to change the business models in logistics, exploration into new forms of organisation in logistics is still limited (Montreuil et al. 2012, Sternberg and Norrman 2017, Zijm and Klumpp 2017, among others).

As we are looking towards the Digital Internet for inspiration on how to organize our logistic flows, it seems logical to look in the same direction to identify possible novel business and organisation models for the Physical Internet. In section 2 the similarities and differences between the Digital and the Physical Internet will be identified to determine how alike they actually are. Next, in section 3, I will look at a concept which might shape the future development of the Physical Internet as it did the Digital Internet: Net Neutrality. Then, in section 4, I will illustrate the possibility of (partially) transposing business models from Digital Internet to Physical Internet by giving two examples. Finally, in section 5 the main conclusions are outlined.

2. Physical versus Digital: how alike are they?

At first glance, the differences between the Digital and the Physical Internet seem rather large: where one is seemingly instantaneous, free and flexible, the other is perceived as relatively slow, expensive and in need of fixed infrastructures and networks. However, as shown by Sarraj et al. (2014) and further elaborated by Hofman et al. (2017) and Dong and Franklin (2020), the network logic of both systems can evolve to be very similar: a network of networks, interconnected by nodes (routers), transporting standardized packages from origin to destination, following a standardised set of protocols.
The ease of use of the Digital Internet hides the fact that the sending and receiving of data also requires addresses, networks and infrastructure, and that it does cost time and money to achieve. The fact that things move slower, or that the cost of a specific handling is higher, does not mean the same basic principles cannot apply to logistic networks. We will look first at the elements of which both networks consist, to determine how they can be translated from Digital Internet to PI. This will set the framework upon which further analogies in terms of governing principles and business models can be build.

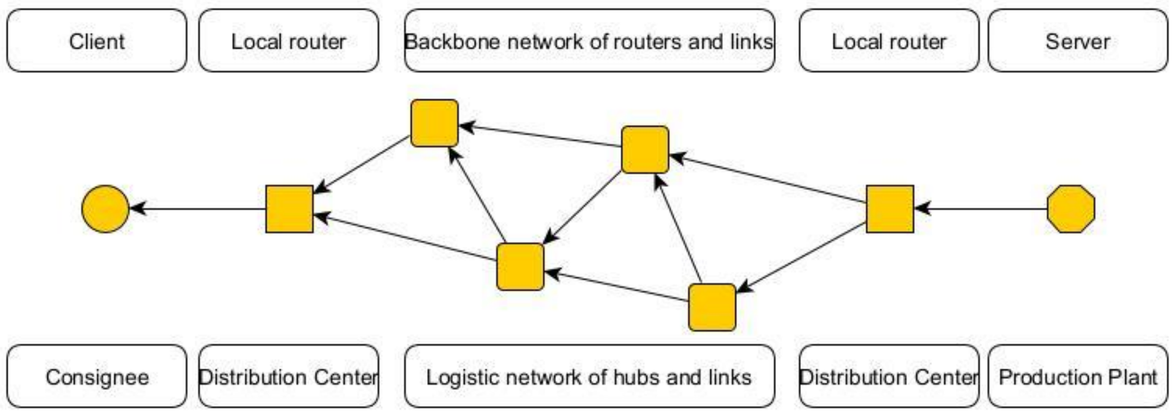

Figure 1: Conceptual sketch of the Digital Internet and Physical Internet networks

As figure 1 shows, both networks consist of a set routers (DI) or hubs (PI), connected by links, transporting data (DI) or cargo (PI) from a server to a client (DI) or from a production plant to a consignee (PI). The network is controlled and operated by an Internet Service Provider (ISP) (DI) or a

PI-Logistic Service Provider (LSP) (PI), who interact with each other following a set of protocols (DI&PI). Both networks use packaging to envelop data or cargo, but only Physical Internet needs transporters to move those. In the Digital Internet the **client** is defined as a device linking to the internet, who will request data from the network. These can be easily linked to the **consignee** in the PI, having a physical addresses or geolocations in the physical world. In fact, the physical world already has a standardized address-system (both in GPS-coordinates and in addresses consisting of countrycode, region and/or city code, street and number) that is fit for this purpose.

