Examining the value of flexible logistics offerings

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Abstract

In the order fulfilment and retail industry, the provision of fast and low cost delivery services has received significant focus over the last decade. What is often neglected is other factors that contribute to a customer's overall experience like customisation and flexibility of deliveries, especially in cases when a customer's needs and plans change between order placement and order delivery. This paper explores the value of a flexible type of logistics offering in which the customer is able to change the order requirements (such as delivery date) after the order has been placed. In particular, we focus on the interactions between a retailer and a customer in agreeing and executing such logistics orders. We examine the benefits of this type of flexible logistics offerings because flexibility and customisation are critical factors for the success of omni-channel commerce. Such offerings are clearly connected with recent developments in digital technologies as these technologies are essential for the implementation. Our results indicate that flexible logistics offerings can be beneficial both for retailers and for customers. They also highlight the importance of receiving orders that do not fully meet the requirements of a customer.

Keywords:
logistics, e-commerce, retailing, omni-channel, flexibility

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1. Introduction

E-commerce retailing has experienced a tremendous growth over the last decade (Melacini et al., 2018; Lin, 2018; Statista, 2018). This is evident in terms of growth in revenue, number of consumers choosing to order online, number of orders placed, and even parcels distributed to end customers. The adoption of omni-channel practices by multiple online retailers and platforms and the seamless experience they aim to create is argued to be one of the main reasons for this phenomenon (Hübner et al., 2016b). Besides being able to place an order via a number of channels, this experience is highly affected by the selection of post order placement practices such the the delivery of an order to the end-customer. Indeed, the choice of logistics operations play a key role for the proper delivery of an order but also for customer satisfaction in general (Hübner et al., 2016a).

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Recognising the importance of post order placement to the customer experience, retailers place significant efforts in improving it, with a clear focus towards speed (i.e. lead time reduction). Indeed, one can see initiatives ranging from next-day deliveries to even 1-2 hour deliveries receiving a lot of attention by academia and practice (Bensinger and Dulaney, 2014; Lin et al., 2018). Even though these initiatives improve customer satisfaction to a certain extent, they also create logistics and environmental challenges due to the high number of frequent small deliveries they generate (Fernie et al., 2010; Kembro et al., 2018; Ivanova, 2019). Other initiatives, target the need for customisation and flexibility for e-commerce deliveries with practices that support post ordering amendments to an order's contents, delivery location, speed and time (FedEx, 2016; UPS, 2017). These practices are very often supported by digital systems that enable (almost real-time) interaction between customers and retailers for the proper handling of an order (Holmström et al., 2010; Mou et al., 2018).

This study focuses on this latter issue, and more specifically, the evaluation of logistics services that allow order amendments should a customer's requirements change after the placement of an order (therein *flexible logistics offerings*[1]). We do this by developing a game theoretic model that analyses the interactions between customers and retailers. More specifically, the model is used to assess the value of such offerings and examine when and whether they provide benefits to retailers and customers. In short, this study aims to answer the following research question: *How can the value of flexible logistics offerings be measured and under which conditions can they be beneficial for a retailer and a customer?* Indirectly, this study also identifies the (types of) products/orders that are best suited for flexible logistics offerings.

This paper is organised as follows: we first review in Section 2 the relevant literature on customisation and flexibility in logistics and the systems supporting those. We then develop a model that more formally describes a flexible logistics offering along with a game that studies the interactions between retailers and customers in Sections 3 and 4 respectively The game is adapted and further studied in Section 5. A critical discussion on the study's findings and associated issues follows in Section 6. We conclude this paper with a discussion on this study's contributions, limitations and future research in Section 7.

2. Background

In this section, we provide the necessary background covering two main aspects: firstly, we look at customisation and flexibility in logistics operations and the connections they have with other areas in the literature. Secondly, we discuss the role information and digital technologies have in developing systems to support such services.

In today's multi-channel supply chains, customer orientation has been recognised as a critical aspect of a company's success (Reiner, 2005; Jeong and Hong, 2007; Tian et al., 2010; Lado et al.,

[1] By the term 'offering', we refer to *the products or services a company offers to its customer along with price and costs elements associated with it* (Hedman and Kalling, 2003).

2011; Lyons et al., 2012; Kalia, 2017). In e-commerce logistics in particular, retailers and third party logistics providers —which are increasingly required to fulfil logistics orders placed via multiple different channels and systems— aim to satisfy their customers by offering services that cover a wide range of customer needs, by offering better visibility of customer orders and by being flexible to special requests and changes (Jeong and Hong, 2007; Tian et al., 2010; Shan-ling and Zhao-hui, 2012; McFarlane et al., 2016). The ability of a logistics operation to be flexible to meet the special needs of their customers can be of particular importance since it can be directly linked with customer satisfaction (Zhang et al., 2005; Jafari, 2015) following in accordance to more general remarks made on the importance of flexibility in modem supply chains (Thomé et al., 2014; Manders et al., 2016; Schütz and Tomasgard, 2011; Stevenson and Spring, 2007).

In this study, we focus in particular in the type of flexible operations needed in order to allow amendments to an order after its placement. Amendments in this context often refer to changes to the contents of an order, its delivery location/time and its delivery speed. Conceptually, this has strong connections with the concepts of late customisation and postponement, often found in the manufacturing literature but recently explored in retail supply chains (Jafari et al., 2016). Indeed, the literature is vast in the impact customisation in manufacturing has on customer satisfaction (Fogliatto et al., 2012; MacCarthy et al., 2003; Da Silveira et al., 2001). Similar arguments can be found in the services literature (Peters and Saidin, 2000; Silvestro and Lustrato, 2015) that this study is closer to.

Looking at current practice of omni-channel and e-retailing today, one can easily see that great progress has been made over the last decade. There is a wide range of examples of retailers and courier/parcel companies who are increasingly trying to offer greater customised and flexible options to their clients. In grocery retail for example, it is common for retailers to allow order changes up until the day before the delivery (Tesco, 2019). In general retail, there are examples where changes are allowed until an order enters a 'shipping' process (Amazon, 2019). In certain cases, the courier companies fulfilling the delivery of an order allow for changes to delivery dates up until the morning of a delivery (DPD, 2019). A common aspect in all the cases above is that there is often a 'cut-off' time after which changes are not allowed or they are allowed in an ad-hoc basis, often following a direct phone call or web discussion (Giannikas et al., 2019). As a result, it is often unclear whether an order can be amended and if so, at what cost.

In order to enable such flexible services, retailers and logistics providers utilise digital technologies, to develop platforms and systems in two main areas. Firstly, to allow the customer to track his order and receive information about its current status (Holmström et al., 2010). Tracking systems are today widely utilised offering real-time information from the assembly and transportation of a customised laptop to the preparation and delivery of take-away food. Secondly, to enable a means of interaction between the customer and the retailer and to allow, when possible, the direct control of a customer's order (Meyer et al., 2009; Giannikas et al., 2019). More sophisticated versions of such systems link products and orders not only with information about their lifecycle but also with rules that govern the way they should be handled through it (McFarlane et al., 2013; Kärkkäinen et al., 2003; Meyer et al., 2009; Wong et al., 2002). This way, a customer has the opportunity to express his special requirements and needs as well as update them at any time, and make decisions about the management of his orders before the physical products are delivered to his premises.

3. The Model

This section introduces a model for describing the flexible logistics offerings that allow a customer to make amendments to a placed order should his requirements change. We first present the assumptions behind this model and we then summarise the flexible and fixed logistics offering in this setting.

The model concerns two parties: a retailer and an end-customer. The end-customer purchases goods by the retailer, by placing orders via an available channel (e.g. online, mobile, over the phone). An order is then delivered to the end-customer via a logistics service. Here, the logistics service in question refers to the transportation of an order from a retailer to the end-customer. We consider the popular case where the logistics service is offered by a third-party logistics company (e.g. online order fulfilment, courier) and is purchased by the retailer at a specific cost. As the interaction we wish to examine is the one between the retailer and the end-customer, we do not include the logistics company in our model. Furthermore, as we are primarily interested in the logistics-related part of the customer experience, we will refer to the retailer as the *provider* (PR). In this way, we highlight the fact that the model does not primarily concern "retailing" goods but "providing" orders. For simplicity, we will also refer to the end-customer as the *customer* (CU). We assume that the two parties are risk neutral and maximise expected payoffs.

When placing an order, the customer is required to choose among a set of options i, ($i = A, B, \ldots, n$) that will specify the way his order will be handled by the provider (e.g. delivery speed). The customer's decision is based on the premise that the chosen option will fulfil his requirements from his interaction with the provider (i.e. the order will be delivered on time for the use required by the customer). To simplify the problem, we assume the following:

Assumption 1 (Customer's requirements)**.** *A customer's order requirements are likely to change after the placement of an order with probability* λ.

