A New ‘Gain-Sharing’ Business Model to facilitate the Physical Internet via a Competitive, Collaborative Logistics Platform

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Abstract: *Collaboration in the freight industry has the potential to deliver significant socio-economic and environmental benefits and is key to the development of a Physical Internet. However, until now convincing logistics companies of the business case for collaboration has represented a significant barrier to generating those benefits. The Freight Share Lab (FSL) project, which is funded by Innovate UK, offers a solution. It demonstrates that there is a potential ‘win-win’ for logistics service providers and their customers, where “coopetition” can be delivered through a collaboration platform that yields significant commercial benefits for all participants. The platform developed by FSL project partners, Heriot-Watt University and Trakm8 PLC, uses a multi-fleet logistics optimisation and decision support algorithm, in the management of freight logistics assets which, when combined, deliver a lower priced service and reduced carbon footprint than would have been achievable by the original contract holder. The business model developed by Connected Places Catapult Ltd (CPC) ensures that both the original contract holder and those deployed by the FSL platform to fulfill the contract, retain their profit margins and share the differential between the operating costs of the former and the price charged by the latter, using game theory approach. The initial results obtained from model simulations using realistic data indicate there are significant financial benefits for FSL platform members using this ‘gain-sharing’ model.*

Keywords: *business model, logistics platform, gain sharing, physical internet, barriers to collaboration, efficiencies, business case, coopetition, increased utilisation, reduced emissions*

1 Introduction

Horizontal and multilateral collaboration in the freight industry have the potential to generate significant benefits for society, the environment and the economy. Additionally, freight service providers would benefit from the reduced operating costs resulting from fewer trucks, lower mileage, and increased trailer utilisation, from which – assuming perfect competition – customers would also benefit. According to the World Business Council for Sustainable Development, collaboration between logistics operators using freight exchanges, can yield cost savings of c.20% and a reduction in CO2 emissions of c.32% (wbscd, 2017).

The barriers to sharing logistics assets with others (potentially one’s competitors) are significant. In large part, these barriers hinge around lack of trust between potential collaborators, a refusal to share data and a reluctance to change one’s business model. However, by demonstrating a clear business case and showing a ‘win-win’ for all stakeholders, industry is more likely to consider collaboration.

Yet collaboration should not compromise or exclude competition. Creating a competitive-collaborative business model that can capture the significant benefits from horizontal collaboration seems improbable. Without it however, further strides towards the commercial realisation of a Physical Internet would seem remote. The Freight Share Lab (FSL) project confronts such scepticism by showing that so-called “coopetition” can be established in a horizontal collaboration platform which demonstrates that elusive ‘win-win’ business case.

The FSL platform uses a multi-fleet logistics optimisation and decision support algorithm. This seeks out the logistics solution that can fulfil contracts at a lower price and with lower emissions by exploiting the combination of assets available to the FSL Platform (FSLP). The business model developed by CPC ensures that both the original contract holder and those companies that provide the assets deployed by the FSLP to fulfil the contract retain their profit margins. Not only that, but they also share the differential between the operating costs of the contract holder and the price of the fulfilment provider. The platform, therefore, is able to reward those operators that submit their contracts to the FSLP and those that the FSLP algorithm determines are the best to fulfil the contract. This feature drives competition between the members of FSL. The FSLP links freight providers with a wider pool of asset owners and operators: the larger the pool the more chance of finding a better solution. In theory, participating companies can only gain, financially, from this model.

The initial results obtained from model simulations using realistic data, indicate significant financial benefits for FSLP members using this ‘gain-sharing’ model. The analysis further demonstrates marked reductions in total mileage, implying increases in the average utilisation of trucks, thus leading to reduced road congestion and emissions. This could be a significant step forward in the development pathway proposed by the Alliance for Logistics Innovation through Collaboration in Europe (ALICE), for a Physical Internet by 2030-2040 and zero emissions-logistics by 2050.

This paper sets out the journey the FSL project team has made in arriving at this point and these conclusions. Section 2 provides a critical review of the literature regarding: collaboration in supply chains, collaboration in freight logistics, forms of collaboration, strategies for collaboration, barriers to collaboration and enablers for collaboration. Section 3 presents the freight collaboration platform architecture. Section 4 presents the adapted business model canvas for FreightShare Lab and details including: value proposition, key activities, customer segments and relationships, cost structures and revenue streams. Section 5 presents the results of the economic and wider social and environmental impacts. Finally, Section 6 includes the main conclusions and suggestions for further work.

2 Literature review and background

2.1 Collaboration in supply chain

The concept of collaboration in the supply chain has been discussed and applied extensively in both industry and academic circles (Cao and Zhang, 2011; Liao and Kuo, 2014). Several types of organisations are using collaboration in the supply chain to gain advantages in efficiency, costs and customer satisfaction (Alarcón, 2005). Collaboration-based business models enable cost reduction and improved customer service through shared information and assets and better coordinated collaborative network activities (Alarcón, 2005), and generate synergistic benefits that companies cannot achieve individually. It is important to recognise that there must be a driving motive for all parties to work together, becoming a "committee of equals" that find greater value in collaboration to ensure long-term success (Sutherland, 2006) and allowing coordination to help meet common business objectives (Osório et al., 2013). Collaboration is possible when at least two actors share their efforts, data and/or assets to reach a common objective (Gonzalez-Feliu & Salanova, 2012). An increasing number of diverse forms of collaborative networks have emerged because of advances in information and communication technologies, market and societal needs, and the progress made in many international projects (Camarinha-Matos, et al., 2008). A collaborative network (CN) is defined as "A network composed of a variety of entities (e.g. organisations, people, machines) that are autonomous, geographically distributed and heterogeneous in terms of their work environment, culture, social capital and objectives, but they collaborate to better achieve common or compatible objectives, generating value together, and whose interactions are supported by computer networks" (Camarinha-Matos & Afsarmanesh, 2005).

2.2 Collaboration in freight logistics

This trend towards collaboration that seems to be engaging different suppliers and manufacturers in the supply chain field does not seem to have the same effect in the freight industry itself. This is mainly due to competition between operators and their low profit margins (Vargas et al., 2018). Peeta & Hernandez (2011) noted that a growing number of small or medium-sized carriers have launched collaborative networks in a bid to improve profit margins and competitiveness; yet, there remain significant inefficiencies in the sector.