On the other side of the Digital Internet you have **servers** that store information, which could be translated to **production plants** (or shops or depots depending on the level of the network you are looking at). As in the Digital Internet, they will send you their products upon request, given you provide them with the necessary data (address, amount,…) and sufficient payment. This is a first clear difference between the Digital Internet and the PI. Where in Digital Internet you don't pay directly for the data you receive (in most cases), you will have to do so in the Physical Internet before anything is shipped to you.

To provide an interconnected network, also the **packaging** and the **transport carriers** need to be standardised over all networks (Montreuil et al. 2010, other authors). The ISO-container is a first example of standardising in this manner and is already well accepted. To incorporate also different flows in the Physical Internet, further standardization will be needed.

The **routers**, the nodes in de Digital Internet network, serve as **hubs** or distribution centres, where data are shifted from one link in the network to another. In both the Digital and the Physical Internet these routers/hubs can also act as buffers, making sure the data/goods arrive at the destination at the appropriate time (and/or in the appropriate order). The role of these routers in de Digital Internet is larger than it would probably be in the Physical Internet. In Digital Internet, routing is done (mostly) in a dynamic way: routers decide on-the-fly were to send the package next. Fixed routing exists, but is regarded as the exception, as it is not flexible enough to deal with changes in the network and is prone to errors in the programming. In the Physical Internet, pre-planned, fixed routes will probably remain the main routing logic. In a full PI-network however, dynamic routing would be introduced as a back-up. A hub in a Physical Internet network would check the route ahead for any changes compared to the pre-planned situation and adjust (or recommend adjustment) accordingly.

Between these hubs/routers, goods/data are transported over **links** in a **network**. In the Digital Internet, this network is only defined by its infrastructure. In the Physical Internet, it is not only the infrastructure (road, rail, waterways) that determines the capacity, but also the capacity and frequency of the PI-transporters that move upon this network. In fact, the network, without these transport carriers, does not function like a logistics network at all, as it cannot move goods on its own. This adds an important layer of complexity to the Physical Internet, that simply does not exist in its Digital counterpart.

In addition to the complexity of timetables and capacity of transporter carriers, a big difference between Digital Internet and Physical Internet that will remain, is exactly these **transport carriers** and the **packaging** they carry. As they are physical entities, they don't just 'appear' when goods are sent or 'disappear' at arrival, as data packaging would. This creates the desire to reuse (refill) them in an optimal way to avoid empty travel as much as possible. Also, they are owned by one specific company, who could allow other companies to handle them (lease, rent,…), but would still require some level of control over and revenue from them. This means the reuse of these assets for a different transport is not as self-evident as it might seem to outsiders. And even if this problem were to be solved, we still have to deal with the human drivers of the transports involved, who cannot just be 'handed over' to the next movement in any scenario.

Although a lot of this might seem a vision for the distant future, we could consider current **Logistic Service Providers (LSP)** and/or **Forwarders** as operators of limited PI-networks, much in the way **Internet Service Providers** do in the Digital Internet. They operate and/or use a system of 'links' and nodes, operated by themselves or other logistic partners, to send goods over the network. The current way of working has some limitations however, which prevents the system from operating as a PI; the main one being the lack of (operational and infrastructural) interoperability between the different Forwarders and LSP's. As they only consider and handle their own flows, a real interoperable and dynamic system cannot be realised.

To make different networks work together, a set of clear **protocols** is needed. In the Digital Internet, these protocols only have to deal with things like addresses and package order. In today logistic systems, protocol-like structures already exist, namely Incoterms, customs agreements, international modal legislation, international postal agreements. These aspects will be mirrored in the Physical Internet IT-system and enriched with all information on how to handle a specific container (next destination, next mode, timeslots,…). This information is standardized and send ahead of the actual container, so any hub or transporter will know how to handle each specific container.