Assumption 2 (Effectiveness of chosen option)**.** *The probability that the logistics option chosen at the time of order placement will fulfil the customer's requirements is 1 unless those requirements change before delivery.*

Assumption 1 acknowledges the fact that a customer's requirements might change between the time an order is placed and the time an order is delivered. Assumption 2 essentially requires the customer to know which logistics option will fulfil his requirements with certainty, assuming that his requirements do not change after his places his order. For example, if a customer places an order at $t = 0$ and he requires it to be delivered by $t = 8$ then an option that offers delivery between $t = 1$ and $t = 3$ is guaranteed to fulfil his requirements. On the contrary, an option that offers delivery between $t = 4$ and $t = 10$ is not guaranteed to fulfil his requirements but there is a chance it will do so.

From Assumptions 1 and 2, it follows that there is a probability that option i will not remain adequate if a customer's requirements change. As the practical example indicates this probability is not necessarily equal to 1. For example, if a customer had access to the two aforementioned options and his required delivery date changed from $t = 12$ to $t = 8$, there is a probability that the second option could still deliver the order on time. We will use q_i to denote the probability that option i will remain adequate even if a customer's requirements change and we formulate our third assumption:

Assumption 3 (Adequateness of chosen option after change in requirements)**.** *There is a probability q_i that the logistics option chosen at the time of order placement will fulfil a customer's requirements even if they change after the placement of an order.*

In the event that a flexible logistics offering is available to the customer, the customer has the option to ask the provider for a special service k ($k = 1, 2, \ldots, m$) that will allow the customer to satisfy his needs (e.g. by expediting the order). At this stage, the customer is unaware as to whether his initially choice i is still adequate, as he lacks access to information about the provider's operations and plans.

In summary, a *fixed logistics offering* allows the customer to choose among a set of logistics options for the preparation and delivery of his order while placing one. Different logistics options come at a different prices providing different services (e.g. delivery speed). Should the requirements of the customer change after the placement of his order, he cannot make any amendments to it and relies on the probability that the retailer's plan will satisfy his new requirements (e.g. the order will be delivered faster than expected). On the contrary, a *flexible logistics offering* is an offering that allows a customer to make amendments to an order should his requirements change after its placement. The customer still needs to choose among a set of logistics options when placing his order. However, if a flexible offering is available (and that depends on whether the retailer wishes to make one available), then the customer can interact with the retailer to express his new requirements and ask for amendments. The aforementioned model is depicted with a simple illustration in Figure 1. There are several ways one can think of for the implementation of a flexible logistics offering; we will examine three of those in the next two sections, starting with a "base" case and then examining two variations.

4. The Game

A game with two players (provider and customer) can be developed to formalise and examine the interactions between the provider and customer as they were described in the previous section. The game is played in 4 sequential stages. At the first stage of the game, the provider makes a decision between offering a *flexible logistics offering* to his customer or limiting the customer to a *fixed offering* only (noted by *Flexible* and *Fixed*). This will impact the customer's options later on

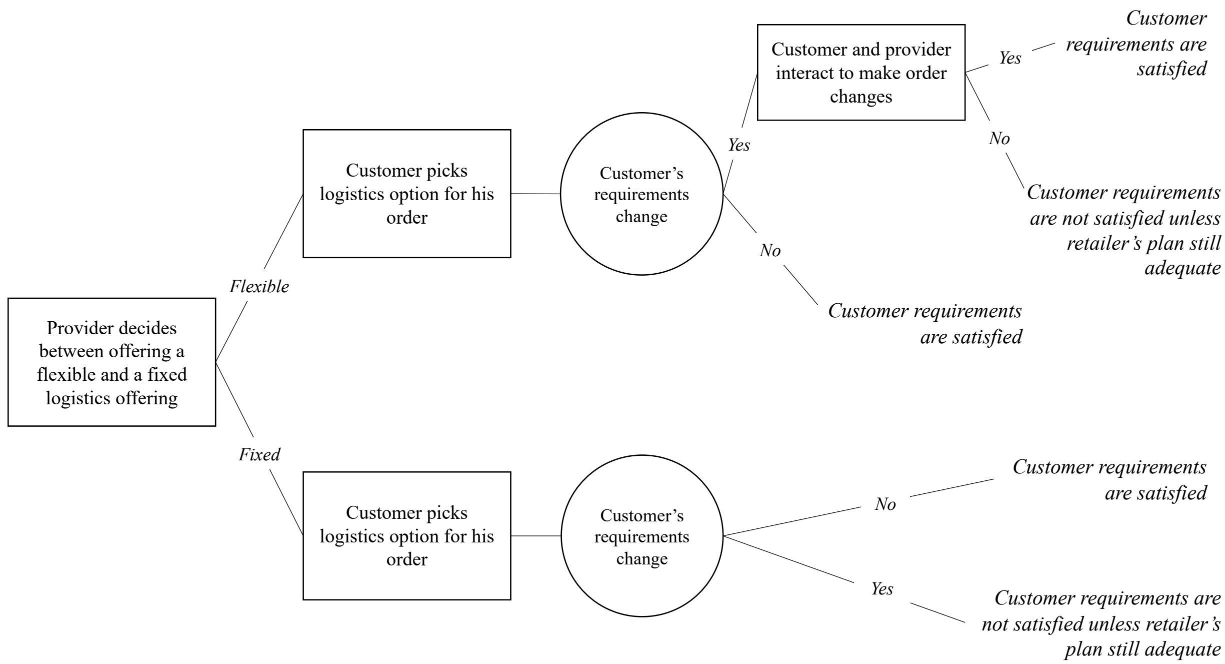


Figure 1: Visual representation of the model comparing fixed and flexible logistics offerings

(i.e. if his requirements change after the placement of an order). At the second stage, the customer places his order and chooses among the available logistics options paying the related price (noted by *Option A*, *Option B*) etc. At the third stage, the two parties make no decisions but the customer's requirements might change (the likelihood of change noted by probability λ). At the fourth and final stage, the customer and the provider need to decide whether a special service will now be used assuming the customer's requirements having changed (customer chooses to *Ask* or *Don't Ask* and provider chooses to *Serve* or *Don't Serve*). The fourth stage takes place only if a flexible logistics offering is chosen in Stage 1 and incorporates the partial information the customer has over the provider's plan (noted by the probability q_i). A visual representation of the game (and its variations as they are described in later sections) are available in the Appendix, along with proofs for all propositions. In particular, the reader is referred to Appendix A.1 and Figure A.6 for the version of the game examined in this section.

In order to express the players payoffs in monetary terms, we need to define the following:

b : benefit customer receives for fulfilling his requirements from his interaction with the provider

p_i : price paid by the customer to the provider for option i

c_i : cost incurred by the provider to offer option i

r : reduction in customer's benefit if new requirements are not fulfilled

p_s^k : price paid by the customer to the provider in order to request a modification to his initial choice and receive extra service k

c_{ry}^k : cost incurred by the provider for modifying his initial plan to satisfy new customer requirements

c_{rn}^k : cost incurred by the provider for modifying his initial plan to *not* satisfy new customer requirements

4.1. Payoffs

Let us now examine the functions describing the payoffs received by each player resulting from the sequence of actions made by them. For the customer payoff, we have:

Proposition 1 (Customer payoff function)**.** *The customer's payoff function (u_{CU}^i) from choosing logistics option i is given by the following function:*

$u_{CU}^i = b - p_i - y_1 \cdot r - y_2 \cdot p_s^k$, *where*

$$y_1 = \begin{cases} 1 & \textit{if customer's requirements are not fulfilled} \quad (1a) \\ 0 & \textit{otherwise} \quad (1b) \end{cases}$$

and

$$y_2 = \begin{cases} 1 & \textit{if customer requests extra service } k \textit{ and receives it} \quad (2a) \\ 0 & \textit{otherwise} \quad (2b) \end{cases}$$

The first two terms in Proposition 1 indicate the revenue a customer expects to receive at order placement, while the last two terms the potential cost that might incur after order placement. Similarly, for the provider payoff, we have:

Proposition 2 (Provider payoff function)**.** *The provider's payoff function (u_{PR}^i) from his customer choosing logistics option i is given by the following function:*

$u_{PR}^i = p_i - c_i + y_2 \cdot p_s^k - y_3 \cdot c_{ry}^k - y_4 \cdot c_{rn}^k$, *where*

$$y_3 = \begin{cases} 1 & \textit{if } y_2 = 1 \textit{ and provider's plan is not adequate} \quad (3a) \\ 0 & \textit{otherwise} \quad (3b) \end{cases}$$

and

$$y_4 = \begin{cases} 1 & \textit{if provider chooses to change plan in order to not satisfy new needs} \quad (4a) \\ 0 & \textit{otherwise} \quad (4b) \end{cases}$$

Similar to the customer payoff, Proposition 2 indicates the expected payoff for the provider at order placement (first two terms) and the potential cost after order placement (last three terms). As shown in the previous section, it is important to note again that a change in customer's requirements does not automatically require a change in the provider's operational plans in order to satisfy them. As a result c_{ry}^k is not always incurred by the provider even if a customer decides to modify his initial choice. The reader will also notice the term c_{rn}^k which represents the cost to change a provider's initial plan in order to *not* satisfy a new request. Although it would be counter intuitive for a provider to do so (as this leads to both extra cost for the provider and an unsatisfied customer), we include this case here for completion.