Freight logistics both drives and enables economic growth as well as representing a major source of employment in Europe (Gonzalez-Feliu et al., 2013). Logistics and supply chains impose significant external costs on society (BESTUFSll, 2007). These cross-sectoral costs range from health and environmental costs of pollution and traffic congestion, costs of delays borne by road users, and nuisance costs, such as increased levels of noise, among others.

The Department for Transport (DfT) has reported that 'empty running' increased from 27% to 30% between 2006 and 2016 in the UK (DfT, 2017); capacity utilisation is only 68%. This translates to a meagre overall freight efficiency of just 47.6%. Considering that trucks are 'on the road' for barely a third of their time the remaining two-thirds being fallow periods including driver resting times and weekends, etc. (Frost & Sullivan, 2016), this translates to an asset efficiency of only 15%-16%. Collaboration in the freight industry would reduce the number of HGVs on the road, decrease GHG emissions, reduce empty running, and identify routes and journeys where operators can consolidate their loads into a single vehicle trip (TRL, 2017).There is clear potential evident for collaborative initiatives to deliver significant benefits in the freight industry, particularly if the right business models can be identified.

2.2.1 Forms of collaboration

There are two different, but inter-linked collaborative approaches. The first identifies who takes part in the collaboration, and defines its *physical structure*. In this approach three main categories have been used specifically for the transport industry (Caballini et al., 2014; Okdinawati et al., 2015): a) *vertical collaboration* which concerns two or more organisations at different levels of the logistics chain; b) *horizontal collaboration* which concerns two or more competing organisations at the same level of the logistics network; and c) *multilateral collaboration* which combines and shares capabilities both vertically and horizontally.

The second approach is the one on which FSL is particularly focused. In this approach, there can be different *types of coordination* established between the members. These forms of coordination are (Dudek, 2009; Ribas and Companys, 2007): a) *centralised*, involving decision-making at a common higher level by generating synchronized instructions at lower levels; and b) *decentralised*, which implies consensus, agreement of objectives, indicators and equality rules between partners. This collaboration is usually achieved through communication and negotiation processes between the partners. This becomes an important factor in shaping the processes and procedures, terms and conditions, of the FSLP.

2.2.2 Strategies of collaboration

In freight logistics, collaborative strategies can take place in the transport of goods, warehousing, equipment pooling (e.g. container pools, pallet networks etc.) and other operations. They usually take the form of agreements and partnerships among a small number of companies and may even be ad-hoc rather than comprise any formal arrangement (Gonzalez-Feliu and Morana, 2011). Various authors have identified a number of strategies (Peeta and Hernandez, 2011; TRL, 2017; wbcsd, 2016), e.g.: cooperative alliances, route scheduling/planning, backhauling, freight exchanges, consolidation centres, delivery and servicing plans, and joint optimisation of assets and sharing capacity.

2.2.3 Barriers to collaboration

Strategies of collaboration and development of collaborative networks are, however, sparsely employed in the freight industry. By isolating barriers and limitations to collaboration, strategies to overcome them can be identified. Vargas et al. (2018) compiled the main barriers and limitations found in the literature and strategies to overcome them (Table 1).

Table 1 Barriers for collaboration in the freight industry and strategies to overcome them.

Barriers/Limitations for Collaboration	Author	Strategies to Overcome Them
Shipper concerns of having a different carrier from its usual contracted carrier.	(Peeta and Hernandez, 2011)	Concerns over branding could be resolved through use of independent third parties and non-liveried vehicles. Involving the shipper into the alliance, through agreements, showing them the advantages of collaboration.
Load compatibility can restrict the ability for loads to be shared.	(TRL, 2017)	Matching companies moving similar products with similar handling equipment on similar types of vehicles.
Responsibility for transportation operations.	(Fabbe-Costes, 2007)	If the collaborations for logistics sharing follow a contract or a chart where the responsibilities are well defined, these questions will not constitute an obstacle to sharing.
Legal barriers, there are laws that interfere with the ability to share data: competition law.	(Audy et al., 2012; Fabbe-Costes, 2007; Greening et al., 2015; Jenks et al., 2013; TRL, 2017)	The European Union (EU) recommends the use of a neutral trustee, to whom different stakeholders give data to be held and analysed preventing the transfer of commercial data such as, volumes, delivery addresses, costs, product characteristics, etc.
Lack of human resources, especially for small operators.	(Jenks et al., 2013)	By giving to a central entity the authority of decision making in terms of optimisation and route scheduling for a group of partners that are collaborating, there is no need to increase utilisation of human resources for fleet operators.
Significant coordination is needed to achieve data and asset sharing.	(Jenks et al., 2013)	In a centralised structure collaboration scheme, the central coordinator is responsible for coordination of the partners in the collaboration and the partners are committed to follow central instructions to allow the collaboration scheme to work.
Lack of available accurate data.	(Eckartz et al., 2014; Greening et al., 2015; TRL, 2017)	Definition of data structure requirements for collection of unified and accurate data for collaboration. The confidentiality of data collection will be defined through contracts between the partners in the collaboration and the central trustee authority.

Lack of trust and common goals.	(Peeta and Hernandez, 2011; TRL, 2017)	Use of clear contract agreements, where partners define confidentiality policies, service levels agreements, penalties in case of failing, payment conditions, coordination structure, management of unexpected events and contract duration.
Lack of a fair allocation mechanism for collaboration revenues.	(Audy et al., 2012; Nadarajah and Bookbinder, 2013; Peeta and Hernandez, 2011; TRL, 2017)	Giving different options for revenue sharing to the partners and showing them the cost benefits of each option will allow them to choose, during the negotiation phase, which mechanism will be used for revenue sharing.
A neutral third party is required to facilitate collaboration.	(Nadarajah and Bookbinder, 2013)	A trustee figure is necessary to implement collaboration. The trustee needs to be a connector between the collaboration partners. Partners might be reluctant to accept a third party, but, this can be overcome through contracts between each partner and the trustee.
There are clear regional imbalances in freight movement.	(TRL, 2017)	Use the practice of triangulation, where a truck is diverted from its main back route to a third point in order to pick up a return load, potentially increasing the mileage but reducing the amount of empty running.
Unawareness of the benefits of participating in collaborative projects.	(Kale et al., 2007)	Engagement of stakeholders to participate in collaborative networks is crucial. During the initial engagement, it is necessary to show to the possible partners the real benefits of similar collaborative projects.
High risk of strategic behaviour in auction collaborative process.	(Gansterer and Hartl, 2018)	Effective profit-sharing mechanisms are needed, since these have the potential to impede strategic behaviour.

