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CROSS-BORDER PARCEL LOGISTICS

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Deliverable Aim

This deliverable explores the parcel logistics operations and its associated costs, in the context of the EU28, and focusing on B2C logistics chains. In particular, the deliverable:

- Describes the logistics operations in cross-border parcel delivery of postal operators, integrators, and other parcel delivery operators;
- Estimates and analyses cost factors and drivers in different phases of the logistics chain;
- Examines the cost impacts of last-mile delivery options (lockers, retail points, delivery to premises);
- Describes the reverse logistics operations and its costs.

Approach

Structure	Methods
Main market actors	**Desk research and past research**
Products typology	**Interviews and desk research**
Network, relations, and outsourcing	**Interviews and desk research**
Cost and drivers	**Literature survey and interviews**
Last mile delivery typology	**Desk research**
Last mile cost drivers	**Desk research and interviews**
Cross-border delivery cost simulation	**Interviews, desk research, IDEF0, and scenarios analyses**
Reverse logistics operations	**Interviews**
Reverse logistics typology	**Desk research and interviews**

Cross-border parcel logistics

European cross-border parcel logistics operate under complex market environments. In a single geographical space, multiple market players may be present, each one of them with scale of operations as large as their transportation and sorting hub networks. The degree of competition among operators varies according to the geographical scope of the parcel delivery service. For instance, at the global level the market is an oligopoly due to the fact that only a few, large integrators concentrate a large share of the market. The degree of market concentration lowers at the local level, due to the fact that local markets are served by a large number of operators. The next sections describe the current market actors at the global, the European, the national and the local level and, when available, the market concentration is detailed at each level. The description leads to a European market actors typology.

Market actors

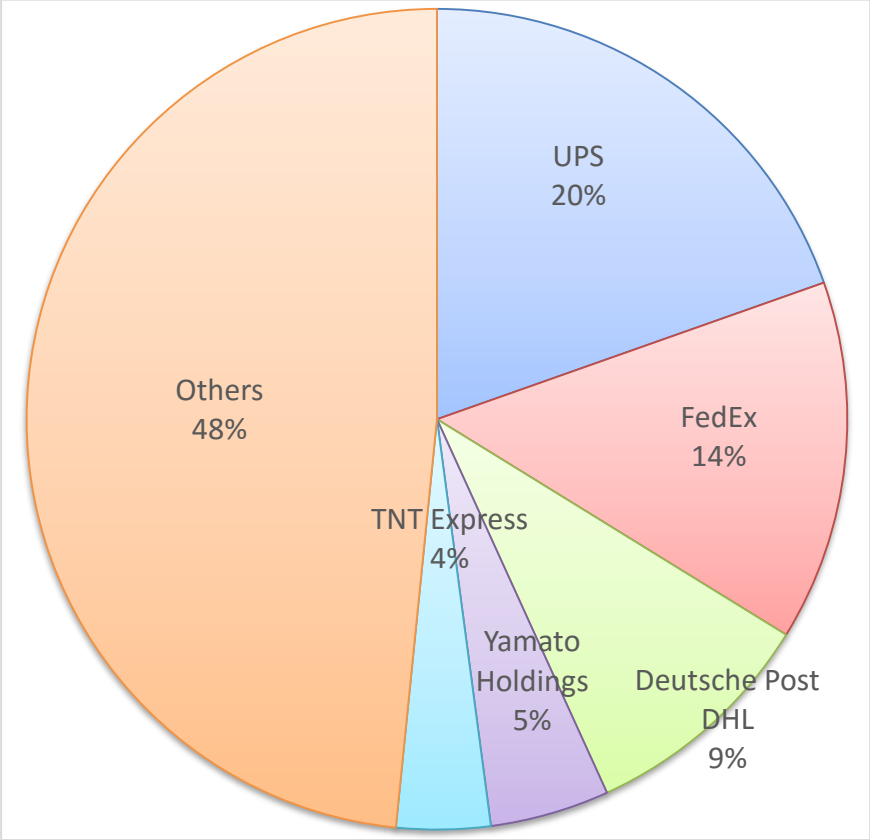
At global level, the Courier, Express and Parcel Industry is led by a number of global integrators. In the express segment, five operators account for 52% of the B2B and B2C global market share in 2014, measured by their revenues. The main actors at the global level, listed according to their market share, are UPS, FedEx, DHL, Yamato and TNT Express. There are also a large number of express operators with global presence. Globally, there are a large number of small operators, accounting for 48% of the market, as can be seen in Figure 1 (Statista, 2015).

The large share of 'others' in Figure 1 corresponds to smaller operators including national postal operators (NPOs) and multiple regional and local operators that by means of international networks connect shippers and consignees anywhere in the world.

Yamato Holdings is the main Japanese operator and a new global player. Its cross-border flows are mainly deferred services. The company's main operations are intra-Asia (between Asian countries), though it also engages in business activities in the EU. Their express deliveries are performed in agreement with UPS (Yamato, 2015).

At the European level, according to the number of packages delivered, the joint market share of the top five players-i.e. DHL, Hermes, DPD, TNT, and GLS- is 82% as shown in Figure 2 (Statista, 2012). The contribution of UPS and FedEx to the European B2C parcel delivery is only 3%. The market share of National Postal Operators (NPOs) is 10%, while 5% is held by other local operators.

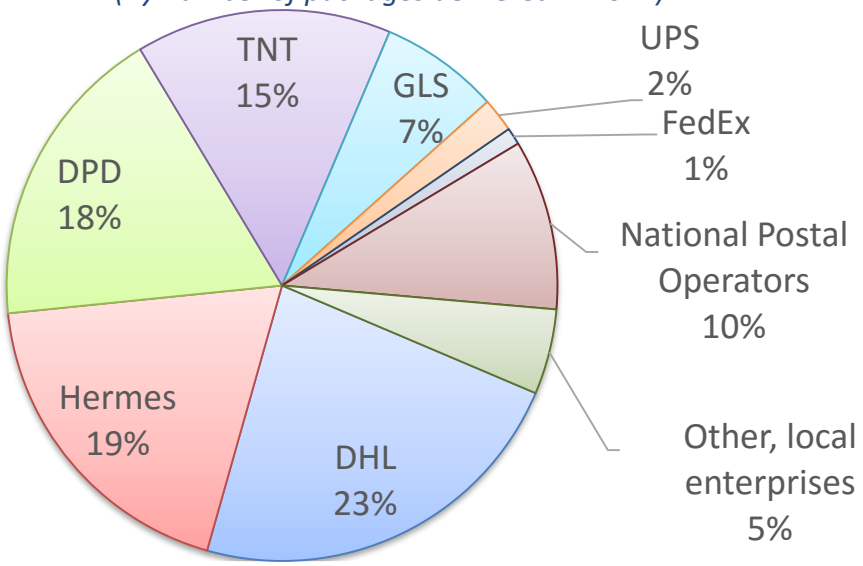
Figure 1. Express and courier service providers' global market share 2014[1]



Source: Elaborated based on Statista (2015)

[1] Data were drawn from annual reports available as of August 30; market share is based on the annual revenue generated by a company in an industry, divided by the industry revenue generated by public companies as of August 30. This includes only public companies.

Figure 2. B2C market share of parcel services in Europe (By number of packages delivered in 2011)



Source: Statista (2012)

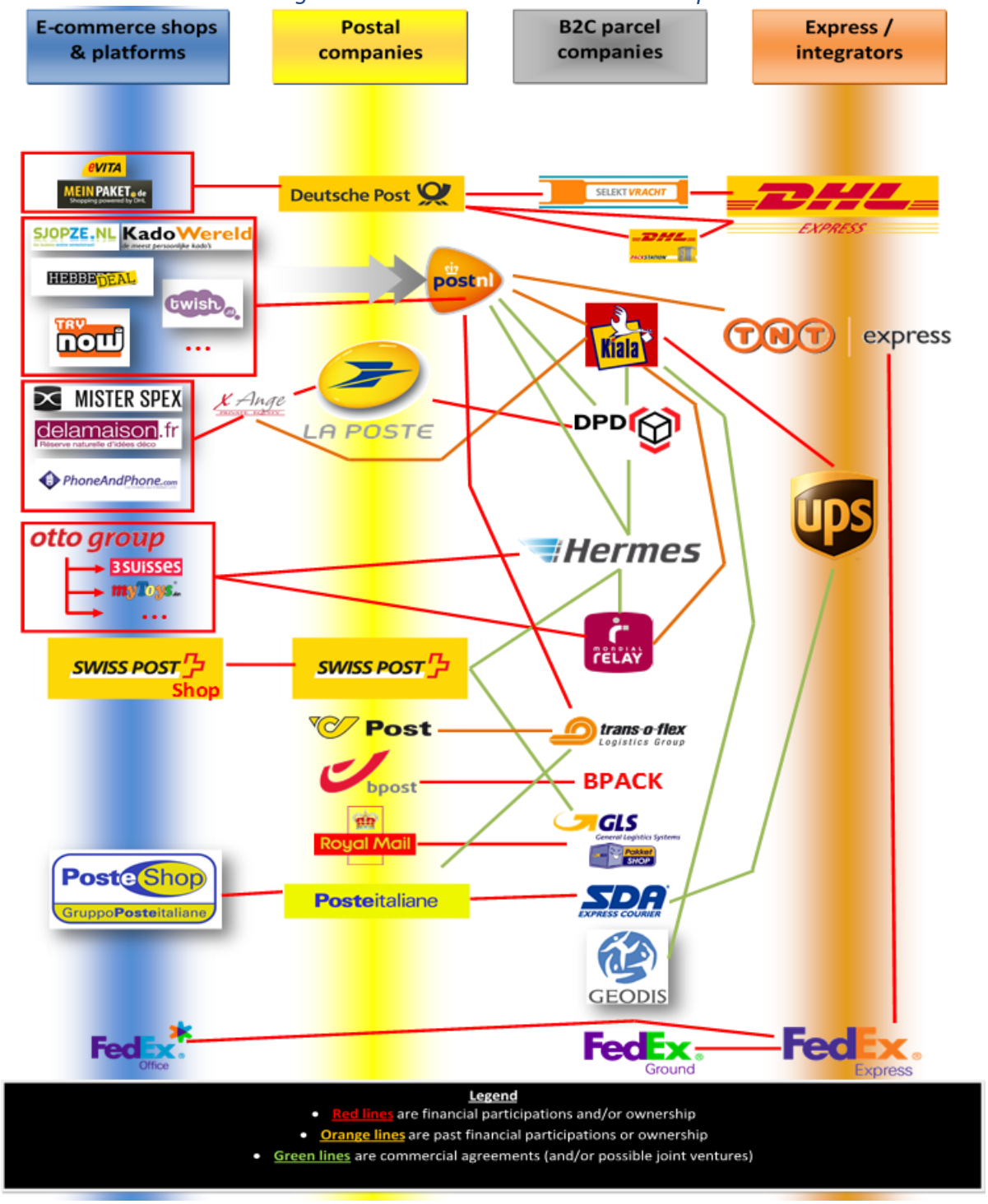
The European B2C parcel market in Figure 3 shows the relationship between E-commerce shops, postal companies, B2C parcel companies, and express companies and integrators. Relationships can be established forms of ownership or financial participation (red lines), past ownerships or financial participation (orange lines), and commercial agreements, and potential joint ventures or takeovers (green lines).

The actors in the parcel market in Figure 3 do not show the extent of their European operational network. Based on the degree of network presence from global to local, in the European B2C parcel market, mainly 6 types of actors exist:

1. Global integrators
2. European parcel operators
3. Operators in European alliances
4. Operators with their own intra-European regional networks
5. NPOs with national networks
6. Operators with local networks[2]. Below, each type of actor is explained.

[2] It is important to note that operators can be classified in more than one type of actor, for instance PostNord which is an operator with intra-European networks, also part of NetExpress Europe (NEE), which are operators in European alliances.

Figure 3. B2C Parcel Market Relationships



Source: Update of Gevaers (2013).

Global integrators

Global integrators are operators who set up international networks including all transport modes. They have complex information technology infrastructures that allow them to have not only full visibility of their operation, but also to maintain control over the door-to-door delivery chain (Dieke, Hillebrand, Joyce, & Niederprüm, 2014; Onghena, 2013). Depending on the operator, the degree of outsourcing of the transportation varies, yet the outsourced transportation company needs to be fully integrated to the operator's communication systems, to offer full traceability. TNT for instance outsources approximately 90% of its fleet in Belgium, UPS outsources between 30 and 40% of its European fleet, whereas DHL only outsources between 0 and 5% of its German fleet (Joseph, 2015).

European parcel operators

There is a limited number of NPOs with a network of subsidiaries in Europe for B2C parcel deliveries. It requires a wide road transport network with own and subcontracted fleets, depending on the country and the company. The main subsidiaries of NPOs are DPD (subsidiary of French La Poste), GLS (subsidiary of British Royal Mail) and DHL (subsidiary of Deutsche Post). These three operators alone account for a market share of 48% in the European B2C parcel delivery market. Hermes is an exception, being part of Otto group, a retail, financial and services group.

There are other important NPOs with subsidiaries in Europe. For instance, the Belgian NPO Bpost operates a subsidiary named Landmark Global, which is the European and international network for its cross-border operations (Post&Parcel, 2014). There are also forwarders entering the B2C cross-border parcel market, such as DB-Schenker and GLS, planning an alliance operational at European level from 2016 (DB Schenker, 2015).

European alliances

An important part of the European B2C parcel delivery is performed by a number of non-postal operators. This concerns mainly e-commerce related operations for intra-European customers. EuroExpress alliance is such a network, currently including three operators: the German Transport and Logistics company Gebrüder Weiss, the Italian BRT (Bartonini), and the Spanish Azkar Logistics.

Another example is NetExpress Europe (NEE), a network of 14 postal, transportation and logistics operators (CARGOS, FAN Courier, DX, GEL Express Logistics, Streck Transport, SE Schiphol Express, SEUR, Raben, Interlogistics, Transline Logistik, Geodis Calberson, SEL Slovakia Express Logistics, Ontime Logistics, and PostNord Logistics) which specializes in the delivery of express door-to-door services in EU and EFTA countries. NEE allows full Track & Trace interoperability within the network.

Another example of a large European network is managed by the German operator EURODIS. This network includes NPO's and freight companies from Austria, Belgium, Bosnia-Hercegovina, Croatia, Czech Republic, Germany, Hungary, Ireland, Italy, Montenegro, The Netherlands, Portugal, Serbia, Slovakia, Spain, Switzerland, and the UK.

Intra-European regional networks
There are a number of operators with strong regional networks delivering B2C parcels to neighbouring countries. An analysis of the operators' websites shows operations expanding throughout Europe. For instance, PostNL based in The Netherlands, is recognised as a strong regional operator. It has subsidiaries in Belgium, Italy, the UK and Germany, and operates under the different brands, namely PostNL Parcel, Nexive, Whistl and Postcon, correspondingly. PostNL Parcel is the brand for European operations. PostNord is another operator with strong regional presence, and owned by the Danish and the Swedish States, and their B2C parcel delivery network focuses on the Nordic region. Another regional operator is the Portuguese NPO CTT, which owns Tourline Express with headquarters in Spain and specializes in courier services. Furthermore, there is REDUR, an operator specialised in e-commerce B2C, B2B, and C2C with headquarters in Spain and deliveries in Portugal and Andorra with its own logistics network. Finally, Swiss Post and Hermes have stakes in Italy's B2C company Porta a Porta (Post&Parcel, 2009). In addition, Swiss Post has its own subsidiary in Italy, La Posta (La Posta, 2015).

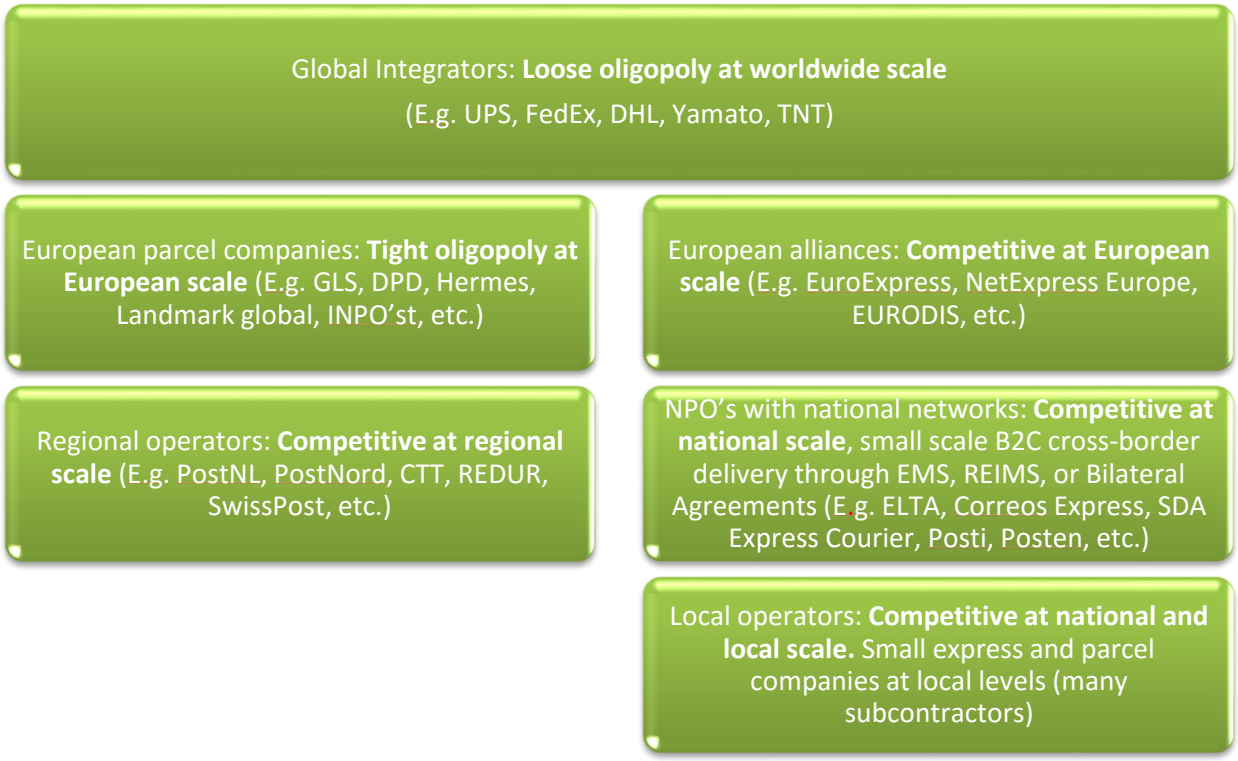
NPOs with national transport networks
There are National Postal Operators operating national transport networks, set up mainly for domestic road transport deliveries. The way to offer cross-border parcel deliveries is through agreements with foreign NPOs or other operators to load parcels on foreign operators' fleets.