In order to start analysing the game and characterise the best responses of the players in it, we will first investigate a version where only two logistics options are available to the customer. Option A, which is adequate even if the customer's requirements change (i.e. $q_A = 1$), and Option B, which is not guaranteed to be adequate (i.e. $0 < q_B < 1$) but can be modified in a flexible offering. To illustrate that Option A can always cover the customer, we will determine its price such that $p_A > p_B$. For simplicity and since there is only one option that can be modified, we are not going to use the numerical superscripts for the variables p_s, c_{ry} and c_{rn} and letter subscripts for the variable q. We use α_{CU} and α_{PR} to refer to a specific choice (or set of choices) made in the game, if a particular decision point has been reached by the customer and the provider respectively. It can be used to more easily follow the action a player is expected to make *if* he reaches a particular part of the game. This differs from a player's strategy in equilibrium, s^*_{CU} (for the customer) and s^*_{PR} (for the provider), which describes the complete set of best responses for each player regardless of whether a decision point is actually reached.

4.2. The customer perspective

First, let us look at how the two offerings compare from the customer perspective.

Proposition 3 (Customer's choice in a fixed offering)**.** *When a customer knows he cannot modify his initial logistics option, his choice is given by the following:*

$$\alpha_{CU} = \begin{cases} \text{Option A} & \textit{if } p_A < p_B + \lambda(1-q)r \quad (5a) \\ \text{Option B} & \textit{if } p_A > p_B + \lambda(1-q)r \quad (5b) \end{cases}$$

This proposition indicates that, if modifications to initial choices are not permitted, a customer will choose by comparing the price of the more expensive and reliable option (i.e. Option A) with the expected total cost of the cheaper option, which has a degree of risk (i.e. Option B).

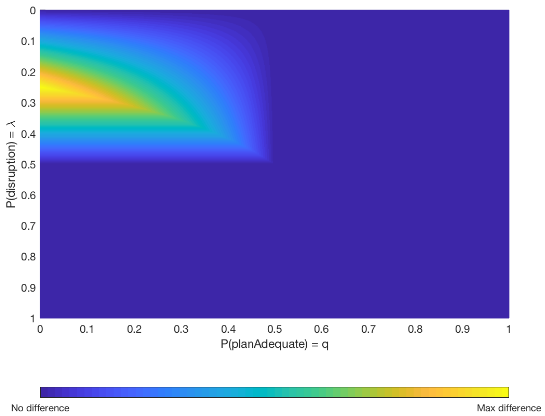
Proposition 4 (Customer's choice in a flexible offering)**.** *When a customer knows he can request the modification of his initial logistics option, his choices are given by the following:*

$$\alpha_{CU} = \begin{cases} \text{Option A} & \textit{if } p_s > c_{ry},\ p_s < (1-q)r \ \textit{ and } p_A < p_B + \lambda p_s & \text{(6a)} \\ \text{Option A} & \textit{if } p_s > c_{ry},\ p_s > (1-q)r \ \textit{ and } p_A < p_B + \lambda(1-q)r & \text{(6b)} \\ \text{Option B, Ask} & \textit{if } p_s > c_{ry},\ p_s < (1-q)r \ \textit{ and } p_A > p_B + \lambda p_s & \text{(6c)} \\ \text{Option B, Don't Ask} & \textit{if } p_s > c_{ry},\ p_s > (1-q)r \ \textit{ and } p_A > p_B + \lambda(1-q)r & \text{(6d)} \end{cases}$$

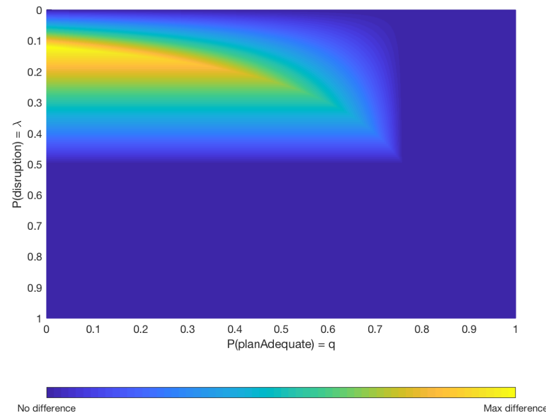
The proposition indicates that, in order for a customer to choose his preferred logistics option, he also needs to take into account the probability his requirements are going to change, as well as the probability the provider's plan will remain adequate if the requirements change. In fact, the customer makes two decisions: which logistics option is preferable and whether he will inform the provider about his new requirements. The proposition also shows that a provider needs to price the extra service in a way that will cover the cost for offering it; we will relax this requirement later on.

To gain intuition of the above propositions, it is convenient to plot the difference between the payoff received by the customer in a fixed and in a flexible offering. In Figure 2 we graphically compare these two payoffs ($flexible - fixed$) under several conditions affecting a customer's payoff (as per Propositions 3 and 4) including the probability for change in requirements, probability of adequateness of provider's plan, cost for not satisfying requirements and price for modifications. While other graphical representations are possible, we believe that the aforementioned conditions are among the most important factors and therefore we emphasize their role in the graphs. It is worth examining the subfigures line by line but also collectively.

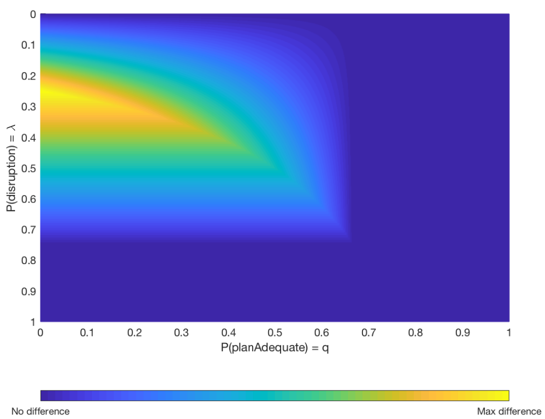
Comparing figures 2a and 2b illustrates the importance of the cost a customer will bear if his requirements are not satisfied (i.e. of r). As the value of r increases, the opportunity to amend ones initial choices become more attractive. Likewise, Figures 2c and 2d, show that as the price for modifications decreases compared to the more expensive and reliable option, the customer tends to prefer access to a cheaper option that he can later on amend, if needed. Looking at all four subfigures, one can see that the benefit of a flexible offering gets its maximum value when it is unlikely that the provider will satisfy any new customer requirements by following his initial plan ($q = 0$). Likewise, the more probable it is that the provider's initial plan will be adequate for any new requirements, the smaller the expected benefit of a flexible offering will get. An interesting observation here is that a flexible offering is not more beneficial than a fixed one when there is a very high probability of new requirements arising. Although this might seem odd at first sight, it reveals a very interesting fact: a customer facing regular disruptions (i.e. frequent need to amend initial choices), will prefer to spend more money up front in order to eliminate the risk of paying an extra cost later on. This is why, although the benefit from a flexible offering is initially increasing as λ increases, there exists a critical point after which the benefit starts decreasing.



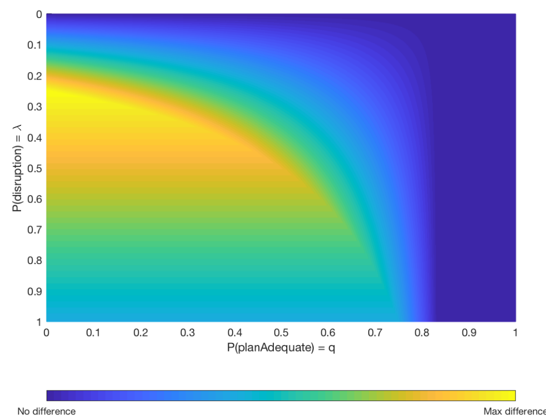
(a) $r = 1/2 * b$
Medium cost for unsatisfied requirements



(b) $r = b$
High cost for unsatisfied requirements



(c) $p_s = p_A$
High cost to amend first choice



(d) $p_s = 1/2 * p_A$
Medium cost to amend first choice

Figure 2: Customer payoff in a flexible offering minus the payoff in a fixed offering

4.3. Best response functions

We now turn our attention to the provider who is the sole decision maker for the provision (or not) of a flexible logistics offering. A provider's choice can be analysed by looking at the full game and analysing its equilibria (since the provider moves first). By doing so, we also investigate the best strategies for both the customer and the provider.