2.2.4 Enablers for collaboration

A successful business model must consider known, tried and tested enablers for collaboration. Table 2 shows a compilation of enablers and opportunities found in the literature.

Table 2 Enablers and opportunities for collaboration

Enabler	Authors	Opportunity
Common Cultural Mind Set.	(NexTrust, 2017; Peeters et al., 2017)	The fundamental breakthrough for the success of collaborative projects in the freight industry comes from the willingness of the different industry actors to cooperate. It is critical that partners who decide to collaborate have a common cultural mind-set allowing the implementations of collaborative process to run smoothly. It is necessary that a fundamental change in the management of transportation sourcing and operations requires that shippers and carriers, make an actual "mental shift", de-coupling from their own networks first and then agreeing to re-connect with other shipper network flows.
Establishment of Non-disclosure Agreements.	(Bogens and Stumm, 2017; Jenks et al., 2013)	An important way to protect data and assets that are intended to be shared and to assure that owners of the data and assets are willing to provide them to the consortium, is to execute non-disclosure or privacy agreements. These may be part of legal contracts or separately negotiated documents. The use of this document will help to increase trust among the partners
Stakeholder Engagement.	(Jenks et al., 2013)	It is incumbent upon project leaders and participants in a collaboration project to get to know each other well, establishing .a bond and trust between partners prior to collaboration. In this way the partners get to know each other deeply and increase the sense of confidence and trust among them. This will ultimately assure the success of the project.
Technology Innovation.	(Jenks et al., 2013)	In many cases the implementation of a particular technology makes it easier to share data and assets and helps a project to succeed. An automated technology which could accomplish the identification, for instance, of a transportation vehicle without requiring the divulgence of certain data about that vehicle could be a motivator for participants.
Articulating Benefits of Sharing.	(Jenks et al., 2013)	It is important for project proponents to be able to explain to the public, to private sector participants, and to other stakeholders how they will benefit from the conduct of the project. Articulating benefits is an important part of project coordination. For instance, publishing analyses of the expected costs savings and benefits of the project reveals openness and transparency such that it could help to assure its success and the involvement of different stakeholders.
Legislative Changes.	(Fabbe-Costes, 2007; Jenks et al., 2013)	Normative and jurisprudence aspects of sharing are related to public administrations. Nowadays, the most important facilitators in this category are the different local laws and legislation that help the development of sharing approaches in urban and regional freight transportation. There are two types of approaches: restrictions to non-sharing and incentives to sharing. In the first approach, local authorities could use zero emissions zones to force carriers to collaborate with EV operators to avoid expensive penalties. In the second approach, local authorities could, for instance, incentivise the reduction of empty running, through reduced taxation for companies that join collaborative schemes.
Previous Relationships Among Partners.	(Fabbe-Costes, 2007)	When participants have already collaborated, because of common interests or because they belong to the same network o, transportation sharing is more naturally occurring; it can seem like a step forward in the relationship building among participants. Thus, the trust factor is already in place and the collaboration relationship flows smoothly.
Definition of Penalties for Non-Compliance.	(Kale et al., 2007)	Penalties for non-compliance with contract terms could be made through default payments for each shipment in which a default occurs. Moreover, in some collaborative arrangements, default payments may not be assessed on a shipment basis. The approach used to define the type of penalties for non-compliance with specific terms in a contract will be defined for the collaborative network. The partners that are committed will work with extra care to achieve their liabilities.

3 Freight Collaboration Platform Architecture

3.1 Operating Cycle, Data, and Algorithms

Most operators in the freight industry work in a daily cycle, whereby operations are planned on day 1, typically in the evening, and executed on day 2; delivery plans for

Thursday (for example) will typically be calculated on Wednesday, based on up-to-date customer orders and availabilities, and then sent to drivers in advance. The FSL Collaboration Platform (FSLP) aligns with this general practice; that is, every day, data relevant to *tomorrow's* plan is collected, up to an agreed cutoff time (e.g. 7pm). Then, collaborative delivery plans are derived, and are sent to the members, for distribution to drivers and warehouses in advance of their execution the next day. In the remainder, the discussion of the FSLP will be on the context of this daily cycle. However, it is worth noting that this does not limit the concept. For example, separate FSL platforms could independently handle nightwork, or multiday planning horizons, each focusing on a distinct subset of participants.

FSL members who use the FSLP can upload either, or both, of two main types of data: (i) **vehicles** that the member wishes to make available to the platform, and (ii) **jobs** that the member wishes to have processed by the platform. The member also indicates the type of sharing arrangements that are appropriate for them. Hence, at the cutoff time on any given day, the FSLP will have a dataset $\boldsymbol{D} = (\mathbf{V}, \mathbf{J}, \mathbf{S})$, respectively denoting the full set of vehicles and jobs available, and the corresponding sharing arrangements. It may be tempting to view $\boldsymbol{D}$ as a single large-scale vehicle routing problem with specialised constraints (Laporte, 1992; Solomon, 1987). However, the typical scale of $\boldsymbol{D}$ (e.g. 20,000 jobs, 5,000 vehicles) compromises the ability of current algorithms to address this in a reasonable time-frame. Therefore, the FSLP instead operates a 'divide-and-conquer' strategy to partition $\boldsymbol{D}$ into a series of smaller problems, $\boldsymbol{D}_1$, $\boldsymbol{D}_2$ …, $\boldsymbol{D}_n$, and then solves each of these problems in turn.