Local operators
Local express and courier operators are mainly specialised in first and last mile operations. Cross-border B2C parcel deliveries happen through agreements with other operators with national or international transportation networks. Local operators face highly competitive markets, with scale of operations including single-person companies and their delivery/collection capacity (Gevaers, 2013).

In sum, B2C cross-border parcel deliveries can be performed by global integrators, European parcel companies with European networks, operators in European alliances, operators with their own intra-European network, NPO's with their own national networks, and operators with local networks. According to the market concentration studies of multiple sectors, markets where the top four companies (CR4) hold 41% to 60% of the market share, are considered to be a loose oligopoly (Abdel-Raouf, 2009; Giordano, 2008; Naldi & Flamini, 2014; Sys, 2009). The European B2C parcel delivery segment shows a CR4 (i.e. DHL, Hermes, DPD, and TNT) of 75%, a tight oligopoly, given that in the transportation industry - typically CR4 over 60% - is considered a tight oligopoly. It is important to note that such tight oligopoly includes two of the global integrators, DHL and TNT Express, which are of European origin. The takeover of TNT Express by FedEx would increase the CR4 to 76%. Overall, the European B2C parcels market is an oligopoly, even when at regional, national, and local level there is more competition.

Figure 4 depicts the operators according to the geographical scope of the markets in which they are present.

Figure 4. European Market Actors Typology



Source: Own elaboration based on Interviews, desk research, and previous composition by Gevaers (2013)

Products typology

This section describes how product characteristics and services offered by operators affect cross-border operational costs. The typology of services can bring two main constraints to cross-border operations: time and technological capabilities. Time capabilities relate for instance to the availability of resources for the cross-border delivery of a parcel within the time limits requested by the customers. For example, it will generally require more expensive resources to deliver a parcel cross-border within a day, than to deliver it within a week. As for technological capabilities, it means more expensive resources if the parcel needs to be monitored under a Track&Trace. Thus, the main objective of this section is to identify potential cost drivers for each type of delivery service.

Standard and express services

The standard type of service is the deferred delivery. This product or service commits the operator to deliver, but with an extended number of days. This service is the one that implies the least cost to operators, as it allows re-scheduling of parcel delivery in order to re-optimize operations or capacity. Express delivery is a product or service usually with a dedicated delivery stream, that will typically not be queuing in the overall delivery stream of the operator. Express parcels can skip processes that deferred parcels typically do not, thus reducing the lead time to within 3 days inside the European Union. For instance, while deferred parcels can be put to wait for more deferred parcels to arrive until a large delivery vehicle can be filled, an express parcel is immediately loaded in the next delivery route, even though the vehicle may not be fully loaded, because there is a commitment to deliver on time. Thus a deferred parcel allows for cost reductions by using full truck loads, whilst express

parcels may drive operators to use under-utilised vehicles, resulting in higher costs per parcel delivered.

Services with delivery time windows
Delivery time windows are specifications on the time and hour of delivery of the parcel to the final recipient or destination. They include the possibility of delivery overnight, or to deliver within a time range, or at a precise time (i.e. time-definite). Parcels with these set of services tend to be more expensive than deferred parcel services as they set a constraint on the optimization of the network. For instance, if most parcels are deferred, and only one is time-definite, the latter becomes a constraint for the vehicle routing problem[3] of the operator, and all the deferred parcels deliveries need to be re-optimised. The more the number of time-definite parcels, the more constraints need to be added to the optimization model and the harder it becomes to find optimal solutions. To illustrate this by an example, two parcels set to be delivered at 12:00 cannot be distributed by the same last-mile driver. Thus there are two options: default to the time-definite commitment which corresponds to a reduction in service level, or the allocation of the second parcel to an additional driver, which implies duplicating resources and costs.

Scheduled and on-demand services
At collection, customers can opt for scheduled or on-demand services. Scheduled service have the advantage for the operators that network optimization can take place ahead of a working day, which is why most operators prefer to set up a contract with the e-retailer that specifies the conditions and collection days in advance. This allows for an optimal resource utilization. On-demand collection represents an optimization problem that can be optimal only in cases where diversion of the scheduled collection routes is not substantial, and when excess capacity exists in the vehicle. Otherwise, more resources need to be allocated and costs may increase correspondingly. In fact, on-demand collection is a service that not all NPOs offer.

Track&trace services
Track & trace are services based on automatic identification of the parcels' location and status by use of technologies such as RFID, barcodes, etc. When parts of transport of the delivery chain are outsourced, usually the subcontracting transportation company has the capability to interoperate. Setting up the system requires large set-up costs. But, after the amortization of the investment, savings come from long-term offsetting of the operational costs of manual imputation of routing, re-routing, time of delivery of each parcel. of communication with the transportation manager to inform about the location of the driver, diversions, and all other paperwork involved, etc.

Return services
Returns are not cost-free for any operator. Usually, when returns are offered to the e-retailer, the contract clearly stipulates the return price, distinguishing it from the normal cost of sending a parcel. It can however be the case that e-retailers absorb the cost when the e-shopper wants to return a parcel, which then are advertised by e-retailers as free returns.

[3] Vehicle routing problem is a programming or algorithm to optimize the route according to the minimum distance or time travelled, or minimum cost of transportation, or maximum revenue per delivery to multiple destinations. See for instance Pillac, Gendreau, Guéret, and Medaglia (2013).

Payment on delivery
Payment on delivery is highly cultural determined and can represent substantial costs in the last mile delivery. It increases the operations' time in the final receipt process with the e-shopper, because it is not in fact seen as a delivery, but as a purchase operation, including all components of a sales transaction: verification of the product list, VAT collection, etc. This is in fact a service that can be offered by global integrators and European parcel companies, and whilst some NPOs offer the service, this is at an additional cost.

Signature on receipt and unattended services
Signature upon receipt of the parcel is a service that most operators offer, but, especially in urban areas, the e-shopper is often not at home, and failed deliveries in this case tend to be high. The corresponding operation upon a failed delivery is a second delivery attempt in a second day. If the e-shopper is again not at home, then the parcel is left to the nearest post office or parcel shop, etc. Because of additional administrative operations associated to the re-scheduling of failed deliveries, the last mile delivery costs may more than double., Unattended deliveries are products or services that reduce costs substantially. Delivering to a neighbour, a locker or a parcel shop potentially reduces failed deliveries to about 0%. In case of delivery to lockers or parcel shops, costs decrease further when allowing the operator to consolidate deliveries in larger vehicles, which reduces the number of stops, and the corresponding number of parcels dropped in each stop. These economies of scale allow the per parcel costs to be cut down. In the case of delivery lockers, there is a set- up cost that upon amortization allows for net cost savings on this delivery product or service. Parcel shops set up by the own operator also imply investment and amortization periods, because a fee needs to be paid for each parcel delivered to the retail outlet (gas station, retail shop, etc.). However, the agreements with these shops do not require substantial setup costs, and savings can be reflected from the start.

Table 1 summarizes the product typology and cost effects. Some products can add costs to the normal operations, while others can reduce costs. In some cases, there will be high set up costs which may be offset by operational savings at the end of the amortisation period, Finally, there are also products for which it is unclear whether the effects on costs are positive or negative.

As mentioned before, meeting the demand for B2C cross-border parcel services requires an array of resources and operations that potentially have an impact on the cost structure of the company and, depending on the policies to set margins, may also affect profitability.
The next section describes the door-to-door B2C cross-border parcel delivery and its cost drivers and simulates its cost structure.

Table 1. Products typology and cost effects

	Cost effect
Delivery time windows	↑
Deferred delivery time	↓
Express delivery	↑
Scheduled collection	↓
On demand collection	↕
Vehicle type (larger load capacity)	↑
Track & Trace	↶
Packaging (air)	↑
Payment on delivery	↑
Receipt signature	↑
Delivery at parcel shop and post office	↓
Delivery lockers	↶
Unattended home delivery	↓
Work place delivery	↓
On the move delivery	?
Green city logistics standards	↑
Hybrid delivery (3D or postposed printing)	↶

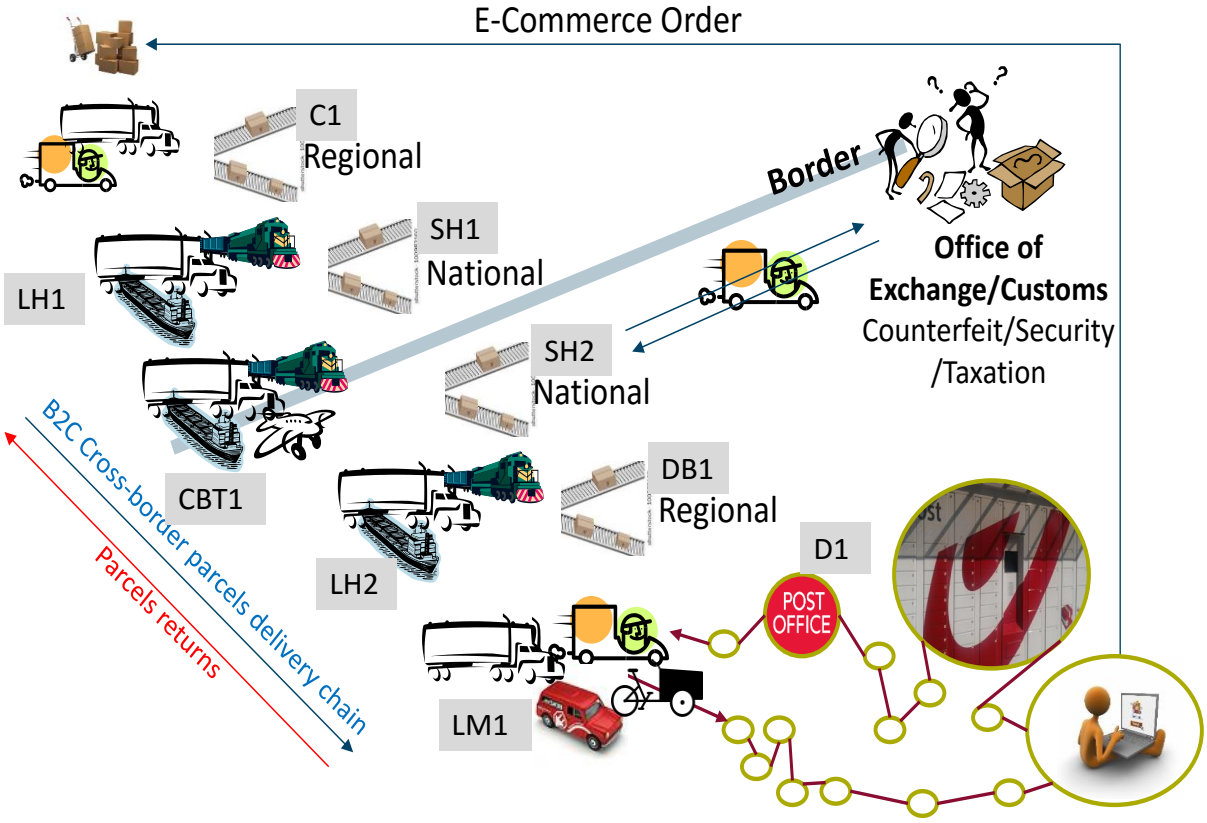
Source: Own elaboration based on desk research and interviews

Simulation modelling of the B2C Cross-border parcel delivery chain

The organisation and operational design of B2C cross-border parcel delivery may have multiple forms. The description below is based on interviews with several NPOs, cross-border and domestic parcel companies and global integrators.

Depending on the operator's strategy, B2C parcel delivery companies may jointly operate cross-border and domestic streams. The generic B2C cross-border parcel delivery chain initiates with the customer placing an order, an e-retailer picking and shipping the order, and then the various step in the operator's delivery process of collecting the shipment, transporting to a regional hub (if a national hub is not enabled to collect directly), handling at the regional hub, transporting to a national hub, handling at the national hub to consolidate according to cross-border destinations, transport to the destination country's national hub, handling by destination and handling in case customs clearance is required at customs warehouses (when the operator does not have customs operations in-house), transport to a regional distribution base, handling at the distribution base, last-mile delivery, and receipt by the e-shopper (see Figure 5).

Figure 5. Generic B2C Cross-border parcels delivery chain



Source: own elaboration based on interviews

Figure 5 shows the stages of the B2C cross-border parcel delivery including Collect, Line-haul, Sort Hub, Cross-border transport, Foreign Sort Hub, Foreign Line-Haul, Distribution depot, Last mile delivery. In the next section each stage is elaborated on in detail. The description is part of a modelling methodology called IDEF0[4], suitable for operational models.

IDEF0 modelling of B2C Cross-border parcel delivery

The description of operational models that are shown below are based on the most common strategies as taken from scientific and sector literature, but are complemented with alternatives referred to by stakeholders during the interviews. These descriptions include the discussion of the key operations, resources, and drivers of the cost structures. In general, each operational model describes the activities and key resources that occur in each stage of the delivery chain.

[4] IDEF0 is a method to model the decisions, actions and activities of an organization or system. It allows identifying inputs, outputs, controls, and mechanisms in the system or operations. For an extensive explanation of the methodology see IDEF (2015).

Methodological note

The IDEF0 model comes with a code (i.e. C1, LH1, SH1, SH2, LH2, DB1, LM1) on the top left indicating the stage as referred to in Figure 5. To describe the detail of the IDEF0 model, we use Figure 6 and subsequent figures. Depot collect requires personnel, internal vehicles, auto-ID equipment and other equipment. In the IDEF0 methodology these resources are called mechanisms, as they relate to the ways tasks are performed, and are indicated with vertical arrows coming from below to link to the operation (e.g. depot collect) indicated in the rectangular box.

Each operation has as inputs the parcels to be processed, and it is indicated by a horizontal arrow linking into the operation (e.g. collect from customer). As parcel operations have no manufacturing operation[5], the output is also a parcel and indicated by horizontal arrows linking to the next stage in the delivery chain.

Vertical arrows linking from top to the operation, indicate the standards and key performance indicators (i.e. throughout) set for each operation. These are called controls in the IDEF0 methodology.

Collect operational models

A collect operational model describes specific methods to collect parcels from the sender. The three most common collect operational model for e-commerce-based cross-border parcel deliveries to consumer are depot collect, e-retailer collect, and outsourced collect (see Figure 6). Depot collect is when the e-retailer with its own means of transport takes the parcels to the parcel operator's depot[6] (depot collect); the e-retailer collect is when the parcel operator with its own means of transport picks up the parcels from the e-retailers' warehouse; and the outsourced collect is an intermediate point between the operators' depot and the e-retailer's warehouse, for instance parcels shops where the parcel is collected by the operator.

According to interviews with parcel operators, depot collect is the preferred method by both e-retailers and parcels operators. There are a number of reasons for this:

- The first-mile costs are run by the e-retailer, and thus not factored in the overall delivery chain costs for the operator;
- Retailers avoid the constraints placed by the operators' fleets minimum and maximum parcels loading;
- It brings certainty that parcels are immediately placed into the delivery stream;
- Large e-retailers with regional transportation capacity can take advantage of this operational model as they have the resources to move parcels from retail to the depot;
- E-retailers tend to be registered and have contractual arrangements with parcel operators. This allows reducing processing time and increasing the throughput (i.e. number of parcels processed by the depot in a day). For instance, based on interviews and estimations with Universal Postal Union data (UPU, 2015), the throughput of a

[5] An alternative to this operational model is shown in Figure 17, where desk research shows the potential use of 3D printing as the analogous service of hybrid delivery services. Figure 17Figure 17

[6] The parcel operator's depot can be a local sort hub, a regional sort hub, or a national sort hub, depending on the parcel operator's network extension and configuration. For the purpose of this report, a depot refers to a regional sort hub, or otherwise it is specified.

regional NPO's sorting centre for cross-border parcel deliveries in the EU27 was approximately 11,600 parcels daily.

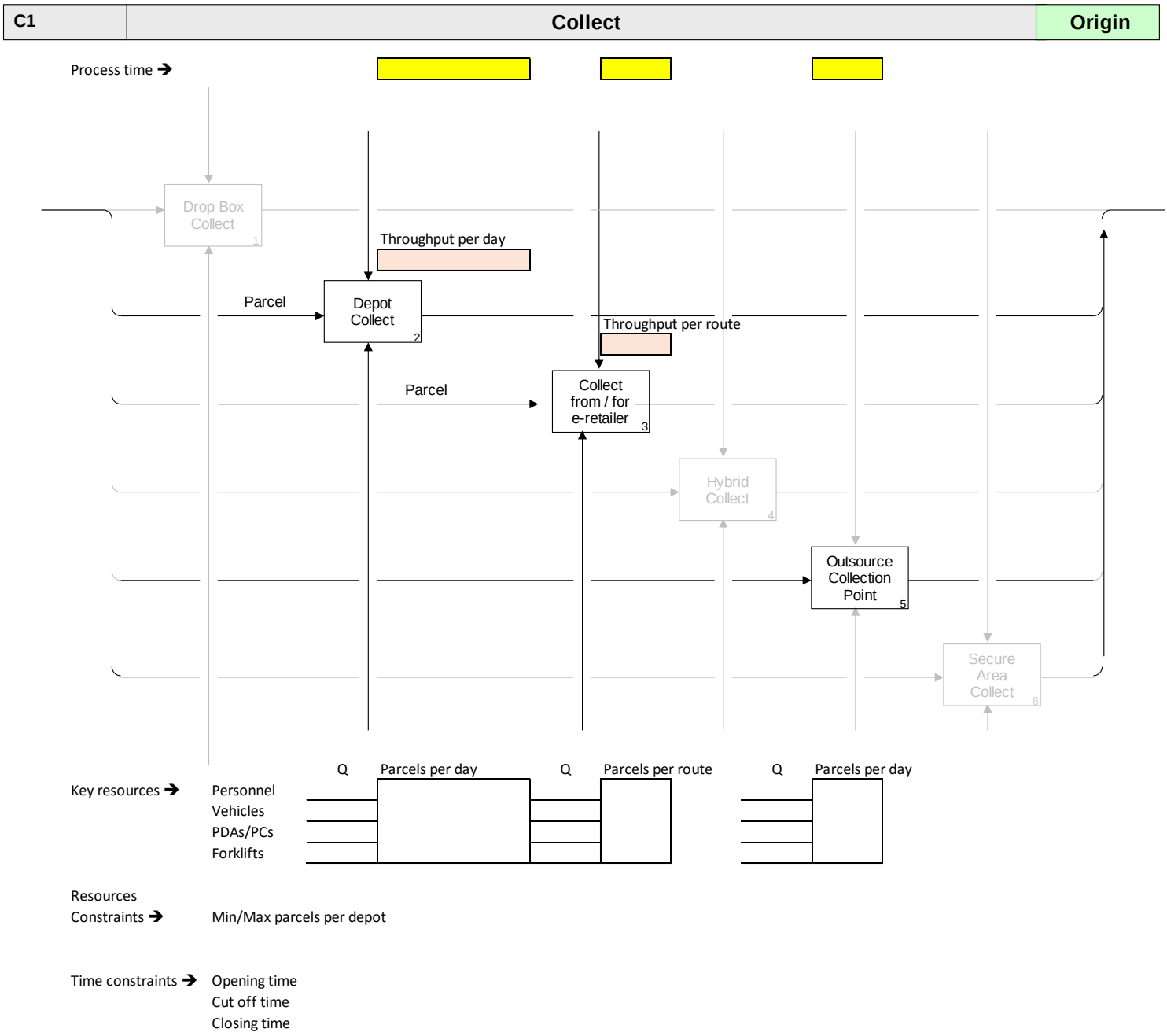
Collect from the e-retailer's warehouse brings in additional service revenues for the parcel operator, but it also has a number of advantages especially for the e-retailers, such as:

- No need to set up transportation capacity to ship parcels to the operators' depot.
- Economies of scale by the parcel operator factors in lower total distribution costs. Parcel operators tend to combine B2B and B2C cargoes to increase loading factors and reduce the size of the fleet.
- The e-retailer omits the allocation of funds for transportation personnel, communication technologies with the drivers, as well as additional future investments due to reduced accessibility to urban areas by road.