Proposition 5 (Subgame perfect equilibria)**.** *The subgame perfect equilibria in the two-option game are described by Tables 1 and 2. The first three columns of the table along with the first row, form the set of conditions required in order for the specific equilibria in each box in the fourth and fifth column to be true. The first row of each box includes a counter to refer to that particular case, the next two are the strategies of each player in this equilibrium (s^*_{CU} for the Customer and s^*_{PR} for the Provider) and the last two rows are the expected payoffs for each player in the specific case/ equilibrium. We list the strategy profile of each player at* every *node he needs to make a decision,* *even if this node is never reached following the other player's decisions or if there is a chance node*[2].

Table 1: Subgame perfect equilibria and their conditions

Conditions			$p_A < p_B + \lambda(1-q)r$	$p_A > p_B + \lambda(1-q)r$
$p_s > c_{ry}$	$p_s < (1-q)r$	$p_A < p_B + \lambda p_s$	Case 1-A $s^*_{CU} = (OptionA, Ask, OptionA)$ $s^*_{PR} = (Flexible \| \| Fixed, Serve)$ $u_{CU} = b - p_A$ $u_{PR} = p_A - c_A$	Case 1-B Non feasible scenario
		$p_A > p_B + \lambda p_s$	Case 2-A There exist two sub-cases for this Case. Please refer to Table 2.	Case 2-B $s^*_{CU} = (OptionB, Ask, OptionB)$ $s^*_{PR} = (Flexible, Serve)$ $u_{CU} = b - p_B - \lambda p_s$ $u_{PR} = p_B - c_B + \lambda p_s - \lambda(1-q)c_{ry}$
	$p_s > (1-q)r$	$p_A < p_B + \lambda(1-q)r$	Case 3-A $s^*_{CU} = (OptionA, Don'tAsk, OptionA)$ $s^*_{PR} = (Flexible \| \| Fixed, Serve)$ $u_{CU} = b - p_A$ $u_{PR} = p_A - c_A$	Case 3-B Non feasible scenario
		$p_A > p_B + \lambda(1-q)r$	Case 4-A Non feasible scenario	Case 4-B $s^*_{CU} = (OptionB, Don'tAsk, OptionB)$ $s^*_{PR} = (Flexible \| \| Fixed, Serve)$ $u_{CU} = b - p_B - \lambda(1-q)r$ $u_{PR} = p_B - c_B$

Table 2: Breakdown of 'Case 2-A' equilibria

Condition	**Case**
$p_A - (p_B + \lambda p_s) >$ $c_A - (c_B + \lambda(1-q)c_{ry})$	Case 2-A-i $s^*_{PR} = (OptionB, Ask, OptionA)$ $s^*_R = (Fixed, Serve)$ $u_{CU} = b - p_A$ $u_{PR} = p_A - c_A$
$p_A - (p_B + \lambda p_s) <$ $c_A - (c_B + \lambda(1-q)c_{ry})$	Case 2-A-ii $s^*_{PR} = (OptionB, Ask, OptionA)$ $s^*_R = (Flexible, Serve)$ $u_{CU} = b - p_B - \lambda p_s$ $u_{PR} = p_B - c_B + \lambda p_s - \lambda(1-q)c_{ry}$

The cases in Proposition 5 can be easier interpreted in practical terms as follows:

1. When it comes to a customer's initial choice between the available Options (A,B), the customer compares the price of the more expensive and safer option with the expected total cost

[2]For the Customer, the first two decisions reflect his decisions should a flexible logistics offering is in place while the third decision illustrates his choice should a fixed logistics offering is in place. For the Provider, the first decision describes his choice between flexible and fixed offerings, while the second decision explains what he would do if a flexible offering is in place and he is asked for an amendment.

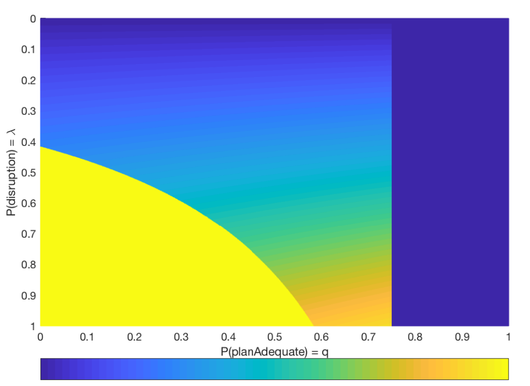
he will incur if a) he needs to modify his initial choice or b) he does not satisfy his new needs in case of a disruption.

2. A customer is willing to ask for amendments as long as the price for this extra service is less than his expected cost in case the provider's initial plan is not adequate;

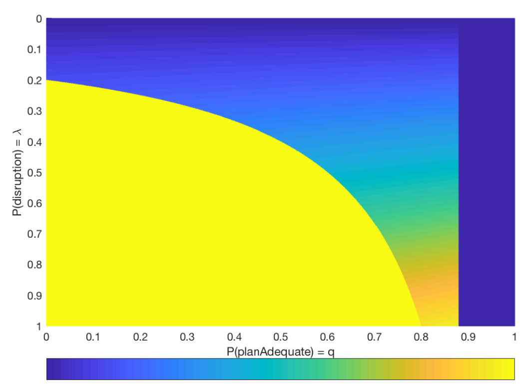
3. Given that the price requested for the extra service can cover the cost for providing it, (i.e. the provider has suitable facilities and/or staff to provide the service), the provider's decision about enabling flexible offerings depends on whether he prefers to limit his customer's options. The provider would consider doing so knowing that his customer will pick the more expensive option in order to eliminate the risk of not satisfying his needs.

4.3.1. The provider in equilibria

Figure 3 plots the provider's payoff under the equilibria in Proposition 5. Figure 3 does not perform a comparison between different offerings but rather shows the provider's payoff under his best response. One can easily observe the distinct cases in Proposition 5 in Figure 3a: The bright yellow area shows the case where the customer picks the more expensive and reliable option regardless of whether his initial option can be amended. This happens when a disruption is highly likely or when a provider is unlikely to be able to satisfy new needs with his initial plan. Similarly, the dark blue area shows the case where the customer picks the cheaper option, which is partially explained by the high probability of the adequateness of a provider's plan. These two areas increase and decrease in size respectively as a customer's potential exposure to risk increases (Figure 3b). The remaining area covers cases where the provider should enable a flexible logistics offering and allow amendments.



(a) $r = 1/2 * b$

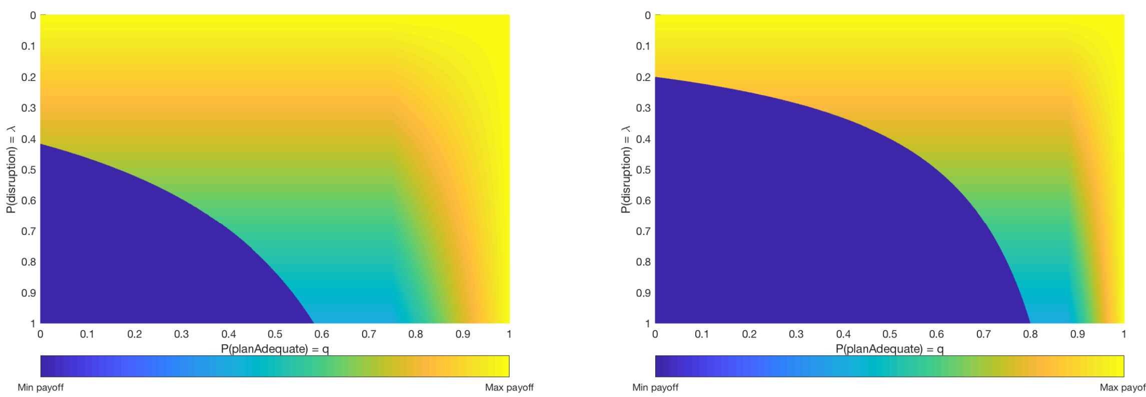


(b) $r = b$

Figure 3: Provider payoff in equilibria

4.3.2. The customer in equilibria

In Section 4.2 we looked at the customer's perspective when it comes to comparing the benefits of a flexible over a fixed logistics offering. However, since the final decisions for enabling such offerings lies with the provider, it is worth examining again what the actual payoffs a customer should expect are. Figure 4 illustrates the customer's payoff in equilibria. A careful comparison between Figure 4, Figure 3 and Figure 2 reveals two very interesting points. Firstly, there are cases that a customer's and a provider's preferences differ. This does not mean that the two parties' payoffs are at odds. On the contrary, as Proposition 5 showed, both parties can benefit from the existence of flexible logistics offerings. Nevertheless, what is often the best outcome for one party is not the best outcome for the other party. Secondly, a customer's preferences are not always satisfied by the provider. This can be easily seen by comparing the values for q and λ that lead to maximum payoff for the customer in Figures 2 and 4. They paint a very different picture and this is due to the fact that a provider's best move is not always the best move for a customer as well.