The partitioning strategy makes use of a specialised metric, called *sharefactor*, which predicts the extent to which two FSL members would benefit by working together. Essentially (and highly simplified), asset sharing is effective to the extent that fleet A's orders are geographically more convenient for fleet B's vehicles to handle than they are for fleet A's vehicles. This notion is estimated for each job by a *sharescore*. In short, suppose two FSL members, A and B, submit their data ($\boldsymbol{V_A}, \boldsymbol{J_A}, \boldsymbol{S_A}$) and ($\boldsymbol{V_B}, \boldsymbol{J_B}, \boldsymbol{S_B}$) to the FSLP, and that their respective sharing arrangements are compatible (e.g. A's vehicles are able to carry B's jobs and vice versa). The *sharescore* $ss(j)$ for each job from $\boldsymbol{J_A}$ is defined as follows: $ss(j)$ is Tc/Ts, where Tc is the time it would take for a vehicle from $\boldsymbol{V_B}$ to process the job if it were located for pickup at B's depot, and Ts is the time it would take a vehicle from $\boldsymbol{V_A}$ to process it from A's depot. A *sharescore* below 1 suggests a time and mileage advantage. Moreover, the *sharefactor*(A,B) for two fleets is the proportion of the combined jobs (from both $\boldsymbol{J_A}$ and $J_{\boldsymbol{B}}$) that have a sharescore below 1. The larger the sharefactor, the larger the potential benefits for collaboration, since it suggests, for example, that an initial shuttling of orders between the depots could result in more efficient delivery, more than compensating for the shuttling costs.

Using primarily the *sharefactor*, calculated for all pairs and triplets of fleets, a fast filtering algorithm first ranks potential groupings of fleets for potential resource savings from collaboration. The FSLP then proceeds to consider each of these groups in turn, and solves the associated specialised fleet planning problem that arises from combining their assets according to their declared sharing arrangements among the group. Hence, following an initial phase that partitions the potentially nationwide logistics task into individual multi-fleet planning problems, each of the latter problems is then solved by a centralized collaborative planning strategy (Gansterer and Hartl, 2018) using a solver described next.

The fleet planning solver used by FSL is a variant of commercial software that is currently operating in the (single) fleet planning industry. Consistent with state of the art algorithms of its type, its design combines various aspects of metaheuristics search (Blum and Roli, 2003), many-objective search (Corne and Knowles, 2007) and traditional AI planning (Ghallab et al., 2004).The range of factors considered by the algorithm are those with material impact on time, costs, and mileage, including: a) *Costs*: Cost-per-mile, potentially different for different vehicles; driver cost-per-hour (and, if relevant, overtime costs per hour); a fixed cost per vehicle; an ‘Opportunity Cost’ of not delivering a job; this is commonly supplied by users of fleet optimisation software, and can be considered as a penalty fee to be paid to the customer if the job is not delivered; b) *Times and associated constraints*: driver shift times and working time constraints; time windows for pickup and delivery of each job; service times for pickup and delivery of each job; driver briefing time; realistic times for every journey, given vehicle type; and c) *Capacity issues*: weight and volume capacity of each vehicle, weight and volume of each job, ensuring vehicles are never overloaded.

The solver produces a detailed schedule of activities, specifying an itinerary for all or some of the vehicles involved, similar to the itineraries typically delivered by fleet optimisation software. The schedule for a group of fleets (typically two or three) will usually process all jobs involved in the group, although this is not always possible. However, in such circumstances, a collaborative schedule will always be able to process at least as many of the jobs as would be achievable without asset sharing, and usually more.

3.2 Arrangements for Collaboration

Horizontal collaboration between FSL members is the essence of the proposed solution and business model. The key aspects of the ‘sharing arrangements’ data that FSL members supply (as indicated above) are now outlined. Essentially, each FSL member indicates its preferences in terms of the following four scenarios: a) Full Sharing without special arrangements; b) Full Sharing with morning transfer arrangements; c) Full Sharing with a consolidation site; and d) Partial Sharing with no arrangements, as well as any associated parameters. When the FSLP is considering a particular group of fleets, this group has already been determined to have compatible sharing arrangements. The Full Sharing scenarios are where FSL members are willing to both undertake other members’ jobs as well as handing over some of their own jobs for others to handle, i.e. there is full sharing of assets and contracted jobs. Notice that this does not necessarily mean that each FSL member submits all of their vehicles and jobs to FSL, this only means that the member provides both one or more vehicles and one or more jobs. A standard use-case, for example, could be for a member to submit only the vehicles left unused and the jobs left unprocessed following their in-house planning. Whilst this would potentially limit the opportunity to increase revenue for members and limit the number of assets available to the algorithm, this might be considered a likely scenario in the early days of FSL whilst members build their ‘trust’ of the system.

The Partial Sharing scenario, currently under development, assumes some of the FSL members will only leave vehicles at the platform's disposal. However, FSL's business model requires members to input contracts for logistics jobs, for the platform to reallocate them to a more cost- and emission-efficient solution. For FSL to be sustainable and most effective, there must be sufficient members willing to share their jobs.

3.2.1 Full Sharing without special arrangements

In this scenario, the collaborating members have not set up any special arrangements (e.g. consolidating freight at a specific consolidation centre). For one member to handle a job provided by another member, the former will simply pick up that job from the latter's depot. A grafical representation of this arrangement is presented in Figure 1. This arrengement has the potential to be more efficient than single fleet operations if the collaborating members are quite near to one another, and/or if there is a significant geographical overlap in jobs, such as delivery windows in the same areas during the same period of time. However, when the overlap in customer locations is low, the result of this collaboration may only slightly improve upon the 'no-sharing' default scenario.

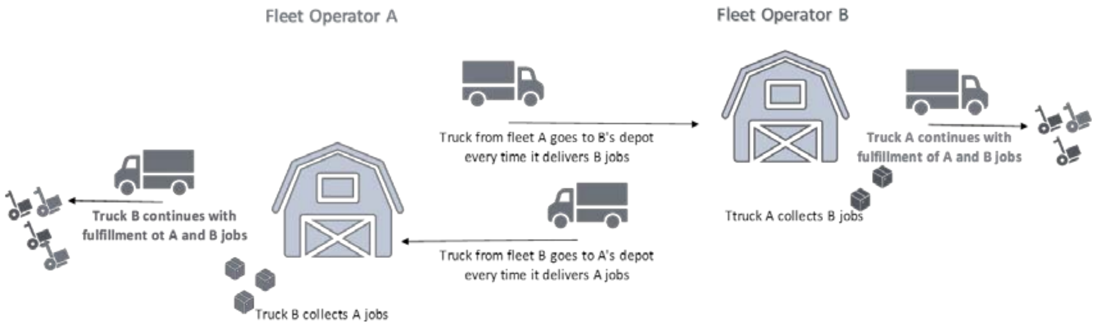

Figure 1: No Special Arrangements Collaboration Scenario

3.2.2 Full Sharing with morning transfer arrangements

In this scenario, each fleet in the group is prepared to accommodate a 'morning transfer' arrangement, whereby a vehicle with suitable capacity (from any of the fleets) will transfer jobs between depots at the beginning of the day. For example, a vehicle from member A will first load up with several jobs from JA that have a good sharescore, and take these to B's depot, and then return to A's depot carrying several jobs from member B that also have a good sharescore. Figure 2 illustrates the arrangement. The corresponding combined delivery plan will only be assigned by the platform if the efficiencies gained through collaboration significantly outweigh the costs of the 'morning transfer' shuttle arrangements.