Collect from the e-retailer at outsourced collection points or shops has similar characteristics as the collection at the depot, but the operator increases the convenience for the e-retailer by offering more locations to drop the parcel for collect by the operator (for example gas stations, supermarkets, etc.). In this case, the first-mile collection costs are shared between the e-retailer and the parcel operator. Yet, the part of the first-mile by the parcel operator can be done with larger vehicles, and allows for a higher number of parcels to be moved from the outsourced collection point to the regional sort hub or to the national sort hub.

Interviews reveal that services offered for B2C and B2B are agreed and formalised by a contract that takes in account cost differences. Operators will often require from e-retailers to ship with regularity, homogeneous volumes and dimensions, because this reduces the extra resource allocation costs they otherwise would incur (for example when e-retailers exceed the maximum expected parcels to deliver in a single shipment). Operators can manage variability or on-demand collection by foreseeing excess capacity, but this represents extra operational costs for the operator. Another operational model for managing on-demand and high variability of parcels shipments is the depot collect operational model, where the vehicle size or loadings do not represent a constraint for the parcel operator because the transportation from the e-retailer warehouse to the operators' depot is arranged by the e-retailer.

Figure 6. Collect operational models



Source: Own elaboration based on stakeholder interviews

Line-haul operational models

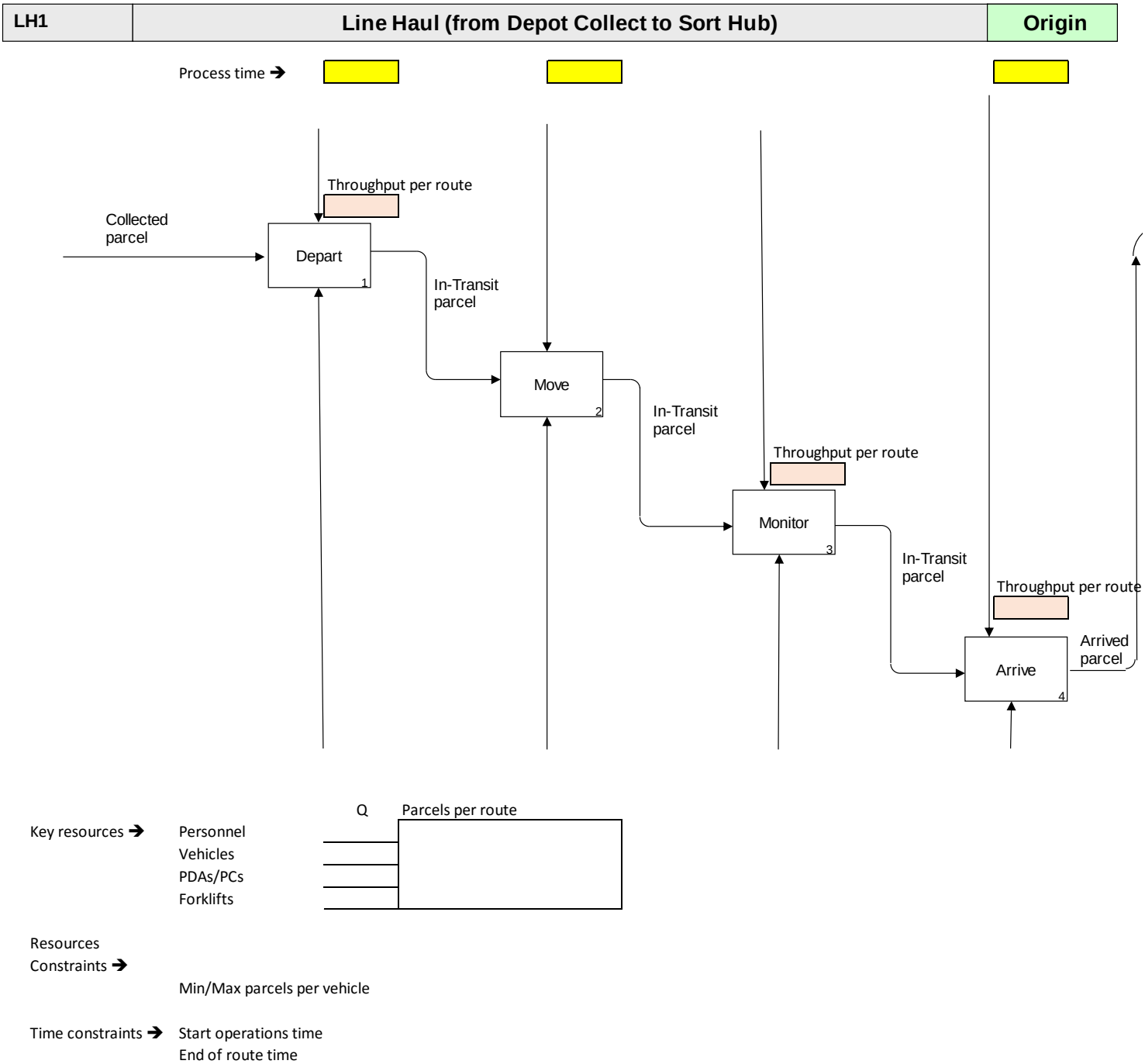
Line-haul operational models refer to transportation activities and resources from the operator's depot (local or regional) up to the national sort hub. This is different from the first and last mile as the line-haul does not transport to or from senders or receivers. It also differs from the long-haul, as it does not entail too long transportation distances nor cross-border transportation. From the operator's depot (regional sort hub), the next stage in the delivery chain is the line-haul of parcels to the national sorting hub.

Interviews show that in case of European parcel operators, (described in Figure 4) even for cross-border destinations as close as 10 km away, such as from the Netherlands to Belgium, parcels still need to be loaded from the regional depot to the national sort hubs to be sent later cross-border for delivery. These operations may entail hundreds of kilometres before reaching the e-shopper, which may be 10km away from the e-retailer.

The four main operations in line-haul, like in any transportation model, are departure, move, monitoring and arrival (see Figure 7). When e-retailers and e-shoppers opt for a specific delivery time this affect the choice of transport mode. Longer delivery times allow parcel operators to use more cost-efficient modes of transport like rail or waterways, rather than road or air. Another way to optimise costs includes the use of vehicles with excess capacity, which implies that instead of allocating additional vehicles by the operator the parcels wait until excess capacity is available to make the trip. Also in case of road transport, avoiding tolls is a way to save costs. In sum, there are alternatives by which operators can optimize the transportation costs when time is not a hard constraint.

For monitoring, track and trace systems are widely used mainly by global integrators and European parcel companies. Local operators are not always equipped with track and trace systems, but even if they were, those systems may not be interoperable with the rest of the parcel companies they interconnect with in the cross-border delivery chain. Equipment for interoperability represent investment costs, but they reduce operational costs of monitoring through manual means and by use of paperwork. Track and trace systems based on auto-ID technologies (GPS, RFID, Barcode Readers, Near Frequency Fields, etc.) allow to monitor without interrupting the move of operations. Manual updates of line-haul location and the status of the parcels on the other hand, interrupt the move operation, therefore increasing the time between departure and arrival, and thus also the line-haul operational costs (i.e. personnel). Alternatively, additional drivers may be assigned to the line-haul to avoid interruption of the move operation. However, this also represents line-haul operational cost increases. For instance, rather than having one person operating one vehicle, it would be necessary having at least two persons, one driving and another in charge of the track and trace operations.

Figure 7. Line-haul operational model from Depot collect (Regional SC) to Sort Hub (National SC) collect



Source: own elaboration based on stakeholder interviews

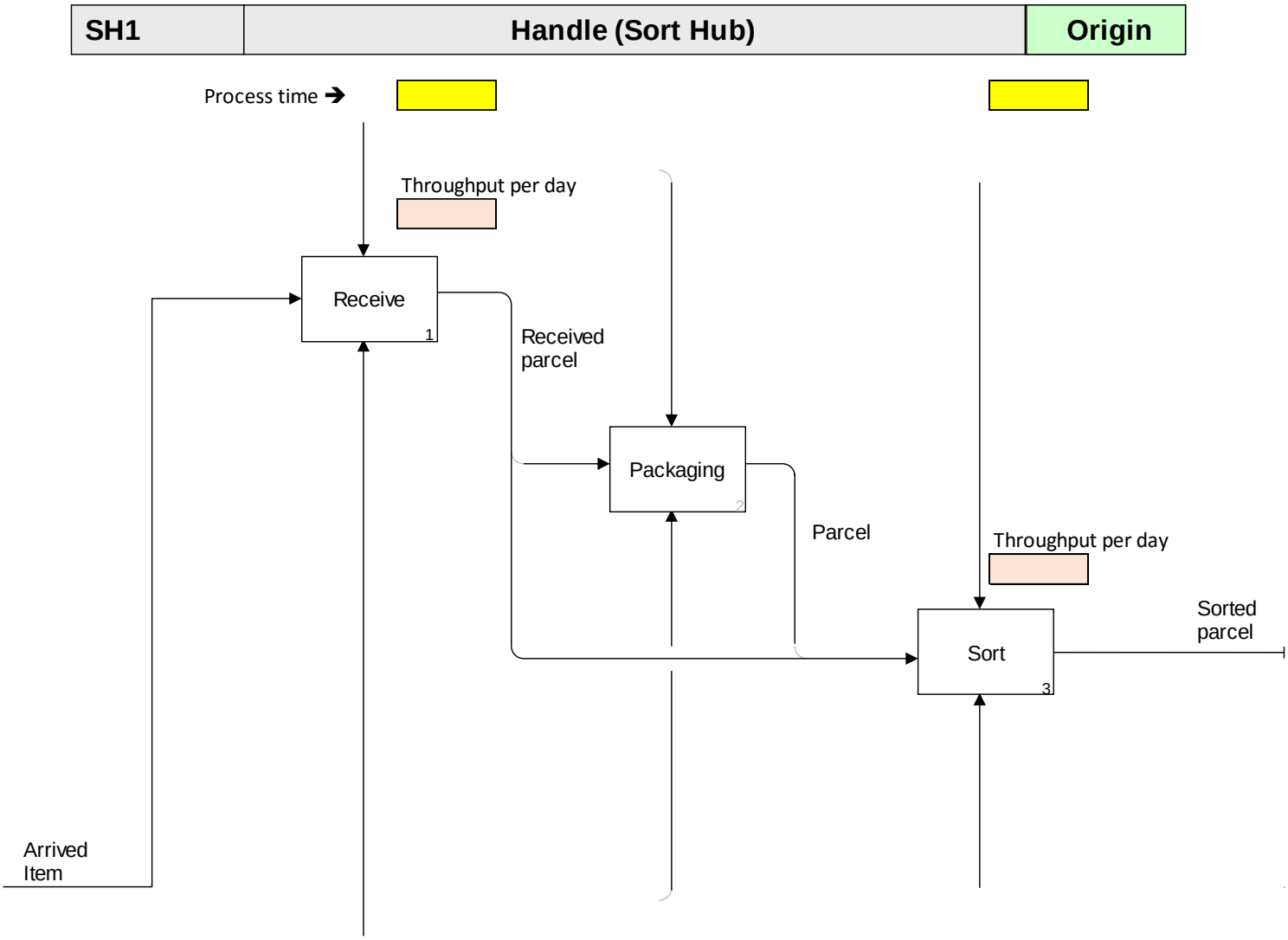
Sort hub handling and sorting operational models

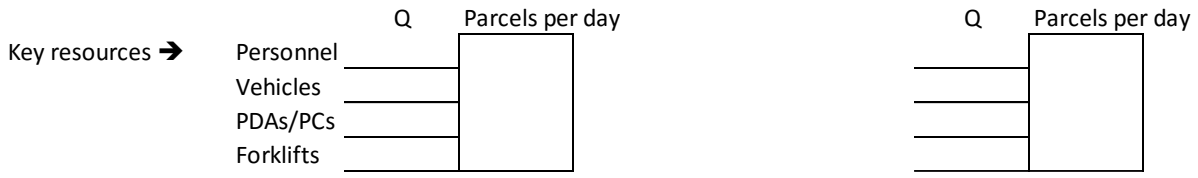
The main operations in the parcel sort hub are parcel reception and sorting (Figure 8). Depending on the automation level of the sort hub, the throughput and per parcel operational cost may vary. Automated sort hubs such as those of global integrators or European parcel operators have the capacity to sort more parcels in a given time span than semi-automatic or manual sortation. Although the total operational costs increase, the number of parcels processed per day rises more than proportionally (i.e. increasing throughput), thus reducing average sortation costs per parcel substantially.

The repackaging of parcels is often included in the normal price, when it is not requested with high frequency. When the received parcel's packaging is fragile, operators tend to repackage the parcel, usually absorbing the cost, unless it is agreed between the operator and the e-retailer that packaging is part of the regular service, and then costs are assigned to the e-retailer.

In order to improve customer convenience for B2C cross-border parcel delivery, there are operators that dedicate a team to arrange transportation, as customs, security operations or coordination with foreign operators.

Figure 8. Sort hub handling and sorting operational models





Resources Constraints ➔ Min/Max parcels per sort hub

Time constraints ➔ Opening time
Cut off time
Closing time

Source: own elaboration based on stakeholder interviews

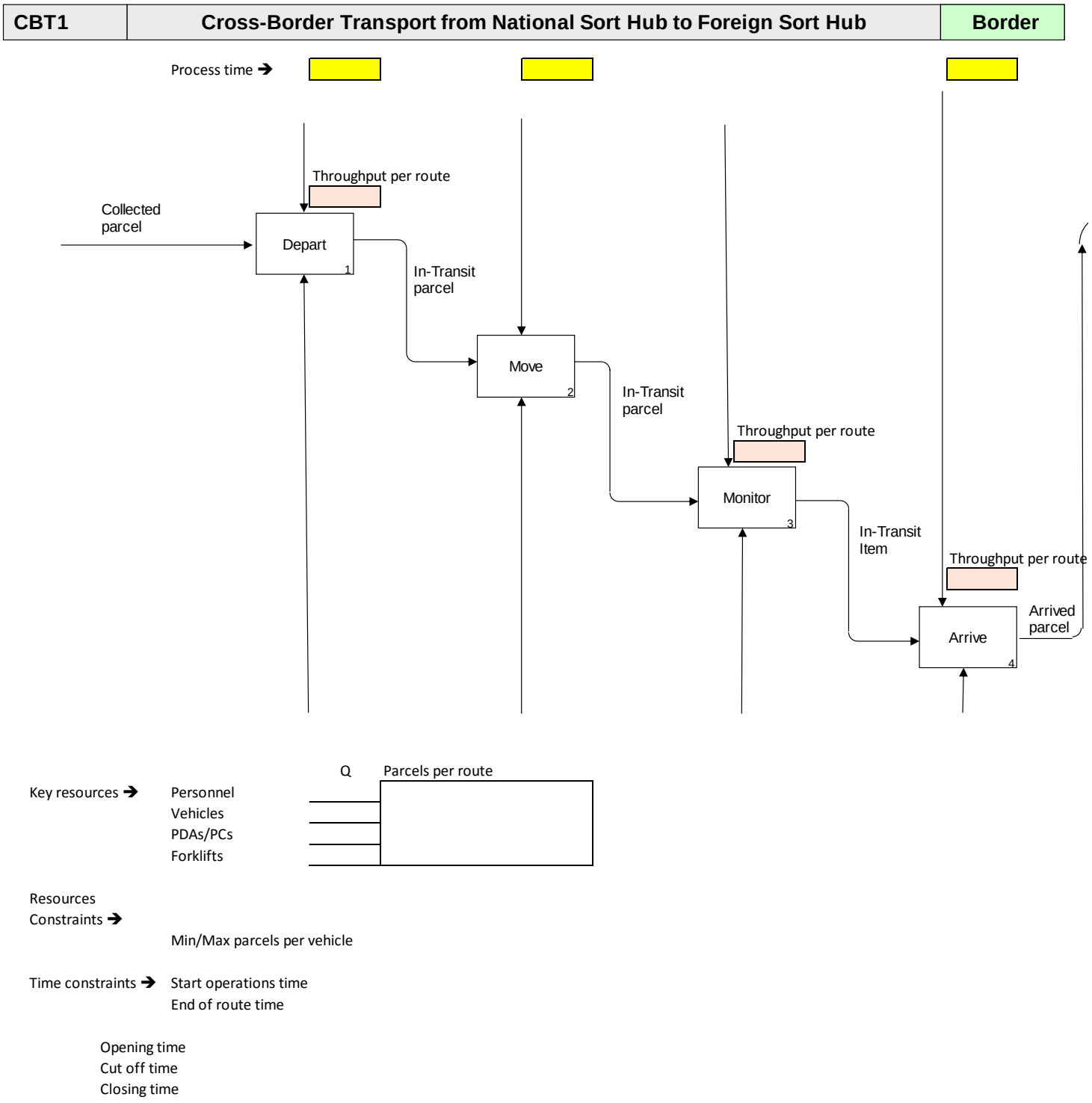
Cross-border transport operational model

Similar as for line-haul transportation, the cross-border transport mode depends heavily on the selected delivery time (see Figure 9).