(a) $r = 1/2 * b$ (b) $r = b$

Figure 4: Customer payoff in equilibria

5. Game variations

In this section, we present variations of the two-option game to study two other interesting cases of flexible logistics offerings. In the first case, we require the customer to pay a fee up front in order to be able to amend his initial choice if needed. This is inspired by our analysis in the previous section that showed that a customer is always better off when given access to a flexible logistics offering. In the second case, we relax the provider's need to set a price for the extra service higher than the cost for providing it as it is common for the exact cost not to be known upfront.

5.1. Upfront payment to access flexible logistics offering

The analysis so far indicates that the existence of a flexible offering will always be beneficial to a customer (see especially Figure 2). A flexible offering is always at least as profitable as a fixed one for the customer, as it simply extends the range of options for the customer at no extra cost. This is evident from the fact that, even if a flexible offering is in place, the customer still has the opportunity not to use it (i.e. by not informing the provider). Moreover, the customer is not required to pay anything in advance in order to have the options available in a flexible offering; he is only asked to pay for the extra service needed only when this is actually required.

An alternative way to provide a flexible offering is via an initial fee. Here, the customer needs to decide in advance whether he is willing to pay a fee that will allow him to access the services provided in a flexible offering. Similar pricing models are often provided by airline companies for flight tickets. In these cases, a customer chooses among a set of tickets with different prices for the same seat, each of them giving him different options if his requirements change after the purchase of the ticket (Mason, 2006).

In order to study this scenario, a change in the game tree describing the decisions and payoffs for the customer and the provider is needed (see Figure A.7). This adds an extra stage in the four-stage game presented in Section 4. In particular, after the provider chooses between a flexible and and a fixed offering, the customer needs to decide whether to pay a fee in advance that will allow him access to the services offered by a flexible offering. Alternatively, the customer can choose to avoid this cost and select a fixed offering.

Proposition 6 (Changes to subgame perfect equilibria under upfront payment). *When a customer is required to pay an upfront fee to access a flexible logistics offering the equilibria presented in Proposition 5 still apply by replacing p_A and p_B with p'_A and p'_B respectively, with exceptions in Cases 2-A and 2-B which create new conditions:*

In Case 2-A:

$$\alpha_{CU} = \begin{cases} \text{Access} & \textit{if } p_{uf} < p_A - p_B - \lambda p_s \quad (7a) \\ \text{Don't Access} & \textit{if } p_{uf} > p_A - p_B - \lambda p_s \quad (7b) \end{cases}$$

In Case 2-A-i:

$$\alpha_{PR} = \begin{cases} \text{Flexible} & \textit{if } p_A - (p_B + p_{uf} + \lambda p_s) < c_A - (c_B + \lambda(1-q)c_{ry}) \quad (8a) \\ \text{Fixed} & \textit{if } p_A - (p_B + p_{uf} + \lambda p_s) > c_A - (c_B + \lambda(1-q)c_{ry}) \quad (8b) \end{cases}$$

In Case 2-B:

$$\alpha_{CU} = \begin{cases} \text{Access} & \textit{if } p_{uf} < \lambda((1-q)r - p_s) \quad (9a) \\ \text{Don't Access} & \textit{if } p_{uf} > \lambda((1-q)r - p_s) \quad (9b) \end{cases}$$

Let us briefly discuss these two cases. In Case 2-A, the customer has a different preference at each offering as he chooses Option B in a flexible and Option A in a fixed offering. As a result he needs to take into account the new cost p_{uf} in order to make his decision. If p_{uf} is high enough to lead the customer to choose the more reliable and expensive option, then the provider is indifferent as a flexible offering will not be used, even if it is available. If, however, p_{uf} is not too high, the provider needs to choose between limiting his customer's options (by offering only a fixed offering in the first place) or extending them. In order to do so, he compares the expected earnings and costs of each option (Case 2-A-i). In Case 2-B, the customer always chooses the cheaper option. His decision between accessing or not a flexible logistics offering will depend on the tradeoff between the cost for modifying his decision ($p_{uf} + \lambda p_s$) and the expected cost from not fulfilling his needs ($\lambda(1-q)r$).

This different pricing model gives the opportunity to a provider to offer a flexible logistics offering in a way that might be more attractive to the eyes of some customers (even if it does not fundamentally change their expected payoffs). The upfront fee acts, in fact, as an insurance premium that many individuals and organisations would prefer paying in order to reduce the potential impact of an unfortunate event.

5.2. Provider obliged to allow amendments

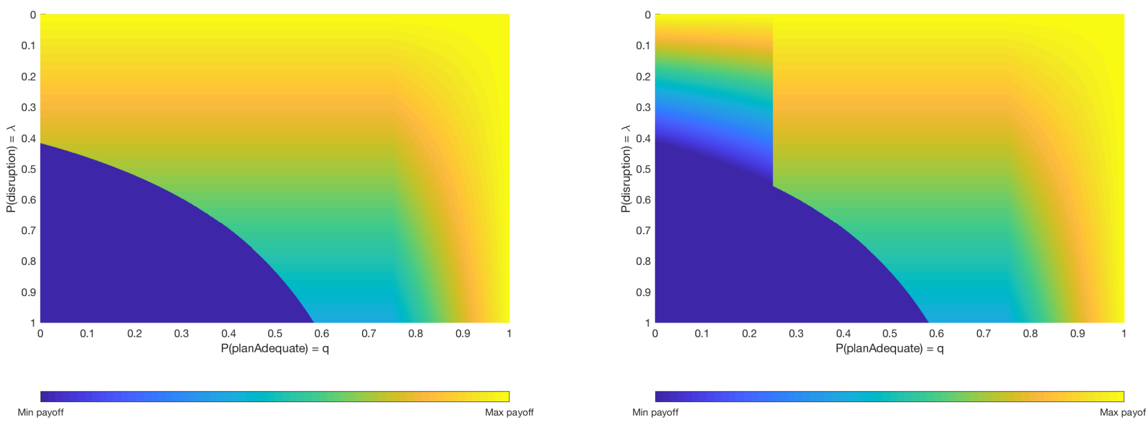
When setting the game in the previous section, we gave the provider the opportunity to not allow modifications (and therefore offer the necessary service associated with it) after being asked to do so. As a result, one of the conditions in Proposition 5 required the provider to set a price for allowing modifications high enough in order to cover the associated cost for enabling the change. This scenario is valid in many practical cases today where flexible logistics offerings are not formally defined and customers ask for ad-hoc solutions or 'favours' when new requirements arise, thus giving the opportunity to a provider to reject a customer's request. This can also be true in a more 'formalised' offering, especially in cases where modifications are allowed for free.

However, should a provider launch a new flexible offering, it is reasonable that he will want to guarantee the extra service if he is asked for it. In this scenario, the provider should allow a customer to change his initial decision even if the cost for supporting this change is not covered by the price requested; that is, the provider cannot make any decision after a customer asks for the extra service (Figure A.8). We therefore propose the following proposition:

Proposition 7 (Changes to subgame perfect equilibria under obligation to allow amendments)**.** *When a provider does not have the option to deny service to a customer if he asks for an amendment in a flexible logistics offering, the equilibria presented in Proposition 5 still apply with three exceptions: Firstly, the condition that $p_s > c_{ry}$ is no longer required. Secondly, the provider can no longer play 'Serve' at any strategy as this is no longer a feasible option. Thirdly the provider's best strategy in Case 2-B is as follows:*

$$s^*_{PR} = \begin{cases} \text{Flexible} & \textit{if } p_s > (1-q)c_{ry} \quad (10a) \\ \text{Fixed} & \textit{if } p_s < (1-q)c_{ry} \quad (10b) \end{cases}$$

Proposition 7 shows the analysis performed previously still applies with the only significant exception having to do with one condition. In this scenario, even if the cost for offering the extra service is higher than the price requested for it (i.e. $p_s < c_{ry}$), the provider is still better off by enabling a flexible offering. The new price requested does not need to cover the full cost for offering the extra service (i.e. the condition $p_s > c_{ry}$ is not required) but rather it just needs to cover the expected cost for offering it *if needed* ($p_s > (1-q)c_{ry}$). As a result, the price asked for the extra service can now be lower than previously. In this scenario, the provider, by making a choice to accept the risk of not recovering full cost, accepts that the price he can ask for the extra service can be lower than before.



(a) $p_s > c_{ry}$
Profitable to offer extra service

(b) $p_s < c_{ry}$
Non profitable to offer extra service

Figure 5: Customer payoff in equilibria under obligation of service

The difference between Figures 5a and 5b illustrates the fact that for small values of λ and q, the provider is better off providing a fixed offering, thus reducing the customer's payoff. At first instance, this might look as a worse situation for the client as his payoff is reduced under certain conditions. However, note that the provider is now able to offer amendments at a cheaper price and in more cases as the condition $p_s > c_{ry}$ is no longer required.