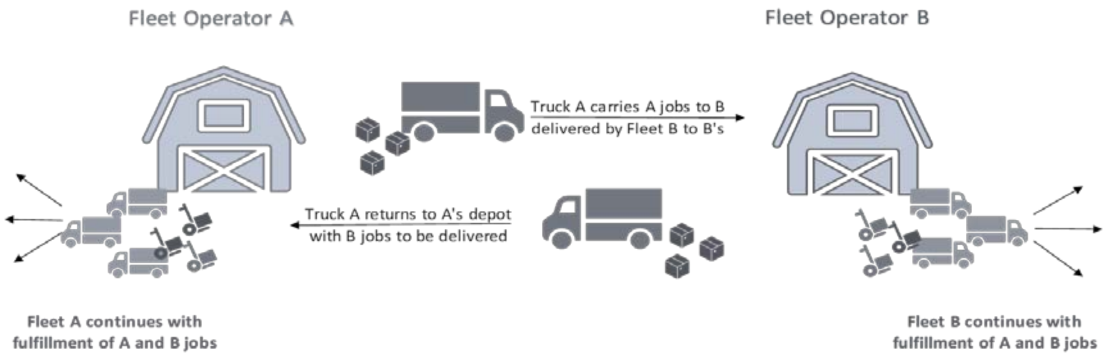

Figure 2: Morning Transfer Collaboration Arrangement Scenario

3.2.3 Full Sharing with a consolidation site

In this scenario, the collaborating companies have chosen a mutually agreed site, and one or more vehicles from each fleet in the group will transfer selected jobs to that site at the start of the day. This site may be a commercial consolidation centre or a site owned by one of the collaborating partners. This scenario resembles the 'morning transfer', but effectively reduces the additional costs when there are multiple nearby companies in the group.

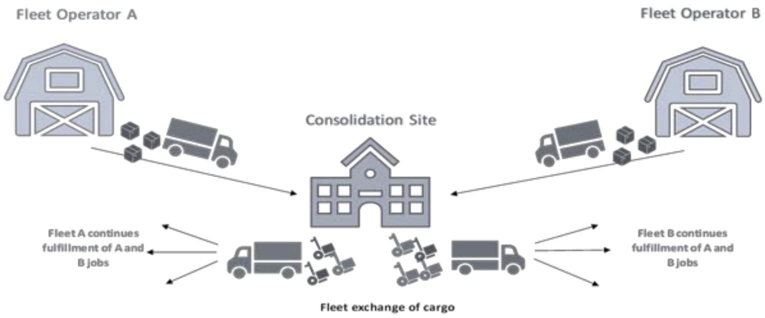

Figure 3: Consolidation Site Collaboration Arrangement Scenario

3.2.4 Partial sharing without arrangements

In this scenario, a collaborating company only supplies vehicle resources to the system, hoping to generate income from underutilized assets. The platform may identify those resources as being strategically located for efficiently fulfilling a subset of other fleets' contracts, and hence this might be seen as a form of subcontracting.

3.3 Estimated Benefits

While the algorithms discussed above were being developed, extensive experimentation was conducted to investigate the potential benefits in comparison to non-sharing scenarios. The experimental setup and results were reported in (wbcsd, 2016) and focused on 'full sharing with no special arrangements', using synthetic data. Here a briefly summary of the results: (i) with two fleets fully collaborating, the reduction in mileage and costs ranged from 16% to 53%, with a mean of 19% (ii) improvements were more marked in denser road networks (e.g. European vs US), where neighbouring cities tended to be closer, and (iii) with up to five fleets working together, savings as much as 70% could be achieved, with diminishing returns beyond five fleets. Following these early indications of potential benefits, the FSLP has been prototyped and a business model has been developed, as introduced in this paper. A number of simulations have been done using realistic data to ascertain how these estimated savings translate into business gains in a commercial setting; the outcome of this is summarised in section 5.

4 Freight Collaboration Business Model

Collaboration in the freight industry has the potential to deliver significant socio-economic and environmental benefits and is key to the development of a Physical Internet. Amongst the many barriers for collaboration, discussed in Section 2.2.3, convincing logistics companies of the business case for collaboration has until now represented a significant barrier. The business model developed by CPC aims to address these barriers by demonstrating there is a win-win for logistics service providers as well as their customers, where "coopetition" can be delivered through a collaboration platform yielding significant commercial benefits for all participants, based on game theory. In Netherlands, a similar platform was developed and was operating commercially, but failed to develop a healthy and scalable business model with the resources they had and therefore they had to shut down in 2018 (Ploos van Amstel, 2018). After discussion with Dr. Ploos Van Amstel, it was appointed that the FSL business model is not the same used by the Netherlands. At this stage, it is worth noticing that FSL has a very different business model than typical freight exchange platforms like Uber Freight, Quicargo, Returnloads or TG Matrix, and this session will describe those differences. Figure 4 provides a high level visual representation of the proposed adapted business model canvas (Osterwalder and Pigneur, 2010; Vargas et al., 2018). The following subsections will develop further the most critical elements of the proposed adapted business model canvas.