Additional factors for the selection of the cross-border transport mode are:

- Distance. There are estimations from operators that up to 600km, road transport is more competitive than any other mode, whilst beyond 600km, air transport becomes increasingly competitive, both in terms of transportation time and operational cost of the transit per parcel.
- Neighbouring countries as destination. Global integrators, European parcel companies and European alliances, described in Figure 4, are able to optimise their European transportation networks to deliver not only to neighbouring countries, but also to countries beyond. However, there are NPOs who can only rely on national transportation networks and Intra-European Regional transportation networks, and these are therefore able to optimise transportation networks up to their neighbouring countries.
- Per unit transportation costs. This is especially important in the case of air transport where small-scale cross-border deliveries to a long-distance destination can be booked inexpensively (up to 2 Euro per kilo) by using excess capacity of commercial airlines.
- Scale of operations, frequency and agreements with commercial airlines. When volumes increase, agreements with commercial airlines need to reserve fixed space which increase the unit cost of air transport. Alternative operational models exist that fully exploit excess capacity of commercial airlines by splitting parcels or cargo into multiple departure airports and/or multiple commercial airlines that go to the same destination. This increases line-haul transportation planning from the national sort hub to the departure airports. Thus, the operators' roles consist of optimising the total and per unit costs.

Figure 9. Cross-border transport operational model

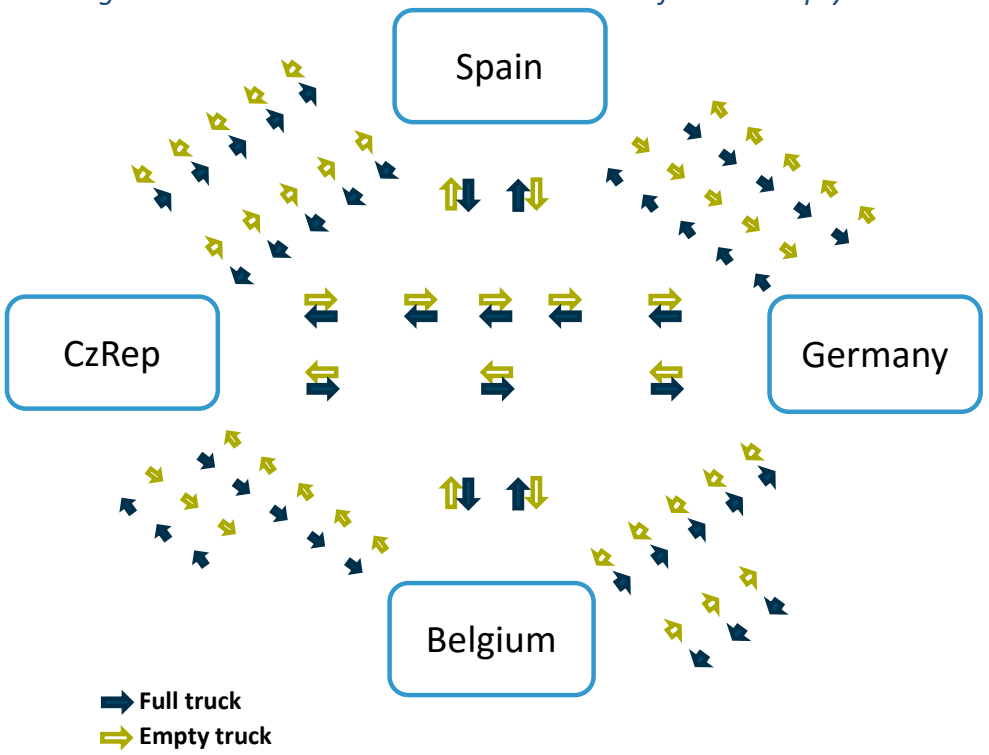


Source: own elaboration based on stakeholder interviews

- Trade imbalance. An important cost factor in B2C and B2B cross-border deliveries is the fact that imbalances in the inbound and outbound volumes of parcels exist. To illustrate this with an example, imagine that Czech Republic sends systematically 5 trucks to Belgium, whilst Belgium sends systematically 3 trucks to Czech Republic; and Belgium sends 5 trucks to Germany, whilst Germany sends 3 trucks to Belgium. Due to the trade imbalances (exports ≠ imports) transport units would have to systematically be stored in one country's yards because the receiving country does not have enough parcels to send. There exist three operational models operators can use to deal with these imbalances. The first option involves that each country sends the empty trucks back to the sending country, which implies underutilisation costs (see Figure 10). The second option is that the destination country, after unloading the inbound trucks, fills them up with outbound parcels, and sends them back to the origin country. Yet, due to the imbalance of trade between the countries, there empty trucks might return to the other country (see Figure 11). Only operators with large European scale can manage to do this by their own network, therefore this is more feasible to do for global integrators, European parcel operators, or operators with access to the European network of road transport. The third option is a balancing of the entire cross-border transportation network by optimising multiple origins and destinations. For instance, empty trucks originating from Germany to Czech Republic are filled up with parcels to be sent from Czech Republic to Belgium. The empty trucks originating from Czech Republic to Belgium, are filled up with parcels to be sent to Germany. And the empty trucks originating from Belgium to Germany, are filled up with parcels to be sent to Czech Republic (see Figure 12). In this case, global integrators and European parcel companies split the transportation of B2C cross-border parcel delivery in three cost segments: first and last mile, line-haul, and cross-border transportation network. This optimisation is done for the two main transport modes, road and air. If the cost of an optimised road cross-border parcel delivery from country A to country B is higher than that of an optimised air cross-border parcel delivery, the modal switch is justified.

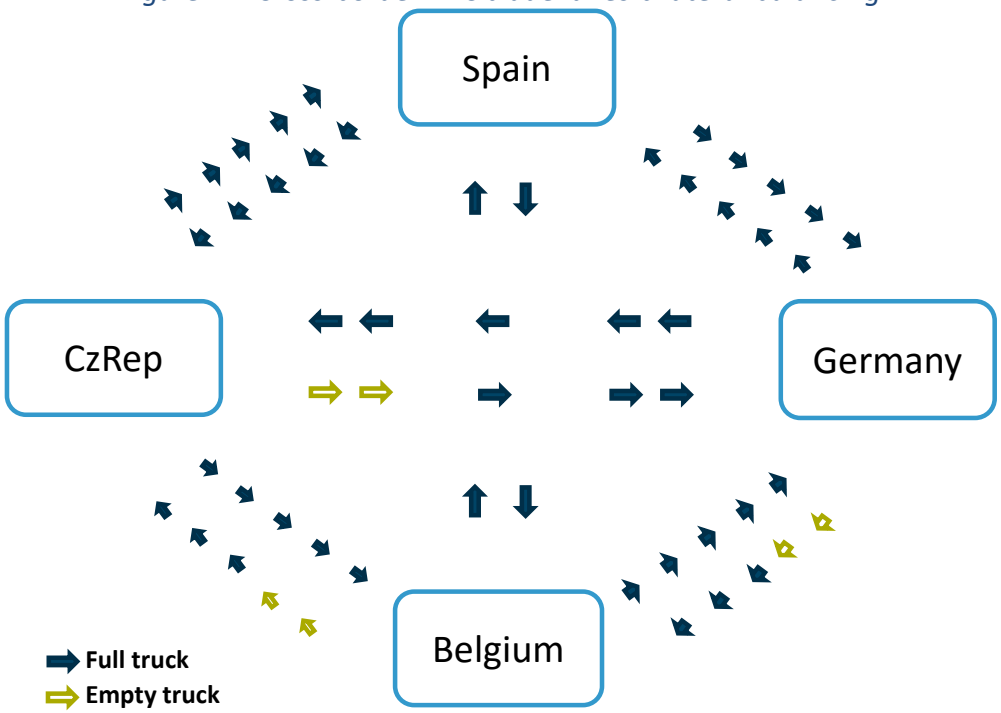
According to interviews, NPOs with national transportation networks tend to outsource the cross-border transportation to freight forwarders, although, they are also able to transport to neighbouring countries directly. However, the receiving NPOs is not allowed to load the returning vehicle with parcels for the vehicle's country of origin. Instead, the foreign country outsources or transports directly the parcels to the origin country, moving at the same time an empty vehicle and a full vehicle from the foreign to the origin countries.

Figure 10. Cross-border B2C trade lanes with full and empty runs



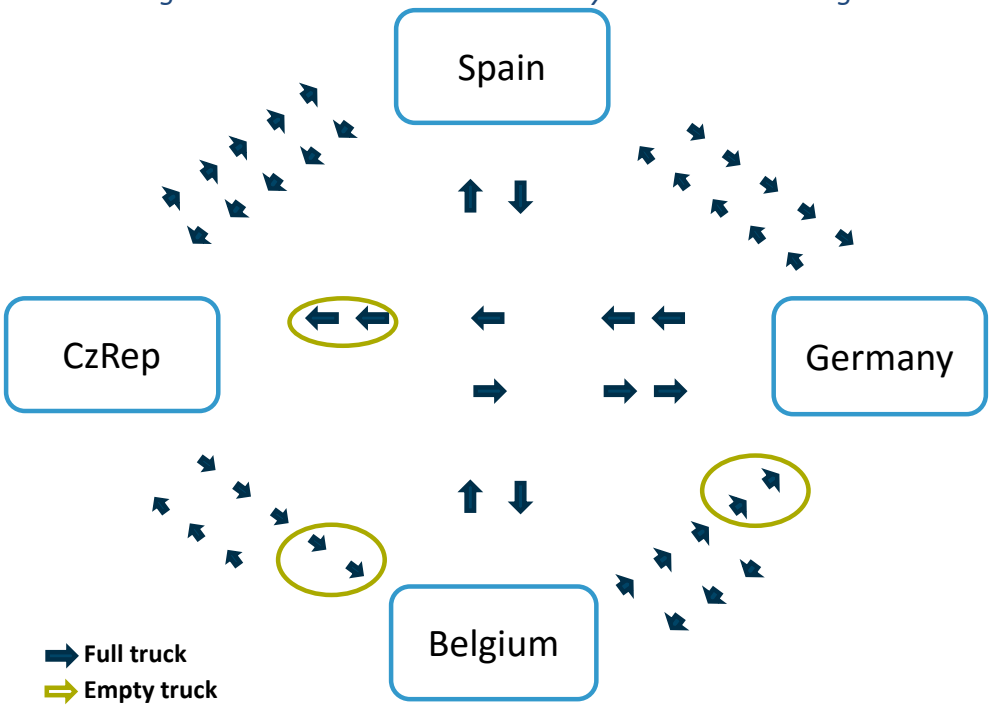
Source: own elaboration based on stakeholder interviews

Figure 11. Cross-border B2C trade lanes bilateral balancing



Source: own elaboration based on stakeholder interviews

Figure 12. Cross-border B2C delivery network balancing



Source: own elaboration based on stakeholder interviews

The cost of cross-border B2C without and with a balanced road network, based on interview and desk data, is estimated in the following section. It shows for B2C cross border parcel delivery (for urban to urban cross-border B2C parcel delivery) minimum savings between 23% for the Belgium-Germany trade lane, up to 44% for the Spain-Czech Republic one (see Table 2). It must be noted, that this estimate assumes the full elimination of empty runs when switching from trade imbalance to a network balanced approach.

According to Joseph (2015) and with adjustments based on stakeholders interviews in this study, the parcel market is estimated to outsource most of the transportation. DPD, GLS and Hermes are estimated to outsource approximately 90% of their transportation needs. In fact, 95% of the intra-EU cross-border road transport of all types of goods, is performed by subcontractors. The reason is that freight forwarders (i.e. the subcontracted parties) coordinate and optimise entire supply chains and networks at European level (AECOM, 2014).

Table 2. Cross-border B2C network balancing costs savings (costs in Euros/trip)

Trade lane	Imbalanced costs	Balanced costs	Cost change
Belgium-Germany	1032	795	-23%
Germany-Belgium	1013	772	-24%
Belgium-CzRep	1543	986	-36%
CzRep.-Belgium	1219	800	-34%
Germany-CzRep	1044	725	-31%
CzRep.-Germany	820	600	-27%
Spain.-CzRep	2518	1419	-44%
CzRep-Spain	2114	1206	-43%
Spain-Belgium	2038	1249	-39%
Belgium-Spain	2415	1445	-40%

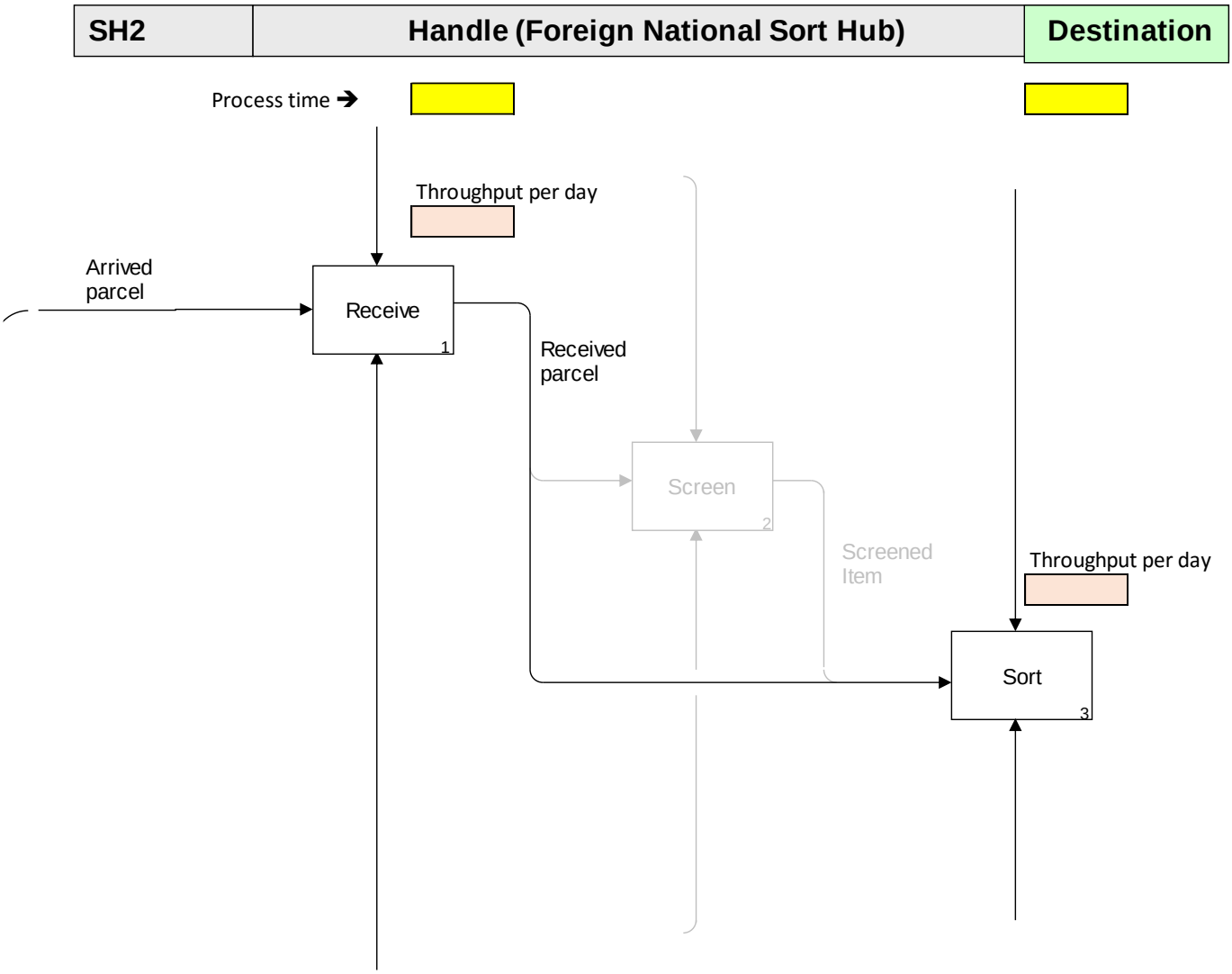
Source: own composition

Foreign sort hub and handling operational models

The national sort hub in the destination country carries out the same basic operations as the national sort hub in the country of origin (see Figure 13). The main operations are thus receiving and sorting. An important sorting activity at this stage is to sort the parcels either by rural or urban destination. There is another operation, screening, which is not typically mentioned because it is not always performed. Operators then foresee customs operations to be carried out in the national sort hub, where parcel screenings and inspections can take place. There are also operators which do not have customs in-house. In this case, they are obliged to transport the parcels indicated by customs authorities from the national sort hub to a customs warehouse. This incurs extra costs for these operators, a cost that cannot be assigned to the specific parcel under scrutiny, because customs administrations targeted the parcel to be inspected and later cleared from tax duties and or security concerns.

The same logic as for the other operational models applies, costs per parcel depend on the amount of resources deployed at the national sort hub and the throughput achieved by those resources in a day.