6. Discussion

Following the analysis conducted in the previous sections, the key outcome related to the research question posed in Section 1 is that a logistics offering that allows amendments to be made to an order's details after its placement can be beneficial both to the customer who receives the service but also to the retailer who provides it. Via a flexible logistics offering, a customer gets the opportunity to initially choose cheaper options for the delivery of his order and, if needed, request and pay for an extra service that will satisfy any new requirements. From the retailer's perspective, a flexible logistics offering gives him the opportunity to increase his earnings by providing an extra service in case of customer modifications rather than receive only the profit from his fixed offering. In fact, we showed that there are certain conditions under which both parties benefit from the existence of a flexible offering without any of them having to suffer for gains received by the other. Similar observations on the value of flexibility have also been made by recent empirical studies that have demonstrated how customers offer prefer flexibility over more traditional factors such as speed (Gawor and Hoberg, 2019; Amorim et al., 2020).

The specific conditions might vary depending on the details of the pricing model, the availability of initial options, the profitability of each option etc. Overall, four main conditions affect whether a flexible logistics offering will be used: for the retailer, *i*) whether he can cover the expected cost for providing the extra service of a flexible logistics offering, and *ii*) whether the total expected profit from a customer paying for an extra service is greater than the expected profit from a customer choosing a more expensive and safer option up front. For the customer, *iii*) whether the expected cost for using a flexible offering is less than the expected cost for not satisfying his changed needs, and *iv*) whether the expected cost for using a flexible logistics offering is less than the expected cost for choosing a safer and more expensive option up front.

The results also indicate that flexible logistics offerings are more appropriate in cases where uncertainty about the need for order amendments is neither low or high. This might seem odd since a flexible logistics offering gives the opportunity to a customer to satisfy new needs. However, when uncertainty is very high and the customer knows that there is a high probability that a cheaper initial option will not be adequate, he will try to minimise this risk by choosing a safer strategy from the beginning. Of course, this requires such a safer strategy to be available and that the customer can estimate the characteristics of the new needs that might appear. For example, a customer that requires an item for an event that could happen at any time in the next week (i.e. high uncertainty) is more likely to choose a safer and faster delivery option up front instead of relying on a flexible offering.

Perhaps one of the more interesting observations is that the success of a delivery does not depend on the monetary value of the product/order itself but rather the cost for not receiving it at the right time and place. Indeed, one is hard to place a value on the contents of a grocery order intended to be used for baking a birthday cake of a beloved one or the value of a dress to be used for a graduation prom (Nguyen et al., 2019; Fisher et al., 2019). This indicates the difficulty of a retailer to estimate the value of an order from the perspective of the customer but also the impact wrong deliveries have on them. On one hand, this indicates that a retailer can specify the price for the flexible logistics offering in a way that makes this offering beneficial for him and the customer regardless of specific characteristics of the products or the customers it involves. On the other hand, it highlights the importance of the actual value a delivery has for a customer for the success of such offerings. Here, the price associated with the provision of a flexible logistics offering can reduce the impact of wrong deliveries (i.e. reduce the losses a customer might suffer if his requirements are not satisfied), even if his resulting payoff might end up being negative as the flexibility will actually help him avoid an even more negative payoff.

While considering the practical implementation of such offerings a retailer should be careful when specifying the pricing model as maximising his payoff could reduce the customer's one. Since a fee is always paid by the customer to the retailer in a flexible offering, it follows that the higher this price is the smaller the payoff received by a customer. The risk here is that, after a certain price, the difference between the customer payoff received in a flexible and a fixed offering becomes very small, making the customer indifferent between the two offerings. In practice, a retailer might prefer reducing his own payoffs in order to make a flexible logistics offering more attractive for his customer. Notice that for any meaningful comparison between flexible and fixed offerings to be conducted, the customer should always expect a positive payoff from his interaction with the retailer (i.e. it needs to be profitable for him to place an order and purchase a product in the first place). This is because the comparison in this paper aims to examine the potential benefits of post order placement services rather than the original intention of a customer to purchase (or not) an item.

Our analysis showed clear direct benefits for the customer, and potential benefits for the retailer. Nevertheless it is also important to understand and consider the indirect benefits of successful deliveries (i.e. deliveries based on the actual needs of the customer). Besides the clear benefit of increased customer satisfaction (Vakulenko et al., 2019), this can lead to significant operational and financial gains for a retailer who will not need to deal with cost-bearing operations like *i*) missed deliveries, *ii*) order returns, *iii*) customer service of unsatisfied customers. In industry, it is often the case that these costs compare in size the more standard warehousing and transportation costs of an order.

Even though the analysis in the paper used as a motivating example the need for amending the delivery speed of an order (i.e. expediting it), it is important to note here that the post order placement customer experience is not limited to that. In a truly omni-channel environment, a customer is in fact seeking for the full control of his order throughout its lifecycle; this starts with small changes but should ideally extend to complete flexibility and customisation of the services required for a customer to get access to the physical goods he ordered (Wollenburg et al., 2018). One can think of a case where a customer, after placing an order online, finds himself the next day wondering around the physical store of the same retailer. In a seamless omni-channel world, the customer should be able to simply walk in the store and pick the same item without having to go through order cancellations, order returns, payment of extra fees etc. This latter example indicates another important aspect: order amendments can be beneficial not only when costs need to be avoided due to new requirements arising but also when extra benefits can be received when an opportunity arises. We did not look at this latter issue specifically in this study but the game theoretic model developed can be easily adapted to study such cases.

Finally, we comment on the operations and information systems necessary to enable such flexible offerings. The development and adoption of digital technologies by the retail and the logistics industries have set the foundations that can allow the implementation of more flexible and customised services towards a more convenient fulfilment experience (Giannikas et al., 2019). In some cases, the implementation is a matter of cultural acceptance rather than practical feasibility. One is hard to understand why an extra bottle of milk cannot be added to a groceries order after the cut-off time (that is set 12–24 hours before the actual delivery is planned). In fact, the power of today's computational systems and the availability of appropriate algorithms make the planning of one day's deliveries a matter of minutes (or few hours). Elsewhere, a more careful consideration is needed as the digital systems alone are not enough to execute the necessary operations in the physical world. In these cases, digital technologies can still be used to support and enhance physical operations in ways that may not be directly visible to a customer but can contribute to the development of better services.

7. Conclusions

This research study has investigated the value of flexible offerings in logistics that target post order placement services. These logistics offerings allow customers to modify their initial decisions about the orders/services requested before their delivery by a retailer. A game-theoretic model was developed to investigate the main research question and compare the relative benefits of fixed and flexible logistics offerings and the conditions under which the latter can be beneficial for customers and retailers. Although the model can be used to quantify the expected payoffs of both parties, we notice here that it is the retailer's ultimate decision whether a flexible logistics offering will be offered as he is the one who needs to invest in the appropriate systems that support them. Nevertheless, it is the customer's decision whether such an offering will be used, even if it is in place, thus affecting its benefits significantly.

From a theoretical point view, this paper aims to highlight the importance of post order placement services to the customer experience in omni-channel retail. More specifically, it argues on the value of services that allow a customer to customise and modify his orders and deliveries even after their placement. More generally, our study contributes to the ongoing discussion on customer-orientation in supply chain and logistics management. The model developed in this study offers a tool for the understanding of the interactions emerging between providers and customers in flexible and fixed offerings. An advantage of this model is that it can be easily modified to cover other similar flexible offerings —and their associated pricing models— depending on the details of each logistics case.

The main practical contribution of this paper is the demonstration of potential benefits from offering greater flexibility both to the customer and to the retailer while highlighting the key factors affecting the size of those benefits. Practical cases that would benefit more from greater flexibility are those where uncertainty is neither low or high. That is, where the customer expects no changes to be required or where he prefers a safe option, respectively. Moreover, the game-theoretic model can be used by potential adopters to analyse specific industrial cases and determine whether to offer and how to price a flexible logistics offering. Interestingly, the application area of this work can be extended to cases where different types of *providers* and *customers* interact via a logistics service. For example, in retail, one could consider retailers who own and manage their own logistics resources —instead of purchasing logistics services from other companies— thus potentially affecting the cost structure. Outside retailing, the model can be adapted to cases where B2B commerce requires modifications after an order placement, e.g. a part is needed previously than expected due to unexpected maintenance of an aircraft. Last but not least, this paper aims to advocate that in a fulfilment world that focusses on speed and cost, convenience is often as important (if not more) for consumers.

Perhaps one of the main limitations of our work is the assumption that —due to the nature of game-theoretical modelling— both players know the structure of the game and each other's payoff functions. Although in the version presented in this paper, the customer's knowledge on the payoff function of the provider will not affect his own decisions, this is not true for the provider's side. However, it has been shown in previous sections how this issue can be tackled (at least partially) through the conduction of sensitivity analysis over the unknown parameters, so that decisions can be made even if exact values are not known. Another issue that should be noted, is the calculation of the probabilities used in the framework. Even though at first glance, their estimation might seem complicated, there are many cases where this can be feasible given the availability of data gathered and collected by retailers and logistics providers today. As an example, one can think of a regular customer of an online store who can quite accurately predict the delivery date of his orders even when there is no defined date given by the company. Equally, a retailer can estimate the probability a customer will amend his order by looking at past orders. Over time, and in the presence of a flexible logistics offering that allows easy amendments, more data points will be available for a more accurate estimation of these probabilities. In practice, it is more likely for a retailer to use a model like the one introduced in this study based on well-informed estimations rather than on the knowledge of the actual parameters. Again, sensitivity analysis over the unknown parameters can be used to better support decision making. Future research may also develop models that implement partial information among the players in other ways, e.g. over the probability a customer's requirements will change.