A first conclusion from this analysis is that there are a lot of similarities between the Digital and Physical Internet and we can apply (an adapted version of) a lot of the concepts from Digital Internet to PI. We can assume that this will also be the case for possible business models and governance principles. Thus, it makes sense to look at existing practices and debates in the Digital Internet to translate good practices to the Physical Internet and avoid pitfalls already identified in Digital Internet. This paper will focus on one governance principle and two business models:

- Net Neutrality as an important governance principle in Digital Internet
- The auction model as a possible business model
- The subscription model as a possible business model

3. Net Neutrality

Net Neutrality is one of the governing principles of the Digital Internet, and was first proposed by Wu (2003). Since then, much research has been done regarding the benefits and disadvantages of this principle to the overall functioning of the Digital Internet (a search on Mendeley returns 1.263 results for the search string "Net Neutrality", dating from 2007 to 2021, a recent review is presented by Gardinger in 2020). To the best of our knowledge, this principle is not yet considered from the Physical Internet viewpoint. I will first explain the concept of Net Neutrality further, before exploring its possible translation to Physical Internet.

The European Union adopted the 'Net Neutrality' concept as a policy, according to Regulation 2015/2120.1 (adopted by the European Union on November 25, 2015). This implies:

- No Blocking: [Internet Service Providers ("ISPs")] shall not block lawful content, applications, services, or non-harmful devices, subject to reasonable network management.
- No throttling: [ISPs] shall not impair or degrade lawful Internet traffic on the basis of Internet content, application, or service, or use of a non-harmful device, subject to reasonable network management.
- No paid prioritization: [ISPs] shall not engage in paid prioritization.

The first two are relatively easy to understand: if moving data or goods from another entity, you should treat them in the same way as your own data or goods, unless the data or goods are unlawful. Paid prioritization is more difficult to grasp and more debatable. In the Digital Internet, this refers to allowing certain providers priority over 'general' internet traffic, for a fee or because they are part of the same company. This is feared to lead to a 'dirt road' (Lessig, 2006), where non-paying content providers are virtually blocked and cannot be accessed by users. Within the Digital Internet, this is a purely hypothetical concern at this moment, as the capacity is large enough to service both the paying and the non-paying content providers.

Translating to the physical world, an LSP could cooperate with specific suppliers, giving their goods privilege over other goods to be transported, thus creating very long delays for goods from other suppliers. This would force clients to buy goods from the supplier affiliated with the LSP to obtain reasonable lead times.

The concept of Net Neutrality is well established within the Digital Internet and regarded as a fundamental principle to make the network of networks feasible (Marcus, 2016, among others). The concept also has fierce opponents however, both from commercial businesses and from academia. Sidak and Teece (2010), among others, claim the concept will have a negative impact on investment and innovation, competition, speech and civic participation and congestion management and list an overview of opponents of the Net Neutrality concept. From the business side, opponents are mainly the ISP's, as they lose freedom to determine their own business model, including offering different quality of service to clients according to their budget or increasing their revenue by offering paid prioritisation to certain (affiliated) content providers.

We can see that the same questions will have to be treated in the Physical Internet. If Net Neutrality is adopted or not, and how it is exactly defined, will have a profound impact on how the logistic networks will interact with each other. An important factor in this discussion is at which level routing options are calculated and routing choices are made. Will transport companies keep the freedom to accept or decline a transport, or will a transport simply be assigned to them if it fits their specifications? Will these decisions be centralised at a 'control tower' for a certain region or completely be decentralised at the end users? Or do we adopt the Digital Internet way of working, in which case the nodes (routers) decide which route the cargo will take?

4. Possible business models

Lots of different business models are used related to the Digital Internet. Companies focus on creating the infrastructure, managing data flows, creating content and/or play an intermediary role to bring together different players. Depending on their role, they use different approaches to gain profit. In the following paragraphs, I will explore two common business models in Digital Internet and their applicability in PI.