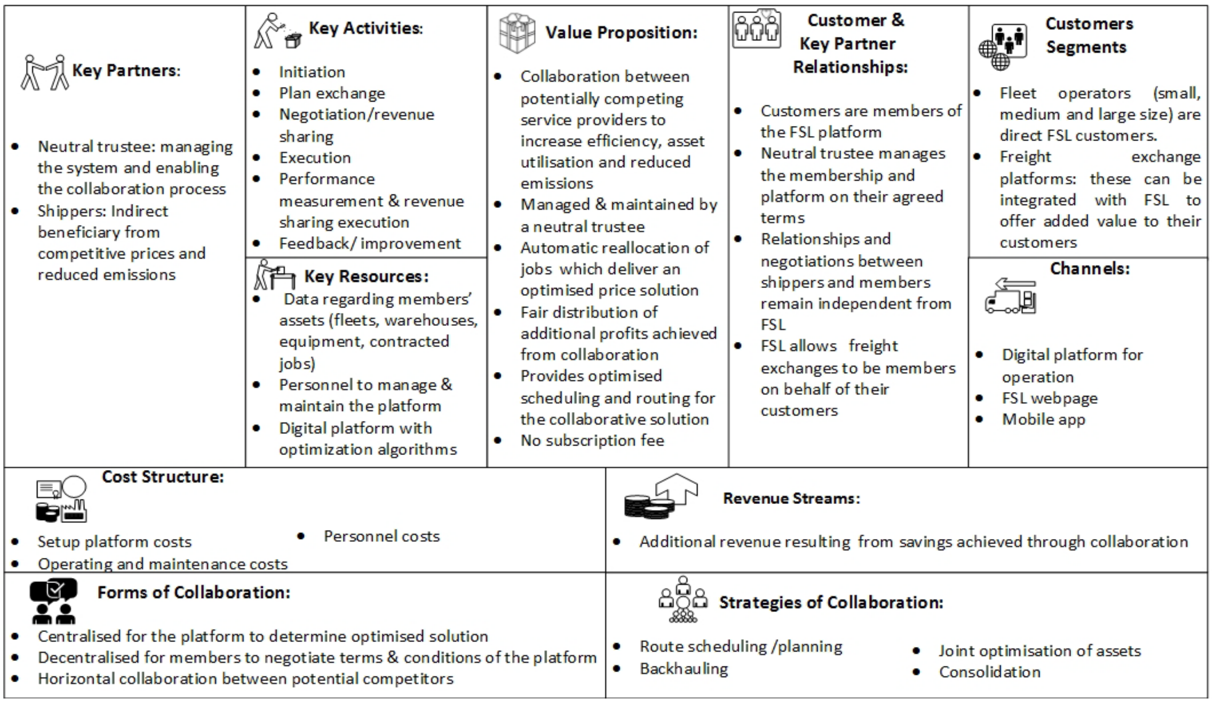

Figure 4: Adapted business model canvas for FSL

4.1 Value proposition and business model validation

The objective of the FSL platform is to increase competitiveness, efficiency and utilisation, by creating a collaborative ecosystem. The platform will search for the most efficient delivery, in terms of operating costs, fleet utilisation and emissions for the fulfilment of contracts submitted by members of FSL using assets of FSL members.

With a wide geographic coverage of members' assets, this also increases the likelihood of capacity being available and in turn increases the chances of fulfilling more contracts in any given period of time. However, the FSL algorithm will only reallocate jobs where price and emissions are lower than those possible if performed by the contract holder. In the event that lower price and emissions cannot be found the contract holder would then fulfill the contracted job.

To ensure the fair reallocation of jobs, as well as to guarantee these are delivered in the most efficient way, the jobs' fulfillment costs must be estimated as accurately as possible. These will be the members' operating costs to deliver such jobs, which the platform algorithm will estimate based on fleet-specific parameters and daily requirements of the delivery of jobs inputted by each of the collaborating members, as described in Section 3.1.

To validate the proposed business model, a financial and economic analysis has been undertaken based on the algorithm results using historic transport operational data. To provide an understanding of the impact of collaboration, the analysis provides a comparison between the 'business as usual' scenario of non-collaborating operators and the form of collaboration determined by the FSLP. It should be noted that the 'business as usual' scenario presents the situation where the individual fleet operations have been optimised (e.g. using an optimisation tool or service), which on average provides a 12.5% (wbcsd, 2016) reduction in costs and distance travelled than when fleets operate without the use of any optimisation tool or service.

Furthermore, it should be noted that the algorithm was in development phase when results were analysed and supported by only a day's worth of data representing 27 fleet operators. This data was provided by the project partner Routemonkey (Trackm8), which were then extrapolated to cover a whole year. Due to these limitations, the results should be treated with caution. Even so, these illustrate the type of benefits that might, with further analysis and greater amounts of more real-world data, be achievable from FSL.

4.2 Customer segments and relationships

Fleet operators are Freight Share Lab's principal direct customers. Given their competitive nature, and to ensure compliance with competition law, it is necessary for a neutral trustee to facilitate the collaboration between them.

A neutral trustee is an organisation responsible for ensuring the collaborative network will be constructed in such a way that a fruitful long-term, sustainable relationship is established and maintained. Partners in a collaboration agreement (possibly competitors) could provide commercially sensitive data to the trustee organisation, which can maintain the required confidentiality and security of such data but use, according to contractual terms and conditions agreed with the data owners, for fulfilling the purposes of FSL. In this way, compliance with EU competition and data protection laws is provided.

Arguably, the platform is best managed as a cooperative by the FSL members: all terms and conditions, rules of the FSL business, quality and standards shall be agreed in a decentralised manner by the members and profits distributed among them. FSL members would upload contracts they have individually agreed with their customers into the platform, securely and confidentially, for the system to analyse.

In this model, shippers, do not have direct access to the platform, but will benefit from it through sustainable competition among the logistics service providers and lower emissions associated with the fulfilment of their jobs. The relationships, interactions and negotiations between shippers and carriers remain the same. Logistics companies will still need to negotiate and agree contracts with their customers. Where the logistics operators or their customers participate in specific load-sharing, auction, return-load freight exchange platforms, FSL will look to provide a value add for them also: FSL will offer a collaborative relationship by which those contracts awarded through these other platforms can be uploaded into FSL system to see if a better alternative can be found and arranged (i.e. at a lower price and reduced emissions); in effect the FSL platform acts as a ‘platform of platforms’.

4.3 Key activities

The definition of the key activities in a collaborative process has been proposed in (Vargas et al., 2013, 2018) based on previous ideas (Alarcón, 2005; Audy et al., 2012; Kilger et al., 2008; Petersen et al., 2005; Ribas and Companys, 2007; Stadtler, 2009; Verheij and Augenbroe, 2006). These activities are: 1) Initiation, 2) Plan Exchange, 3) Negotiation/Revenue Sharing, 4) Execution, 5) Performance Measurement & Revenue Sharing Execution, and 6) Feedback/ Improvement. In this proposal, the benefits of using a combination of decentralised and centralised coordination in each key activity was highlighted. Findings of different European projects proposed centralised coordination being led by a neutral trustee (NexTrust, 2017). A high-level workflow showing the interrelation of these key activities and the key actors involved is presented in Figure 5.