Figure 13. Foreign sort hub and handling operational models



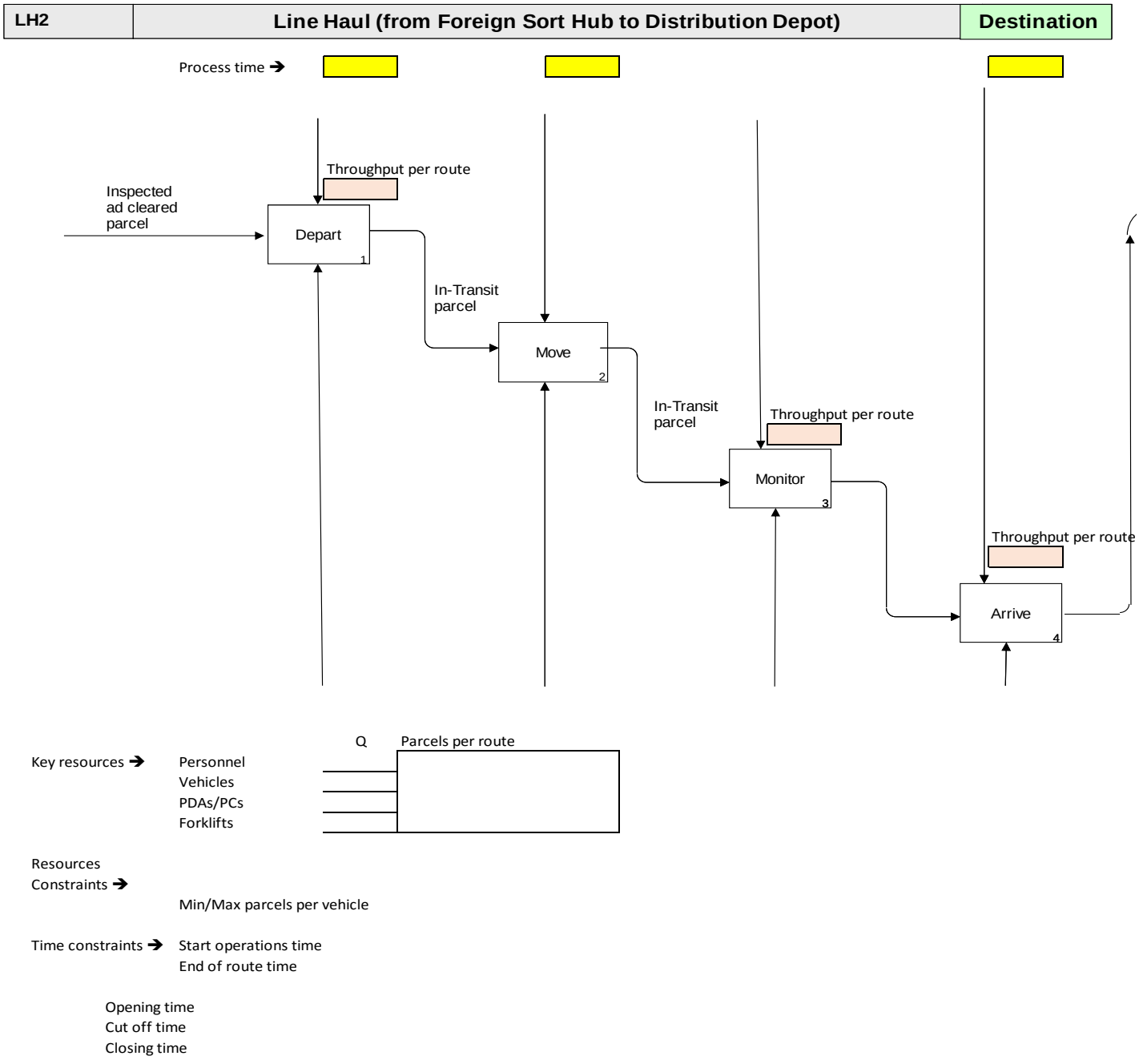
		Q	Parcels per day	Q	Parcels per day
Key resources ➔	Personnel				
	Vehicles				
	PDAs/PCs				
	Forklifts				
Resources Constraints ➔	Min/Max parcels per sort hub				
Time constraints ➔	Opening time				
	Cut off time				
	Closing time				

Source: own elaboration based on stakeholder interviews

Line-haul operational model from foreign Sort Hub to Distribution Base (Regional SC)

The operational model for the line-haul from the foreign national sortation hub to the distribution base, has no substantial differences with the line-haul operations in the country of origin. The costs are mainly driven by the operational resources and per unit costs by the throughput per route (total number of parcels able to be moved by the vehicle in a single delivery route -see Figure 14). The throughput can be split between urban or rural distribution base.

Figure 14. Line haul operational model form foreign Sort Hub to Distribution Base

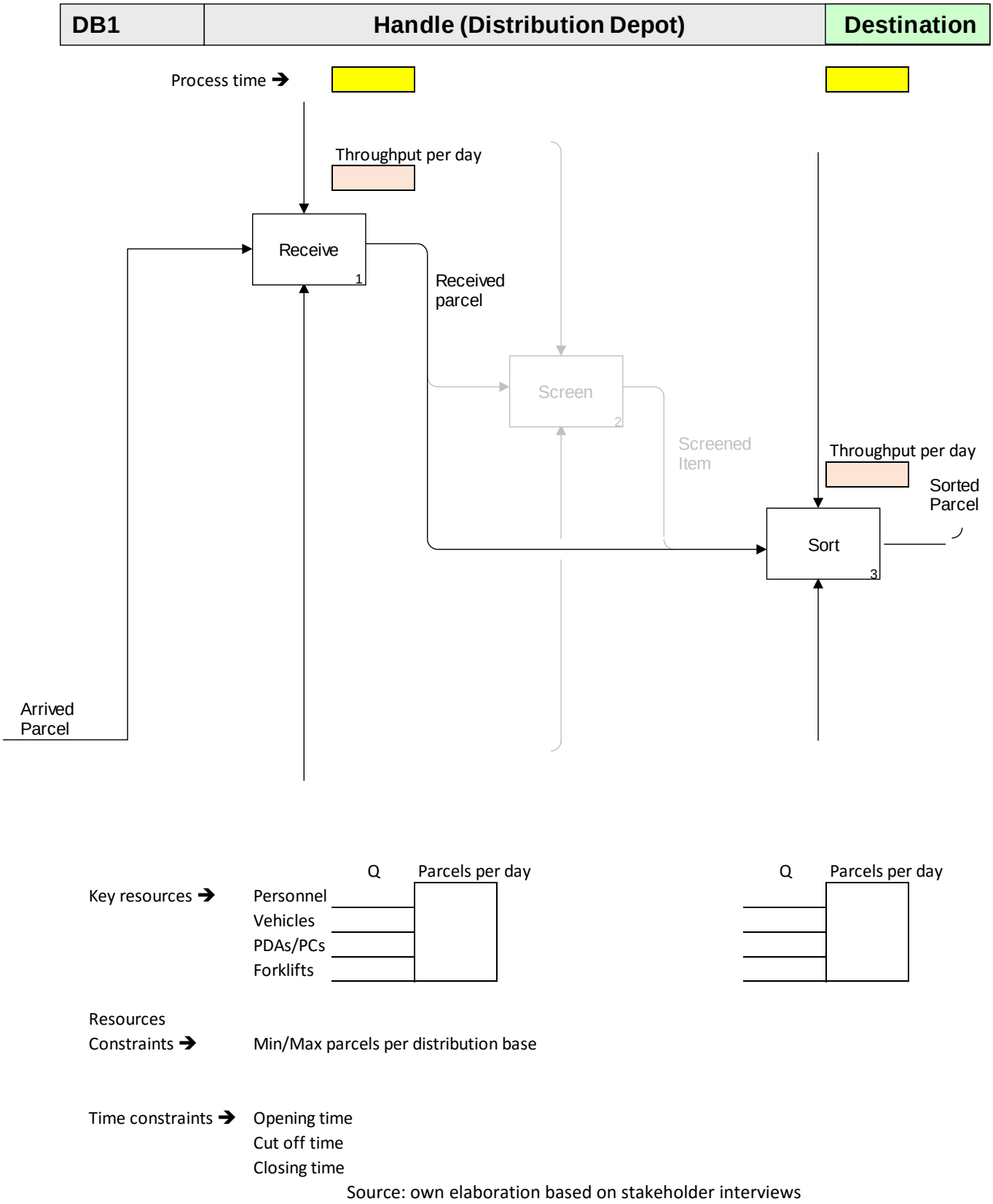


Source: own elaboration based on stakeholder interviews

Foreign Distribution Base operational models

The fairly simple operations of the foreign distribution base include the reception and sortation of the parcels (see Figure 15). With regards to sorting, the distribution base needs to take into account the services committed to the e-retailer. The sorting must be performed according to the specifications of the last mile delivery (i.e. deliver to lockers, to the e-shopper's address, to parcel shops or post offices). The operational model in the distribution base makes no distinction in the handling of cross-border and domestic B2C parcel delivery. Here, the destination is known to be either urban, suburban, or rural. The throughput (parcels sorted per depot) in the distribution base may differ for each type of last-mile delivery: parcels per day for lockers delivery, parcels per day for parcel shops or postal office, or parcels per day for e-shoppers' addresses, etc.

Figure 15. Foreign Distribution Base operational models



Source: own elaboration based on stakeholder interviews

Last-mile delivery and receipt operational models

The last-mile delivery follows the same operations as the line-haul (see Figure 16). However, there may be different streams involved to deliver to the e-shopper. According to interviews, the default service is deferred delivery, followed by express delivery, time window and time-definite delivery. The resources required to perform a time-definite delivery are much higher than those to meet a deferred one, they also depend on the extent in which the number of time-definite deliveries (delivery at a specific time of day) in a single route are requested. Operators argue that one single time-definite delivery is not problematic, as long as it remains a single constraint in their vehicle routing problem. However, when the number of time-definite deliveries increases, the likelihood of two customers asking for the same time-definite (e.g. Monday at 12:00) delivery increases, leaving the vehicle routing with sub-optimal solutions, i.e. only one customer can be delivered at that time. Only by assigning additional vehicles and drivers to a route with overlapping time-definite deliveries, the demanded time-definite service can be fulfilled. This implies additional costs. Although to a lesser extent, the same situation exists for time windows and express deliveries.

Operators explain that routing problems without constraints offer better solutions to minimise delivery costs. Operational models with delivery lockers and parcel shops or post office delivery relax to some extent those constraints, as opposed to delivery to the e-shopper's address.

- Delivery to lockers (Click & Collect) allow vehicles to be larger than typical delivery vans used for delivery to the recipient's address. This results in higher average speed and lower vehicle fuel consumption and depreciation cost per parcel, because the vehicles are able to move larger number of parcels per tour. Interviews indicate that operational models with delivery to the e-shoppers' address allow for delivery up to 120 parcels per typical day, when delivery to lockers is used, a minimum of 800 parcels per typical day can be transported. In addition, delivery lockers have the advantage that both the operator and the e-shopper have access at any time of the day to the lockers, whereas the other operational model usually has office hour restrictions.
- Parcel shops or post office deliveries have similar characteristics and advantages as the delivery lockers, except that they have hour restrictions for the e-shopper to pick-up the parcels.

Last-mile operational models may include the use of greener and quieter vehicles for deliveries, which certainly increase the operational costs, and tend to have reduced load capacity. On the other hand, environment friendly vehicles can gain access to urban areas where heavier and contaminant vehicles are not allowed to enter.

As failed delivery rates can vary from 15 to 30%, operators mention the high costs of failed delivery rate in the e-shoppers' address delivery model as an important issue. Failed deliveries lead to second delivery attempts or to storage in the nearest post office. In both cases, they represent direct costs of transport, storage, and the indirect opportunity costs of not transporting parcels with potentially successful deliveries. Unattended home deliveries or delivery with the neighbours allow to reduce the failed delivery rate, as does the option to deliver to the work place. Another important challenge in the delivery to the recipient's

address is the payment on delivery. This is a common practice in Eastern-European countries, it however makes delivery operations very time-consuming. The implication of this is the deployment of a larger fleet and more drivers to deliver the same amount of parcels.

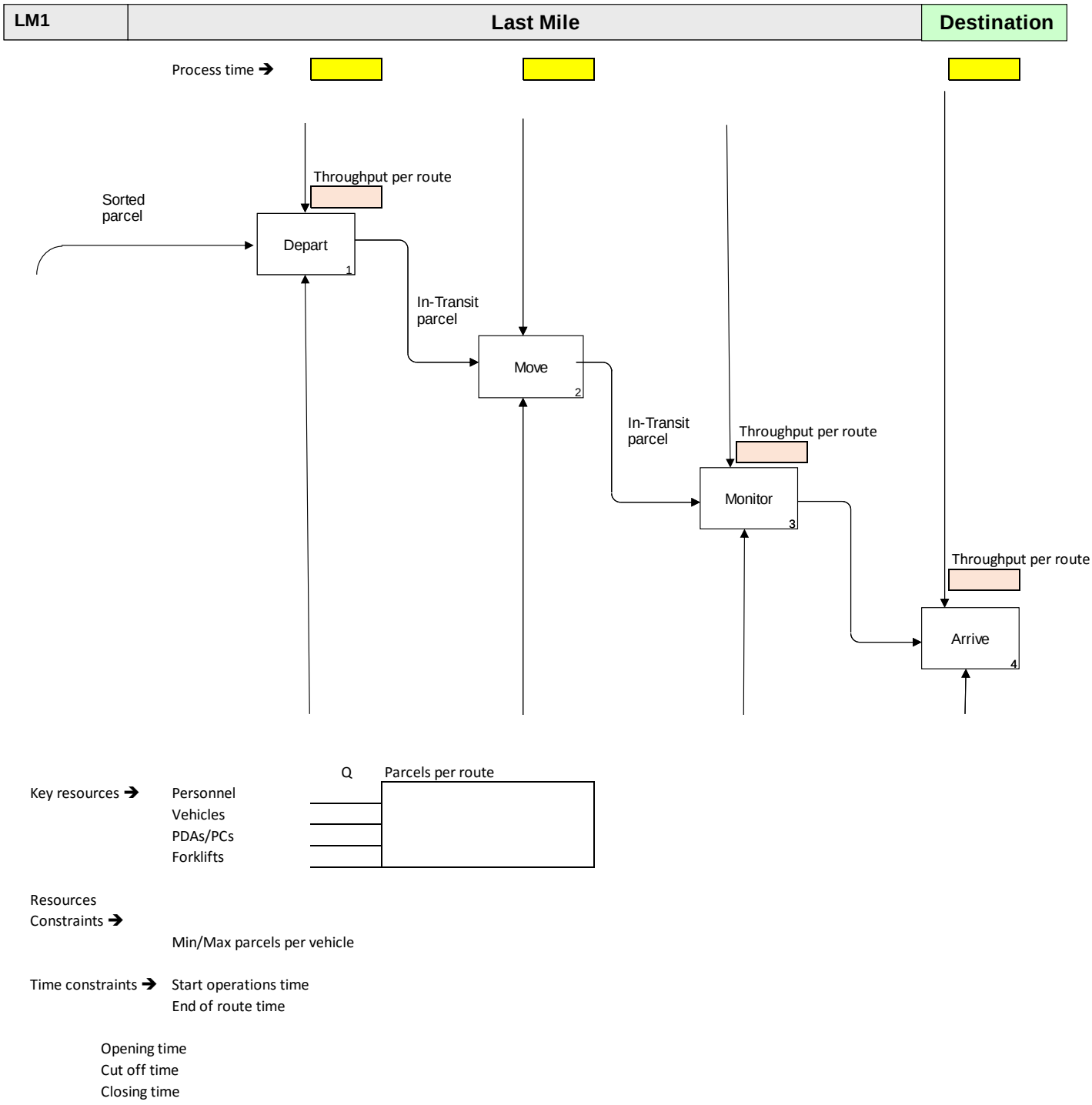
According to interviews, parcel returns in the cross-border parcel delivery do not require the set-up of special or additional operations. Return parcels are integrated in the normal cross-border stream to the origin country.

The receipt operational model for B2C cross-border parcel includes, as described in Figure 17 before automatic lockers, delivery to the shopper' address, and parcel shop or post office parcels deliveries. According to the desk research, there are additional delivery operational models emerging such as mobile deliveries and hybrid deliveries, but these are not yet mentioned by operators as being practically deployed. Mobile deliveries require parcel operators to locate the e-shopper through mobile location services and deliver parcels into the e-shopper's vehicle[7]. Hybrid delivery corresponds to e-retailers sending 3D printing blueprints to the parcel company, which then print the product, pack it, and deliver it to the e-shopper[8], just as postal operators deliver hybrid mail.

[7] See for instance http://www.cardrops.com/

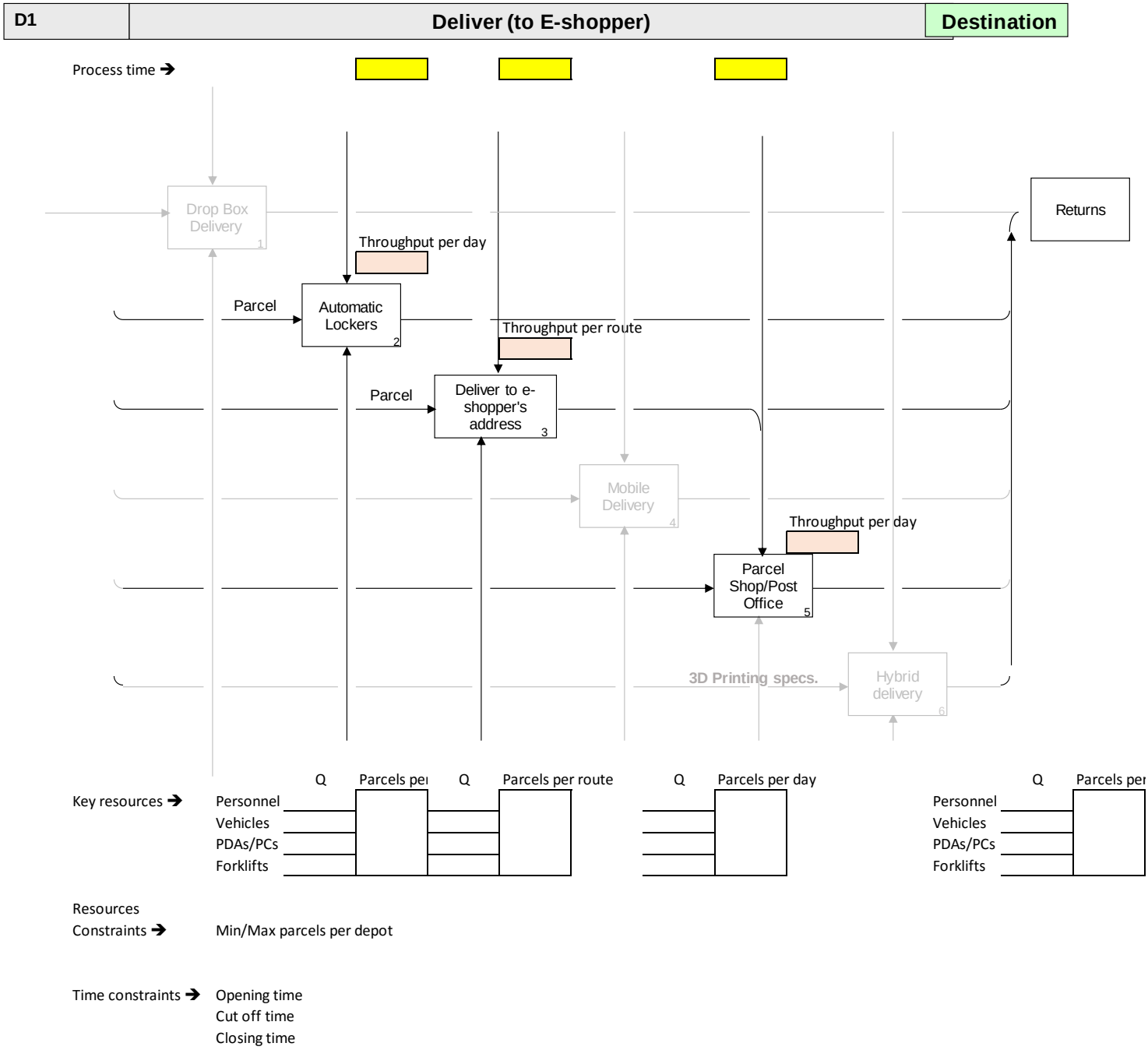
[8] See for instance http://3dprint.com/46934/amazon-3d-printing-patent/

Figure 16. Last mile delivery operational models



Source: own elaboration based on stakeholder interviews

Figure 17. Receipt operational models



Source: own elaboration based on stakeholder interviews

This section, by showing operational models for the B2C cross-border parcel delivery, with its IDEF0 model, indicated the main cost drivers. The following section summarises the cost drivers, based on interviews and desk research, and simulates a series of B2C cross-border parcel deliveries.