4.1 The auction model

One of the first business models that comes to mind when thinking of the Digital Internet, is the selling of add-space on websites, called 'programmatic advertising'. In this concept, shown in figure 2, a content creator offers space on a website for adds through a Supply-Side Platform (SSP), which auctions this add spaces off to interested parties through an ad exchange using a specific bidding strategy (which may differ from SSP to SSP). Interest (and as a consequence price) may vary depending on how much is known about the user currently looking at the website and whether or not this user fits the target audience of the add.

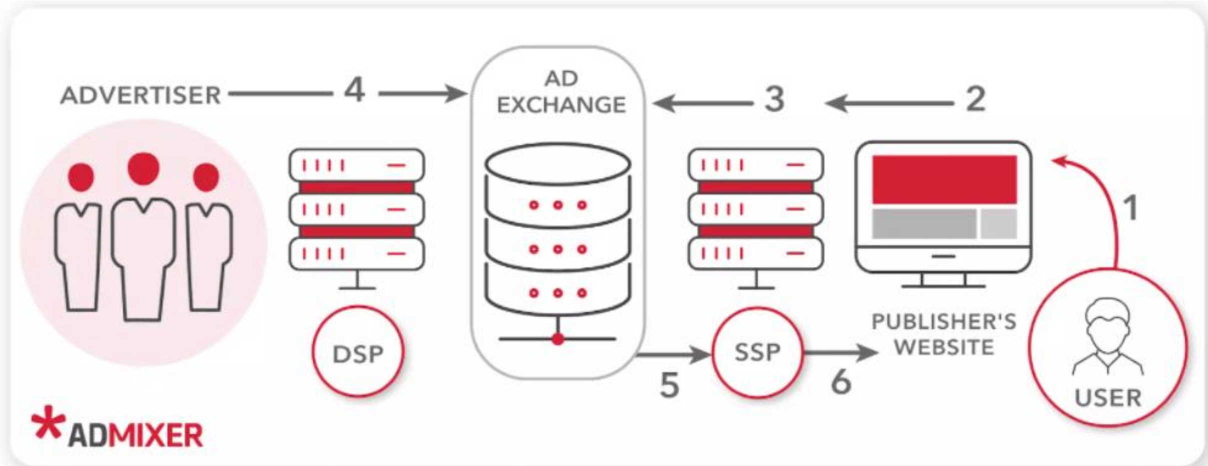

Figure 2: programmatic advertising (source [Admixer | Full-Stack Programmatic Ad Tech Solutions](#))

A pricing model based on smart auctions has already been described in the context of Physical Internet. For now, this work is focussing on perishable goods auctioning linked to smart logistics (Kong et al. 2016) and less-than-truckload (LTL) request pricing (Qiao et al. 2020 and earlier work). Qiao et al (2020) show that dynamic pricing in freight transport has not been applied (or even studied) widely.

On the contrary, price decisions are mostly statical and do not include the forecasted opportunities at the next hub. To fill this gap a dynamic pricing system for LTL is proposed, where the hubs are the active players, issuing the request to the transporters. This organisation stays very close to the concept of the Digital Internet, where routers decide independently on the next link a package of data needs to take.

Control over the logistic flows in this kind of setting can be extremely decentralised, with all the intelligence and decision power of the system resting with the hubs, who forward cargo on the next link of the network. Given the relatively high value of cargo as compared to data packages and the impossibility to 'resend' or 'copy' in an instance, as could be done with data, this would imply a very proficient network and a high level of trust from all parties involved. Although organising the intelligence of the Physical Internet through the hubs might be plausible, the decision making will, at least on the short term, probably remain with the shipper or consignee of the cargo.

In this system, a shipper/consignee would, after issuing a request for cargo to be transported, receive several offers from different combinations of hubs and transporters, each with their own characteristics such as cost and leadtime. In a fixed price / fixed schedule setting, this is not even a farfetched concept, as several carriers, forwarders and hubs already offer this kind of overview for their own services. By combining the available information about capabilities and prices for all (or many) nodes and links in the network, a cargo-routeplanner could be created.