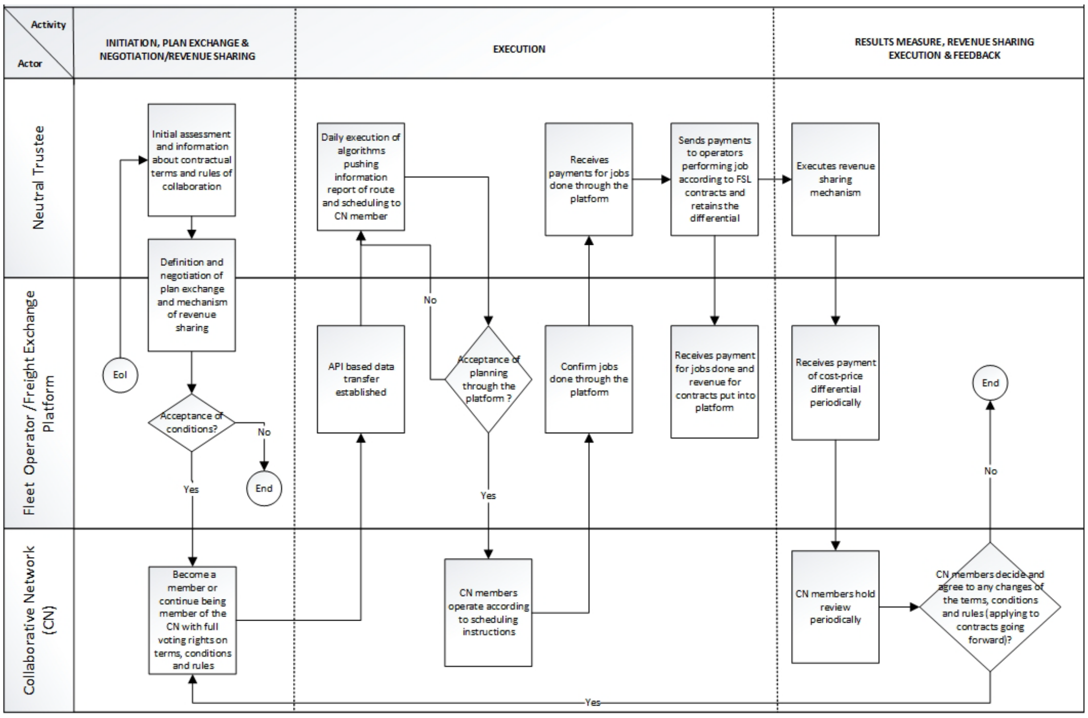

Figure 5: FSL collaborative process workflow

The *Initiation* requires all the partners, including the neutral trustee to agree to collaborate. *Plan exchange and Negotiation/Revenue Sharing* involves defining responsibilities, contracts, joint processes, and mechanisms of revenue sharing among all the partners in the collaboration. The *Execution* is led by the neutral trustee that informs each partner about the optimised routes and schedules and, each partner follows instructions to complete the assigned task. The *Results Measure and Revenue Sharing Execution* are performed by the neutral trustee, as per the agreed contract, where the specific mechanism of revenue sharing was selected. Finally, the *Feedback* is completed among all the partners and it is refined, if necessary, to improve the process and determine if the partners will continue collaborating. A detail of these activities can be consulted in Vargas et al., (2018), including the management of unexpected events (Vargas et al., 2016).

4.4 Cost structure

The business model provides that all savings achieved through the platform will be shared between members, once the costs of running the platform are covered. Costs will be distributed across collaborating members in proportion to the savings they generate, and hence those members that do not participate in any transaction will neither incur any costs during that period nor share any additional revenue generated.

For the proposed business model to be sustainable, the savings achieved through collaboration must be able to cover the platform costs. The platform operating costs were therefore estimated as part of the analysis: a) *Fixed costs* – such as labour and office space; these are fixed for specific ranges based on the number of jobs run through the platform, i.e. more jobs would require more labour and hence more office space; and b) *Variable costs* – the costs associated with running each job through the FSL platform. The cost per job decreases as more jobs are run through the platform and are capped at £0.05 per job.

Although these are highly speculative at this stage, cost assumptions are based on information provided by project partners from their different experiences. Investment costs for setting up the platform have not been considered at this stage, and, would have to be dealt with at the outset when no revenue from FSL would have been generated to cover them. However, this is under the assumption that the main applications and algorithms would be developed once the Innovate UK project is finalised.

4.5 Revenue streams

The FSL algorithm will reallocate jobs where the total fulfilment price is lower than the cost of fulfilling their own contracted jobs with their own logistics assets. This will guarantee all collaborating members, both the original contract holder and those deployed by the platform, maintain their agreed profit margins, as well as providing them with additional revenue.

Firstly, the platform provides members access to a wider pool of potential jobs - contracted to other members. Contracts are uploaded to the FSLP for other members to fulfil – if they can fulfill them at a lower price and lower emissions than the contract holders' operating costs. Secondly, with profit margins protected for all (10% gross profit margin has been assumed for operating costs for the purpose of the analysis to date), additional revenue is awarded to the original contract holder and those fulfilling the contract from a share of the cost-price differential. The shipper still pays the original contract price but benefits from reduced emissions and sustainable competition between the operators. Therefore, with the proposed business model, collaborating members will have the following net revenue streams: a) *Profit from the contracted job*; b) *Profit from completing other members' jobs; and c) Sharing of cost-price differential* once any platform costs are deducted.

Furthermore, the business model assumes that the price-cost differential is held by FSL, in the so-called FSL 'bank' (this name is used just for hypothetical reasons), for an agreed period, generating interest. Therefore, the amount to be shared depends on the period for which funds are held in the FSL bank, the interest rate, and the costs of running the platform. For the purpose of the analysis, it has been assumed that the savings are held by the FSL bank for one year, with an annual interest rate of 0.5%.