B2C Cross-border parcel delivery cost structures and drivers

In general, based on interviews, we can sum up the cost drivers in parcel deliveries in different factors that impact costs and their operators' economies of scale, scope and reach. By economies of scale we mean the total number of parcels transported by the operator, by scope the capability to integrate B2C, B2B, and C2C, and by reach we mean the capability to optimise networks rather than trade lanes bilaterally.

The basic drivers in the B2C cross-border postal delivery are: distance, time, speed, density (parcels per stop, stops per tour), and first delivery/collect failure rate. These drivers are then expressed in the operational data (see Table 3). The operational data relates to the vehicle costs: vehicle leasing, wages, equipment leasing, energy cost, and fixed costs.

The sources of information are twofold: interviews constitute the principal source of operational data, whilst costs are based, in addition to interview data, on desk research for instance regarding the vehicle leasing costs, fuel costs, insurance costs, for the year 2015 for each of the countries.

In order to have comparable data across countries there are a number of assumptions made:

- Urban collect
    - Tour traveling time: 8 hrs
    - Tour distance: 45 km
    - Line haul distance: 45 km
    - Average speed line haul: 35 km/hr
    - Stops per tour: 45
    - Parcels per e-retailer: 80
- Rural collect
    - Tour traveling time: 8 hrs
    - Tour distance: 150 km
    - Line haul distance: 45 km
    - Average speed line haul: 60 km/hr
    - Stops per tour: 10
    - Parcels per e-retailer: 20
- Urban delivery
    - Tour traveling time: 8 hrs
    - Tour distance: 45 km
    - Line haul distance: 45 km
    - Average speed line haul: 35 km/hr
    - Stops per tour: 100
    - Parcels per e-shopper: 1
    - Failed first time delivery rate: 20%
- Rural delivery
    - Tour traveling time: 8 hrs
    - Tour distance: 150 km
    - Line haul distance: 45 km
    - Average speed line haul: 50 km/hr
    - Stops per tour: 30
    - Parcels per e-shopper: 1
    - Failed first time delivery rate: 5%
- Long haul cross-border trip

- Parcels per trip: 3000
- Empty truck return after delivery to destination country (not network balance) as depicted in Figure 10.

Due to lack of data on operational costs of depot/sorting hub/delivery base, the next sections present simulations that include only transportation costs.
The cost structures are divided in four stages: first mile, line haul, long haul, and last mile. Each stage includes operational data, which allows simulating B2C cross-border parcel delivery chain costs per tour, per stop, and per parcel (see for instance Table 3 for the Belgium Urban Collect Cost Structure), and in annex for remaining stages and countries.
Table 3 shows the cost structure of the urban collect. Its components are the following:

- Total cost per parcel = Total cost per stop / parcels per stop
- Total cost per stop = Total cost per tour / Stops per tour (1-Failed collection rate)
- Total cost per tour = Vehicle cost + Collection cost + Line haul cost
- Vehicle costs = Monthly Lease + Basic Maintenance + Summer Tires + Annual Inspection + Road Tax + License + Insurances
- Collection costs = Labour cost in collection route + Distance cost in collection route
- Line haul cost = (Labour cost per kilometre in line haul + Fuel cost per kilometre)*Line haul distance
- Labour cost in collection route = Labour cost * Tour travelling time
- Labour cost per kilometre in line haul = Labour cost / Avg. Speed Line Haul

Similar calculations were performed for B2C Urban collect, B2C Urban delivery, B2C Rural Collect, B2C Rural delivery, and B2C Long-Haul from origin to destination countries. This was done for representative countries: Czech Republic, Belgium, Germany, and Spain (periphery country).

Table 3. B2C urban collect in Belgium

Belgium		
Operational Data		
Tour Travelling Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	35	Kilometers/hour
Collection Tour Distance	45	Kilometers/tour
Stops per Tour	45	Stops/tour
Parcels per stop	80	Parcels/stop
Failed Collection Rate	0%	
Vehicle Costs		
Monthly Lease	440	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	148	Euros/year
License	450	Euros/year
Insurances	183	Euros/year
Labour Cost	18.12	Euros/hour
Fuel Costs	1.18	Euros/litre
Calculations		
Labor cost per kilometer in line haul	0.52	Euros/kilometer
Fuel cost per kilometer	0.15	Euros/kilometer
Line Haul Costs	**59.87**	**Euros/tour**
Labor cost in collection route	144.96	Euros/tour
Distance cost in collection route	6.64	Euros/tour
Collection Costs	**151.60**	**Euros/tour**
Vehicle Costs	**32.50**	**Euros/tour**
Total Costs		
Total cost per tour	**243.96**	**Euros/tour**
Total cost per stop	**5.42**	**Euros/stop**
Total cost per parcel	**0.07**	**Euros/parcel**

Source: own composition based on interviews and desk research

Scenarios and simulations

The simulations in this study include the three countries mentioned in the previous section, and the following 6 trade lanes:

- Belgium-Germany
- Germany-Belgium
- Belgium-Czech Republic
- Czech Republic-Belgium
- Germany-Czech Republic
- Czech Republic-Germany
- Spain-Czech Republic
- Czech Republic-Spain
- Belgium-Spain
- Spain-Belgium

Assessing these trade lanes will allow verifying whether and why sending parcels from country A to country B has a different cost than sending parcels from country B to country A. Also, it will show whether and why sending parcels from a country in ecommerce development, C, to an ecommerce mature country B, has different costs than sending from an ecommerce mature country B to an ecommerce development country C. The simulation refers to Door-to-Door B2C deferred parcel delivery. The costs of the sorting centres were not included in this analysis, as there is not enough relevant data for the estimation of the sort hub costs for each one of the countries we evaluate below. Thus the costs referred here are vehicle costs as shown in Table 3 (i.e. monthly lease, basic maintenance, summer tires, annual inspection, road tax, license, insurance, drivers' wage, and fuel cost) for first-mile, line-haul, cross-border road transport, foreign line-haul, and last-mile.
The cost estimates are per trip and per parcel. The cost per trip is the sum of the costs of operating each vehicle involved in transporting a parcel from one country to another. The first-mile costs of a single vehicle route include parcels for B2C, B2B, C2C, and for domestic and cross-border. The same is estimated for line-haul, cross-border transportation (i.e. long-haul), etc. Furthermore, the cross-border trip merges parcels from any first-mile origin to be delivered in any last-mile destination in the foreign country. The cost per parcel, takes the vehicle cost in each stage per parcel, such that adding up cost per parcel of each transportation stage allows to estimate the door-to-door per parcel cross-border delivery cost. Hence, the cost drivers are not only those changing the cost structure of the transportation, but also those changing the number of parcels transported in each stage of the delivery chain.

Table 4 shows the urban to urban B2C cross-border parcel delivery cost. The trade lane with the highest costs per parcel is Spain to Belgium. Two reasons for this are the higher cost related to the long-haul transportation distance between the countries, and the high last-mile delivery costs in Belgium. The least costly trade lane per parcel is Germany to Czech Republic. The reasons are the short distance between the countries and low cost for last-mile delivery in Czech Republic, compared to other countries.
The trade lane with the highest cost per trip is Spain to Czech Republic, whilst the trade lane with the lowest cost per trip is Czech Republic to Germany (see Table 4).

The reason for the lowest cost per trip and the lowest cost per parcel not to be the same in the trade lane for a bilateral pair of countries is for instance, because the costs per parcel in

Germany in the last-mile is much costlier than the first mile and long-haul from Czech Republic. For instance, the long-haul from Czech Republic to Germany costs 473 Euro, but because it is moving 3000 parcels, the cost per parcel of the long-haul is 0.16 Euro, whilst the long-haul from Germany to Czech Republic costs 697 Euro, and moving 3000 parcels brings the cost per parcel to 0.23 Euro. As the urban last-mile in Germany costs 242 Euro, and moving 100 parcels, the last-mile cost per parcel is 3.04 Euro, whilst the urban last mile in Czech Republic costs 104 Euro, and moving 100 parcels, the last-mile cost per parcel is 1.30 Euro. Thus, the total cost door to door, is not necessarily proportional to the door to door cost per parcel. From this example, it can be observed that higher volume drives down the cost per parcel even if the total operational cost is higher.
Given the costs are calculated without network optimisation, all these costs have large potential for cost reductions it is was to be tried anything from bilateral to full network balancing as described in Figures 10 to 12.

Table 4. Urban to urban B2C cross-border parcel delivery cost (Euro)

Trade lanes	Urban-Urban	
	Per Trip	Per Parcel
Belgium-Germany	1,032.01	3.29
Germany-Belgium	1,012.81	3.29
Belgium-CzRep	1,543.05	1.77
CzRep.-Belgium	1,218.82	3.37
Germany-CzRep	1,044.39	**1.60**
CzRep.-Germany	**820.35**	3.22
Spain-CzRep	**2,518.10**	2.10
CzRep-Spain	2,114.40	2.66
Spain-Belgium	2,038.37	**3.64**
Belgium-Spain	2,414.84	2.75

Source: own composition

Table 5 shows the delivery costs from rural to rural areas. The costliest trade lane is Germany to Belgium, and it is approximately 9.98 Euro per parcel. Surprisingly, the least costly is Germany to Czech Republic with an estimated cost of 5.38 Euros per parcel.

Table 5. Rural to rural B2C cross-border parcel delivery cost (Euro)

Trade lanes	Rural-Rural	
	Per Trip	Per Parcel
Belgium-Germany	1,029.39	9.95
Germany-Belgium	1,010.32	9.98
Belgium-CzRep	1,547.51	5.55
CzRep.-Belgium	1,226.92	9.46
Germany-CzRep	1,048.78	**5.38**
CzRep.-Germany	**828.25**	9.28
Spain-CzRep	**2,528.47**	5.52
CzRep-Spain	2,126.36	7.02
Spain-Belgium	2,041.87	9.97
Belgium-Spain	2,416.28	7.71

Source: own composition

In the Rural to Urban the least and costliest trade lanes per parcel are Germany to Czech Republic and Czech Republic to Belgium, correspondingly (See Table 6). Whilst the least and costliest Urban to Rural trade lanes per parcel are Germany to Czech Republic and Spain to Belgium, correspondingly (See Table 7).

Table 6. Rural to Urban B2C cross-border parcel delivery cost (Euro)

Trade lanes	Rural-Urban	
	Per Trip	Per Parcel
Belgium-Germany	1,028.08	4.41
Germany-Belgium	1,008.81	4.41
Belgium-CzRep	1,539.13	2.90
CzRep.-Belgium	1,353.47	**4.53**
Germany-CzRep	1,040.39	**2.73**
CzRep.-Germany	**826.95**	3.75
Spain-CzRep	**2,520.09**	2.87
CzRep-Spain	2,120.99	3.19
Spain-Belgium	2,040.36	4.41
Belgium-Spain	2,410.91	3.89

Source: own composition

Table 7. Urban to rural B2C cross-border parcel delivery cost (Euro)

Trade lanes	Urban-Rural	
	Per Trip	Per Parcel
Belgium-Germany	1,033.32	8.82
Germany-Belgium	1,014.32	8.85
Belgium-CzRep	1,551.44	4.42
CzRep.-Belgium	1,220.33	8.93
Germany-CzRep	1,052.78	**4.25**
CzRep.-Germany	**821.66**	8.76
Spain-CzRep	**2,526.48**	4.75
CzRep-Spain	2,119.77	6.49
Spain-Belgium	2,039.88	**9.20**
Belgium-Spain	2,420.20	6.58

Source: own composition

Last-mile strategies cost assessments

The main cost drivers, operational or market conditions that lead to increases or reductions in costs of the last-mile in the cross-border parcel delivery are behavioural, scale, scope and reach of the operations. Each one of these drivers interacts with the last-mile cost structure in ways that can either increase of reduce the cost per parcel. The following sections describe the cost drivers and simulate how behavioural drivers -represented in the choice of first and last mile options - can have an effect on the costs per parcel.

Last-mile cost drivers

As shown in the product typology (see Table 1), delivery options can have impacts on the last mile cost structure and their throughput. Cost drivers are mainly of four types: behavioural, scale, scope and reach.

A behavioural driver, for instance, can be the sense or need of security or safety reflected in the need of signature receipt of the recipient, like for pharmaceutical products or those requiring parental control, or it can be the perceived need for convenience to deliver door-to-door from the e-retailer to the e-shopper. A combination of the previous two examples generates one of the costliest last-mile delivery options, as it represents a door-to-door delivery with a receipt signature (standard), that induce following logistic operations: first mile collection at the e-retailers warehouse, domestic line haul, cross-border long haul, foreign line haul and last-mile delivery. For this delivery option, the signature upon receipt implies some risk of a first and second delivery fail, thus increasing the delivery cost of the parcel.

The scale of operations is another cost driver, where the collect and delivery costs depend on the tour distance, operations time, vehicle load capacity, number of stops, number of parcels delivered per stop. In general, the more resources and time for moving and handling the same number of parcels, the costlier the delivery will be. More parcels moved with the same number of resources is said to bring scale economies, and reduces unit costs.

Increasing the scope of operations also drives costs. When B2C parcels are moved jointly with the letter stream (for example in the case of NPOs), or with B2B parcels, or C2C parcels, it may reduce costs per parcel. In the analysis below, it is not specified whether B2C parcels flow in a B2B stream, and all costs are currently assigned to B2C parcels. However, if the stream is handling 50% B2C and 50% B2B parcels, then the costs per parcel estimated earlier should be half.

Increasing the reach of the transportation operations drives costs down. Economies of reach here mean that rather than using the use of transportation resources on bilateral trade lanes (e.g. Belgium-Germany, Germany-Belgium, Spain-Belgium, Belgium-Spain, etc.), resources are used in a network optimisation fashion (Belgium-Germany-Spain, Spain-Germany-Belgium, etc.). For instance, bilateral trade lanes use full long hauls from Belgium to Spain and return back empty, whilst Spain sends full long haul to Belgium and return empty. An attempt to optimise bilateral trade lanes there is a possibility of important cost savings if long hauls from Belgium unloading in Spain are later used by Spain to perform the long haul to Belgium. Yet, since trade is usually imbalanced, the number of long hauls needed from Belgium to Spain may be different than from Spain to Belgium. Then some empty returns are inevitable, and

further cost savings cannot longer be achieved, unless operators engage in a network balancing optimisation process.

Last-mile costs simulation

A simulation of various last-mile delivery options shows the importance of cumulating economies of scale and scope, and the importance of effective receipt behaviour by the e-shopper for reducing last mile costs.

The simulations in this study included the following delivery options in urban contexts: Standard door-to-door service, door-to-door (unattended), depot-to-door (attended), door-to-locker, and depot-to-locker (see Table 8).

The simulation shows that switching from attended to unattended deliveries reduces the delivery costs per parcel by approximately 16.4%. The most cost-effective last-mile delivery option is the delivery to lockers, and it is more important in the most expensive urban delivery countries with cost drops between 73.8% and 75.8% (see Table 8).

*Table 8. B2C Cross-Border Parcel Delivery Costs - Last mile delivery options (Cost per parcel in Euro)**

Trade lanes	Cost per parcel of the last mile delivery option								
	Click&Collect Depot2Locker	% diff of Standard D2D†	Click&Collect Door2Locker	% diff of Standard D2D†	Standard Depot2Door	% diff of Standard D2D†	Unattended Door2Door	% diff of Standard D2D†	**Standard Door2Door**
Belgium-Germany	0.49	-85.2%	0.55	-83.2%	3.22	-2.1%	2.68	-18.5%	**3.29**
Germany-Belgium	0.48	-85.4%	0.55	-83.4%	3.22	-2.0%	2.68	-18.5%	**3.29**
Belgium-CzRep	0.53	-70.1%	0.60	-66.3%	1.70	-3.8%	1.51	-14.7%	**1.77**
CzRep.-Belgium	0.60	-82.3%	0.62	-81.5%	3.34	-0.9%	2.76	-18.1%	**3.37**
Germany-CzRep	0.36	-77.4%	0.43	-73.2%	1.54	-4.2%	1.34	-16.4%	**1.60**
CzRep.-Germany	0.46	-85.7%	0.49	-84.8%	3.19	-0.9%	2.62	-18.7%	**3.22**
Spain.-CzRep	0.88	-58.0%	0.93	-55.9%	2.05	-2.1%	1.84	-12.4%	**2.10**
CzRep-Spain	0.82	-69.3%	0.85	-68.2%	2.63	-1.1%	2.26	-15.1%	**2.66**
Spain-Belgium	0.85	-76.7%	0.89	-75.4%	3.59	-1.2%	3.03	-16.7%	**3.64**
Belgium-Spain	0.87	-68.3%	0.94	-65.9%	2.69	-2.5%	2.35	-14.6%	**2.75**
Average	**0.63**	**-75.8%**	**0.68**	**-73.8%**	**2.72**	**-2.1%**	**2.31**	**-16.4%**	**2.77**

Source: Own elaboration

*Collection from urban areas and delivery to urban areas

† % of Standard D2D = (cost per parcel of the last mile delivery option / cost per parcel of the Standard Door2Door)*100 = Cost difference in %

Last-mile logistics typology

The parcel delivery chain starts with the first-mile. As indicated, there are two options: the operator collects from the e-retailer or the e-retailer brings to the sorting centre or regional depot as agreed previously between the e-retailer and the operator. As discussed in the last mile delivery operational models, there are multiple delivery options, and e-retailers can afford the most expensive delivery options for parcels of high value, or when cash needs to be collected upon receipt.