Although the above issues might limit the usage of the game-theoretic model in certain cases, there is a significant potential for extension and future research. First of all, scenarios based on specific real-life cases can be modelled and examined using the main components of the game, taking into account more complex settings and thus including other elements of time, cost and information availability. For example, researchers can investigate how demand cycles, which are typical in today's e-commerce environment, can be taken into consideration. Similarly, one can look into how the cost for unfulfilled customer requirements might change over time as the day when the customer needs to use the purchased items approaches. Secondly, the analysis of the equilibria can be extended in order to examine long term relations by using repeated games theory. Thirdly, the case of negotiation between customers and retailers for the details of a flexible logistics offering can be presented and tested using bargaining mechanisms in parts of the game.

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2007–2013.

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Appendix A. Proof of propositions

Appendix A.1. Proof of Propositions 1 and 2

Figure A.6 illustrates the game theoretic model along with the payoff functions for each player at each terminal history. Payoffs are shown at the right hand side of each end node in the form '*Payoff for Customer* (u_{CU})*, Payoff for Provider* (u_{PR})'. The model depicted uses option A as a special option that always satisfies a customer's requirements even if they change after order placement (e.g. very fast delivery).

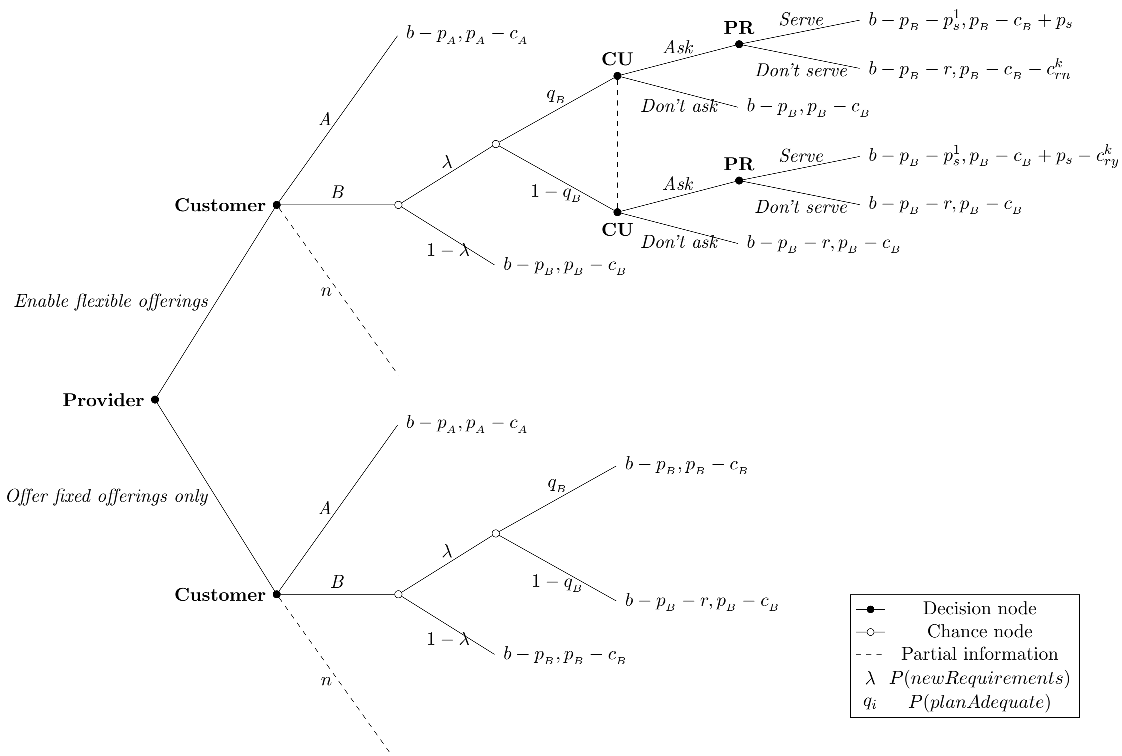

Figure A.6: Game theoretic model: generic structure

From the figure, one can see that the expressions for each player's payoff follow. □

Appendix A.2. Proof of Proposition 3

We study the subgame that begins after the Provider chooses to offer a fixed offering only in Figure A.6 (assuming only Options A and B are available). In order for the Customer to pick

Option A it should hold true that:

$$u_{CU}(OptionA) > u_{CU}(OptionB)$$
$$b - p_A > b - p_B - \lambda(1-q)r$$
$$p_A < p_B + \lambda(1-q)r\square$$

Appendix A.3. Proof of Proposition 4

Similar to Proposition 3, we study the subgame that begins after the Provider chooses to offer a flexible offering in Figure A.6. We use solve the subgame backwards.

Serve is the provider's dominant strategy as long as $p_s > c_{ry}$ as then $u_{PR}(Serve) > u_{PR}(Don'tServe)$. If $p_s < c_{ry}$, the provider will choose not to serve; this case will not be studied in more detail here since it describes the odd situation in which a provider chooses to provide flexible offerings, but then decides not to offer them even if needed by the customer.

Focusing next on the chance node of the game we compare a customer's choice to inform the provider about his new requirements against sticking with his initial decision. We have:

$$\begin{aligned}
u_{CU}(Ask \mid Serve) =& q \cdot u_{CU}(Ask, Serve \mid PlanAdequate) + \\
& (1-q) \cdot u_{CU}(Ask, Serve \mid PlanNotAdequate) = \\
& q(b - p_B - p_s) + (1-q)(b - p_B - p_s) = b - p_B - p_s \\
u_{CU}(Don'tAsk \mid Serve) =& q \cdot u_{CU}(Don'tAsk, Serve \mid PlanAdequate) + \\
& (1-q) \cdot u_{CU}(Don'tAsk, Serve \mid PlanNotAdequate) = \\
& q(b - p_B) + (1-q)(b - p_B - r) = b - p_B - (1-q)r
\end{aligned}$$

Comparing the two:

$$u_{CU}(Ask \mid Serve) > u_{CU}(Don'tAsk \mid Serve) \Rightarrow$$
$$b - p_B - p_s > b - p_B - (1-q)r \Rightarrow$$
$$p_s < (1-q)r$$

We now need to compare the two logistics options with and without the customer requesting modifications.

$$\begin{aligned}
u_{CU}(OptionA \mid Ask, Serve) =& u_{CU}(OptionA \mid Don'tAsk, Serve) = b - p_A \\
u_{CU}(OptionB \mid Ask, Serve) =& \lambda \cdot u_{CU}(OptionB \mid Ask, Serve, NewReq) + \\
& (1-\lambda) \cdot u_{CU}(OptionB \mid Ask, Serve, NoNewReq) = \\
& \lambda(b - p_B - p_s) + (1-\lambda)(b - p_B) = b - p_B - \lambda p_s \\
u_{CU}(OptionB \mid Don'tAsk, Serve) =& \lambda \cdot u_{CU}(OptionB \mid Don'tAsk, Serve, NewReq) + \\
& (1-\lambda) \cdot u_{CU}(OptionB \mid Don'tAsk, Serve, NoNewReq) = \\
& \lambda(b - p_B - (1-q)r) + (1-\lambda)(b - p_B) = \\
& b - p_B - \lambda(1-q)r
\end{aligned}$$

Comparing the first two we have:

$$\begin{aligned}
u_{CU}(OptionA \mid Ask, Serve) > u_{CU}(OptionB \mid Ask, Serve) \Rightarrow \\
b - p_A > b - p_B - \lambda p_s \Rightarrow \\
p_A < p_B + \lambda p_s
\end{aligned}$$

Comparing the first and the third strategies we have:

$$\begin{aligned}
u_{CU}(OptionA \mid Ask, Serve) > u_{CU}(OptionB \mid Don'tAsk, Serve) \Rightarrow \\
b - p_A > b - p_B - \lambda(1-q)r \Rightarrow \\
p_A < p_B + \lambda(1-q)r \square
\end{aligned}$$

Appendix A.4. Proof of Proposition 5

We now study the whole game with the provider choosing between providing a flexible and a fixed offering. As shown in Propositions 3 and 4 the are four different cases when a flexible offering is available and two when a fixed offering is available. By comparing the payoff for the provider in all combinations of cases, the results in Table 1 easily follows. The only case that differentiates is Case 2-A, the results of which depend on the difference between the provider costs for Options A and B (c_A and c_B). Assuming $c_A \neq c_B$ and comparing the provider's payoff Table 2 follows. □