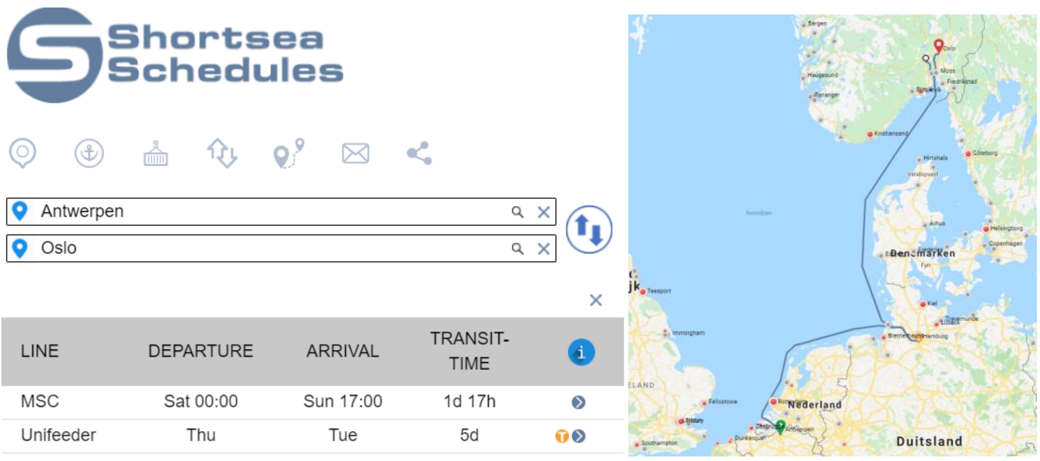

Figure 3: Shortsea Route planner, centralising offers from different carriers (source: Shortsea Schedules)

Combining both dynamic pricing and decentralised decision making at a large scale, human decision making will no longer be sufficient to provide adequate responses. Here we can look to the algorithms used by SSP's when selling adds. Obviously, cargo to be transported is more differentiated than add space is, so the system will be inevitably more complex. On the other hand, the add business today already keeps track of both the websites and the clients profiles to decide to bid or not and which price to set. Within a full PI-system, working with standardised PI-packaging, size differences become less decisive and the system should only check for compliance with other parameters as maximum cost, timeslots to be respected and so on.

Although the shipper in this context is in full control, this concept would break the existing trusted client – LSP/forwarder/transporter connections, which will still make it more difficult to trust 'the system' with valuable cargo (although less so than if routing decisions were made by hubs). In addition, the level of decentralisation makes it hard to implement overall goals to the logistic system as a whole (increased sustainability, less traffic accidents,…).

4.2 The subscription model

The day to day operations of the Digital Internet are organised by the Internet Service Providers (ISP). Here we find a diversification between client-oriented IAP's (Internet Acces Providers: Proximus, Telenet,…) and upstream or backbone ISP's (EUNet, Deutsche Telekom,…) who control the larger international or intercontinental infrastructure of the internet.
IAP's and backbone-ISP's can either assume a peering or a transit relationship, as described in Cremer, Rey and Tirole (1999). This now seems self-evident, but at the emergence of the Digital Internet as a commercial endeavour (the largest part of the initial network was privatised in 1995), the question on how the business model related to this newly emerging network should ideally look like, was as prominent as the question on how a PI-business model could function is today. Up until that time, studies focussed on smart market auctions to allocated scarce transmission capacity among end users, much as the auction model for Physical Internet described above. With increasing commercial interest and increasing capacity, this model was no longer relevant and the attention of researchers shifted to a subscription model.

These subscriptions work at different levels: an end-customer subscribes to an IAP, who subscribes to a higher-level (backbone)ISP and so on. ISP's of the same level generally work together based on 'peering agreements', where they agree to route all traffic from each other's customers. Mostly this is done free of charge (bill-and-keep) assuming the net-payment would be zero. Instead they charge their customers (who again charge their customers and so on) for their subscription. The prices can either be fixed or depend on the number of access points or the amount of traffic. ASP's typically offer different levels of access to their customers, with different access speeds, where higher access equals a higher subscription fee.