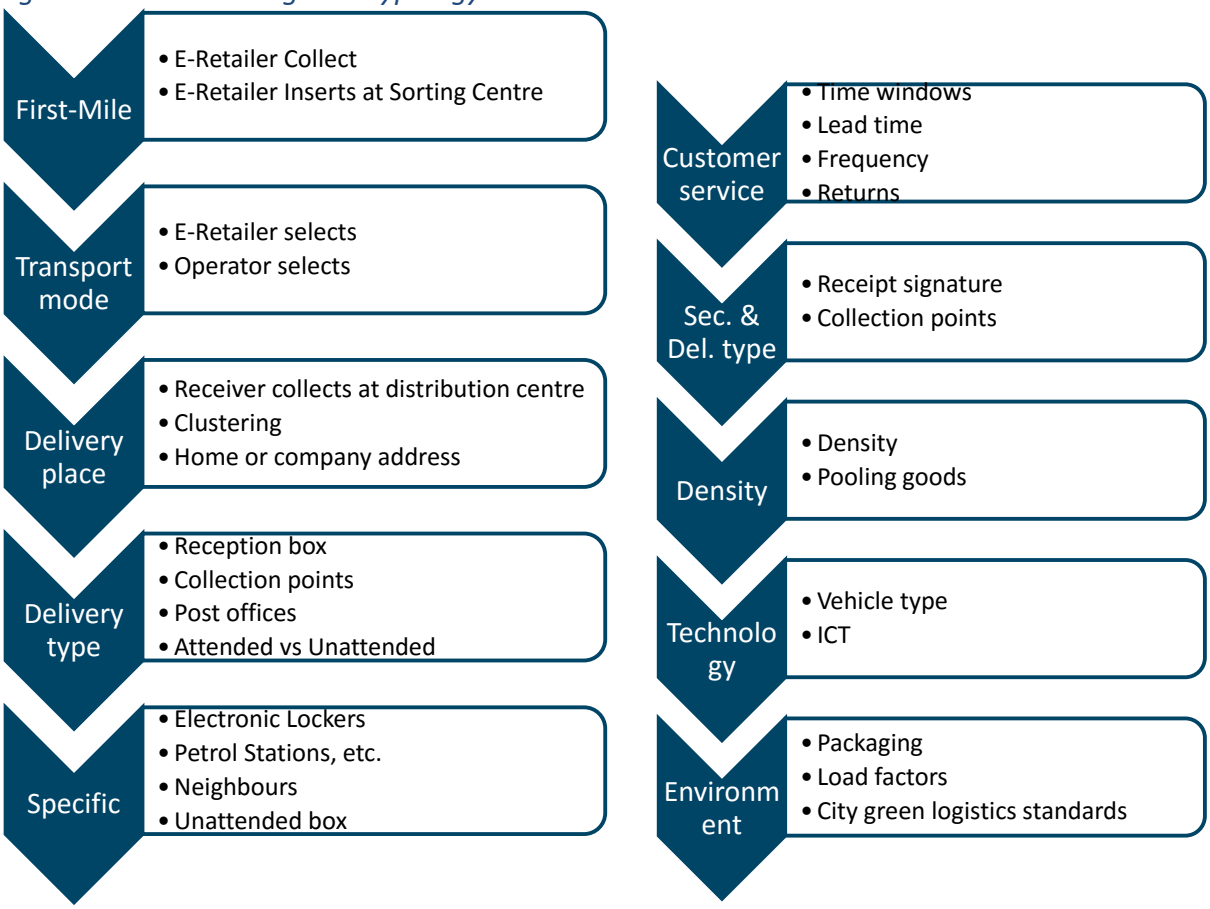
The cost per parcel in the last mile delivery increases when the lead times are short, time windows narrow, frequency of delivery not regular and when returns are to be done by the operator. Returns are usually offered with a discount to the e-retailer, compared to the normal cost of an outbound parcel from the e-shopper's address to the e-retailer's location. Again, at times, the cost of returns may not be justified by the value of the product to be returned.

The costs per parcel in the last mile are higher in areas with low delivery density or when parcels are not consolidated with different streams (e.g. B2B mixed with B2C), thus, it is important to take into account whether the value of the parcel justifies the last mile delivery costs.

An important determinant of the last mile costs is the specific vehicle type used for delivery. The vehicle determines the load capacity, the accessibility into urban areas, etc. But also, it determines an important part of the delivery costs, reflected by the vehicle lease in our cost structure.

ICT interoperability is a service that not all operators in the final delivery can offer. Thus full track & trace is not guaranteed, unless the full delivery is done with well-known operators by their track and trace capabilities.

Figure 18. Last-mile logistics typology



Source: own composition based on stakeholder interviews

Reverse cross-border parcel

Reverse cross-border parcel logistics for parcels returns can be organised in two ways: setting up a dedicated reverse stream or using the regular outbound streams to consolidate with the rest of the parcels and to reduce costs. The challenges with the reverse logistics is that they cannot be scheduled. In the contract with the e-retailer, the service of reverse logistics needs to be specified. However, the e-retailer can arrange different operators for parcel returns. There are two reasons for this, the operator is not able to offer the return service with full track & trace, or the cost of the return is too expensive in relation to the value of the product. In this circumstance, parcel delivery can be arranged with one operator, and return with another one. In fact, there are local operators not capable of offering reverse logistics due to lack of agreements with foreign operators, thus the e-retailer can in this instance only ask the e-shopper to pay the charge for the return of the parcel to an operator selected by the e-retailer, or to allow e-shopper to select the parcel operator to collect and send the parcel back to the e-retailer.

Reverse logistics operations and costs

The cost of return products can be as high as a normal delivery from the returning area to the e-retailer's site. In fact, as most operator integrate returned products in the delivery stream, then a parcel for instance flowing from rural Spain to rural Czech Republic and returned back, can have a cost of 5.52 Euro per parcel for delivery, and an additional 7.02 Euro cost for return (see Table 5). Note that the cost of return can be almost double that of the delivery, if the flow is Urban Belgium to Urban Czech Republic (see Table 4).

Conclusions and recommendations

This study focused on the understanding of B2C cross-border parcel deliveries. We show that the European market is rather complex, segmented. Multiple players with their different degree of extension of their networks compete in some circumstances, and cooperate in other. Thus, the European B2C parcel market is not homogeneous, and a deeper insight is required with respect to the interrelated consequences of the adjustments in any given segment of the market.

Currently, there is no overall agreement of the up-to-date information on intra-EU flows and even less on who moves which type of parcel (e.g. B2C, B2B, C2C, so on). As an example, the number of parcels per person sent and received in the EU Member States, is not reported by all EU member States to the UPU or Eurostat. And even so, data on the UPU correspond to NPOs, it does not do so for all the market players.

The first and last miles are segmented and much of it is outsourced. The high value parcels segment tends to be handled with operators' own transportation. Operators also use their own transportation in cases where the priority of the parcels is set high (e.g. express and time definite). Lower value parcels constitute another segment (e.g. deferred), which tends to be handled by outsourced transportation offering first mile collect and last mile delivery. Further we observe also that the cross-border long haul is outsourced to transportation operators. NPOs without European networks use forwarders and transportation companies for cross-border transport.

The outsourcing does not aim at lower labour and overhead cost gained through working with cheaper external providers, it focusses more on the correction of trade imbalance costs through trade lanes balancing and network balancing. It is more the capacity to increase load factors what drives the most substantial cost changes. This capability to switch capacity between trade lanes requires European-wide networks, as the capacity to optimise within trade lanes is much more limited than to optimise across trade lanes, and according to interviews, all global integrators with strong presence in Europe balance networks for driving down costs. Also NPOs have the opportunity to engage in transportation network balancing at EU level based on co-ordinated operations, interoperable technologies, and resources sharing.

The four most important cost drivers in the B2C cross-border parcel delivery are behaviour, scale, scope, and reach. Behaviour refers for example to the preference for e-shopper to realise credit card transactions rather than cash on delivery or the cultural determined willingness to allow for neighbour deliveries, which is more a tradition in rural than in urban areas. Scale refers to the increase of factor loading of the transportation by means of capturing a larger share of the B2C cross-border parcel market. Scope refers to the capacity to allocate the same resources to different market segments in the transportation and sortation centres, to increase resource utilisation. And finally, reach refers to the capacity to correct for trade imbalances.

A limitation in this study is the non-comprehensive analysis for all EU27 member states, due to data availability. Yet, the simulations are enough to show the impact of different cost drivers (i.e. behaviour, scale, scope, and reach) on the cost structure. Behavioural drivers

include actions that lead to reduce or increase operations time; for instance, the wider use of electronic payment and receipt systems may reduce costs. Scale drivers include actions that lead to changes in throughputs; for instance, widening the use of efficient and safe unattended or lockers deliveries may reduce costs. Scope drivers include actions that lead to changes in resources utilisation; for instance, moving and handling parcels from different market segments (i.e. B2B, B2C, C2C, etc.) may reduce costs. Reach drivers include actions that lead to changes in trade imbalances; for instance, agreements between NPOs at European level to reduce empty transportation runs may reduce costs. There are also important differences between rural and urban areas and across countries but it mainly is explained by the scale, as rural collect tends to be substantially less than urban collect, and the behaviour, as failed first time delivery rate is lower in rural areas as neighbours delivery are more acceptable than in urban areas.

The same drivers apply to last mile, however, here is particularly important the need to allocate resources depending on the delivery time constraints. Time definite and short delivery times may increase costs if there is need to allocate more resources. On the other hand, innovative business models such as click & collect door to lockers as shows in Table 8, allow to scale up operations substituting small delivery vehicles for larger delivery vehicles to deliver more parcels per trip. Moreover, this innovative business model may allow for increasing the scope of operations, by combining in such larger vehicles the collect and delivery operations in the same trip, thus with potential savings that could go beyond the 73% simulated in Table 8.

With regards to reverse logistics, the analysis showed that returning a parcel from a foreign country to a local country is equivalent to a normal parcel shipment from the foreign country to the local country. Thus, whereas for some trade lanes the parcel return from a foreign country can cost the same as sending the parcel from the local country, such as Belgium – Germany, for other trade lanes like Germany to Czech Republic the return from Germany to Czech Republic may be less costly.

Another key factor element to highlight is the difference mentioned by operators between their cost structures and the market prices they offer. And these two are not necessarily correlated, as the second follows more market trends, presence of competitors and prices offered by competitors, and the capacity to cross-subsidise trade lanes at European scale, given that it is an unregulated market. Furthermore, prices for B2C parcel delivery are not usually visible to e-shoppers at the point of e-commerce, as it can be advertised by the e-retailers as free delivery and returns. These are aspects that fall out of the parcels operators' hands. Furthermore, SME operator may be required high investment requirements due to lack of wider networks and lack of IT interoperability. This might be a large number of companies given the great deal of small parcel companies in the first and last mile operating under the outsourcing agreements with larger global and European operators.

Further and deeper analyses are advised to cover the EU27 countries, yet up to date data on the parcel market flows, by segments and operators is required. A possibility is engaging PostEurop, the European Commission, and Member States' Regulators in setting up a European observatory of the postal and parcel industries.

Annex

Urban Collect Cost Structure

Belgium

Operational Data		
Tour Travelling Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	35	Kilometers/hour
Collection Tour Distance	45	Kilometers/tour
Stops per Tour	45	Stops/tour
Parcels per stop	80	Parcels/stop
Failed Collection Rate	0%	
Vehicle Costs		
Monthly Lease	440	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	148	Euros/year
License	450	Euros/year
Insurances	183	Euros/year
Labour Cost	18.12	Euros/hour
Fuel Costs	1.18	Euros/litre
Calculations		
Labor cost per kilometer in line haul	0.52	Euros/kilometer
Fuel cost per kilometer	0.15	Euros/kilometer
Line Haul Costs	**59.87**	**Euros/tour**
Labor cost in collection route	144.96	Euros/tour
Distance cost in collection route	6.64	Euros/tour
Collection Costs	**151.60**	**Euros/tour**
Vehicle Costs	**32.50**	**Euros/tour**
Total cost per tour	**243.96**	**Euros/tour**
Total cost per stop	**5.42**	**Euros/stop**
Total cost per parcel	**0.07**	**Euros/parcel**

Czech Republic

Tour Travelling Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	35	Kilometers/hour
Collection Tour Distance	45	Kilometers/tour
Stops per Tour	45	Stops/tour
Parcels per stop	80	Parcels/stop
Failed Collection Rate	0%	
Vehicle Costs		
Monthly Lease	313	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	0	Euros/year
License	25	Euros/year
Insurances	252	Euros/year
Labour Cost	5.98	Euros/hour
Fuel Costs	1.0	Euros/litre

Labor cost per kilometer in line haul	0.17	Euros/kilometer
Fuel cost per kilometer	0.12	Euros/kilometer
Line Haul Costs	**26.50**	**Euros/tour**
Labor cost in collection route	47.81	Euros/tour
Distance cost in collection route	5.57	Euros/tour
Collection Costs	**53.38**	**Euros/tour**
Vehicle Costs	**24.43**	**Euros/tour**
Total cost per tour	**104.31**	**Euros/tour**
Total cost per stop	**2.32**	**Euros/stop**
Total cost per parcel	**0.03**	**Euros/parcel**

Germany

Tour Travelling Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	35	Kilometers/hour
Collection Tour Distance	45	Kilometers/tour
Stops per Tour	45	Stops/tour
Parcels per stop	80	Parcels/stop
Failed Collection Rate	0%	
Vehicle Costs		
Monthly Lease	300	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	373	Euros/year
License	595	Euros/year
Insurances	2519	Euros/year
Labour Cost	17.70	Euros/hour
Fuel Costs	1.14	Euros/litre

Labor cost per kilometer in line haul	0.51	Euros/kilometer
Fuel cost per kilometer	0.14	Euros/kilometer
Line Haul Costs	**58.34**	**Euros/tour**
Labor cost in collection route	141.60	Euros/tour
Distance cost in collection route	6.41	Euros/tour
Collection Costs	**148.01**	**Euros/tour**
Vehicle Costs	**36.60**	**Euros/tour**
Total cost per tour	**242.95**	**Euros/tour**
Total cost per stop	**5.40**	**Euros/stop**
Total cost per parcel	**0.07**	**Euros/parcel**

Spain

Tour Travelling Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	35	Kilometers/hour
Collection Tour Distance	45	Kilometers/tour
Stops per Tour	45	Stops/tour
Parcels per stop	80	Parcels/stop
Failed Collection Rate	0%	
Vehicle Costs		
Monthly Lease	236	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	224	Euros/year
License	228	Euros/year
Insurances	700	Euros/year
Labour Cost	11.25	Euros/hour
Fuel Costs	1.07	Euros/litre

Labor cost per kilometer in line haul	0.32	Euros/kilometer
Fuel cost per kilometer	0.13	Euros/kilometer
Line Haul Costs	**40.97**	**Euros/tour**
Labor cost in collection route	90.00	Euros/tour
Distance cost in collection route	6.02	Euros/tour
Collection Costs	**96.02**	**Euros/tour**
Vehicle Costs	**24.23**	**Euros/tour**
Total cost per tour	**161.21**	**Euros/tour**
Total cost per stop	**3.58**	**Euros/stop**
Total cost per parcel	**0.04**	**Euros/parcel**

Rural Collect Cost Structure

Belgium

Tour Collection Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	60	Kilometers/hour
Collection Tour Distance	150	Kilometers/tour
Vehicle Costs		
Monthly Lease	440	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	148	Euros/year
License	450	Euros/year
Insurances	183	Euros/year
Labour Cost	18.12	Euros/hour
Fuel Costs	1.18	Euros/litre
Stops per Tour	10	Stops/tour
Parcels per stop	20	Parcel/stop
Failed Collection Rate	0%	

Labor cost per kilometer in line haul	0.30	Euros/kilometer
Fuel cost per kilometer	0.15	Euros/kilometer
Line Haul Costs	**40.46**	**Euros/tour**
Labor cost in collection route	144.96	Euros/tour
Distance cost in collection route	22.13	Euros/tour
Collection Costs	**167.09**	**Euros/tour**
Vehicle Costs	**32.50**	**Euros/tour**
Total cost per tour	**240.04**	**Euros/tour**
Total cost per stop	**24.00**	**Euros/stop**
Total cost per parcel	**1.20**	**Euros/parcel**

	Czech Republic	
Tour Collection Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	60	Kilometers/hour
Collection Tour Distance	150	Kilometers/tour
Vehicle Costs		
Monthly Lease	313	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	0	Euros/year
License	25	Euros/year
Insurances	252	Euros/year
Labour Cost	5.98	Euros/hour
Fuel Costs	1.0	Euros/litre
Stops per Tour	10	Stops/tour
Parcels per stop	20	Parcel/stop
Failed Collection Rate	0%	

Labor cost per kilometer in line haul	0.10	Euros/kilometer
Fuel cost per kilometer	0.12	Euros/kilometer
Line Haul Costs	**20.10**	**Euros/tour**
Labor cost in collection route	47.81	Euros/tour
Distance cost in collection route	18.56	Euros/tour
Collection Costs	**66.37**	**Euros/tour**
Vehicle Costs	**24.43**	**Euros/tour**
Total cost per tour	**110.90**	**Euros/tour**
Total cost per stop	**11.09**	**Euros/stop**
Total cost per parcel	**0.55**	**Euros/parcel**

	Germany	
Tour Collection Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	60	Kilometers/hour
Collection Tour Distance	150	Kilometers/tour
Vehicle Costs		
Monthly Lease	300	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	373	Euros/year
License	595	Euros/year
Insurances	2519	Euros/year
Labour Cost	17.70	Euros/hour
Fuel Costs	1.1	Euros/litre
Stops per Tour	10	Stops/tour
Parcels per stop	20	Parcel/stop
Failed Collection Rate	0%	

Labor cost per kilometer in line haul	0.30	Euros/kilometer
Fuel cost per kilometer	0.14	Euros/kilometer
Line Haul Costs	**39.38**	**Euros/tour**
Labor cost in collection route	141.60	Euros/tour
Distance cost in collection route	21.38	Euros/tour
Collection Costs	**162.98**	**Euros/tour**
Vehicle Costs	**36.60**	**Euros/tour**
Total cost per tour	**238.95**	**Euros/tour**
Total cost per stop	**23.90**	**Euros/stop**
Total cost per parcel	**1.19**	**Euros/parcel**