Appendix A.5. Proof of Proposition 6

We begin with drawing a tree that describes the scenario where a customer has to pay an upfront fee to access a flexible logistics offering. Figure A.7 depicts this scenario (upfront fee denoted as p_{uf}). Similar to the proof for Proposition 5, we use backward induction to solve the new sequential tree. Due to length restrictions, the complete proof is omitted here but the principles applied previously still apply and they easily follow. We notice also that much of the analysis previously conducted is also valid here by replacing p_A with $p'_A = p_A + p_{uf}$ and p_B with $p'_B = p_B + p_{uf}$ where needed. Re-calculating the game's equilibria, one can easily see that only Cases 2-A-i and Case 2-B will be different (compared to the equilibria of Table 1). We focus on these cases only here:

Case 2-A: Customer prefers paying for the upfront cost and accessing a flexible offerings when:

$$\begin{aligned}
u_{CU}(Access) &> u_{CU}(Don'tAccess) \Rightarrow \\
b - p'_B - \lambda p_s &> b - p_A \Rightarrow \\
p_B + p_{uf} + \lambda p_s &< p_A \Rightarrow \\
p_{uf} &< p_A - p_B - \lambda p_s
\end{aligned}$$

Case 2-A-i: Provider prefers flexible when:

$$\begin{aligned}
u_{PR}(Flexible) &> u_{PR}(Fixed) \Rightarrow \\
p_B - c_B + p_{uf} + \lambda p_s - \lambda(1-q)c_{ry} &> p_A - c_A \Rightarrow \\
p_A - (p_B + p_{uf} + \lambda p_s) &< c_A - (c_B + \lambda(1-q)c_{ry})
\end{aligned}$$

Case 2-B: Customer prefers paying for the upfront cost and accessing a flexible offerings when:

$$\begin{aligned}
u_{CU}(Access) &> u_{CU}(Don'tAccess) \Rightarrow \\
b - p'_B - \lambda p_s &> b - p_B - \lambda(1-q)r \Rightarrow \\
p_B + p_{uf} + \lambda p_s &< p_B + \lambda(1-q)r \Rightarrow \\
p_{uf} + \lambda p_s &< \lambda(1-q)r \Rightarrow \\
p_{uf} &< \lambda(1-q)r - \lambda p_s \Rightarrow \\
p_{uf} &< \lambda((1-q)r - p_s)\Box
\end{aligned}$$

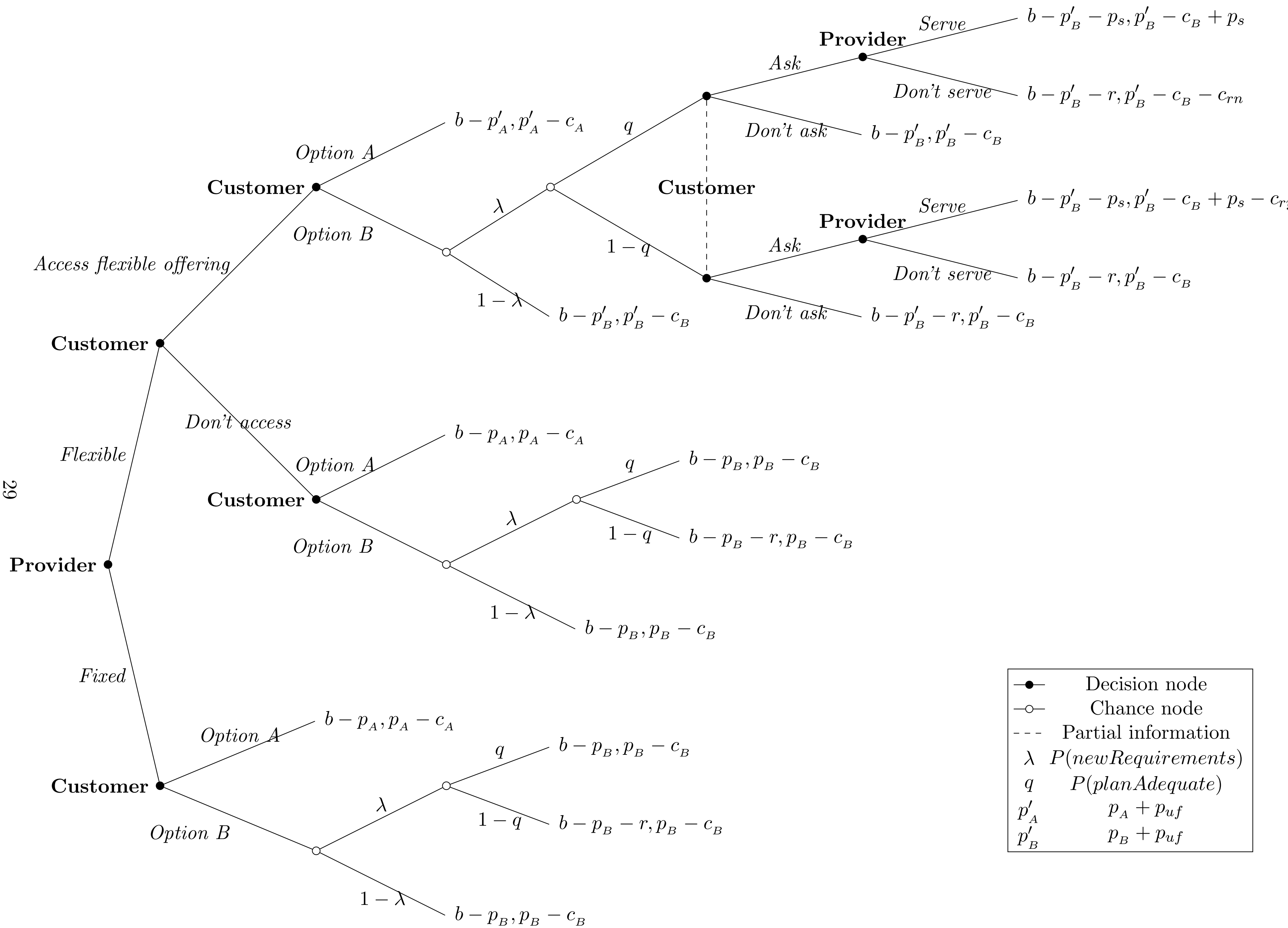

Figure A.7: Game tree requiring upfront payment of a fee to access flexible offering

Appendix A.6. Proof of Proposition 7

In the two-option game studied in this paper, this scenario would practically mean the removal of the final decision nodes of a provider in a flexible logistics offering and it is illustrated in Figure A.8. The revised game tree illustrates that after a customer makes a decision to ask for a change, no more decisions will be made by either of the parties. The rest of the tree remains the same as in Figure A.6.

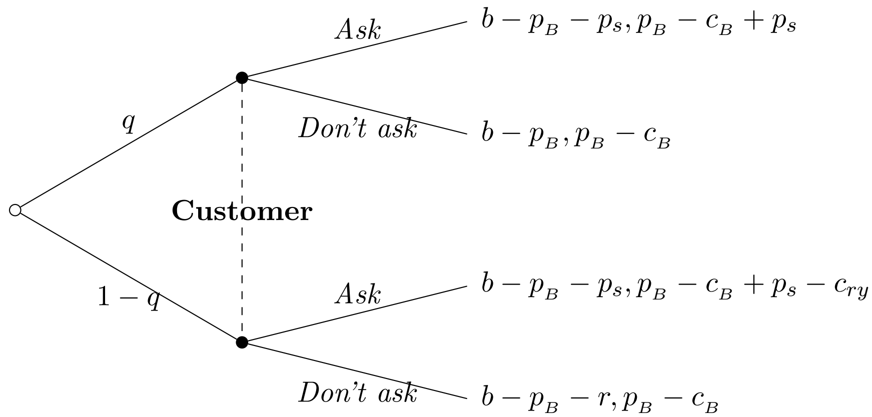

Figure A.8: Part of modified game tree without decision for offering extra service

Similar to the proof for Proposition 5, we use backward induction to solve the new sequential tree. Re-calculating the game's equilibria, one can easily see that only Case 2-B will be different (compared to the equilibria of Table 1). In Case 2-B, the provider's expected payoff from the fixed offering is $u_{PR}(Fixed) = p_B - c_B$ and from the flexible offering $u_{PR}(Flexible) = p_B - c_B + \lambda p_s - \lambda(1-q)c_{ry}$. Thus, the provider will choose *Flexible* if:

$$
\begin{aligned}
u_{PR}(Flexible) &> u_{PR}(Fixed) \Rightarrow \\
p_B - c_B + \lambda p_s - \lambda(1-q)c_{ry} &> p_B - c_B \Rightarrow \\
p_s &> (1-q)c_{ry} \square
\end{aligned}
$$