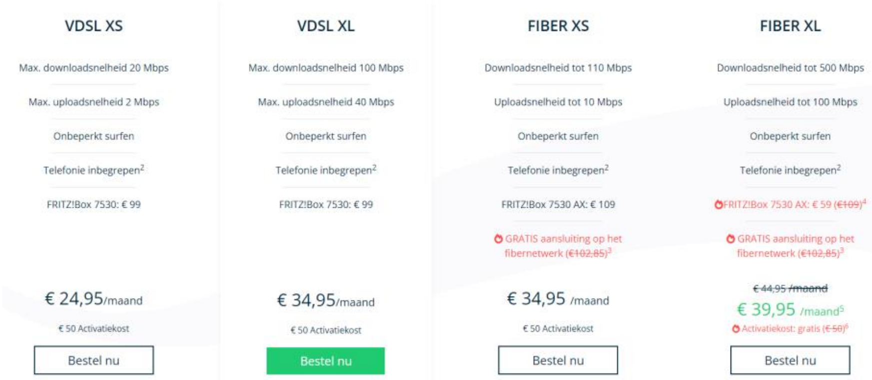

Figure 4: subscription offerings of an IAP

A similar system is conceivable for logistics: a customer can subscribe to the services of a LAP (Logistics Access Provider), who is responsible for the last mile and the general service a customer receives. The customer can choose the level of access they want (1 day delivery, fixed day delivery,…) and the location to which the delivery should be made (home, work, dropbox, flexible,…).

This system has the benefit of allowing customers (both private and business) to choose their LAP freely and as a result allow LAP's to compete to offer the best service to the clients. It also puts part of the delivery cost with the end customer, which makes them conscious of the cost of transport. Allowing clients to consciously choose a slower but cheaper delivery, might also allow LAP's to optimise their last mile deliveries.

The downside of this is that it would not necessarily result in a more optimal logistic system. Several LAP's could still service the same area, realising no real change compared to the current situation. It could even decrease efficiency if sender and receiver are not clients of the same LAP, making a change between LAP's necessary. On the other hand this might stimulate a limited number of horizontally integrated Distribution Centres per region or city, which could again increase efficiency.

The rules laid out in general (Net Neutrality or not?) and in the specific peering agreements (bill-and-keep or not, which are the conditions to enter into a peering agreement?) will be crucial to determine whether this could lead to viable business cases or not.

5. Conclusions

The Physical Internet could develop to be similar to its Digital counterpart in numerous ways, as they are both a network of networks, interconnected by nodes (routers), transporting standardized packages from origin to destination, following a standardised set of protocols. They do however have some important differences. A first one is the physical form of packaging and transport carriers in the Physical Internet, making return journeys necessary. Another difference is the way routes are planned: in DI, this is done on-the-fly by the routers themselves, in Physical Internet some advance route planning will probably remain.

The final layout of the Physical Internet will greatly depend on the choices made regarding the governing principles and the business models. These choices will shape the way shippers and receivers interact with the network and the level of control they have over the way their freight is transported. It will also affect the way logistic companies interact with each other, at which levels they will cooperate and at which levels they will compete. By posing these questions now, the effects of different choices can be analysed and both policy makers and companies can evaluate how to adjust.

Both business models described seem to have their possibilities in a future Physical Internet system. The extend to which each of them is integrated in PI, affect the organisation of the network, from very decentralised (auction model) to moderately centralised (subscription model). To determine possible business models and the levels of (de)centrality associated with them, will require further research. Depending on which goals are prioritised (cost, level of service, sustainability, congestion,…), different systems could be more beneficial and should be weighed against each other.

Additionally, the question should be asked whether these business models are as new and disruptive as they are currently perceived or if they rather represent a new way to look at existing processes and interactions. Indeed, logistics is not an emerging industry, but a long standing endeavour which poses its own challenges as to the extend in which the system can be changed without unwanted disruptions. Presenting both changes and similarities in a clear manner to all stakeholders will increase the ease with which they can be adopted.

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