	Spain	
Tour Collection Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	60	Kilometers/hour
Collection Tour Distance	150	Kilometers/tour
Vehicle Costs		
Monthly Lease	236	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	224	Euros/year
License	228	Euros/year
Insurances	700	Euros/year
Labour Cost	11.25	Euros/hour
Fuel Costs	1.07	Euros/litre
Stops per Tour	10	Stops/tour
Parcels per stop	20	Parcel/stop
Failed Collection Rate	0%	

Labor cost per kilometer in line haul	0.19	Euros/kilometer
Fuel cost per kilometer	0.13	Euros/kilometer
Line Haul Costs	**28.91**	**Euros/tour**
Labor cost in collection route	90.00	Euros/tour
Distance cost in collection route	20.06	Euros/tour
Collection Costs	**110.06**	**Euros/tour**
Vehicle Costs	**24.23**	**Euros/tour**
Total cost per tour	**163.20**	**Euros/tour**
Total cost per stop	**16.32**	**Euros/stop**
Total cost per parcel	**0.82**	**Euros/parcel**

Urban Delivery Cost Structure

Belgium

Tour Travelling Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	35	Kilometers/hour
Delivery Tour Distance	45	Kilometers/tour
Vehicle Costs		
Monthly Lease	440	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	148	Euros/year
License	450	Euros/year
Insurances	183	Euros/year
Labour Cost	18.12	Euros/hour
Fuel Costs	1.18	Euros/litre
Stops per Tour	100	Stops/tour
Parcels per stop	1	Parcel/stop
Failed Delivery Rate	20%	

Labor cost per kilometer in line haul	0.52	Euros/kilometer
Fuel cost per kilometer	0.15	Euros/kilometer
Line Haul Costs	**59.87**	**Euros/tour**
Labor cost in delivery route	144.96	Euros/tour
Distance cost in delivery route	6.64	Euros/tour
Delivery Costs	**151.60**	**Euros/tour**
Vehicle Costs	**32.50**	**Euros/tour**
Total cost per tour	**243.96**	**Euros/tour**
Total cost per stop	**3.05**	**Euros/stop**
Total cost per parcel	**3.05**	**Euros/parcel**

	Czech Republic	
Tour Travelling Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	35	Kilometers/hour
Delivery Tour Distance	45	Kilometers/tour
Vehicle Costs		
Monthly Lease	313	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	0	Euros/year
License	25	Euros/year
Insurances	252	Euros/year
Labour Cost	5.98	Euros/hour
Fuel Costs	1.0	Euros/litre
Stops per Tour	100	Stops/tour
Parcels per stop	1	Parcel/stop
Failed Delivery Rate	20%	

Labor cost per kilometer in line haul	0.17	Euros/kilometer
Fuel cost per kilometer	0.12	Euros/kilometer
Line Haul Costs	**26.50**	**Euros/tour**
Labor cost in delivery route	47.81	Euros/tour
Distance cost in delivery route	5.57	Euros/tour
Delivery Costs	**53.38**	**Euros/tour**
Vehicle Costs	**24.43**	**Euros/tour**
Total cost per tour	**104.31**	**Euros/tour**
Total cost per stop	**1.30**	**Euros/stop**
Total cost per parcel	**1.30**	**Euros/parcel**

	Germany	
Tour Travelling Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	35	Kilometers/hour
Delivery Tour Distance	45	Kilometers/tour
Vehicle Costs		
Monthly Lease	300	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	373	Euros/year
License	595	Euros/year
Insurances	2519	Euros/year
Labour Cost	17.70	Euros/hour
Fuel Costs	1.1	Euros/litre
Stops per Tour	100	Stops/tour
Parcels per stop	1	Parcel/stop
Failed Delivery Rate	20%	

Labor cost per kilometer in line haul	0.51	Euros/kilometer
Fuel cost per kilometer	0.14	Euros/kilometer
Line Haul Costs	**58.34**	**Euros/tour**
Labor cost in delivery route	141.60	Euros/tour
Distance cost in delivery route	6.41	Euros/tour
Delivery Costs	**148.01**	**Euros/tour**
Vehicle Costs	**36.60**	**Euros/tour**
Total cost per tour	**242.95**	**Euros/tour**
Total cost per stop	**3.04**	**Euros/stop**
Total cost per parcel	**3.04**	**Euros/parcel**

	Spain	
Tour Travelling Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	35	Kilometers/hour
Delivery Tour Distance	45	Kilometers/tour
Vehicle Costs		
Monthly Lease	236	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	224	Euros/year
License	228	Euros/year
Insurances	700	Euros/year
Labour Cost	11.25	Euros/hour
Fuel Costs	1.1	Euros/litre
Stops per Tour	100	Stops/tour
Parcels per stop	1	Parcel/stop
Failed Delivery Rate	20%	

Labor cost per kilometer in line haul	0.32	Euros/kilometer
Fuel cost per kilometer	0.13	Euros/kilometer
Line Haul Costs	**40.97**	**Euros/tour**
Labor cost in delivery route	90.00	Euros/tour
Distance cost in delivery route	6.02	Euros/tour
Delivery Costs	**96.02**	**Euros/tour**
Vehicle Costs	**24.23**	**Euros/tour**
Total cost per tour	**161.21**	**Euros/tour**
Total cost per stop	**2.02**	**Euros/stop**
Total cost per parcel	**2.02**	**Euros/parcel**

Rural Delivery Cost Structure

Belgium

Tour Travelling Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	50	Kilometers/hour
Collection Tour Distance	150	Kilometers/tour
Vehicle Costs		
Monthly Lease	440	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	148	Euros/year
License	450	Euros/year
Insurances	183	Euros/year
Labour Cost	18.12	Euros/hour
Fuel Costs	1.180	Euros/litre
Stops per Tour	30	Stops/tour
Parcels per stop	1	Parcel/stop
Failed Delivery Rate	5%	

Labor cost per kilometer in line haul	0.36	Euros/kilometer
Fuel cost per kilometer	0.15	Euros/kilometer
Line Haul Costs	**45.89**	**Euros/tour**
Labor cost in delivery route	144.96	Euros/tour
Distance cost in delivery route	22.13	Euros/tour
Delivery Costs	**167.09**	**Euros/tour**
Vehicle Costs	**32.50**	**Euros/tour**
Total cost per tour	**245.47**	**Euros/tour**
Total cost per stop	**8.61**	**Euros/stop**
Total cost per parcel	**8.61**	**Euros/parcel**

	Czech Republic	
Tour Travelling Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	50	Kilometers/hour
Collection Tour Distance	150	Kilometers/tour
Vehicle Costs		
Monthly Lease	313	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	0	Euros/year
License	25	Euros/year
Insurances	252	Euros/year
Labour Cost	5.98	Euros/hour
Fuel Costs	0.990	Euros/litre
Stops per Tour	30	Stops/tour
Parcels per stop	1	Parcel/stop
Failed Delivery Rate	5%	

Labor cost per kilometer in line haul	0.12	Euros/kilometer
Fuel cost per kilometer	0.12	Euros/kilometer
Line Haul Costs	**21.89**	**Euros/tour**
Labor cost in delivery route	47.81	Euros/tour
Distance cost in delivery route	18.56	Euros/tour
Delivery Costs	**66.37**	**Euros/tour**
Vehicle Costs	**24.43**	**Euros/tour**
Total cost per tour	**112.69**	**Euros/tour**
Total cost per stop	**3.95**	**Euros/stop**
Total cost per parcel	**3.95**	**Euros/parcel**

	Germany	
Tour Travelling Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	50	Kilometers/hour
Collection Tour Distance	150	Kilometers/tour
Vehicle Costs		
Monthly Lease	300	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	373	Euros/year
License	595	Euros/year
Insurances	2519	Euros/year
Labour Cost	17.70	Euros/hour
Fuel Costs	1.140	Euros/litre
Stops per Tour	30	Stops/tour
Parcels per stop	1	Parcel/stop
Failed Delivery Rate	5%	

Labor cost per kilometer in line haul	0.35	Euros/kilometer
Fuel cost per kilometer	0.14	Euros/kilometer
Line Haul Costs	**44.69**	**Euros/tour**
Labor cost in delivery route	141.60	Euros/tour
Distance cost in delivery route	21.38	Euros/tour
Delivery Costs	**162.98**	**Euros/tour**
Vehicle Costs	**36.60**	**Euros/tour**
Total cost per tour	**244.26**	**Euros/tour**
Total cost per stop	**8.57**	**Euros/stop**
Total cost per parcel	**8.57**	**Euros/parcel**

	Spain	
Tour Travelling Time	8	Hours/Tour
Line Haul Distance	45	Kilometers/tour
Avg. Speed Line Haul	50	Kilometers/hour
Collection Tour Distance	150	Kilometers/tour
Vehicle Costs		
Monthly Lease	236	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	224	Euros/year
License	228	Euros/year
Insurances	700	Euros/year
Labour Cost	11.25	Euros/hour
Fuel Costs	1.070	Euros/litre
Stops per Tour	30	Stops/tour
Parcels per stop	1	Parcel/stop
Failed Delivery Rate	5%	

Labor cost per kilometer in line haul	0.23	Euros/kilometer
Fuel cost per kilometer	0.13	Euros/kilometer
Line Haul Costs	**32.29**	**Euros/tour**
Labor cost in delivery route	90.00	Euros/tour
Distance cost in delivery route	20.06	Euros/tour
Delivery Costs	**110.06**	**Euros/tour**
Vehicle Costs	**24.23**	**Euros/tour**
Total cost per tour	**166.58**	**Euros/tour**
Total cost per stop	**5.84**	**Euros/stop**
Total cost per parcel	**5.84**	**Euros/parcel**

Long Haul Cost Structure

Belgium-Germany

Long Haul Distance	386	Kilometers/tour
Avg. Speed Long Haul	90	Kilometers/hour
Vehicle Costs		
Monthly Lease	1242	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	148	Euros/year
License	450	Euros/year
Insurances	183	Euros/year
Labour Cost	18.12	Euros/hour
Fuel Costs	1.180	Euros/litre
Stops per Tour	1	Stops/tour
Parcels per stop	3000	Parcel/stop

Labor cost per kilometer in line haul	0.20	Euros/kilometer
Fuel cost per kilometer	0.41	Euros/kilometer
Long Haul Costs	**474.27**	**Euros/tour**
Vehicle Costs	**70.82**	**Euros/tour**
Total cost per tour	**545.09**	**Euros/tour**
Total cost per stop	**545.09**	**Euros/stop**
Total cost per parcel	**0.18**	**Euros/parcel**

Germany-Czech Republic

Long Haul Distance	537	Kilometers/tour
Avg. Speed Long Haul	90	Kilometers/hour
Vehicle Costs		
Monthly Lease	735	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	373	Euros/year
License	595	Euros/year
Insurances	2519	Euros/year
Labour Cost	17.70	Euros/hour
Fuel Costs	1.1	Euros/litre
Stops per Tour	1	Stops/tour
Parcels per stop	3000	Parcel/stop

Labor cost per kilometer in line haul	0.20	Euros/kilometer
Fuel cost per kilometer	0.40	Euros/kilometer
Long Haul Costs	**639.75**	**Euros/tour**
Vehicle Costs	**57.38**	**Euros/tour**
Total cost per tour	**697.13**	**Euros/tour**
Total cost per stop	**697.13**	**Euros/stop**
Total cost per parcel	**0.23**	**Euros/parcel**

Czech Republic-Belgium

Long Haul Distance	1015.3	Kilometers/tour
Avg. Speed Long Haul	90	Kilometers/hour
Vehicle Costs		
Monthly Lease	474	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	0	Euros/year
License	25	Euros/year
Insurances	252	Euros/year
Labour Cost	5.98	Euros/hour
Fuel Costs	0.99	Euros/litre
Stops per Tour	1	Stops/tour
Parcels per stop	3000	Parcel/stop

Labor cost per kilometer in line haul	0.07	Euros/kilometer
Fuel cost per kilometer	0.3465	Euros/kilometer
Long Haul Costs	**838.44**	**Euros/tour**
Vehicle Costs	**32.11**	**Euros/tour**
Total cost per tour	**870.55**	**Euros/tour**
Total cost per stop	**870.55**	**Euros/stop**
Total cost per parcel	**0.29**	**Euros/parcel**

Czech Republic-Spain

Long Haul Distance	2200	Kilometers/tour
Avg. Speed Long Haul	90	Kilometers/hour
Vehicle Costs		
Monthly Lease	474	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	0	Euros/year
License	25	Euros/year
Insurances	252	Euros/year
Labour Cost	5.98	Euros/hour
Fuel Costs	0.99	Euros/litre
Stops per Tour	1	Stops/tour
Parcels per stop	3000	Parcel/stop

Labor cost per kilometer in line haul	0.07	Euros/kilometer
Fuel cost per kilometer	0.3465	Euros/kilometer
Long Haul Costs	**1816.76**	**Euros/tour**
Vehicle Costs	**32.11**	**Euros/tour**
Total cost per tour	**1848.88**	**Euros/tour**
Total cost per stop	**1848.88**	**Euros/stop**
Total cost per parcel	**0.62**	**Euros/parcel**

Belgium-Spain

Long Haul Distance	1578	Kilometers/tour
Avg. Speed Long Haul	90	Kilometers/hour
Vehicle Costs		
Monthly Lease	1242	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	148	Euros/year
License	450	Euros/year
Insurances	183	Euros/year
Labour Cost	18.12	Euros/hour
Fuel Costs	1.180	Euros/litre
Stops per Tour	1	Stops/tour
Parcels per stop	3000	Parcel/stop

Labor cost per kilometer in line haul	0.20	Euros/kilometer
Fuel cost per kilometer	0.41	Euros/kilometer
Long Haul Costs	**1938.84**	**Euros/tour**
Vehicle Costs	**70.82**	**Euros/tour**
Total cost per tour	**2009.66**	**Euros/tour**
Total cost per stop	**2009.66**	**Euros/stop**
Total cost per parcel	**0.67**	**Euros/parcel**

Belgium-Czech Republic

Long Haul Distance	906	Kilometers/tour
Avg. Speed Long Haul	90	Kilometers/hour
Vehicle Costs		
Monthly Lease	1242	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	373	Euros/year
License	595	Euros/year
Insurances	2519	Euros/year
Labour Cost	18.12	Euros/hour
Fuel Costs	1.180	Euros/litre
Stops per Tour	1	Stops/tour
Parcels per stop	3000	Parcel/stop

Labor cost per kilometer in line haul	0.20	Euros/kilometer
Fuel cost per kilometer	0.41	Euros/kilometer
Long Haul Costs	**1113.17**	**Euros/tour**
Vehicle Costs	**81.61**	**Euros/tour**
Total cost per tour	**1194.78**	**Euros/tour**
Total cost per stop	**1194.78**	**Euros/stop**
Total cost per parcel	**0.40**	**Euros/parcel**

Czech Republic-Germany

Long Haul Distance	534	Kilometers/tour
Avg. Speed Long Haul	90	Kilometers/hour
Vehicle Costs		
Monthly Lease	474	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	0	Euros/year
License	25	Euros/year
Insurances	252	Euros/year
Labour Cost	5.98	Euros/hour
Fuel Costs	0.990	Euros/litre
Stops per Tour	1	Stops/tour
Parcels per stop	3000	Parcel/stop

Labor cost per kilometer in line haul	0.07	Euros/kilometer
Fuel cost per kilometer	0.35	Euros/kilometer
Long Haul Costs	**440.98**	**Euros/tour**
Vehicle Costs	**32.11**	**Euros/tour**
Total cost per tour	**473.09**	**Euros/tour**
Total cost per stop	**473.09**	**Euros/stop**
Total cost per parcel	**0.16**	**Euros/parcel**

Germany-Belgium

Long Haul Distance	404	Kilometers/tour
Avg. Speed Long Haul	90	Kilometers/hour
Vehicle Costs		
Monthly Lease	735	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	0	Euros/year
License	25	Euros/year
Insurances	252	Euros/year
Labour Cost	17.70	Euros/hour
Fuel Costs	1.140	Euros/litre
Stops per Tour	1	Stops/tour
Parcels per stop	3000	Parcel/stop

Labor cost per kilometer in line haul	0.20	Euros/kilometer
Fuel cost per kilometer	0.40	Euros/kilometer
Long Haul Costs	**481.30**	**Euros/tour**
Vehicle Costs	**44.59**	**Euros/tour**
Total cost per tour	**525.89**	**Euros/tour**
Total cost per stop	**525.89**	**Euros/stop**
Total cost per parcel	**0.18**	**Euros/parcel**

Spain-Czech Republic

Long Haul Distance	2200	Kilometers/tour
Avg. Speed Long Haul	90	Kilometers/hour
Vehicle Costs		
Monthly Lease	875	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	224	Euros/year
License	228	Euros/year
Insurances	700	Euros/year
Labour Cost	11.25	Euros/hour
Fuel Costs	1.07	Euros/litre
Stops per Tour	1	Stops/tour
Parcels per stop	3000	Parcel/stop

Labor cost per kilometer in line haul	0.13	Euros/kilometer
Fuel cost per kilometer	0.37	Euros/kilometer
Long Haul Costs	**2197.80**	**Euros/tour**
Vehicle Costs	**54.77**	**Euros/tour**
Total cost per tour	**2252.57**	**Euros/tour**
Total cost per stop	**2252.57**	**Euros/stop**
Total cost per parcel	**0.75**	**Euros/parcel**

Spain-Belgium

Long Haul Distance	1580	Kilometers/tour
Avg. Speed Long Haul	90	Kilometers/hour
Vehicle Costs		
Monthly Lease	875	Euros/month
Basic Maintenance	130	Euros/month
Summer Tires	38	Euros/month
Annual Inspection	80	Euros/year
Road Tax	224	Euros/year
License	228	Euros/year
Insurances	700	Euros/year
Labour Cost	11.25	Euros/hour
Fuel Costs	1.07	Euros/litre
Stops per Tour	1	Stops/tour
Parcels per stop	3000	Parcel/stop

Labor cost per kilometer in line haul	0.13	Euros/kilometer
Fuel cost per kilometer	0.37	Euros/kilometer
Long Haul Costs	**1578.42**	**Euros/tour**
Vehicle Costs	**54.77**	**Euros/tour**
Total cost per tour	**1633.19**	**Euros/tour**
Total cost per stop	**1633.19**	**Euros/stop**
Total cost per parcel	**0.54**	**Euros/parcel**

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