Figure 6 shows the aggregated daily FSL business model proposed revenue for all fleets involved, covering those for which the FSLP identifies an optimised solution through collaboration and those for which it does not: it also covers each of the three full-sharing collaboration scenarios. The 'No Special Arrangements' scenario generates the least cost-price differential, as it is the scenario which provides the least cost-efficiencies and lowest additional capacity compared to members operating individually outside of FSL.

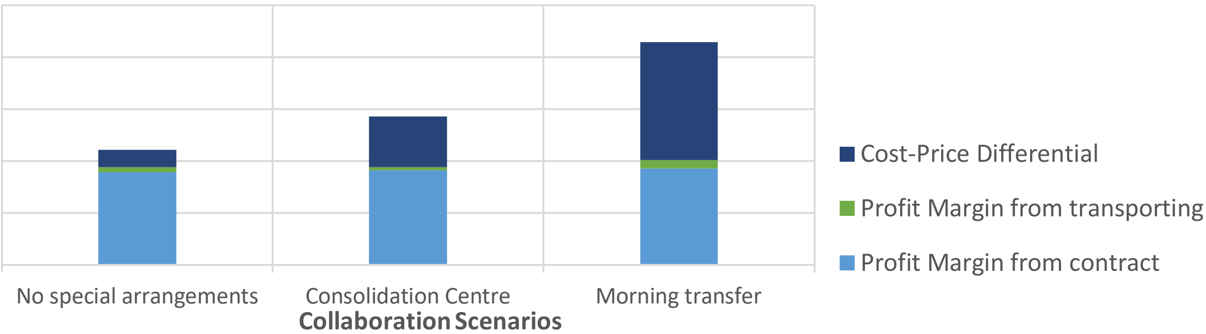

Figure 6- Total daily Revenue Streams with FSL

As can be observed, significant efficiencies can be realised through collaboration, and the increased profits these can generate through the proposed business model are significant.

5 Results

5.1 Efficiencies

Analysis was undertaken on the initial algorithm results, where approximately 6,700 daily jobs were run through the FSLP. Significant commercial benefits can be seen from the FSL collaborative business model, combined with important increases to profits, as shown in Section 4.5. Results have indicated that a high proportion of jobs can be delivered at a lower cost than that of fleets operating independently. Furthermore, the collaboration made further capacity available, with a corresponding increase in the number of jobs that could be delivered in a single day. Table 3 presents results for the three collaboration arrangements scenarios.

Table 3: Efficiencies achieved through the different collaboration arrangements

	No Special arrangements	Consolidation Centre	Morning transfer
% of jobs with savings	48%	63%	72%
% increase of jobs completed per day	3%	1%	5%
Daily mileage reduction	-3,012 km	3,523 km	2,143 km

5.2 Wider socio-economic and environmental benefits

In addition to the private costs borne by logistics operators, their activity imposes externalities on society and the environment. Optimised truck journeys through collaboration will lead to a reduced total distance travelled and reduced number of trucks on the road with consequent reduction in environmental and social costs.

The initial algorithm results, shown in Table 4 and Table 5 have been utilised to quantify the annual change in these external costs and hence, if reduced, offer an understanding of the level of benefits that can be expected through collaboration. The changes were calculated based on reduced mileage, following the UK Department for Transport's WebTAG unit A5-4 and TRL publications for the reduction in emissions.

Table 4: Annual mileage and emissions savings through the different collaboration scenarios

Collaboration Arrangement	Emissions Saved			
	CO2 (tonnes)	PM (Kgs)	NOx (Kgs)	HC (Kgs)
No Special Arrangements	-629	-122	-12	-996
Consolidation Centre	735	143	14	1165
Morning Transfer	447	87	9	708

Table 5: Annual wider economic costs savings through the different collaboration scenarios

Collaboration Arrangement	Other Wider Economic Cost Savings		
	Congestion (k£)	Infrastructure (k£)	Accidents (k£)
No Special Arrangements	-211	-107	-3
Consolidation Centre	247	125	4
Morning Transfer	150	76	2

It can be seen that, although 'morning transfer' leads to the highest cost efficiencies and therefore profits, as shown in Figure 6, mileage reduction is behind that achieved from the consolidation centre scenario, which leads to wider economic cost savings. Meanwhile, 'No Special Arrangements' leads to additional mileage due to the journeys vehicles have to do to get to other fleets' depots, thus generating additional emissions as well as other wider economic costs. At this stage in our analysis, it would seem most appropriate to stipulate that participation in the FSL must be limited to those that are willing to enter into operations that incorporate 'morning transfer' or other special arrangements (e.g. consolidation).

6 Conclusions

The development of the Physical Internet requires multilateral collaboration among logistics asset-owners and operators; horizontal collaboration, potentially between competitors, appears to be a barrier to this. The Freight Share Lab project is seeking to demonstrate that, by engineering a gain share model into a collaboration platform architecture that enables horizontal collaboration, it is possible to break the barriers to collaboration. The hypothesis we are evoking is to say that more practitioners in the freight and logistics sector will be encouraged to participate in such collaboration platforms when it is shown that they provide a clear business case, and a win-win situation exists for all participants; and secondly, that such a collaborative platform can exist without compromising any competition between participants.

This paper has drawn on the experiences of other works in this area and literature which has revealed the barriers and efforts to overcome those barriers to collaboration in the freight and logistics sector. Various elements of business models have been explored. The FSLP architecture and the theory behind it has been explained and adapted from existing optimisation platform architecture. A gain-share business model has been established that will provide the sought-after collaboration in a competitive environment. It will satisfy the commercial imperatives of improving participants' revenue-earning potential and their customers need for access to service providers at competitive rates, with all the sustainability benefits for a clear pathway to zero emissions logistics.

The results from the simulation of hypothetical operations in the FSLP, as shown in this paper, have provided promising results and guidance as to the final commercial proposition for FSL. It is hoped that these results will encourage enough logistics operators to enable us to move from a hypothetical to real-world operational test environment.

The project will seek logistics operators to individually test the FSL algorithm and business model, using their own historic data. If the results prove as positive as early results suggest, the operators will be encouraged to enter a trial, imputing live operational and contract data and performing collaborative operations. Due to the available time for this project to complete, such a live trial will represent a post-project activity on the way to full commercial development of FSL. The central hypothesis can then be tested to see if a demonstration of the potential revenue gains, service coverage, competitive rates and sustainability benefits in the real-world will stimulate even greater collaboration, a key precept of the Physical Internet.

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